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DISSERTATION

ARCHITECTURE'S UNWANTED CHILD:

BUILDING CLIMATOLOGY IN ISRAEL, 1940-1977

Ausgeführt zum Zwecke der Erlangung des akademischen Grades
einer Doktorin/eines Doktors der technischen Wissenschaften unter
der Leitung von

Univ. Prof. DI Dr. Ardeshir Mahdavi
E 259-3 Abteilung Bauphysik und Bauökologie
Institut für Architekturwissenschaften

eingerichtet an der
Technischen Universität Wien
Fakultät für Architektur und Raumplanung

von
DI Or Aleksandrowicz
Matrikelnr. 0927381
Gußhausstraße 26/7, 1040 Wien

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Kurzfassung

Der Begriff der Bauklimatologie kam in der zweiten Hälfte des 20. Jahrhunderts auf. Er bezeichnet eine interdisziplinäre Anwendungswissenschaft aus den Bereichen Architektur, Physik, Bauwesen und Klimatologie. Ziel ist es, die thermischen Eigenschaften von Gebäuden und die Nutzerreaktion auf thermische Bedingungen in Gebäuden zu untersuchen. Wissenschaftliche Erkenntnisse sollen hierbei für den Entwurfs- und Planungsprozess genutzt werden, um so Gebäude zu errichten, welche insbesondere optimale klimatische Bedingungen im Innenraum aber auch in der direkten Umgebung berücksichtigen. Hierfür wurde eine beachtliche Wissensbasis geschaffen, welche es Architekten ermöglichen sollte Bauwerke so zu planen, dass diese optimal an die standortspezifischen Klimabedingungen angepasst sind. Dennoch werden diese Erkenntnisse und Werkzeuge von Planern immer noch weitestgehend ignoriert. In Anbetracht der Anstrengungen die auf diesem Gebiet in den letzten Jahrzehnten gemacht worden sind, ist es wichtig sich die Ursachen und Gründe für die fehlende Akzeptanz und Anwendung dieses Wissens anzuschauen.

Die vorliegende Arbeit untersucht die Beziehung zwischen angewandter Architektur und der Bauklimaforschung in Israel zwischen 1940 und der Mitte der 1970er Jahre. Aufgrund der klimatischen Bedingungen und der damit verbundenen Notwendigkeit einer Auseinandersetzung mit dem Thema des klimagerechten Bauens, wurde in Israel besonders intensive auf diesem Gebiet geforscht. Der Forschungsbereich entwickelte sich fast ausschließlich um eine Gruppe deutscher Immigranten und wurde intensiv vom Wohnungsbauministerium unterstütz. In den 60er und 70er Jahren des vorigen Jahrhunderts erlangten diese israelischen Wissenschaftler auch internationale Anerkennung für ihre Intensiven Forschungen auf dem Gebiet der Bioklimatologie. Trotz dieser Erfolge und obwohl es unter den Architekten ein Bewusstsein für diese Problematik gab, war der Effekt auf die Planungs- und Baupraxis in Israel minimal. In diesem Widerspruch lassen sich die Mängel bei der Interpretation und Umsetzung der gewonnenen Erkenntnisse durch die lokalen Architekten ablesen. Gleichzeitig mit der Weiterentwicklung der wissenschaftlichen Forschung auf dem Gebiet, sank auch das Interesse der Architekturschaffenden an einer tieferen Auseinandersetzung mit dem Thema.

Die vorliegende Studie zeigt einen multidisziplinären Ansatz zur Analyse der Beziehung zwischen Architektur und Bauklimatologie am Beispiel der Situation in Israel. Im ersten Teil wird ein Überblick über die bauklimatische Forschung in Israel, ihre Schwierigkeiten, ihre Erfolge und ihre Auswirkungen auf die Architekturschaffenden gegeben. Darauf folgt eine Analyse von drei Fallbeispielen: das Gilman Gebäude in Tel Aviv, einer Siedlung in Be'er Sheva und dem Eshkol Tower in Haifa. Jedes dieser Gebäude repräsentiert einen anderen Entwurfsansatz und eine unterschiedliche Herangehensweise in Bezug auf die wissenschaftlichen Erkenntnisse. Die Analyse der vorliegenden Fallbeispiele bindet architekturhistorische Untersuchungsmethoden und Effizienzanalysen der Gebäude ein. Die Anwendung verschiedener Untersuchungs- und Analysemethoden ermöglicht eine facettenreiche Darstellung der Beziehung zwischen Architektur und bauklimatischer Forschung. Daraus lässt sich die von der architektonischen Anwendung entkoppelte Entwicklung der Bauklimatologie in Israel ablesen, und der Schluss liegt nahe, dass die Forschungsergebnisse von den lokalen Architekturschaffenden nie vollends anerkannt bzw. zur Anwendung gebracht wurden. In den wenigen Fällen, in denen das Wissen von sachkundigen Architekten eingesetzt und in allen Planungsphasen berücksichtigt wurde, wurden gute Ergebnisse erzielt. Nichtsdestotrotz kam es zu keinem Umdenken unter den Architekturschaffenden und das Thema der Bauklimatologie wurde auch weiterhin stiefmütterlich behandelt. Die Mehrheit der israelischen Architekten war auch weiterhin nicht interessiert, und lehnte oft auch eine Zusammenarbeit mit entsprechenden Experten ab, was sich in der Geringen Zahl der Gebäude welche unter Einbeziehung des bauklimatischen Wissens entstanden sind ablesen lässt.

Abstract

The discipline of building climatology, which emerged during the first half of the 20th century, combines knowledge in architecture, civil engineering, physiology, meteorology, and physics. It aims at exploring the thermal properties of buildings and the human reaction to thermal conditions created and affected by buildings. Upon its emergence, building climatology implicitly suggested an alternative design methodology in which design decisions could be based on scientifically-sound and quantitative (instead of qualitative) parameters, including parameters which define the desired thermal characteristics of buildings ("indoor climate") and their surroundings ("outdoor climate"). The new discipline has produced an impressive body of knowledge which could have helped architects to scientifically optimize the response of their buildings to climatic conditions. Nevertheless, it can be argued that architects at large still neglect the rich scientific knowledge and tools created by building climatology, failing to integrate them into the design of buildings. Keeping in mind the magnitude of research efforts that were invested in building climatology for more than half a century, it is thus important to look into this failure and to understand its causes and effects.

The current study explores the relation between architectural practice and building climatology research in Israel from the beginning of the 1940's up to the mid-1970's. Israel is an excellent example for a country in which building climatology was rapidly developing because of a pressing need to resolve recurrent climatic failures of common design and building methods, and especially in meeting the challenges of its hot season. A scientific field established almost exclusively by Jewish émigrés from Germany, Israeli building climatology, which received a long-standing support from the country's Ministry of Housing, was developing during the 1960's and 1970's to gain international recognition for its scientific achievements. In spite of its expanding body of knowledge and its impressive scientific level, the effect of Israeli building climatology on local architecture practices was minimal, even in times when local architects continued to express their concern over the climatic aspects of building.

This discrepancy reflected some basic flaws in the way the emerging science has been understood, interpreted, and applied by local architects. The overall tendency was clear: as scientific research became more and more elaborate and detailed, architects were less and less open to exploit its products in a sincere and rigorous manner.

A multi-disciplinary approach for conceptualizing and analysing the relation between architecture and building climatology, based on the Israeli case, is employed in the current study. It first unfolds the history of building climatology research in Israel, its struggles, achievements, and reception among local architects, and then analyses three case studies (the Gilman Building in Tel Aviv, the Model Housing Estate in Be'er Sheva, and the Eshkol Tower in Haifa), each one representing different design habits and approaches towards scientific knowledge, by coupling historical research with the analysis of the buildings' climatic performance. The integration of different research and analysis methods enables to extract a multi-faceted depiction of the relations between climatic research and architecture, and to conclude that building climatology in Israel has been developing as a separate body of knowledge which was never fully accepted or even partially absorbed within the repertoire of local architectural know-how, practices, and techniques. In the few cases where building climatology knowledge was employed by informed architects during all stages of design, the results proved to be satisfactory. On the other hand, the majority of Israeli architects were reluctant to acquire the needed expertise in building climatology or even to cooperate with experts in the field, making the impact of building climatology research on the performance of local buildings limited and partial, if existing at all.

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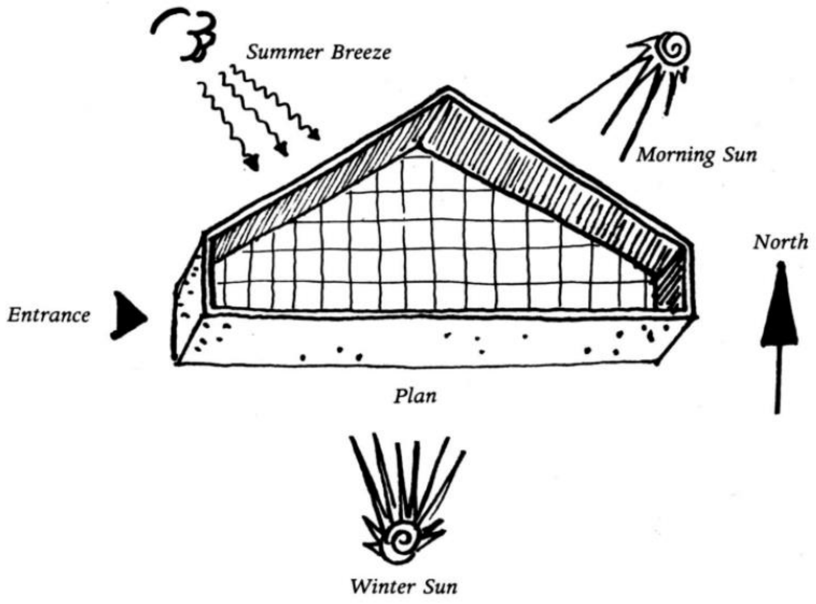
Contents

1 CLIMATE AND ARCHITECTURAL DESIGN: A THEORETICAL FRAMEWORK

1.1 Introduction

December 1953

In a series of lectures we were introduced to the problems of climate and building. The major points were, that in different seasons some sides of the house have advantages over the others. We were told to design an exercise sketch.



My conclusions were that I had to:

1. Minimize the climatically worst walls, east and west,
2. Get the morning sun from the northeast side,
3. Get the winter sun from the south (maximum),
4. Get the summer breeze from the northwest.

If you follow these instructions you cannot miss the trapezoid-shaped plan of the house.

I was very proud of my ability to solve the climatic problems merely by shaping the house.

I got back my sketch marked with a big red question mark. (Goodovitch 1967, 10)

Architecture and climate are inseparable, or at least seem to be inseparable in the eyes of common building users. The relation between architectural design and climatic considerations is, on the other hand, much less established, and in times tends to be purely coincidental. This can be explained by the interdisciplinary nature of architectural design, which has to consider a myriad of sometimes contradictory perspectives and intentions. As noted by the Israeli architect Israel Goodovitch during his first semester as an architecture student at the Technion in Haifa, designing a successful climatically adapted building is usually not an issue of simplistic formulations.

The question of building and climate was regarded as fundamental for the success of the Zionist project since its very early stages, much before the State of Israel was established. In the autumn of 1909, the Jewish-German architect Alexander Baerwald (1877-1930) arrived in Palestine for the first time. A few months earlier, he was invited by the *Hilfsverein der deutschen Juden* to design the main building of a *Technikum* in Haifa, the first technological university in Palestine that would later receive a Hebraized name, the *Technion*. Coming from Berlin, Baerwald was interested in studying the local building technologies as a basis for a new, Zionist architectural idiom suitable for the project he was commissioned to design. In October 1910, following his visit, Baerwald published a detailed account on his findings in *Die Welt*, the mouthpiece of the Zionist movement (Ben-Artzi 2006, Heinze-Greenberg 2011, 133-143). The significance of his text lies not only in its content, but also in its spirit; this is, almost undoubtedly, the first essay to consciously consider the building blocks of a (yet to come) modern Hebrew architecture in Palestine.

A central part from Baerwald's article was dedicated to the climatic challenges of the land. Baerwald saw a direct link between local climate and the built residential vernacular, and argued that climate had a major impact on local building conventions:

> Während, wie wir sahen, für die Anlage von Ansiedlungen die Wasserfrage, die Baumaterialienbeschaffung und die Arbeiterfrage bestimmend sind, hat auf die

> Grundrißdisposition und die Konstruktion des Gebäudes selbst das Klima Palästinas den größten Einfluß. Die Regenperiode, der schnelle Wechsel von großer Hitze am Tage und energischer Abkühlung mit reichlicher Taubildung in der Nacht, die tagelangen Windstillen bei heißestem Sonnenbrand stellen dem entwerfenden Architekten besondere Bedingungen. Das tropische Klima ermöglicht dem Bewohner, das ganze Jahr im Freien zu verweilen. Die jährliche Regenperiode erfordert das flache Dach, der schroffe Temperaturwechsel verlangt starke Wände, am besten mit einer Isolierschicht, und gegen den erschlaffenden Chamzin oder Schirokko gibt es nur ein Mittel: Luftströmungen im Innern der Wohnräume zu schaffen. Allen diesen Bedingungen wird die in Palästina augewandte bodenständige Bauweise in außerordentlich geschickter Art gerecht; und zwar geht die Anpassung der Bauart und die Grundrißbildung der Gebäude an die klimatischen Verhältnisse des Landes so weit, daß in Orten verschiedenen Klimas in Palästina auch verschieden gebaut wird, also z.B. in Jerusalem anders als in Haifa. (Baerwald 1910, 1048-1049)

Baerwald was probably the first Zionist architect to formulate what would later become a recurrent motif in the writing on architecture in Palestine: the belief that local vernacular buildings, especially in cities, are well-adapted to the climate of the land. Since Zionism called for the return of the Jewish people to his ancient homeland, it was evident that not only new forms of life will be constructed in it, but also a new form of building, which the newcomers, most of them originating from much colder countries, must acquire. This state of mind gained even bigger significance after the State of Israel was born: as a developing country absorbing hundreds of thousands of new Jewish immigrants in relatively short spans of time, climatically adapted building was regarded as a vital necessity reaching far beyond the pedantries of high architecture. The local climate was thus receiving primary concern, and was seen as a crucial element to be studied, analysed, and mastered by architects. Reality proved that the issue of climatic adaptation of buildings was far more complex than might have been expected, not only because of insufficient knowledge, but primarily because of the very nature of architectural design.

1.2 Architectural design and its relation to scientific environmental knowledge

Although limited to a particular history and territory (that of Israeli architecture), the current study aims at producing a more general conceptualization of the relation between architectural design and scientific environmental knowledge. It does so by proposing several models for the emergence and application of scientific research in issues relating to the environmental performance of buildings. The story of Israeli architecture, because of the central position attributed to climate throughout its evolvement, is a fruitful testing ground for the hypotheses that are presented here; nevertheless, these hypotheses extend beyond the limits of the specific historical case, and are, so the author believes, highly relevant for the understanding of current trends in architectural design as well.

Vitruvius, the Roman architect whose seminal book on architecture, dedicated to Caesar Augustus, must be regarded as the cornerstone of Western architectural thought, postulated that an architect should be a polymath, whose knowledge encompasses a wide range of fields both in practice and theory; in Vitruvius' own words, an architect should "be educated, skilful with the pencil, instructed in geometry, know much history, have followed the philosophers with attention, understand music, have some knowledge of medicine, know the opinions of the jurists, and be acquainted with astronomy and the theory of the heavens" (Vitruvius 1914, 5-6). Although some changes to the profession have occurred since the heyday of the Roman Empire, it seems that the multi-disciplinary character of it has not yet diminished; what mainly changed over time are the types of knowledge which may come handy during an architectural design process.

Another Vitruvian prescription for good architecture was the well-known combination of "durability, convenience, and beauty" ("*firmitatis, utilitatis, venustatis*" in the Latin original), which, besides making much sense even in today's standards, testifies for the complex nature of architectural design. In its essence, architectural design is a mixture of allegedly contradictory motivations, some quantifiable, the others not. The architectural design process is thus an arena of compromise, where each of the three Vitruvian components of durability, convenience, and beauty might suffer some degree of imperfection. It can thus be said that in architecture we should not look for perfect solutions for a certain design problem, but for solutions that has the minimal negative impact on the building's firmness of structure, usability by human beings, and aesthetic appeal.

Building climatology lies at the heart of the Vitruvian notion of *utilitatis*, translated by Morgan as "convenience" and by Granger (Vitruvius 1931) as "utility". While the exact definition of convenience or utility may be open to discussion, in modern times it is almost always linked to the environmental performance of buildings, and, more specifically, to three types of performance: thermal, luminous, and sonic. Among these three, the attention given to the thermal environment created within buildings was, and still is, much greater when compared to issues of lighting and acoustics. The direct outcome of this additional attention was the development of the science of building climatology, which consists of methodologies and tools exclusively dedicated to the quantification of the complex relation between climate and the built environment.

Building climatology is a relatively young discipline. Until less than a century, buildings were designed and executed following rudimentary climatic wisdom and beliefs which mainly relied on common building habits and experience, the result of a long process of trial and error. Since the last decades of the 19th century, and even more after World War I, scientific methods had gradually been applied in the analysis of indoor climate conditions. After World War II, these efforts eventually consolidated into a new discernible scientific discipline, which combined knowledge in architecture, civil engineering, physiology, meteorology, and physics, and aimed at exploring the thermal properties of buildings and the human reaction to thermal conditions created and enhanced by buildings. Since its inception, building climatology has produced an impressive body of knowledge and enabled architects, for the first time in history, to optimize the interaction of buildings with local climate conditions.

Historically speaking, architectural design of buildings has always been a combination of intuitive problem solving and a premeditated employment of accepted and proven knowledge for the fulfilment of qualitative design needs. The introduction of building climatology during the 20th century as an independent field of scientific exploration presented an alternative design methodology, in which design decisions could be made based on quantitative and scientifically-sound parameters. Nevertheless, it seems as if this alternative approach to building design has been rarely adopted by architects. It can be argued that the architectural profession in general still ignores the rich scientific knowledge and tools of building climatology, and is failing to integrate them into common practice.

While building climatology today is a well-established scientific field, it is surprising to note how little is known about its historical development. Contrary to many other scientific fields, the history of building climatology is almost totally absent from historical writing on architecture, engineering, or science in general. To this date, not a single monograph properly traced the origins and development of building climatology research even in the key countries of its development (Germany, England, the United States), not to mention the historical context in which it emerged and its reception by the architectural practice; moreover, building climatology, as a professional activity accompanying the design of buildings, is almost entirely absent from historical writing on architecture. This neglect is probably the best testimony for the general dismissive attitude towards building climatology among architectural circles, and moreover, for the lack of reflective understanding of its role in the history of modern architecture as well as in the current practice of architecture.

1.3 Reyner Banham and the environmental aspects of building

Reyner Banham (1922-1988), the British architectural historian, was probably the only prominent architectural historian to seriously address questions of environmental (and mainly climatic) performance of buildings within the context of historical writing on modern architecture. Banham was not interested in the evolution of building climatology as a scientific field of research but in the evolution of environmental technology in buildings and its relation to architectural practice. Nonetheless, he was the first to propose new directions in history writing that could potentially shed light on the ways modern architects relate to environmental issues, in their words as well as in their actual buildings. His work in this field still holds much relevance not only to architectural design in general, but also to the starting point of the current study.

1.3.1 Fit environments for human activities

Banham's first book, *Theory and Design in the First Machine Age* (Banham 1960b), did not address directly the environmental aspects of design, but focused on the relation between architecture and modern technology. It consisted of a renewed reading of the Modernist oeuvre of the 1920's and 1930's in a way that shed a reasonable doubt over the "objectivity" and "functionalism" of the so-called machine aesthetic of that era. *Theory and Design* was only the first step in a much deeper exploration into the relation between architecture and technology, in a way that directly led Banham be engaged with the environmental aspects of design. It focused on the "first machine age", i.e. the era in which machines were already reduced in their size to a human scale but were available only for the financial and social elite; questions pertaining to the "second machine age" of the post-World War II era, an era in which new technology was becoming available for the masses, remained open. Banham was expecting that this new era, which brought with it the increasing integration of technology in buildings, will result in a genuine change in the way buildings are designed and in design objectives. The nature of this change was meant to be much more radical than the change promoted by the orthodoxy of Modern architecture, which even before the War was mainly paying lip service to technological inventiveness and was using it as a merely rhetorical device for shaking the traditionally conservative profession of architectural design.

The increasing qualitative discrepancy between the ever more sophisticated indoor environments created by machines (through artificial lighting, mechanical ventilation, central heating, and air conditioning) and the dark, damp, and cooler or warmer than desired environments that the structural envelope alone can provide, became Banham's starting point for the reassessment of the concept of "architecture" as a whole. Banham felt that the technological revolution can no longer allow for the discussion of architecture through concepts and habits which originated much before the invention of the steam engine. Since the new comfort conditions created new expectations for the performance of buildings, a new Archimedean point for discourse on the built environment was needed.

The widening gap between the traditional practice of the architect and the actual performance of the building was brilliantly demonstrated by Banham in the first part of his essay *1960, Stocktaking* (Banham 1960a) in which he described the professional occupation of architects and the technologies of human comfort as two parallel lines which never intersect. This was not only manifested in the verbal content of the essay but also in its graphical arrangement in two parallel columns which surveyed, one paragraph after the other, the advancements in the allegedly isolated worlds of "tradition" (on left) and "technology" (on right). In the world of "tradition", "architecture, as the professional activity of a body of men, can only be defined in terms of its professional history – architects are recognized as architects by their performance of specific roles that have been assigned to the profession in previous generations"; in the world of "technology", "architecture, as a service to human societies, can only be defined as the provision of fit environments for human activities".

The description of architecture as an occupation that aims at the provision of "fit environments" implicitly rejected the structural fetishism towards which architecture established itself over hundreds (if not thousands) of years. It also led Banham to question the relevance of the structural envelope as the main provider of comfort in a world in which other, motorized, solutions for the environmental challenges already existed, some of them (like the caravan) had little to do with conventional structures. According to Banham, "tradition", because of its inherent tendency to adhere to the familiar, was preventing architects from assimilating into their profession the myriad of new technologies like "heating, lighting, ventilating, air-conditioning, acoustics, office machinery and other more specialist services". On the other hand, the repudiation of the new world of technology left the design of the "fit environments" in the hands of other professionals, most of them engineers whose expertise was the introduction of local and narrow solutions during the later stages of the design process (air conditioning, plumbing, electricity, lighting, acoustics). Banham thought that the outcome of this specialization might be the total marginalization of architecture as a profession:

> [...] it is a balancing feat that may prove to need acrobatic skill and expertise in brinkmanship as architects edge temerously along the margin of the scientific disciplines and never quite put a foot over into the other camp. From the scientific side there is neither such caution nor such finesse. It appears always possible that at any unpredictable moment the unorganized hordes of uncoordinated specialists could flood over into the architects' preserves and, ignorant of the lore of the operation, create an Other Architecture by chance, as it were, out of apparent intelligence and the task of creating fit environments for human activities. (Banham 1960a, 100)

The concept of an Other Architecture (or *Architecture Autre* in French) first appeared in Banham seminal essay on "the New Brutalism" (Banham 1955) as his own take on Michel Tapié's *Art Autre* (which was translated to English as "art of another kind"). Citing Nigel Whiteley's words, it meant "an architecture that rejected abstract, formally derived concepts and forms in favour of human presence, signs of life and symbols of living in the 'mass production society' that was the Second Machine Age" (Whiteley 2002, 118). What concerned Banham the most was the allegedly fading relevance of the architectural profession to the imminent *Architecture Autre* in which "one specialist consultant makes the building stand up, six others render it largely useless by means of the services that are intended to make it usable" (Banham 1960a). The solution, he thought, was a radical change in the way architects understand and utilize scientific knowledge and environmental technology.

In 1964, as Banham was making his first steps at the Bartlett, University College London, Banham received a Graham Foundation fellowship "to investigate the role of mechanical services in the rise of modern architecture" (Banham 1965, 73). The fellowship allowed him to visit the United States on several occasions during the following two years and to closely examine not only the historical development of mechanical services in buildings, a history which the US was probably its biggest contributor, but also the American way of integrating the mechanical services and equipment into buildings, which was far more advanced than its European counterpart. The result was further radicalization in Banham's perception of the relationship between architecture and technology. In 1965 Banham published *A Home is not a House*, another seminal essay in which he explicitly questioned the need for architecture in a world in which the basic comfort demands are satisfied by mechanization and motorization. More than anything else, the essay's opening paragraph reflects this mode of thought, which aimed at reinventing architecture in a period in which its traditional roles, including the provision of human comfort, were seemingly performed much better by a variety of compact devices:

> When your house contains such a complex of piping, flues, ducts, wires, lights, inlets, outlets, ovens, sinks, refuse disposers, hi-fi re-verberators, antennae, conduits, freezers, heaters – when it contains so many services that the hardware could stand up by itself without any assistance from the house, why have a house to hold it up. When the

> cost of all this tackle is half of the total outlay (or more, as it often is) what is the house doing except concealing your mechanical pudenda from the stares of folks on the sidewalk? Once or twice recently there have been buildings where the public was genuinely confused about what was mechanical services, what was structure-many visitors to Philadelphia take quite a time to work out that the floors of Louis Kahn's laboratory towers are not supported by the flanking brick duct boxes, and when they have worked it out, they are inclined to wonder if it was worth all the trouble of giving them an independent supporting structure. (Banham 1965, 70)

This wondering, which seemed to hold no answer, could have created such a chasm in the discipline Banham was still adhering to, that Banham was obliged to take a step back and to try to find an architecture that could simultaneously be regarded as a significant work of art and a reliable technological apparatus. As a writer from within the architectural "tradition", Banham preferred to remain active from within the rhetoric field he shared with architects (even without being an architect by profession), instead of crossing the line into the realm of technical engineers. It is therefore less than surprising that the final output of his Graham Foundation research, a book wittingly named *The Architecture of the Well-tempered Environment*, focused on drawing a new horizon for architecture after all.

1.3.2 The Architecture of the Well-tempered Environment

The Architecture of the Well-tempered Environment, a book which the current study took much inspiration from, was written as an attempt to reassess the history of modern architecture through the history of modern technology, and especially through the histories of electrical lighting and air conditioning. It is less radical than the essays that predated it, but remains innovative and relevant enough even today, almost half a century after the publication of its first edition (1969); this can be primarily attributed to Banham's exceptional definition of architecture as the art of providing "fit environments for human activities".

Banham's analysis was based on a distinction between three modes of "environmental management": Conservative (passive absorption of environmental energy, mainly through the opaque surfaces of the structure); Selective (selective introduction of energy into the structure, mainly through openings in the envelope); and Regenerative (active use of external source of energy for the adjustment of indoor conditions to suit human needs). Traditional construction methods, argued Banham, were almost entirely relying on a combination of the first two modes. The domestication of external energy, first through the gas flame and later via the electrical current, was the technological shift that eventually made the regenerative mode a default in almost any kind of construction, diminishing the importance of the building envelope and its openings in securing human comfort (Banham 1984, 18-28). Nevertheless, added Banham, "a whole generation of historians of modern architecture" was blind to see that the free-flowing open spaces behind the modern curtain walls were uninhabitable not only without the structural and material innovations of steel, glass, and concrete, but also "without massive contributions from the arts of mechanical environment-management", referring especially to central heating, electrical lighting, and air conditioning (Banham 1984, 86).

Banham thought that the new technological means presented architects with two different operational trajectories: the first was self-indulgence in the invention of the new heroic idiom of the "machine aesthetic"; the other was to design buildings with enhanced environmental performance, buildings which primarily provide comfortable indoor environments for working or living. What mattered to Banham the most was not the specific detailing of a building, but the mental state of architects. He was not searching only for "an Other Architecture" but also for "an Other Architect", an architect who is familiar enough with the functioning of technical systems to integrate them into architecture. The technological leapfrogging Banham aimed at was not that of the buildings themselves but of the state of mind of their architects. As he argued, this state of mind suffered a severe degeneration, since

> Architects as an organised profession have been happy to hand over all forms of environmental management, except the structural, to other specialists (electrical, mechanical engineers; heating and ventilating specialists; consultants on traffic and system engineering, communication and control) and they have taught young architects to continue this dereliction of manifest duty; most third-year architecture students can calculate a simple concrete structural frame but very few until recently have known how to calculate solar heat loads let alone more subtle environmental considerations. (Banham 1984, 269)

1.3.3 Banham's black box

In *The Architecture of the Well-tempered Environment* Banham's main argument was that the architectural profession is not capable of intelligently and efficiently designing the environments enabled by the modern means of production and construction. The reason, according to Banham, was not the complexity of the technical issues involved, but an inherent reluctance of architects to truly and honestly take responsibility over the environmental aspects of their designs. Instead, architects preferred to let others (namely, engineers) "solve" the environmental "issues" created by what they perceived as "architecture". In other words, architectural design was intentionally resisting the invasion of environmental "technicalities" into its sacred realm:

> Because of this failure of the architectural profession to – almost literally — keep its house in order, it fell to another body of men to assume responsibility for the maintenance of decent environmental conditions: everybody from plumbers to consulting engineers. They represented 'another culture,' so alien that most architects held it beneath contempt, and still do. The works and opinions of this other culture have

> been allowed to impinge as little as possible on the teaching of architecture schools, where the preoccupation still continues to be with the production of elegant graphic compositions rendering the merely structural aspects of plan, elevation, and sometimes section. ('Never mind all that environmental rubbish, get on with your architecture.')
>
> Mechanical services, and even some non-mechanical environmental devices such as partially reflective glass or acoustic surfaces, have largely passed out of the control of architects into the hands of specialist consultants who now comprise a whole range of parallel professions. The rise of these technical specialists may be explained, if not excused, as part of the general specialisation of all the professions in the modern world (and the case with building is hardly worse than that with medicine!), but this does not reduce the tragically deleterious effect on the discourse and practise of architecture. (Banham 1984, 11-12)

Banham's own impression that architecture as a profession had itself shut off from external innovations in science and technology was developed further on in his last essay, *A Black Box: The Secret Profession of Architecture*. It is a telling piece of writing which was intended as his inaugural lecture for a high-esteemed professorship at New York University. The fact that it was written while treated for an illness from which he probably knew he may not recover (Banham 1996, 235, Whiteley 2002, 384) imbue it with additional emphatic significance.

In *A Black Box* Banham argued for the existence of a distinct *modo architecturom*, a certain state of mind and mode of design fostered by the architectural profession. For him, this "architectural mode" can be described as a "black box, recognised by its output though unknown in its contents" (Banham 1990, 23), a primarily social construct of Western societies since the Renaissance which determines *how* architecture is produced (though not the quality of its products). According to Banham,

> We can distinguish that "how" in two crucial ways in the actual behaviour of architects as they perform their allotted tasks as building designers. The first is that architects — almost uniquely among modern design professionals — propose to assume responsibility for all of those six aspects of good building set out above [functional performance, environmental performance, beauty of form, deftness of space, truth to materials, structural efficiency], and to be legally answerable to the client for their proper delivery. Other professions (such as electrical and mechanical engineering) notoriously avoid such overall responsibilities, preferring to remain at one remove from the wrath of clients as "consultants": hired guns who, like minor war criminals, "were only carrying out orders". Or, to be less offensive to engineers, a body of men who are too prone to say, for instance, "You design your concert hall any old shape you like, and I'll try and sort out the acoustics," rather than "That's a stupid shape for a concert hall, this will work a lot better." (Banham 1990, 23)

What eventually "can give hints" about the content of the mysterious black box of architecture, though not entirely open it up, is the concept of "patterns" first introduced by Christopher Alexander (b. 1936), an American architect and mathematician whose work since the beginning of the 1960's was dedicated to deciphering an allegedly intrinsic order that dominates the built environment. Banham reliance on Alexander's concept was restrained, probably because Alexander pretended that his "patterns" described some timeless and cross-cultural "way of building" and that they should be used by builders who want to create "life" or "the quality without a name" (Alexander 1979); but he nonetheless admited that "Alexander's patterns are very like the kind of packages in which architects can often be seen to be doing their thinking, particularly at the sort of second sketch stage when they are re-using some of what was sketched out in the first version" (Banham 1990, 24).

Banham's portrayal of the architectural occupation from the position of an outsider wondering at the arcane lore of its practitioners was of course nothing new in his writing. What was never there before his final essay is the description of architectural design as a "black box" containing unique (and hidden) patterns of conduct. Implicitly, this concept enabled Banham to invigorate his argument from *The Architecture of the Well-tempered Environment* on the incompetency of architects when confronted with environmental challenges. Once again, Banham regretted this withdrawal from environmental responsibility, since "to other interests, however, such as those of the rest of a world increasingly desperate for better buildings and a more habitable environment, architecture's proud but unadmitted acceptance of this parochial rule book can only seem a crippling limitation on building's power to serve humanity" (Banham 1990, 25). Yet this time, assisted by the "black box" concept, Banham could relate to the faults of architects not as mere short-sightedness, but as something intrinsic to their professional comradeship and its traditions. It is the mere structure of the "black box", its mere existence as a complete set of tools resisting any change, which prevented architects from assimilating environmental knowledge, not their ignorance to other forms of knowledge or personal preferences; they can't help it, it's in their nature (or their socialization).

While the "black box" concept implies that it is the sociology of the profession that should be more deeply analysed, it is not hard to sense the undeveloped character of Banham's explanation. The deterministic and static metaphor of the black box, as well as the reference to Alexander's "timeless" patterns, constitute an hermetic conceptual model; this limits the scope of analysis and eventually leads to an essentialist view of architecture, as a profession which cannot, by definition, assimilate any kind of knowledge which does not conform to the profession's old habits. Banham's "black box" fails to explain how and why there are instances in which architects do manage to assimilate state-of-the-art environmental knowledge into their designs, instances which Banham himself emphatically described in *The Architecture of the Well-tempered Environment*. Thus, while Banham's work was the first to eruditely map the problematic relation of modern architects to environmental control, it eventually fell short of productively contextualizing his findings into a general framework which could have assisted further exploration into the subject.

1.4 Culture Research and the architectural profession

Banham's "black box" portrays architecture as a profession of undefined intrinsic properties which disrupt any attempt to integrate scientifically-sound environmental considerations into architectural design. The metaphor of the "black box", because of its hermetic and esoteric nature, implies great difficulties in conceiving and introducing any changes in the practice of architecture. In other words, we are left with Banham's prognosis that "architecture, as commonly taught, practised and understood in the West, is still little more than a peasant vernacular" (Banham 1984, 311), without being able to do much about it.

The following sections present a theoretical framework that could provide a better analytical alternative to Banham's rudimentary concept of the "black box". It aims at developing a new perspective on architecture as a profession, unveiling the mechanisms behind the "black box" mystique; it suggests a way to open up the black box and have a look inside it, to borrow Bruno Latour's famous metaphor (Latour 1987, 131). This framework, which stems from the theories and models of the discipline of Culture Research (see below), is flexible and versatile enough to contain an array of different design methodologies typical to architecture, while maintaining a more general stance that could be applied to other fields of interests and other professions (whether technological, scientific, or artistic). In doing so, it relates to the architectural design process as a cultural activity whose products stem from recurrent patterns of behaviour typical to the profession, while using the same analytical tools for analysing its relation to other complimentary disciplines.

1.4.1 Culture Research: basic concepts

Culture Research as an independent discipline was formed in the late 1980's by a group of scholars at Tel Aviv University. Headed by Itamar Even-Zohar (b. 1939), its main interest was (and still is) the study of culture as a dynamic process of evolution, manifestation, and transmission of life-managing habits of human beings. Its basic definition of culture is partially related to the definition suggested by the American sociologist Ann Swidler (b. 1944), who argued that culture should be seen "as a 'tool kit' of symbols, stories, rituals, and world-views, which people may use in varying configurations to solve different kinds of problems" (Swidler 1986, 273). This concept of "culture-as-tools" is contrasted in Even-Zohar's writings with the alternative (and more common) concept of "culture-as-goods", which sees culture as an agglomeration of human assets, many of them non-material, that bestow societal prestige on their possessors. Even-Zohar argued that

> […] the “culture-as-tools” conception is more useful and allows greater analytical and research versatility for developing research and understanding – and eventually also practical tools for policy-making – in the field of culture. Moreover, "goods" can be fully investigated within the tools-framework, while the opposite is not true. (Even-Zohar 2010, 9)

In the paper which first introduced the "tool-kit" concept, Swidler coined the key concept of cultural "repertoire", following the work of Ulf Hannerz (b. 1942) and resonating Pierre Bourdieu's (1930-2002) concept of "habitus". Swidler argued that "culture provides a repertoire of capacities from which varying strategies of action may be constructed […] a culture has enduring effects on those who hold it, not by shaping the ends they pursue, but by providing the characteristic repertoire from which they build lines of action". The concept of repertoire was thus believed by Swidler to support the development of "more sophisticated theoretical ways of thinking about how culture shapes or constrains action" (Swidler 1986, 284), though Swidler herself did not engage herself in developing such "ways of thinking".

Although coming from a different academic discipline (comparative literature), Even-Zohar's work since the early 1970's touched similar issues as those discussed in Cultural Sociology literature, especially in respect to the planning, evolution, and transfer of cultures. His shift towards culture research began when he felt that the conceptual framework of Translation Theory was not rich enough to support the study of the social and cultural aspects of translation, which at that time was Even-Zohar's main field of interest. He then developed the "polysystem theory", a theory in which cultural activity is always analysed as taking place within a dynamic and heterogeneous "system of various systems" or a "polysystem" (Even-Zohar 1979). By describing "literature" as a polysystem, Even-Zohar was able to relate to "literature" not as a closed and static entity (or system) of analysis, but as an agglomeration of changing, competing, interrelated, and optional "literatures" of different degrees of canonization and dominance, in a way that can better explain the emergence of certain forms and preferences within a given "literature". A polysystemic approach enables to integrate the social and cultural aspect of life into the study of "literature", to understand "literature" as a cultural phenomenon of transformative nature and changing social roles. The same concept can be easily applied to "culture" as a whole or to other cultural fields, including those pertaining to Swidler's definition for culture.

1.4.2 Itamar Even-Zohar's model of cultural event

Polysystem theory, according to Even-Zohar, created the "theoretical environment for the study of culture" (Even-Zohar 1997, 18), a stepping stone in the development of a theoretical model for what was referred to as a "cultural event". Here, Even-Zohar found fertile ground in the work of the Russian-American linguist Roman Jakobson (1896-1982). Describing the poetic function of language, Jakobson argued that in every "speech event" language plays several concurrent functions, only one of them is poetic. These functions correspond to what Jakobson described as the "constitutive factors in any speech event", which were arranged in the following model:

CONTEXT
ADDRESSER MESSAGE ADDRESSEE

CONTACT
CODE

According to Jakobson, in addition to an *Addresser* (speaker) and an *Addressee* (listener), the successful reception of a lingual *Message* depends on the *Context* in which the message is produced, the *Code* by which it is produced, and the channel or *Contact* through which it is delivered (Jakobson 1960, 353). Even-Zohar adapted Jakobson's model for describing a "cultural event", an event of production and consumption of a "cultural product", by relating to its interdependent "constitutive factors", replacing Jakobson terminology with his own and making some changes in the overall arrangement of the factors (Even-Zohar 1997, 19-20):

INSTITUTION
REPERTOIRE
PRODUCER CONSUMER
MARKET
PRODUCT

At the heart of Even-Zohar's model lies the concept of cultural *Repertoire*, which follows Swidler definition of the word. While Swidler saw a repertoire as a "tool-kit" used actively, Even-Zohar argued that repertoire is "the aggregate of rules and materials which govern both the *making* and *handling*, or production and consumption, of any given product" (Even-Zohar 1997, 20). This implicates that each repertoire can be used also "passively", as a "tool-kit" for understanding reality (or for "consuming" its "products"), not only for the active productions of cultural items. In Even-Zohar's model, when a *Producer* (an activator of a repertoire) creates a *Product*, its successful consumption by a *Consumer* relies on the existence of a shared repertoire between the two, assuming that no errors occur in their (active or passive) implementation of the repertoire. This, however, is not enough for securing successful consumption, since two other factors can prevent or disrupt the act of product exchange: *Institution* ("the aggregate of factors involved with the control of culture") and *Market* ("the aggregate of factors involved with the selling and buying of the repertoire of culture"). The institution legitimizes and promotes certain repertoires and the exchange of certain products while blocking or dismissing others; the market is the (supportive or disruptive) environment in which the repertoires are exchanged and perpetuated, or in other words, "consumed" (Even-Zohar 1997, 32-33). According to Even-Zohar, official establishments like schools and universities may perform as both institutions and markets, depending on the analytical perspective. Thus, while teachers in a school are agents of the institution which tries to enforce a certain pedagogic agenda, the school itself as a whole (including its facilities and the interaction patterns they are responsible for creating) is the market, the environment, in which marketing of their agenda is done.

Even-Zohar's model of a cultural event opens a variety of possible applications in the study of culture or parts of it, including culture of certain professions like architecture. When compared to Banham's metaphor of the "black box" for describing "what architects actually do when they do architecture" (Banham 1990, 24), it is easy to see how Even-Zohar's model holds a potential for a much more rewarding reflection on architectural design habits and their products. Banham's "black box" might resemble Even-Zohar's "repertoire" in the sense that it is also perceived as a set of rules which dictates how architects perform while they design, but while Banham's metaphor is deterministic and static, Even-Zohar's dynamic and heterogeneous repertoires are the absolute opposite:

> The more proliferated the repertoire, ideally the more available the resources for change. Often, this is linked to the age of a given culture. When the culture is in its inception stage, its repertoire may be limited, which may render it more disposed to use other accessible cultures. When it has accumulated more options, it may have acquired a larger and more multiform repertoire, and may thus be more likely to attempt recycling repertoremes [Even-Zohar's term for an item of the repertoire] during periods of change rather than seeking extraneous repertoires. However, even when a culture is working with a large and multiform repertoire, a deadlock may occur by blockage of all alternative options. It is then that adjacent, or otherwise accessible repertoires, may be used for replacing the ones people wish to reject. This is how *interference* becomes a strategy of a culture to adapt itself to changing circumstances. (Even-Zohar 1997, 21-22)

Thus, Even-Zohar's model can support the conception of the architectural profession not as a mystified secret society rooted in old-dated rituals (as Banham described it), but as a developing set of practices and habits which may change over time in response to changing circumstances. Further on, Even-Zohar's model can be used for better understanding of the reasons behind the ignorance of architects to issues of environmental management (as Banham contended), taking in mind not only their active repertoire but also other factors, extraneous to their profession, which may affect their practice (namely, the "institution" and "market" in which they act).

1.4.3 The cultural event model and architecture

The application of Even-Zohar's model to the "culture" of architecture seems to be quite straightforward. Nevertheless, things might become more complex when trying to interpret Even-Zohar's "factors" as actual components of architectural design. For example, the architectural product might be a building, but also a set of architectural work plans for a building (realized or not) or even just a conceptual design of a building; the consumer of this product might be a user of the actual building, the developer who commissioned the architect with the project, the architect's professional milieu, or even the architect himself. Each of these interpretations entails a different perspective of analysis and research methodology. Therefore, we must first determine which interpretation or interpretations can become useful for the aim of the current study, namely the conceptualization of the relation between architectural design and scientific environmental knowledge.

Since the current study is dedicated to questions pertaining mainly to the thermal performance of buildings, their evaluation can only be properly done with respect to the physical properties of the design, namely the buildings as realized. Apparently, the "product" of the design process could have been defined as the actual buildings which resulted from the design process, or at least the parts of the buildings whose realization was under the direct responsibility of the architects. Nevertheless, since we are interested in the thermal conditions inside buildings, it is more accurate to define only the indoor environment (or, to follow Banham's words, the "fit environment for human activities") as the actual "product" we are concerned with. Following the same perspective, the "consumer" of the "product" is not simply the actual user of the building (or its indoor environment), but the human body, with its inherent limitation of "discomforts" or negative reactions to undesirable indoor conditions which may affect the success of consumption.

Moving to the "envelope" or framework of the design process, i.e. the cultural environment in which the "fit environment" is produced and consumed, the "repertoire" employed by an architect for the production of indoor environments can be simply defined as an "architectural repertoire" (for further discussion, see section 1.4.5). Determining the identity of the "institution" and "market" is much more complex, but it can be argued that the "institution" which backs and canonizes the architectural repertoire consists of all types of professional bodies concerned with architecture, as governmental agencies issuing architecture certificates, professional associations of architects, architecture schools, architecture research institutes, etc. The "market" is what we shall call "architecture discourse arenas", which include educational establishments, professional meetings, architecture magazines and communication platforms, etc.

The following scheme summarizes our application of Even-Zohar's model to the architectural design process as defined in the current study:

ARCHITECTURE
PROFESSIONAL
BODIES
(INSTITUTION)

ARCHITECTURAL
REPERTOIRE
(REPERTOIRE)

ARCHITECT (PRODUCER)	FIT ENVIRONMENT FOR HUMAN ACTIVITIES (PRODUCT)	HUMAN BODY (CONSUMER)

ARCHITECTURE DISCOURSE ARENAS
(MARKET)

It should be noted that an intentional modification was made to Even-Zohar's original scheme in the location of the "product"; for the current study, it was useful to graphically highlight the elements directly involved in the architectural design process (grey-shaded in the modified scheme) while placing the supporting enablers of its coming into being (the repertoire, institution, and market) in its periphery.

1.4.4 The architectural design process as a cultural event

Even-Zohar's model represents the factors involved in any "cultural event", stressing its semiotic aspects. Even-Zohar was interested in schematizing a process which begins with the creation of a cultural product and ends with its reception by an audience. This perspective, which focuses on the act of "consumption" and on its possible success of failure, does not reveal the motivating force behind the creation or the concrete circumstances that initiated the production and consumption of the specific product. In the case of architectural design, such forces can hardly be ignored, especially not when dealing with actual buildings. In the process of architectural production, the producer is almost always *reacting* to an existing "prescription of duties" or "program" imposed on him by an external actor. Architects might be, as the American architectural historian Spiro Kostof (1936-1991) argued, "conceivers of buildings", which means they "supply concrete images for a new structure so that it can be put up"; but at the same time, they do not "initiate buildings", as Kostof wisely acknowledged (Kostof 1977).

Thus, a crucial element is the architectural design process is missing from Even-Zohar's model. We shall name it the *Initiator*, the element responsible for commissioning the architect (the "producer" in Even-Zohar's terminology) with the project and who usually presents the architect with a *Brief*, a list of explicit expectations or design goals (how many rooms should the building include, how they are to be used, what types of activities should the building host, etc.). In relatively rare cases the initiator and producer of a building are the same person; but even then, this person performs two distinguishable functions: the first sets the framework for the design process (location, goals, budget), the other is responsible for the actual design, in response to that framework and within its confines. In the architectural design process, the function of an initiator is usually performed by a "developer" (who in times can also be the owner of the building or even its everyday user) and his brief is usually called a "program". An adaptation of Even-Zohar's original model to the architectural design process should thus look as follows:

DEVELOPER
(INITIATOR)

PROGRAM
(BRIEF)
↓

ARCHITECT
(PRODUCER)

FIT ENVIRONMENT FOR HUMAN ACTIVITIES
(PRODUCT)
↓

HUMAN BODY
(CONSUMER)

By integrating the initiator into the model we also add another element that can be used for explaining successful or failed consumption of a product. Without the initiator, successful consumption relies on the ability of a producer to master the repertoire he shares with a consumer and on the consumer's ability to use the product by following the same repertoire. This implies that a lack of success is a result of improper implementation of a repertoire (be it active or passive), or even the existence of an improper repertoire altogether. With an initiator as part of the "chain reaction" which ends with the consumption of a product, one can argue that a lack of success can also be attributed to an erroneous brief, which could not be possibly transformed into a successful product by using any of the available repertoires.

In the case of architectural design which should, for example, create "fit environment for human activities", the degree of "unfitness" of the environment can thus be attributed not only to inapt repertoires which do not include tools for creating such "fit environment", but also to an improper brief which did not explicitly assigned the architect with the production of a "fit environment". Although it can be argued (as, for example, does Banham) that any architectural design, irrespective of the minute specifications of programs, should be engaged in creating "fit environments", this seems to be more an ethical stance than an essential element of architectural design. One can also add that today, when consultant engineers are commonly involved in the design of indoor environmental management, architects tend to transfer the responsibility for the "fitness" of these environments to other professionals unless explicitly asked not to do so. It is therefore important when evaluating the environmental performance of an architectural design to verify whether it was explicitly prescribed as being under the architect's responsibility at all; if not, one should first ask why the initiator of the design process ignored the subject altogether.

1.4.5 The evolution of an architectural repertoire

A central ingredient in Even-Zohar's model of culture is that of the repertoire. Even-Zohar distinguished between two operational modes of a repertoire (*active operation*, which results in the act of production, and *passive operation*, which results in the act of consumption), and argued that the active and passive operations are of exactly the same repertoire (Even-Zohar 1997, 20). In the case of architectural design process as described above, there is a need to update these definitions and to distinguish between the repertoire used for production (of a building or "fit environment") and the repertoire used for consumption; in other words, there is a need to distinguish between an active *Professional Repertoire* and a passive *Layman's Repertoire* wholly contained in it.

The professional repertoire's unique identity emanates from its totally different and distinguishable "took-kit" used exclusively for production, a tool-kit which contains all the profession's body of knowledge, methodologies of practice, and special language. For example, while the layman's repertoire may contain conventions on the use and function of certain building elements like window, door, room, etc., it does not contain (or does not have to contain) any knowledge of the ways these elements are designed, produced, and kept in function, which is an integral part of the architect's professional repertoire. In the case of the "fit environment" product, the consumer (the human body) has to know which physical conditions he is expected to find in the indoor environment in order to secure successful consumption, but can be totally indifferent to the ways this "fit environment" is conceived, constructed, and maintained.

According to Even-Zohar, a repertoire is not a static element of culture, but a dynamic and transformable "tool kit", and it can co-exist with other repertoires that can be used for creating similar products. This implies that a constant process of changing hierarchies and synthetic evolution of repertoires is taking place within culture. As Even-Zohar put it,

> Given the hypothesis of heterogeneity in socio-semiotic systems, there is never a situation where only one repertoire may function for each possible set of circumstances in society. Concurrently, different options constitute competing and conflicting repertoires. Often one repertoire manages to establish itself as dominating, thus excluding the others, or at least making their use either inefficient or unrewarding. On the other hand, the alternative repertoires may be in full use in different social clusters, where the dominating repertoire may be rejected as undesirable, and hence unrewarding, too. Eventually, however, a rejected repertoire may push itself to domination. (Even-Zohar 1997, 21)

What is implied from Even-Zohar's description is that a repertoire might absorb new items (which Even-Zohar names "repertoremes") when it proves inadequate for the changing challenges it is confronted with. On the other hand, in case of failure to overcome these challenges, there might be a tendency to search for alternative repertoires. While Even-Zohar is relating this search to the producers, by adding the initiators to the model we can argue that switching to alternative repertoires may also be attributed to change in their own preferences, and that in this case producers may be obliged to replace the repertoires they use in order to "stay in the game" or maintain their connection with the initiators. In the case of architecture, its incompetence to deal with environmental issues using its existing professional repertoire may result in the integration of environmental issues into the professional repertoire or, alternatively, in the total dismissal of architects from responsibility over environmental issues. In the latter case, developers might then approach professionals from other disciplines, holding alternative professional repertoires (e.g., engineers), in order to take care of the environmental aspects of design.

These alternative trajectories of repertoire evolution lie at the core of our interest in the architectural design process. While Even-Zohar generally mapped the possible positions of repertoires and their optional transformations, he did not present a detailed model for the evolvement of repertoires. For our own purposes, it is important to model the possible ways in which scientific knowledge (in our case, mainly in the field of building climatology) may be integrated into the professional repertoire of architects, to understand which conditions can lead to the emergence of additional repertoire items, and to ask what could happen if the professional repertoire remains unchanged in spite of recurrent failures. The suggested model, which is based on the culture research terminology developed in the previous pages, appears in Figure 1.1.

An architectural design process begins when an initiator who asks an architect to solve a *Design Problem* (the "brief"). The architect turns to his *Professional Repertoire* and employs it in the production of a *Design Solution*. When completed, this solution can be judged to be successful or unsuccessful, either by the architect himself, or by others. Generally speaking, a successful solution is not expected to instigate any change within the professional repertoire, since it proves to produce satisfying results. Moreover, a successful solution serves for reassuring the validity of the employed repertoire, thus enhancing its potency to resist changes.

An unsuccessful solution, on the other hand, may lead to several possible results. The first is a total disregard or *Indifference* to failure, which means that the professional repertoire is left intact; this may also reflect a belief that the design problem may not be successfully solvable at all. The other possible reaction to failure is the instigation of *Research*, an inquiry into the reasons of failure, in order to find a solution that could be applied to similar design problems. The research does not have to be strictly scientific, but it should be set in a way that could produce some new insights and lessons. It does not have to be conducted by architects; the important factor is that its results will be useful for architectural practice, so that architects could utilise its fruits in congruence with their own professional repertoire. If this happens, the original repertoire is expected to absorb new tools which will help it to meet the challenges that the older repertoire failed to meet. This is, however, only one optional effect of research; the other is that the new tools that the research was helping to develop are rejected by its potential users, who refuse to use them or to integrate them into their older repertoire.

A rejection of new repertoire items (or tools) that came out of research is expected to lead to the creation of a new repertoire, if we assume that these tools prove to be useful for some sort of problem solving. This new repertoire may thus become a wholly *Alternative Repertoire*, a repertoire that can fully replace the original repertoire and become a new dominant repertoire; or a *Subsidiary Repertoire*, a repertoire that cannot be used on its own for solving a certain problem but only as a supplement to the main and dominant repertoire. Whether alternative or subsidiary, there is a good chance that the new repertoire will not be used by the type of producers (or professionals) who continue to employ the original repertoire, but by others who endorse the new repertoire and affirm their communal identity by employing it.

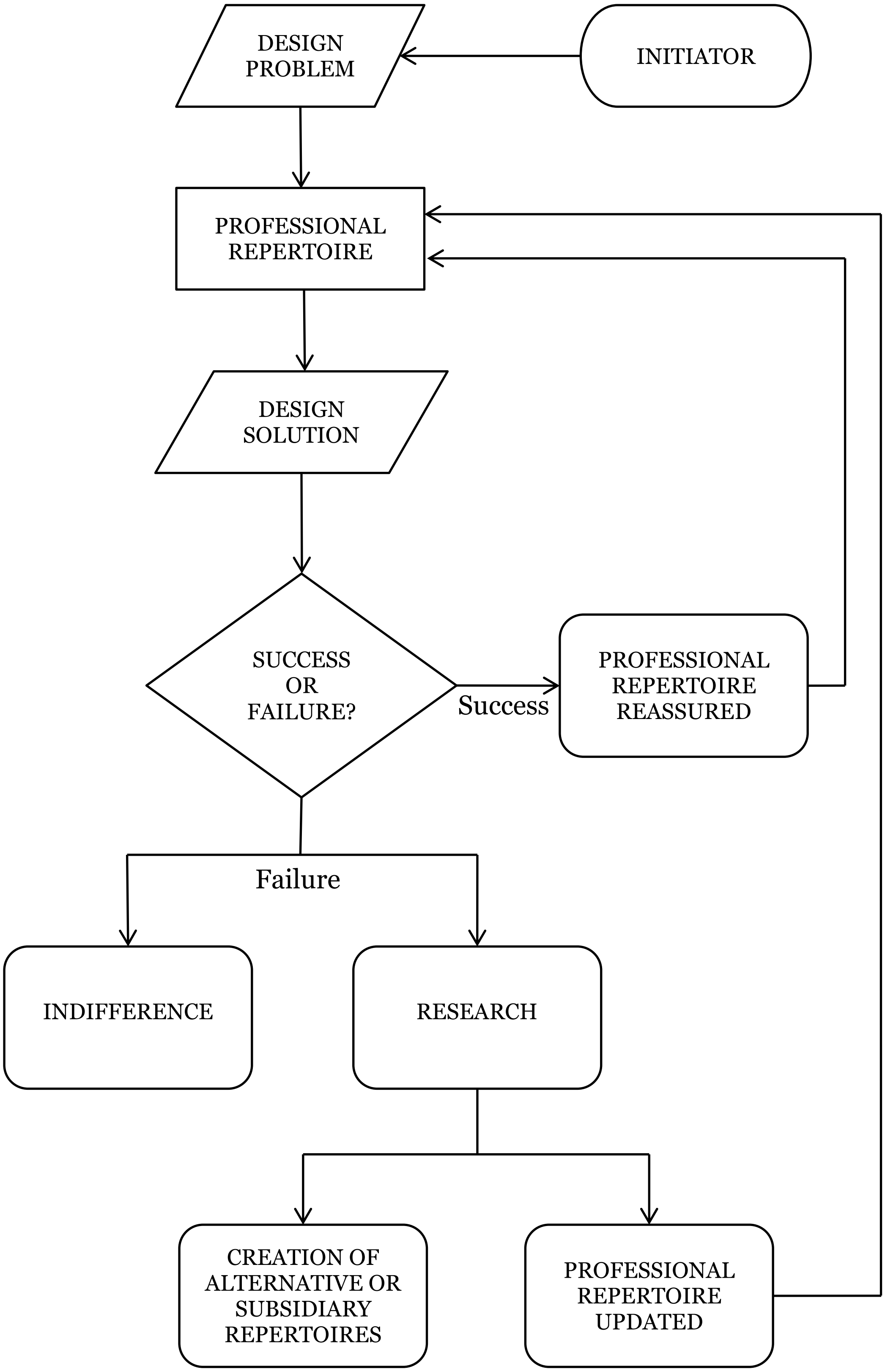


Figure 1.1: Flowchart of architectural repertoire evolution

This, of course, calls to mind Banham's prophetic warning cited earlier on "the unorganized hordes of uncoordinated specialists" that "could flood over into the architects' preserves and, ignorant of the lore of the operation, create an Other Architecture by chance, as it were, out of apparent intelligence and the task of creating fit environments for human activities". Banham was referring to the professional specialization in environmental management that resulted in the creation of new engineering disciplines utilizing what we suggest to call "subsidiary repertoires". Although he was not predicting the total disappearance of the architectural profession, he did understand that its fading capability to solve questions of "fit environments" would also minimize its impact on the contents of buildings, thus disconnecting architecture altogether from the art of creating "fit environments". In other words, Banham saw a scenario in which the growing number of subsidiary repertoires of engineers would result in the overthrowing of the dominant repertoire of architectural practice from its central position.

Yet architecture's failure to meet environmental challenges did not result only in the creation of subsidiary repertoires, but also in devising complete alternatives to the traditional design process. Such an alternative repertoire in architecture can be found in the work of the Hungarian-American architect Victor Olgyay (1910-1970), who, together with his twin brother Aladár (1910-1963), used scientific research and new technologies in order to propose an entirely new professional repertoire that was based on rigorous application of scientific knowledge in building climatology. In the preface to his seminal work, *Design with Climate: Bioclimatic Approach to Architectural Regionalism*, published in 1963, Olgyay wrote that "a new principle of architecture is called for, to blend past solutions of the problems of shelter with new technologies and insights into the effects of climate on human environment [...] architecture so far has been in a subjective trial-and-error stage; it must adopt the techniques of analytical reasoning to mature properly" (Olgyay 1963, v). *Design with Climate* was an apex of a gradual process of investigations that Olgyay and his brother conducted since the beginning of the 1950's, and it called for a totally new design approach to architectural problems while providing a full set of new practical design tools and methods.

As with Banham, Olgyay redefined "the primary task of architecture" so it would emphasize the environmental aspect of architecture; thus, architecture existed in order "to act in man's favour; to interpose itself between man and his natural surroundings in order to remove the environmental load from his shoulders. The fundamental task of architecture is thus to lighten the very stress of life, to maximise man's energies and permit him to focus on spiritual tasks and aims" (cited in Leatherbarrow and Wesley 2014, 167). Although this might seem equivalent to Banham's "fit environments", Olgyay's goals were much more focused than Banham's: he decided to reinvent architectural design by bridging the gap between architecture and scientific knowledge in bioclimatology, meteorology, and physics. This bridging consisted of a detailed and comprehensive methodology for architectural design which, so Olgyay believed, could be easily employed by architects. Olgyay summarized its design principles in the following way:

> The process of building a climate-balanced house can be divided into four steps, of which the last is architectural expression. Architectural expression must be preceded by study of the variables in climate, biology, and technology.
>
> The first step toward environmental adjustment is a survey of climatic elements at a given location. However, each element has a different impact and presents a different problem. Since man is the fundamental measure in architecture and the shelter is designed to fulfill his biological needs, the second step is to evaluate each climate impact in physiological terms. As a third step the technological solutions must be applied to each climate-comfort problem. At the final stage these solutions should be combined, according to their importance, in architectural unity. The sequence for this interplay of variables is Climate

> → Biology → Technology → Architecture, and in general this book will follow that sequence. (Olgyay 1963, 11)

The rest of *Design with Climate* was dedicated to the elaboration of Olgyay's proposed methodology, including detailed case studies of "climate-balanced" design of buildings and large settlements. Nevertheless, as can also be understood from Banham's later criticism, Olgyay's alternative repertoire did not gain much attention (not to mention dominance) within the architectural profession. In that sense, it still exists as an alternative repertoire for architectural design, used (if at all) by a negligible number of architects.

Both Olgyay and Banham were reacting to what they perceived as a crisis in the architectural profession, a crisis that resulted from its insufficient answers to environmental challenges. This failure, as suggested in our model, initiated a considerable amount of research that created a new body of knowledge (as well as new technologies) which could have enhanced the environmental performance of buildings. Nevertheless, in spite of its proven advantages, the emerging repertoire was never adopted by architects, never integrated into their professional repertoire, and therefore remained marginal, performing mainly as a subsidiary repertoire that is only partly used during architectural design processes.

1.4.6 Subsidiary repertoires and the architectural design process

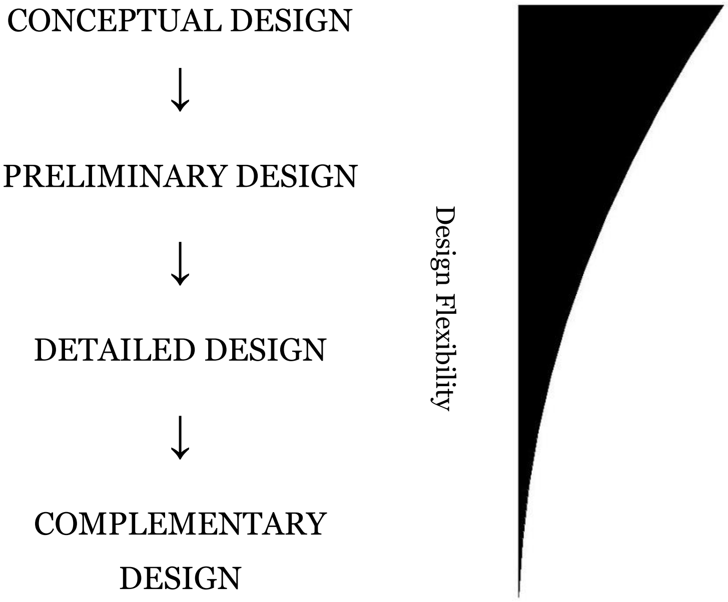
As noted by Even-Zohar, the adoption of a totally new repertoire instead of a well-established one is less likely than the absorption of new items within the old repertoire; this applies also to the profession of architecture. Nevertheless, from a historical perspective and as reiterated by Banham, the architectural profession tends to keep its professional repertoire only slightly changed, preferring the cohabitation with a growing number of subsidiary repertoires which find their way (through other professionals) into the architectural design process. In professional terms, these are the repertoires of the "consultant engineers", who Banham poignantly described as "hired guns who, like minor war criminals, 'were only carrying out orders'" (see above, section 1.3.3). This, however, did not essentially affected the status of the architects as "conceivers of buildings": while architects released themselves from transforming their design into "fit environments", they are still regarded as the archi-designers of buildings, as the main figures who control the design process and who are personally commissioned with their execution.

While there is a considerable amount of building around the world which does not involve architects, these are usually only small-scale or low-profile projects. For the design of buildings occupied by hundreds or thousands of users, the interdisciplinary state of mind of an architect is still sought after. Unfortunately, these are also the types of projects in which inefficient environmental design would have its most deplorable consequences. An inefficient design might be, of course, a result of mere miscalculations or flawed design; but, as Banham remarked in his final essay, it is more likely to stem from the marginal role played by the subsidiary repertoires during the initial stages of design. A consultant will usually be asked to minimize the negative effects of unintelligent architectural design rather than to suggest how to redesign the project from scratch. It can therefore be argued that in order to fully understand the environmental implication of the relation between the architect and his consultant engineers (and between their respective repertoires) one should first understand the role given to subsidiary repertoires within the design process.

While the study of design processes holds a considerable part of what is called Design Theory, this discipline is usually interested in conceptualizing the ways designers approach a design problem and in the unique characteristics of "design thinking" as a cognitive phenomenon (Dorst 2008, Le Masson et al. 2013). This, however, is of little help when trying to understand how and when subsidiary repertoires could be utilized during a design process, especially if we assume that they may have a corrective effect on errors produced by the main repertoire. For this, some other type of conceptualization is needed, which focuses on the gradual evolution of a design solution through definable stages of increased detailing.

A design process usually begins with a short brief and ends with the completion of a concrete product. It can be argued that at each stage of this process, the flexibility of the design (or its capacity to absorb modifications) is gradually diminishing, until the design finally settles into a single fixed solution. In other words, each stage of the design introduces further narrowing of what can be described as the "design horizon". Modifications to the design are still possible throughout the whole design process and even after the final product is produced, but their cost is constantly rising, in opposite relation to the reduction in flexibility.

For the sake of analysis, we shall divide the design process into four distinct stages: *Conceptual Design*, in which a very raw design is suggested, responding only to certain aspects of the brief; *Preliminary Design*, in which the conceptual design is adapted to meet the *full* details of the brief; *Detailed Design*, in which the full details of the end products are addressed; and *Complementary Design*, in which improvements in the design are made after production and as a result from the experience gained during the consumption of the product. The following scheme summarizes the suggested model:



In the architectural context, each design stage is usually characterized by the type of documents the architect produces. While the conceptual design is typically based on freehand sketching and mass modelling, the preliminary and detailed designs are based on standard architectural drawings in ascending scales (1:500, 1:200, 1:100, 1:50, 1:10, 1:5, 1:1, etc.), following the profession's drawing conventions. The move from preliminary design to detailed design could then be expressed also by the move from one scale of drawings to another. Complementary design is less structured, and would usually produce only a very partial set of architectural drawings; it may also include some freehand sketching of details that could replace the more labour-intensive drawings. This means that the identification of the different design stages can not only rely on the nature of the design itself but also on the type of documents that are produced by the architect.

Following the suggested model for design evolution, it is easy to see why the design stage in which environmental considerations are taken into account can be crucial for the environmental success of the design solution. Olgyay's alternative repertoire was revolutionary in that sense, since it suggested gathering all the required environmental data even *before* architectural design begins. This was not a coincidental whim, since Olgyay well understood that the later environmental considerations enter the design process, the lesser impact they have on the design. The same can also be argued in respect to the input of subsidiary repertoires (as those of consultant engineers); and since these repertoires are usually being considered only after conceptual design is completed, they are effectively excluded from the stage in which the most significant design decisions are taken. To borrow Banham's example, this is why we are more likely to hear an acoustics consultant saying "you design your concert hall any old shape you like, and I'll try and sort out the acoustics," and not "that's a stupid shape for a concert hall, this will work a lot better". Nevertheless, since this is not an unavoidable reality of architectural design, but only a common practice, the role of subsidiary repertoires in architectural design can always be different.

1.5 Research methodology of the current study

In order to test the hypotheses presented here on the evolution and application of environmental repertoires in architecture, the current study examines several historical cases in which the integration of environmental knowledge in architecture was perceived as crucial for the production of successful designs. In Israel of the 1950's and 1960's, a relatively poor country with limited material resources and urgent need for housing, the emerging science of building climatology was believed to become an essential tool for overcoming the inherent deficiencies of local architecture in indoor environmental control. At the same time, the application of the scientifically-sound climatic design recommendations in architectural design was in many times partial, superficial, and ineffective.

While architecture in the young State of Israel was consciously modern in nature, receiving much international acclaim because of its application of the most advanced architectural idiom of that time, that idiom was facing quite different climatic conditions than those existing in Europe, the cradle of Modernism. An understanding that some sort of adaptation to the local climate was required existed already during the 1930's, but the type of adaptation that was employed, relying mainly on plain common sense and not on scientific exploration, proved to be insufficient. The recurrent climatic failures of local buildings during the 1930's and 1940's thus led to the adoption of scientific research methods for the provision of concrete answers to down-to-earth architectural questions (the orientation of buildings, the locations of openings, wall and roof composition, etc.). In Israel's culture of scarcity, lacking the means to fully rely on mechanical control of indoor climate, these answers were vital for minimizing the users' discomforts to a tolerable level.

The current study focuses on three case studies, in which the environmental (and mainly thermal) performance of buildings became a central issue throughout the design process in a way that could not have been overlooked by the architects who were involved in the design. In each of the cases enough historical evidence exists for shedding light on the design considerations of the architects and the way environmental knowledge, derived from contemporary building climatology research, was referred to and utilized. The selection of the case studies thus excluded the possibility that environmental data was ignored only because of lack of awareness to environmental questions; in all cases, the architects were well informed of the expected environmental implications of their designs. At the same time, it is important to emphasize that the three projects were not regarded as exceptional in their attitude towards environmental issues nor in their design; their uniqueness may lie only in that an explicit reference by their architects to environmental issues could be easily traced.

Historical reconstruction of the design processes and the original designs of the case studies were based mainly on a combination of original archival research, on-site documentations and measurements, and personal interviews. The author was lucky enough to gain access to unpublished original materials which were of great help in creating a reliable historical reconstruction of the case studies. In two of the three cases the architects who were in charge of the design were interviewed. Complementary research on contemporary trends in Israeli architecture was also conducted, using a wide array of primary and secondary sources.

Apart from the case studies, the study aimed at providing a detailed account of the emergence and development of building climatology in Israel, including the ways in which research in the field was promoted, financed, and executed. This historical account was necessary for two reasons: first, in order to understand what instigated the emergence of the new scientific field and what motivated its further development; and second, in order to find out what type of environmental knowledge was already available for architects during the design of each of the three case studies. In contrast to the history of Israeli architecture, the history of building climatology in Israel is an untold history which had to be entirely reconstructed by the author. The general neglect to its significance can be demonstrated by the fact that the archive of the Technion's Building Research Station, maybe the most important research institute in that field in Israel, is unavailable and was probably entirely liquidated. In spite of this loss, archival materials from Israel State Archives and other Israeli archives, as well as other primary sources as the original publications of the Building Research Station and its several predecessors, enabled the author to produce a relatively clear and comprehensive narrative of the evolution of building climatology in Israel. The author also had the opportunity to interview two of the founders of the field in Israel, Baruch Givoni and Milo Hoffman.

The current study limits itself to the first three decades of building climatology research in Israel (between the beginning of the 1940's and the middle of the 1970's). This period covers the first sporadic scientific efforts in the field as well as Givoni's years as the head of the Department of Building Climatology in the Building Research Station and corresponds to the time frame of the three case studies. Limiting the scope of the current study to that period, in which research was dedicated to providing practical advice to architects, also rules out the possibility that an over-sophistication of scientific data is the reason behind its neglect by architects.

In certain aspects, the current study owes much to Banham's methodological stance in *The Architecture of the Well-tempered Environment*. Banham was probably the first historian to confront the actions of architects with technical and scientific environmental knowledge and the actual performance of their own buildings. Similar approach is applied here: the analysis of the selected projects was done from a perspective which sees the architect as conceiver and provider of "fit environments". Yet it was also important to reassess Banham's methodology in a critical way, taking in mind that almost half a century had passed since the publication of the first edition of his book. Nigel Whiteley, who wrote the first "intellectual biography" of Banham, found a major fault in what he saw as Banham's Modernist bias, which prevented him from approving designs which were stylistically outdated but technologically advanced, and led him to ignore vernacular and low-tech buildings (Whiteley 2002, 199-200). While it is hard to contradict Whiteley's argument, it seems that the major component that is missing almost entirely from Banham's book is not a diversity of building types but a genuine quantitative physical analysis of his case studies.

In all of his case studies but one (St. George School in Wallasey), in which he partially relied on monitoring data produced by others, Banham's own analysis is speculative and impressionistic, almost entirely ignoring the scientific methods for assessment of environmental performance of buildings. This is not very surprising – Banham was, after all, a historian; yet one cannot but feel a sense of disappointment after reading the chapter added to the book's second edition, in which Banham praised the scientific leapfrog which enabled Willis Carrier, the father of air conditioning, to precisely quantify the environmental modifications provided by his systems, while arguing that

> The history set out in this book is not only a history of machines and buildings, it is also a history of the application of rational enquiry and creative thinking to environmental management. The rise of solar architecture has reminded us of this afresh; energy budgets, thermal balance sheets, and the like, are essential to its successful deployment; they depend on an increasing body of tabular information derived from experiment and observation, and on calculations of a complexity that might have been too daunting for everyday application were it not for the availability of electronic computation. (Banham 1984, 294)

Banham praised the way scientific research produces methodologies that lead to the building of structures of ever-growing environmental sophistication, but was reluctant to use the same methodologies for understanding the performance of the buildings that lie at the core of his own research. One salient example of this discrepancy is his analysis of Philip Johnson's "Glass House" in New Canaan: Banham argued that the house is a "unique example of environmental management in an extended sense" (Banham 1984, 230), but then described its thermal mechanisms based only on his own subjective and random impressions from visiting the house. While first hand impression, the insistence on being an "observational" historian, was a key ingredient of Banham's approach to architecture (Whiteley 2002, 400-405), it might not be enough for arriving at decisive and quantitative conclusions pertaining to the physical performance of buildings. Proper answers to questions on environmental performance cannot rely on random visits; they should be based on long-term monitoring of buildings and their reaction to climatic conditions and modes of use, or at least on analytical calculations. In this respect, Banham totally ignored the methodologies of Building Science, which were developed enough during the 1960's and could have allowed him to base at least parts of his environmental verdicts not only on informed hypotheses and personal impressions, but on precise calculations and clear quantifications of the thermal properties of building materials, indoor temperatures, relative humidity, air movement, and illuminance levels, in the way "building scientists" evaluate the performance of buildings.

The study behind *The Architecture of the Well-tempered Environment*, though exceptional in historical writing, is not backed by precise scientific quantification, and the performance of buildings (which is essential to the book's main subject) is evaluated by reading of documents and subjective impressions of little scientific validity. When the concept of "fit environments for human activities" is introduced into architectural discourse, it is almost an imperative to first examine whether the environment actually fitted to human activities, to what extent the architect intelligently employed the technological tools at hand, and whether the proclaimed intentions of the designers resulted in an agreeable solution. Banham did call for the assimilation of technological innovations into architecture, but at the same time continued to study the history of architectural technology by employing tools of the "old world" without crossing the disciplinary lines into the frontier of natural sciences. Thus, *The Architecture of the Well-tempered Environment* presented a new challenge for writers of architectural history, but at the same time was unable to meet it.

The current study, however, accepted the challenge and combined historical research with quantitative assessment of the performance of the analysed buildings. This quantitative assessment was enabled by the application of computer-based building simulation, which, of course, was not available in Banham's time and which, so the author believes, opens an entirely new territory for architectural historians. Although actual building monitoring is always preferable to reliance on simulation software, the integration of such software into historical writing is much less resource intensive (and therefore applicable on a much larger scale) than on-site measurements; moreover, as long as the simulation software are used properly and with care, they can produce results reliable enough for historical assessment of building performance, especially when several alternative design scenarios are examined and compared. We should also remember that building simulation software were developed primarily for design purposes, to enable the comparison between possible design options; the same logic can be applied to historical research, where the original design can be compared to alternative designs that were or were not considered throughout the design process. Last but not least, building simulation software are the only tools that can help in assessing the performance of historic buildings *in their original state*, since many of them, even when still existing, are not preserved in a condition that enables us to draw decisive conclusions on their *original* performance based entirely on monitoring.

Analysis of each of the case studies in the current study followed a similar methodological sequence. Historical materials (architectural plans, correspondence documents, meeting minutes, photographs) were collected (personal interviews helped in times to shed light on some issues, but were not used as reliable resources if no backing documentation for the oral recollections existed). The historical data was used for producing a set of architectural plans of the buildings in their original state, and a list of design objectives as explicitly expressed by the architects or their clients, including reference to issues of environmental performance. The original plans were used for simulating the indoor thermal performance of the buildings in their original state, as well as for simulating alternative design solutions. The analysis of simulation results then led to an assessment of the environmental performance of the original buildings, which was compared with the proclaimed design objectives.

The three case studies were intentionally selected because of the different approaches they represent to the utilization of the accumulating scientific knowledge in building climatology. Moreover, they also reflect how the design stage in which such knowledge is applied determines the effect on the performance of the resultant building. This variety of approaches and design processes enabled to test our general hypotheses on professional repertoires, their emergence, evolvement, and application, while focusing on the complex task of architectural design which always reflects a compromise of competing disciplines. History, as was used here, can thus inform us not only on past events, but also on the very contemporary gamut of operational relations between the relatively young science of building climatology and the architectural profession, its costumes, habits, and fixations.[1]

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[1] It would be interesting to compare the failed adoption of building climatology knowledge by Israeli architects, which is the main focus of this study, with the results of a recent and pioneering study by Hebbert and Mackillop (2013) on an almost similar failure to integrate knowledge in the very close scientific field of urban climatology into town planners' practice in Western countries. The current study offers a conceptual framework for analysing this failure, which is missing from the work of Hebbert and Mackillop.

2 BUILDING CLIMATOLOGY RESEARCH IN ISRAEL: THE FORMATIVE YEARS, 1940-1948

2.1 Introduction

> When I came to Israel (then "Palestine") 50 years ago and inquired about the influence of the summer climate on construction and town-planning I received only one answer: the cool breeze comes from the west! I began intensive studies and succeeded in assembling a team of specialists: for physical problems Prof. Goldberg (formerly from Zeiss-Jena), the Profs. Strauss and Gruschka for questions of hygiene, and the Director of the Meteorological Service of the then Mandatory Government, Mr. Feige, for meteorological problems. (Wittkower 1984, 269)

The above paragraph opened a paper written by the Israeli architect Werner Joseph Wittkower (1903-1997) on his lifetime experience in the field of what he called "climate-adapted building in Israel". The paper was originally presented during an international conference on "applied climatology and its contribution to planning and building", organized by the Israeli climatologist Arieh Bitan from the International Federation for Housing and Planning, which took place in Herzliya in November 1983. Wittkower's paper is probably the only existing written source to retrospectively sketch the first stages of building climatology research in Israel, and though it does so laconically and in a very concise form, it still conveys a truthful depiction of its early evolution and almost coincidental character. Up to the early 1940's, architects in what was then Mandatory Palestine (later to become the State of Israel) showed limited interest in scientific investigation of the relations between climate and building. Even when the challenges presented by the local climate were addressed in a sincere way, this was usually done based on general rules of thumb and climatic common sense that had very little to do with systematic analysis of the physical performance of buildings, not to mention scientific on-site monitoring of indoor climate conditions. The team that Wittkower managed to assemble, most of them (including himself) émigrés from Nazi Germany, was therefore responsible for historical change.

Wittkower, who was personally engaged in questions of climate and building since the late 1930's, was putting up the team in order to design an on-site monitoring experiment of indoor temperatures. The humble campaign, described by Wittkower in his 1984 paper as a "large-scale" program, took place between 28 September and 7 October 1946. Sponsored by the local Meteorological Research Council, a governmental body, it aimed at answering a common design question – what can be regarded as a climatically-optimal building orientation in Palestine. Although this was not the first time in which temperatures inside buildings were monitored as part of local scientific research (the climatologist Dov Ashbel was engaged in such activities since the beginning of the 1940's; see below, section 2.5), this experiment was unique in employing such methods for answering a specific question of building design.

Concern over climatically-adapted buildings was not a new topic for Jewish architects in Palestine, and, as demonstrated above (section 1.11.1), was present in their writings on architecture since the first decade of the 20th century. Nevertheless, this concern did not produce satisfactory results, and by the late 1930's it was acknowledged that the modern way of buildings in Palestine often lacked the climatic benefits of the older "architecture without architects" of Palestine. Another approach was called for, which was expected to lead to better understanding of local climate and its effects on buildings. Building climatology was thus primarily seen by its proponents as an architectural design tool, an integral part of the professional knowledge that should be applied by architects during design. Nevertheless, the actual impact of the emerging scientific activity was much less significant than one could have expected from the proclaimed concern over climate. This discrepancy between what was said about climate and what was actually done to meet its challenges was widening as scientific research provided more and more practical answers to questions of climate and building. And so, in 1979, almost four decades after the science of building climatology first set foot in Israel, the Israeli architect and critic Michael Kuhn, who was famous for his sharp pen and uncompromising style, emphatically wrote:

> In the last generation "the best of architects" (namely, those successful and popular among the elite) excelled in their amazing ignorance in respect to climate and climatically-adapted building. One remarkable example is Heichal Hatarbut [Mann Auditorium], whose large glazed surfaces, oriented to east, south, and west, require an immense air conditioning facility and great expenditure on cleaning. The lesson of that building was not learnt by the architects who renovated and "improved" the adjacent Habima [Theatre] Building. The building is made of an immense glass wall oriented to three of the four winds, receiving the sun's heat throughout the day.
>
> [...]
>
> It is very grave that the knowledge and experience acquired here during the previous generation are being disrespected today. Architects R. Kaufmann and L. Krakauer, who were active during the 1920's and 1930's, were not only pioneers of Israeli architecture, but also pioneers of good modern architecture internationally. Their experiments in creating architecture suitable for the local climate – their fruits still hold value. Experiments done in the area of the Dead Sea and the Jordan Valley for the protection of buildings from sun radiation and for improved ventilation achieved significant results. All of this is forgotten and gone. When the State was founded, its official bodies did not show any understanding, nor respect and appreciation, to the acquired experience. Today students of the Technion's Faculty of Architecture know nothing about these experiments. (Kuhn 1979)

Although Kuhn's criticism was harsh, the most striking fact about his words is not their content, but what is missing from them. Kuhn exalted the practical work of Kaufmann (Figure 2.1) and Krakauer during the 1920's and 1930's, but totally ignored the products of four decades of scientific experiments conducted by architects, meteorologists, physiologists, and physicists. This was probably not just mere chance, since this ignorance was not restricted to Kuhn; more than anything else, it proved that even after years of accumulating knowledge, building climatology in Israel was not accepted as an integral part of the profession. The reasons may be varied, but before looking into them one should first unfold the untold story of this discounted scientific field.

Figure 2.1: Richard Kaufmann, residential buildings in Kibbutz Beit Zera with "double roof" consisting of light roofs shading over the structural concrete roofs, 1932 (photograph by Ze'ev Aleksandrowicz)

2.2 Designing for natural ventilation

In Zionist eyes, the main climatic challenge in Palestine has always been the heat. The heat was mentioned in Baerwald's article from 1910 (see above, section 1.1), and became a recurrent topic not only in the texts produced by architects, but also in almost any other form of writing (Helman 2003). This can be well understood, since most of the Jewish immigrants to Palestine came from Europe and seemed to share a similar amazement at the hot climate of their new country. And while everybody talked about the heat, architects seemed to do something about it, or at least pretended they were trying.

The first approach to the challenge of climate, expressed already in Baerwald's 1910 text, was to turn to the existing vernaculars of the land and to learn how local building practices in Palestine kept indoor spaces cool. Baerwald himself formulated this general conception in a text published in Hebrew in 1925 as the opening article of a special issue on architecture in Palestine published by *Mishar VeTa'asiya* ("Commerce and Industry"), a local journal on questions of trade, industry, and agriculture. Climate occupied a major part of the article, which was dedicated to what Baerwald named "the art of homeland". He saw climate not only as the single most important element to shape the vernacular architecture of Palestine, but also as the main challenge to modern building. His critique on the performance of the new buildings built by Jews in Palestine was clear:

> Only a short time ago people began to acknowledge the significance of the art of the homeland, and around the world people are making efforts to build and adapt architecture to local nature.
>
> This trend, however, is not solely targeted to the mimicry of existing form, but stems from the understanding that local architecture was developing from within the climate and living conditions, as also do the available building materials – as an experience accumulated throughout the ages. And it

can be argued that the more distinct the climate, living conditions, and building materials, the more distinct the buildings.

In Eretz Israel the Arabs have created, after centuries of evolution, buildings which are excellently adapted to these conditions. For this reason any Arab town in Eretz Israel not only has a distinctive character, but every single building is suitable for its purpose – to provide dwelling and shelter.

The Hebrew immigrants have no fixed tradition in building. On the contrary, life in the diaspora as well as the external shape of the cities and buildings had such an influence on them that everyone wants to build his home following the character of his home country. Because of the famous stubbornness of our people, the plan of our first city [Tel Aviv], which lacks any sense of beauty, is in chaos, and the buildings as well are uncomfortable, unhygienic, and unsuitable for the climate of Eretz Israel.

The author does not suggest to blindly mimic the Arab style, but one should attempt to take from the Arab Style whatever has real value. By doing so, we could realize that we can make life in the countries of the Orient more pleasant.

[…]

The main goal is to build cool rooms, full of fresh and changing air. The Arab architect builds high ceilings, thick walls, and inserts special small openings through which the wind breaks out above the windows and doors. He enhances this functioning by placing the longer facade of the house against the prevailing wind, with only the shorter facade oriented to south. He also builds many balconies and a flat roof, which on the one hand helps to receive the rainwater, and on the other hand is useful during the summer nights for

> rest and sleep. These flat roofs are so thick, that even a single beam of the burning sun does not penetrate the rooms below them.
>
> [...]
>
> Unfortunately, the financial situation compelled the majority of building owners to neglect the Arab example and to build seemingly thin walls instead of the thick walls, strictly low ceilings instead of the high ceilings, light tiled roof instead of the flat roof.
>
> After doing so, they cannot be wondering why the heat in their apartments increases during summer, as does the coldness during winter, and why the apartments are wet and damp during the rainy season. They are not allowed to say that they do not know how to build properly in Eretz Israel. These shortcomings resulted from the fact that they have built their homes using inadequate means. Moreover, when they act also as builders, they lack any professional knowledge, and there were cases in which buildings were constructed by people with only a minimal knowledge in the art of building. (Baerwald 1925)

As the founder of architecture studies at the Technion, one cannot overestimate Baerwald's influence on later generations of architects in Palestine. His insights on the relation between climate and local building traditions were received as axiomatic ever since they first appeared in writing. Following Baerwald, local Jewish architects believed that local building types, mainly town houses, provided reasonably (and sometimes even more than that) cool interiors during the hot summer days. This was attributed mainly to their thick stone walls, as well as their typical layout of rooms arranged around a central hall (Koerner 1942, Aleksandrowicz and Mahdavi 2012). Stone walls, however, were not common in Jewish building along the Palestinian Coastal Plain since the beginning of the 1920's, when a Jewish-owned brick factory was opened in Tel Aviv, producing calcium silicate bricks that soon became the preferable building material for modern constructions (Teinovitz 1946). Even before the factory opened in 1922, attempts were made to produce primitive cement bricks, in order to promote unskilled Jewish labour on construction sites, reducing the reliance on the more skill-intensive work of local Arab stone cutters (Aleksandrowicz 2010). The replacement of local stone with bricks resulted in the reduction of wall thickness, and this in turn reduced the walls' capacity to store and resist heat. As noted by Baerwald, this move towards modern building material and construction methods negatively affected the thermal properties of the building envelope, thus increasing the dependency on natural ventilation as a solution for the overheating of indoor spaces.

With thick stone walls disappearing from common practice, Jewish architects in Palestine began to rely almost exclusively on wind for relieving the human sensation of heat when designing residential buildings along the hot and humid Coastal Plain (where most of the Jewish urban population was concentrated). This approach led many architects to orient the buildings to the direction of the prevailing winds, a convention which was documented in a handful of texts. In 1936, for example, architect Dov Karmi (1905-1962) offered some basic guidelines for choosing the preferable apartment orientation in Tel Aviv while giving much more weight to the effect natural winds allegedly have on indoor thermal comfort:

> 1) The living room should receive the west and north directions. Wind coming from the sea passes and flows through the room during all daytime hours. The sun beams too arrive here in the late afternoon, just before sunset. If the living room is oriented directly to west, the room is likely to overheat during the summer months, particularly in non-insulated buildings. This can be corrected by orienting the western wall northwards, i.e. a wall oriented to west by north-west […].

> Living rooms oriented to the south are good enough for wintertime, but, on the contrary, are hot and do not fulfil their role during the summer months.
>
> <u>The west is essential for living rooms.</u>
>
> 2) Bedrooms receive north, east, and south, as long as the parents' bedroom receives east and north and the children's bedroom – east and south. This division is understandable, since children need the sun more than their parents.
>
> During the hot summer evenings the wind comes from inland – eastern wind which refreshes the bedrooms. At the same time, the bedroom which faces east receives the sun beams only during the morning, until about 10:00. The bedroom does not warm up and cools down during daytime, and therefore enables sleep and rest after a laborious day – which is the important point here.
>
> The south in the children bedroom is effective mainly during wintertime. Sun beams penetrate the room much deeper than in summertime, warm it, and the room is a healthy bedroom. West-facing bedrooms warm up during the afternoon and could not cool down enough, and therefore sleeping inside them during the summer months is very difficult.
>
> <u>The east is essential for bedrooms.</u> (Karmi 1936)

Karmi's conclusions were not based on any systematic monitoring, but rather on his own personal impressions. His article appeared next to a similar report by architect Shlomo Ginzburg (1906-1976) on apartment orientation in Haifa, which was far less conclusive. Ginzburg openly admitted that his recommendations are based on personal impressions and beliefs, not on scientific exploration, and wrote that "no institution has engaged itself in investigating the effect of climate on building habits in Haifa and therefore each architect designs his buildings based on his own understanding [...] Therefore, what will be written here is only my personal opinion, acquired through several years of living in Haifa (I was not engaged in scientific investigations)" (Ginzburg 1936).

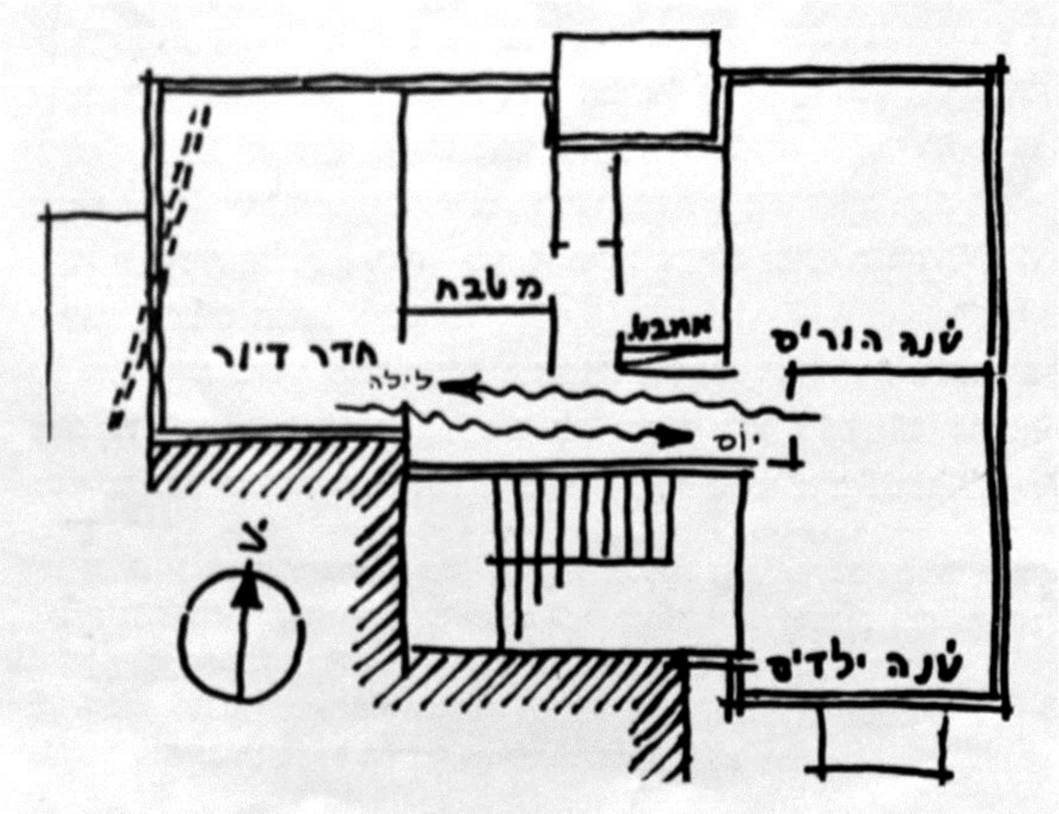

Figure 2.2: Dov Karmi, plan of an optimal arrangement of an apartment in Tel Aviv, showing the expected effect of cross ventilation between the eastern and western parts of the apartment (Karmi 1936)

Moreover, while Ginzburg acknowledged that the sun's effect on buildings depends on the solar orientation of the facades, he reiterated the almost axiomatic belief in the need to orient the building's main facades to the prevalent wind direction:

> When dealing with apartment orientation, the sun introduces a conflict in the design of the apartment's layout. Based on the wind, the bedrooms should be oriented to the west, while the sun commands their orientation to the east. The architect in Haifa leaves the morning sun behind and arranges the rooms westwards. Arranging all rooms on the west requires that the service areas, including the kitchen, will be located on the east. The resulting kitchen is very bad:

> all working hours are spent without wind and with abundance of sun. This shortcoming is tempered by the opening of doors and windows in a way that would result in drafts crossing the entire apartment from west to east, going through the kitchen – an artificial and weak solution. The effect of the sun, which warms up the kitchen's walls, is reduced by protruding the cornices, or, which is more common in Haifa, by making balconies along the kitchen. (Ginzburg 1936)

Almost a similar approach was presented a year later by architect Arieh Sharon (1900-1984), one of a handful of Bauhaus graduates working in Palestine. Writing on public housing in Tel Aviv, Sharon related the apartment design in public housing projects of the 1930's mainly to the buildings orientation towards the winds:

> Because of lack of means of fundamental insulation of walls and ceiling, we arrived in recent years at the conclusion that we should make use of the natural conditions, the wind and sun, for creating an optimal apartment, under the limited financial conditions. Based on this approach, we arrived at the following results (in Tel Aviv and its environs, taking in mind the known modifications in other parts of the country):
>
> The western side is indeed the side of the refreshing wind, but it is also the one that heats the house walls the most, since the sun meets the walls in the afternoon when the walls are already warm and continues to burn them until the evening. This is why the west is good when protected by a wide balcony that defends it also from winter storms. The southern side is good during winter because of the low radiation of the sun and also during summer because of the high sun. It is easy to protect the southern walls by applying a shading ledge on every floor as well as the roof. The eastern side tends to heat less than the western side (the

rising sun finds the walls still cool from the night) and also receives wind during night, and therefore it is common to arrange the bedrooms on this side. Nevertheless, it is required to connect the eastern rooms with the west through doors and apertures. The northern side is pleasant, especially in summer. Usually it is not recommended to pay attention only to ventilation but to consider also the heating up of the house, and therefore one should keep in mind that in the cheap building method (with no insulation) in our country the western rooms are cool before noon and the eastern rooms cool down in the afternoon, so a premeditated link between these rooms would result in satisfactory result during winter and summer alike.

The following [Figure 2.3] is the plan of apartment number 4, where all rooms are ventilated, in addition to the western-eastern ventilation, through northern or southern doors which connect to the balcony and enable additional diagonal ventilation and absorptive ventilation, which should not be forgotten when designing our apartments. (Sharon 1937)

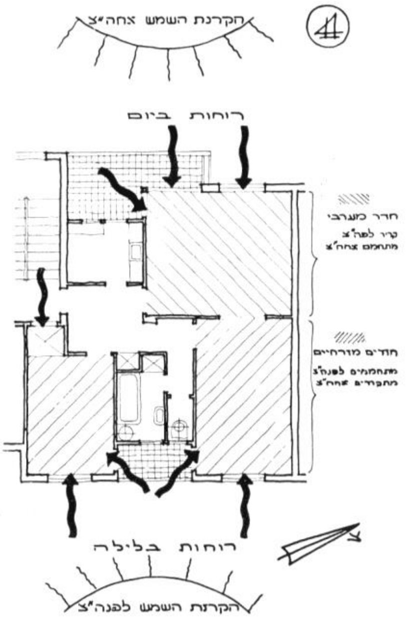

Figure 2.3: Arieh Sharon, plan of an optimal arrangement of an apartment in Tel Aviv, showing the expected effect of prevalent winds during daytime (up) and nighttime (down) on its ventilation (Sharon 1937)

By the early 1940's, the almost absolute reliance on natural ventilation for provision of summer comfort was already widely accepted as an undeniable component of climatic design. The windy trend was documented by architect Alexander Klein (1879-1961), who was one of the main advocates of Functionalism in Berlin of the 1920's, immigrated to Palestine in 1935, and became one of the most distinguished architecture professors at the Technion in Haifa. In his 1942 article on "climatic influences in the organic design of floor-plan and facade", Klein argued that local climates have a distinctive effect on the design of modern buildings, and tried to make his point by comparing typical residential buildings from Palestine, Germany, and Norway. Klein selected two examples from Palestine, one from Haifa, the other from Tel Aviv. On buildings in Haifa he wrote:

> Generally speaking, the wind's direction, unchangeable during most of the year, is west by north-west. This is the reason why all bedrooms, living rooms, kitchens, and balconies are oriented to the west (i.e., facing the wind) and only the stairwell, the bathroom, and the water-closet are oriented to the east. (Klein 1942)

As for Tel Aviv,

> Usually the wind here comes from the west during daytime and from the east during the night. Therefore the bedrooms are oriented to the east and the living rooms, kitchens, and balconies – to the west. (Klein 1942)

However, in reality things seemed to be less than perfect, and what was regarded as an agreeable climatic solution proved to be less successful than expected, if not unsuccessful at all. To his reference to the Haifa way of building Klein added a short footnote which clarified that he does not wish to engage himself in the discussion on "whether it is correct to orient the living rooms and bedrooms to the wind, as was the habit until now" (Klein 1942), revealing that after several years of practice, the climatic effectiveness of the wind-oriented design was beginning to be questioned.

Another article by architect Emanuel Wilensky (1903-1981), dated from April 1946, was even more explicit in questioning the common beliefs on building orientation. Writing on residential buildings in Haifa Bay, Wilensky argued that

> It was usually the habit in Haifa and its environs to orient the residential buildings to the west; but because of the disadvantages of the western direction people started recently to seek the possibility of a different direction. Indeed, now it is common to hear that it is advisable to orient the main long wall to the north. (Wilensky 1946, 18)

To this Wilensky added details on recent results of wind monitoring in the Bay area which revealed that during spring, summer, and autumn the prevalent winds come actually from north-west, and in winter – from south-east. Therefore, Wilensky concluded that buildings in Haifa should be oriented to the north-west instead of perfect west. Nevertheless, this recommendation was followed by a note inserted by the editor of the journal, who argued that "It is well known that according to the common belief among climatologists, in order to prevent the overheating of walls (and in order to decrease the indoor temperature of buildings) it is advisable to orient the long external wall of the buildings to a direction parallel to that of the prevalent summer winds, i.e. to a direction perpendicular to the one recommended by the author" (Wilensky 1946). The editor's note demonstrated that the common practice of architects, who for more than a decade used to orient their buildings so that winds would virtually flood the indoor spaces, now contrasted the common belief among local "climatologists". While it is hard to find concrete documentation that supports the editor's argument, it is clear that by the mid-1940's new ideas and conceptions, as well as new analytical methods, began to emerge, reflecting a continuing dissatisfaction with the way architects were dealing with the climatic challenge.

The emphasis given by Jewish architects in Palestine on the question of ideal building orientation was not only an outcome of the specific conditions of the land, but reflected an earlier preoccupation of European

Modern architects with similar questions. The most significant expression of that trend was the *Zeilenbau* scheme developed in Germany during the mid-1920's (Butti and Perlin 1980, 167-168, Henderson 2013, 400-426); it was explicitly mentioned by Sharon (1937) and Klein (1942) in their articles on housing and was without doubt familiar also to many other local architects, taking in mind the strong German influence on Jewish architecture in Palestine (Adler 1936). The *Zeilenbau* scheme was developed as a response to what was perceived as unhygienic living conditions of the masses resulting from the typical European dense block arrangement. Lack of exposure to sunlight was believed to induce recurrent epidemics, as also did the insufficient natural ventilation. Following a strictly solar logic of a maximal exposure to sunlight, it was assumed that public housing projects should be built in long parallel superblocks which would face east and west. The internal layout of each apartment followed the same solar logic: bedrooms were facing east, to welcome the morning sun, while living rooms faced west, being used mainly during the afternoon and evening hours. Numerous housing projects in Germany of the late 1920's were built according to the *Zeilenbau* scheme, many of them under the guidance of architect Ernst May in Frankfurt. The results, however, were less than optimal, since what was ideal in terms of sunlight was much less favourable in terms of solar heating of the structures:

> Once built, the structures themselves punched the theory full of holes. In the first place, the cost of heating these buildings was excessive. In the second place, the cheerful morning sun varied with the seasons. In midsummer there was plenty of sunlight coming in from the east, while in midwinter, when the sun rose far to the south, there was only a short time in which these rooms received the dubious benefits of their western exposure. In the third place, people living in the west rooms found that for most of the year this exposure was practically intolerable. The interiors were blistered in summer by the late afternoon sun, and the

> strong light coming in at a very low angle was unpleasant and hard to screen out with shades. (Nelson and Wright 1945, 176)

In spite of these undesirable results, the *Zeilenbau* logic – i.e., the use of climatic variables for answering specific design questions – was still embraced by architects in Palestine. While there was very little sense in implementing the *Zeilenbau* scheme as it was in a hot and sunny country, the German experience proved that climatic concerns, assisted by scientific data, can be used for designing modern buildings and neighbourhoods. It is no wonder that by the mid-1930's architects in Palestine were occupying themselves with questions of a "preferable building orientation", and that these discussions were suffused with climatic justifications: this was a direct outcome of the strong German orientation of the architectural profession in Palestine at that time. Nevertheless, and very much like the *Zeilenbau* example, this somewhat simplistic approach to climate proved unsuccessful, calling for a holistic understanding of the climatic effects on both buildings and the human body, as well as for a much more rigorous research methods.

2.3 Indoor climate as a question of hygiene

Experience showed that the non-scientific approach, which attempted to produce "objective" guidelines based on limited knowledge and partial understanding of the main climatic factors, had failed. Architect Avia Hashimshoni (1912-2008), a prominent architect who wrote on climatic issues since the early 1950's, recollected during a symposium on "climate and man in Israel" held in April 1962 (see below, section 3.9) that "one can remember cases in which people hastily jumped into 'pseudo-scientific' conclusions based on partial or incomplete data. One negative example, which was mentioned above, is that, for quite a long period of time, people made do with orienting the rooms to the wind without securing cross wind flow" (Hashimshoni 1962, 128). The "pseudo-science" of architects had to be replaced simply because it could not provide the correct answers to climatic questions. At the same time, the recurrent failures of architects attracted the attention of other professional circles, which were much more inclined to employ scientific research methods.

The shift was starting to gain momentum in the beginning of the 1940's, a time of decline in Palestine's building sector caused by the Second World War. In June 1941, Walter Strauss (1895-1990), the manager of the Nathan and Lina Straus Health Centre in Jerusalem, published the first of a three-part article on "the apartment as a climate shelter" in *Yedi'ot Le'inyeney Higyena UVri'ut* ("Hygiene and Health Chronicles"); the other parts were published in July and August of the same year. Strauss was a newcomer to Palestine; he emigrated from Berlin in 1937 (Herut 1950), and was probably attracted to the subject because of the stark difference between the climatic conditions of his former and new lands. As a physician occupied with questions of hygiene, Strauss wrote about physiological mechanisms that enables the human body to mitigate the effects of hot climate, focusing on the special characteristics of indoor climate. His motivation for writing on apartment design was his own medical concern; as he wrote in the second paragraph of his article

> We do not wish to search here for the reasons why the care for the apartment's functionality suffers such a recurrent

> neglect in times of prosperity in town building – a neglect which took its revenge in the health of the people. But in Palestine we are standing now in the middle of the process of building development, and it is our duty to avoid mistakes. Our mistakes could not possibly resemble those of the barracks-like apartments in Europe, but they can still stem from insufficient care for climatic and hygienic demands. (Strauss 1941a)

According to Strauss, "a residential building which is more adapted to the climate has also a higher hygienic value [...]"; in Palestine, this may have its greatest effect during summer, since the main physical challenge to the human body is the prolonging heat stress caused by the long hot season. Strauss explained that three factors influence the human reaction to heat, in descending order of importance: air temperature, air humidity, and air flow. Since control of air humidity levels cannot be obtained without mechanical aids, Strauss limited his analysis to the optional regulation of indoor temperature and air flow through building design. To him,

> Building technology should enable us:
>
> a. To reduce the heat of the air inside the apartment as much as possible;
> b. To keep the walls, which serve as surfaces of reflective radiation, cool;
> c. To take care of the air movement inside the rooms in a way that will surround the body with fresh air but will not amount to unpleasant draft. (Strauss 1941b)

Strauss argued that "our ideal goal is a building whose walls will receive as little sunlight as possible and will have poor thermal conductivity" (Strauss 1941c), but the modern ways of building that were replacing the local building techniques (in which the thermal mass of the thick walls had also a climatic function) were counter-effective in terms of maintaining indoor thermal comfort:

> The old building tradition of Palestine was almost fully abandoned. The walls of the new houses are thinner, the rooms smaller and their ceilings are low, the upper ventilation cancelled. No windows were inserted above the doors, the balcony does not block the apartment from the outside but deepens it and opens it to the outdoors. (Strauss 1941b)

Another problem was caused by the new uncalculated habit of designing wide windows for introducing as much outdoor air flows as possible into the indoor space. As Strauss told his readers, this strategy proved to worsen the indoor thermal conditions during nighttime, since the prevalent western winds cease to blow when evening comes, just when the walls begin to emit the absorbed heat into the indoor spaces, making the apartments a kind of a heat trap. This phenomenon was enhanced by the structure of the dense city, where "the walls of the streets stand vis-à-vis each other as surfaces of reflective radiation, preventing them from losing heat" (Strauss 1941b). In the end, the situation deteriorates as the hot season progresses. The fortunate wealthy leave the cities during the hot season, while the rest of the population "have no choice but to suffer, 'accommodating' themselves to the situation while assuming that the harsh conditions inside their apartments, which actually result from building malfunctions, are an inevitable outcome of the land's climate" (Strauss 1941b).

Strauss added that while concrete data on indoor climate is still insufficient – a fact which is indicative to the lack of interest in the climatic question as a whole – one can assume that the inner walls heat up during summertime to more than 30°C. This brought him to the revolutionary conclusion that "a system which makes the wind the main element of apartment cooling is fundamentally wrong" (Strauss 1941b). Strauss argued that "the existing building method finds many opponents among architects", and added that the main reason for the poor performance of the newly-built houses is "the exaggerated admiration for the aesthetics of European building"; in other words, the architects, committing themselves to imported Modernist aesthetics, failed in adapting it to the local climate conditions and in creating "a new style that would have answered well all the basic requirements of hygiene" (Strauss 1941b).

The third part of Strauss' article was dedicated to design recommendations that were believed to mitigate the effects of heat on indoor conditions. Strauss admitted that generalized answers cannot be suggested because of the regional differences in climate conditions in Palestine, but stressed that some general recommendations may still be valid. The main interest, he argued, should be the protection of walls from the sun, which can be done in the following ways:

> In urban buildings the eastern and southern walls could be protected using shading ledges. Such ledges above every row of windows can also serve as a good protective aid against excessive illumination of rooms [...] We think that the upper surface, which faces the sun, should not only be smooth and adequately whitewashed, but also retain a parabolic shape in order to reflect the sunbeams that hit it in a certain angle, which depends on the street's width. A wall equipped with an effective sunbeam protection will not significantly overheat above air temperature level, while in the current state of affairs even a northern wall loses its climatic advantage when an opposite southern wall reflects the sunbeams onto it or radiate its own heat in its direction. (Strauss 1941c)

According to Strauss, the same concept should also be applied to rural houses, using an outdoor pergola or by simply projecting the pitched roof beyond the external walls (Strauss 1941c).

Apart from protecting the walls from direct sunlight, Strauss added another general recommendation that focused on the thermal properties of the building's walls. Here, he argued, it is advisable to use porous construction materials with enhanced insulation properties like pumice stone or aerated concrete. Another option might have been the application of an insulation layer on the inner side of the walls, as well as returning to the old habit of designing upper windows for increasing a slow air movement in the apartment. In the end,

> It will be interesting to see what form will cities receive when the idea that the wind is the main element in climatic comfort is abandoned and replaced by acknowledging the need for protection against radiation [...] If we care more about the shade, we would also take into account the shading of buildings when we design streets. Tall and wide-canopied trees would then be planted, and shaded boulevards would not be seen as accidental wonders, as is the case of HaMelakhim Street in Haifa, but would become a normal sight also in commercial districts, as is the case in all southern countries. (Strauss 1941c)

The overall impression that local buildings left on Strauss was that of a grand professional failure. Architects, he argued, neglect their duty to supply proper indoor conditions for their clients because of lack of knowledge in climatic matters, as well as lack of interest. The failure called for a fundamental change not only in design habits but also in the wider professional attitude to the integration of scientific knowledge into design:

> There is a need for a mental and creative reform among architects. One should overcome the hindering element – the European example of the conventional aesthetic forms. The public should be educated and confronted with the fact that its inclination towards European forms of building is an obstacle for progress. And finally – scientific building research, which exists in all civilized countries, should be initiated.
>
> From the firm foundation of scientific and practical experience the design of a new building form will grow, its apex will be the creation of a building style suitable for the

> land of our future – a **national** style in the best meaning of the word. (Strauss 1941c)

When published, Strauss' humble article was the most comprehensive treatise on climatic building design in Palestine written to that date. In spite of its detailed description of the physical mechanisms that affect buildings and the suggested design recommendations, it was not the work of an architect, but of a physician whose expertise was public hygiene; moreover, it was published in a medical journal, not in any of the local professional bulletins which were dedicated to questions of architecture and engineering. These facts are enough to support Strauss' own argument on the professional failure of local architects in addressing the climatic challenge in a serious and rigorous manner. Moreover, Strauss acknowledged his own limits, and argued that only additional scientific research could help in finding the proper answers to the pressing questions of climate and building. The turn to science was critical to Strauss' argument; while his call for a new national style reminds us of Baerwald's design philosophy, Strauss was the first to emphasize that this new style cannot be created without a valid scientific foundation. It was not long before his call was answered.

2.4 Werner Joseph Wittkower, a pioneer of building climatology in Israel

In February 1942, six months after the final part of Strauss' article was published, the same Hebrew medical journal published a letter to the editor written by architect Werner Joseph Wittkower (Figure 2.4). The short letter is probably Wittkower's first published text on the climatic aspects of building in Palestine. After praising Strauss' articles he went on to add that he was pursuing a similar direction "in theory and practice for several years now" and that he has "built accordingly several family houses (in Herzliya and Gedera) following a path totally different from the one which prevails here". He then provided a concise summary of his practical experience:

> The fundamental direction is this: shelter from radiation and effective ventilation potential. The main facades are oriented to the north and south; ledges of about 70 cm deep protect the external walls. In order to protect the living rooms from the heat of the western sun, I usually put the kitchens there, since the residents seldom use them in the afternoon. One side of the bedrooms faces east. The roofs are pitched, covered with tiles. When the means are available I usually put special insulation in the ceiling.
>
> The windows are tall, their upper part can be opened separately. This provides light ventilation above the heads during daytime, thus creating splendid sensation of coolness without causing discomfort. The northern-southern ventilation proved to be remarkably good. In one of these houses I designed, just in case, an upper ventilation aperture, but the residents did not use it and almost forgot about its existence, as I later found out. The northern-southern ventilation was satisfactory enough.
>
> Generally speaking, the residents in these houses find corporal relief in them and rarely affected by the harsh

> summer heat. I believe that it is desirable and feasible to build according to the same guidelines throughout the whole country, except in the Jordan Valley. (Wittkower 1942b)

Although coming from very different professional circles, Wittkower and Strauss shared one common background – they were both born, raised and worked in Berlin and were forced to flee Germany to Palestine during the 1930's as a result of the harsh anti-Semitic policies of the Nazi regime. Wittkower was born on 12 May 1903 to a wealthy Jewish family deeply rooted in German life (Agassi 1993, Warhaftig 1996, 326-331). He studied architecture in Stuttgart under the direction of Paul Bonatz and Paul Schmitthenner and worked in architect Richard Döcker's office. In 1927 he returned to Berlin, where he opened his own architectural practice, working mainly as interior designer. In 1933, realizing that the future of Jews in Germany is grim, Wittkower and his wife decided to leave Germany; his elder brother, Rudolf Wittkower, went to England on the same year, where he became a distinguished and influential art historian.

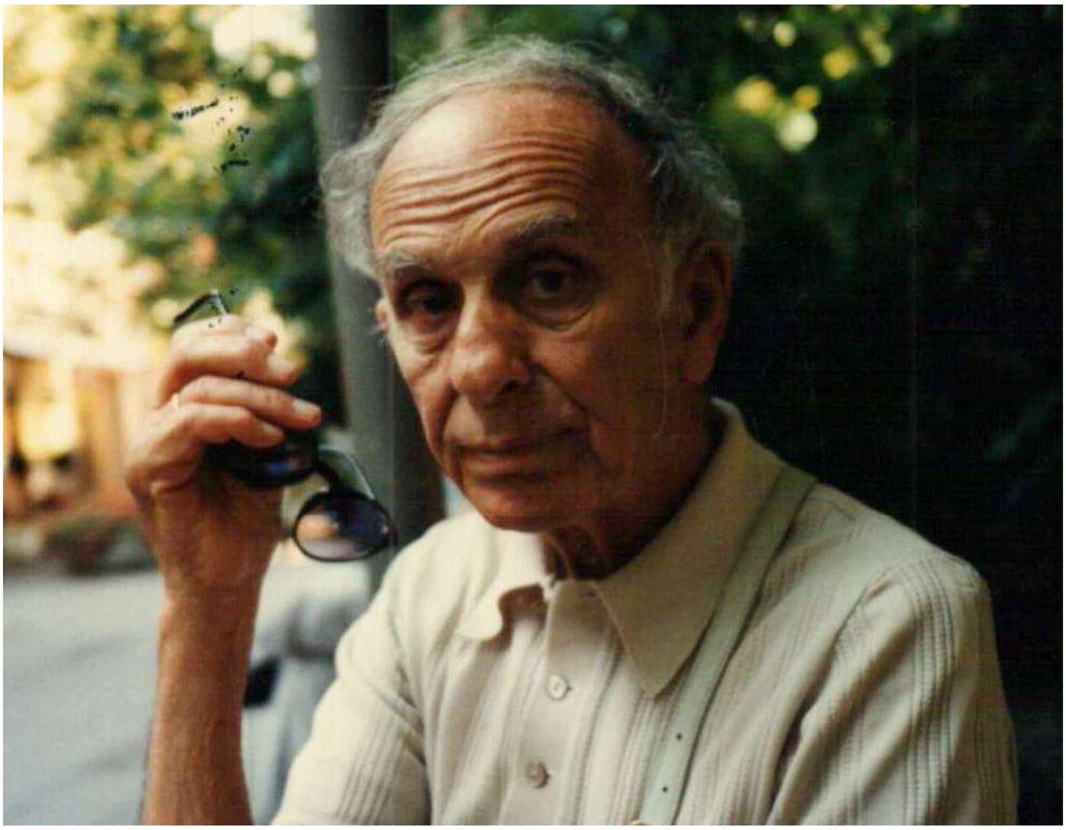

Figure 2.4: Werner Joseph Wittkower in his later years, date unknown (Israel Stein Collection)

Wittkower found ample opportunities to build in his new, developing country. His first major project was constructed in 1938 (Tel Aviv Central Bus Station, cooperating with architect Nahum Salkind), after winning an architectural competition. According to his own recollections, he began to systematically approach climatic issues in 1941 (Agassi 1993, 34), though his letter to the medical journal implicate that some sort of awareness to climatic issues was present in his practical work for years before. His uniqueness of approach is best demonstrated by the fact that in 1942 he completed a manuscript for a book on climatic building design in Palestine; written in German, it was named *Bauliche Gestaltung Klimatisch Gesunder Wohnräume in Palästina*.

Wittkower's manuscript is a remarkable document, especially when taking into account that its author was a practicing architect without the backing of any academic institution. No less remarkable is the fact that this unique and important document survived only by sheer chance. While Wittkower, who was childless, kept an organized archive of his works at his office in Tel Aviv,[2] this archive is long-lost; it was probably carelessly liquidated after Wittkower's death in 1997 or even before, in 1995, when he closed his office, as told the author his long-time secretary, Haviva Eppenstein (Eppenstein 2012). Fortunately enough, Wittkower sent a copy of his manuscript to Rudolf Feige, the founder and director of the Meteorological Service of Palestine, in order to interest him in cooperating in indoor climate monitoring which eventually took place in 1946 (see below, section 2.5). Unlike the personal and professional materials of Wittkower, Feige's archive, which miraculously included Wittkower's full

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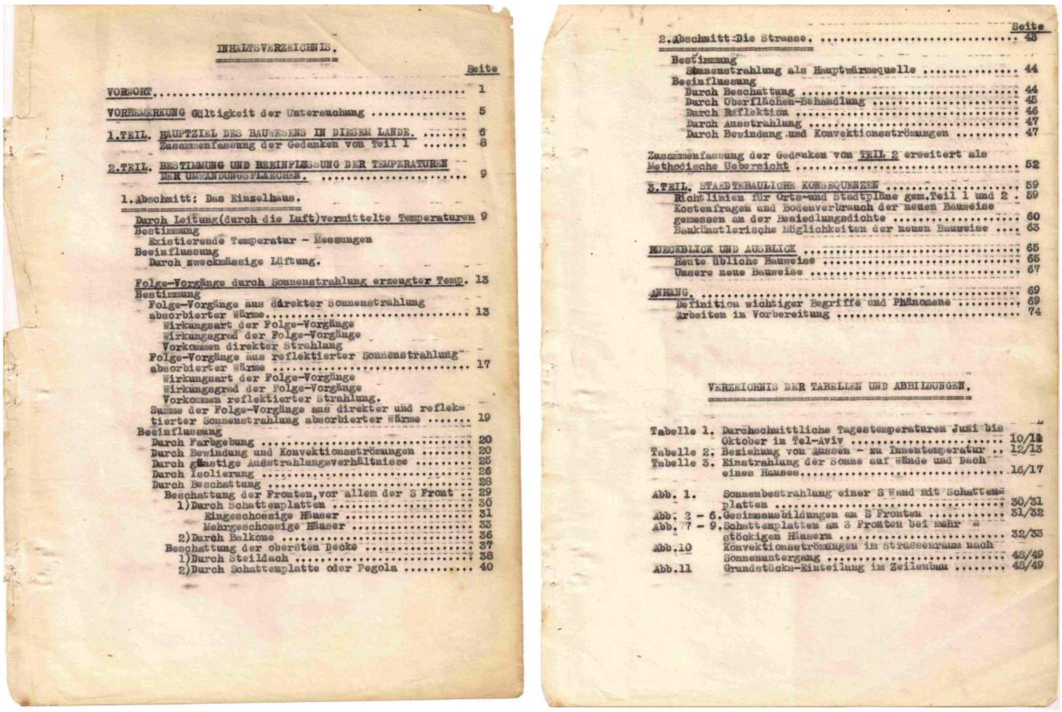
[2] In a term paper on Wittkower submitted in 1990 by Ruthie Polack, an art student at the Hebrew University, she wrote on Wittkower's archive, which contained at that time "work plans and drawings, perspective renderings as well as photographs of the plans […] Architect Wittkower is open to discussions on the gradual and organized transfer of the material to a central authority for its future preservation" (Polack 1990, 7). The paper was submitted to architecture historian Uriel Adiv, and is now kept as part of Adiv's personal collection at Israel Architecture Archive. I am indebted to Zvi Elhyani, Founding Director of the Archive, for informing me about Polack's paper as well as giving me access to a rare voice recording of Polack interviewing Wittkower, also kept in the Archive.

manuscript, was deposited by his family at the German-speaking Jewry Heritage Museum in Tefen (Israel).

Bauliche Gestaltung Klimatisch Gesunder Wohnräume in Palästina, which was probably completed in 1942 (Feige et al. 1952, 2), holds 83 pages (Figure 2.5). While its main lines of thought and analytical conclusions appeared later in a concise form in articles published by Wittkower in Hebrew during the 1940's (see below), other parts of the manuscript open a window to Wittkower's motivation and intentions behind his work; they also reveal the sources Wittkower was relying on. Naturally, these included works in German, like Karl Flügge's 1916 book *Grossstadtwohnungen und Kleinhaussiedelungen in ihre Einwirkung auf die Volksgesundheit*, Richard Flügge's 1926 book *Das Warme Wohnhaus*, and Richard Schachner's 1926 book *Gesundheitstechnik im Hausbau*. Wittkower referred also to Strauss' three-part article in Hebrew from 1941.



INHALTSVERZEICHNIS.

VERZEICHNIS DER TABELLEN UND ABBILDUNGEN.

Figure 2.5: The table of contents of Wittkower's manuscript, *Bauliche Gestaltung Klimatisch Gesunder Wohnräume in Palästina*, as kept in the Rudolf Feige Collection at the German-speaking Jewry Heritage Museum (Wittkower 1942a)

The foreword to the manuscript is probably the only surviving text in which Wittkower allowed himself to openly express his views on the relation between science and architecture. At its basis lies the belief that science is the new and modern way of arriving at climatically-sound building solutions, since it provides the architect with a set of reliable and efficient tools for problem solving, far more directed and effective than the "historic" ways of trial and error. Therefore,

> Was das **richtige Wohnen** anlangt, mit dem wir uns hier zu beschäftigen haben, so ist jedes Volk bestrebt, Richtlinien für sein Bauwesen zu finden, die dem Klima des Landes und den Lebensgewohnheiten seiner Bewohner am besten entsprechen. Diese Richtlinien können durch zwei Methoden entwickelt werden. – Die eine geht den weg jahrhunderte – ja, manchmal jahrtausendelanger Versuche, quasi den Umweg einer "natürlichen Zuchtwahl". Man könnte diese Methode die "historische" nennen; ihre Ergebnisse, die mit den Leiden vieler Generationen bezahlt werden, sind die oft glänzenden Bautraditionen, deren weise Einrichtungen und deren Schönheit wir in vielen Ländern bewundern. Die andere Methode geht auf wissenschaftlichem Wege vor – es ist die Methode unseres Zeitalters! Das, was früher in Jahrhunderten mühsam ausprobiert werden musste, können wir mit unserer modernen Methodik oft in wenigen Jahren oder Jahrzehnten heraus finden; wir können dabei zu Resultaten gelangen, die selbt mit jahrtausendelange Probieren nicht zu erzielen sind. Die Ergebnisse deiser [sic.] wissenschaftlichen Methode sind dann die Grundlagen für die Gestaltung einer Baukunst – Grundlagen, ohne die ein gesundes Bauwesen heutzutage undenkbar ist.
>
> Die "historische" Methode hat bei den Mittelmeervölkern, ohne Rücksicht auf ihre sonstigen Lebensgewohnheiten, dem gleichartigen Klima entsprechend ,in **einer** Beziehung identische Bau- und Wohnsitten entwickelt: Wenn sie wirtschaftlich hierzu in der Lage sind, schützen sie ihre Wohnräume vor den Sonnenstrahlen und der heissen Luft

des Tages. Die wichtigsten Mittel hierzu sind: hochisolierte, nämlich sehr dicke Aussenwände; kleine Fenster und Räume ganz ohne Fenster; öffnen der Fenster nur Nachts. – In neuerer Zeit weicht man in allen Mittelmeerländern teilweise von diesen Traditionen ab – das jüdische Palästina hat sie kaum je verwertet: Wir Juden bauen im allgemeinen nicht isolierte, ganz dünne Aussenwände, wir bauen flache, wenig oder garnicht isolierte Dächer; wir bauen grosse Fenster, und diese halten wir den ganzen Sommer hindurch Tag und nacnt geöffnet.

Welches sind die Gründe für diese erstaunlichen Tatsachen? Kontrastieren etwa unsere Lebensgewohnheiten mit Baumethoden, die dem Klima unseres Landes angepasst sind? Haben wissenschaftliche Untersuchungen zur Aufgabe der sonst im Mittelmeer-Gebiet üblichen Baugewohnhaeiten geführt? – Die vorliegende Arbeit wird zeigen, dass nichts von alledem der Fall ist; dass vielmehr diese unsere Baugewohnheiten – oder besser gesagt "Moden" – von Grund auf falsch sind. **Wir haben weder eine Tradition, noch eine wissenschaft unseres Bauwesens**.

Wie es dazu gekommen ist, dass die Bautraditionen des Landes bei uns im allgemeinen nicht beachtet werden, braucht hier nicht behandelt zu werden. Wie aber ist es möglich, dass bei uns ohne wissenschaftliche Erforschung der dem Lande angemessenen Bedingungen gebaut wird; dass man es zulässt, dass in erschreckendem Umfang falsch gebaut wird, sodass Jahr für Jahr riesige Summen fehlinvestiert werden? Dies ist umso merkwürdiger, wenn man bedenkt, dass es sich bei der Feststellung einer dem Klima angemessenen Bauweise um physikalische Tatsachen und grundlegende hygienische lehren handelt, bei denen es weder Unklarheiten, noch wesentlich verschiedene

Meinungen geben kann. Diese Tatsachen und Lehren sind z.T. bekannt (wenn auch diese Kenntnisse in Palästina in den Kreisen,die es angeht, nicht verbreitet sind), z.T. müssen sie für unser Klima durch Messungen ergänzt werden. Unsere Studie wird zeigen, welche grundlegend neuen Erkenntnisse sich bei richtiger Verwertung der schon heute zugänglichen Tatsachen bereits jetzt erschliessen lassen; **Es ergibt sich eine völlig neue Zielsetzung für unser gesamtes Bauwesen**. – Warum also wurden die Dinge bis heute nicht bearbeitet?

Die Hauptsache dürfte darin zu suchen sein, dass für die in Frage kommenden Kreise – vor allem Aerzte und Architekten – mit ihrer europäischen Ausbildung, diejenige Wissenschaft, die sich mit diesen Dingen beschäftigt, nämlich die Hygiene, ein **Rand**-Gebiet ist. Dennoch werden manche Zweifellos empfunden haben, dass hier in Palästina die hygienischen Belange von unendlich viel grösserer Bedeutung sind als in Europa; dass darum das wenige an wissen das sie in diesen Dingen mitgebracht haben, hier nicht ausreicht, zumal ein Teil dieses Wissens wegen der anderen klimatischen Bedingungen hier nicht verwertbar ist; dass schliesslich ein paar subjektive Beobachtungen, die zu den gegenteiligsten Feststellungen führen, nicht genügen. – Aber woher neben der meist aufreibenden Tagesarbeit Zeit und Kräfte nehmen, woher das wissenschaftliche Rüstzeug, um die Probleme mit wissenschaftlicher Methodik anzugreifen?

Von Seiten der Architektenschaft spielt ausserdem noch eine gewisse, psychologisch leicht verständliche Einstellung, die jede wissenschaftliche Ueberlegung als eine Art Einbruch in die Sphäre des gefühlsmässig – schöpferischen ablehnt, eine traurige Rolle. In Wirklichkeit braucht sich grade der

> wahrhaft schöpferische Künstler keiner Wahrheit zu verschliessen; er wird sie vielmehr mit Freude aufnehmen und verarbeiten.
>
> Es ist nach alledem klar, was geschehen muss: Die wissenschaftlichen Grundlagen für die Gestaltung eines gesunden Bauwesens in diesem Lande müssen geschaffen werden! Hierzu muss eine Gruppe interessierter Fachleute gebildet werden, und die zuständigen Behörden müssen diese Gruppe mit den erforderlichen technischen und finanziellen Mitteln ausrüsten, um in möglichst kurzer Zeit ein Maximum an positiven Ergebnissen zu erzielen. Jeder Tag ist kostbar, denn Tag für Tag werden unersätzliche Werte an Volksgesundheit und Volksvermögen vergeudet. (Wittkower 1942a, 1-3)

While part of Wittkower's foreword calls to mind Baerwald's 1925 article on the unintelligent building customs of Jewish architects in Palestine, Wittkower deviated from Baerwald by introducing a clear and attainable alternative to local design habits which is at the same time very modern in nature. Like Baerwald, Wittkower acknowledged the climatic advantages of local building traditions, but was certain that these traditions are economically and sociologically irrelevant to the current, modern living conditions in Palestine. The need to reinvent and redevelop the local building techniques, leaving the past behind, gave science such importance, since science was the only way by which clear and rigorous answers to pressing design problems could be obtained in a relatively short time, not by the centuries-long process of "natural selection". Wittkower was aware of the fact that his rational approach might be rejected by architects because it allegedly contradicts their belief in the intuitive creative process of design, but saw it as a weak excuse for creating failed designs. At the same time, he thought that only a multi-disciplinary approach to the problems of climate and building could produce actual results, showing his lack of confidence in the ability of the architectural profession to overcome these problems by its own means. This is also why he tended to cooperate with other professionals, like meteorologists, physiologists, and physicists.

Notwithstanding its rhetoric enthusiasm, Wittkower's manuscript was never published, and therefore could not have had much influence on the practice of local architects. Nevertheless, Wittkower was eager to convey his message to his colleagues, and did so in a myriad of mediums, including popular articles (Wittkower 1947), public talks (Hamashqif 1946), and even radio shows (Dvar Hashavua 1949). His first published text in a professional journal, "Towards Reform of Town and House Planning in Palestine", appeared in October 1943 in the *Journal of the Association of Engineers and Architects in Palestine* (JAEAP). The article was based on a lecture presented to the Natural Science Association in Tel Aviv on 8 September 1943 and consisted of an elaborate analysis of the causes for the overheating of indoor spaces. Like his unpublished manuscript, Wittkower's article bears a historical significance – it can be regarded as the first systematic analysis of the effects of local climate on buildings to be published *by an architect* in Palestine.

The opening paragraph of Wittkower's article introduced what he saw as the main climatic challenge in Palestine, namely the summer heat:

> It is widely known that until now we have not learnt to adapt our living conditions to the climate of Palestine. When talking about adaptation to the climatic conditions of our country I mean adaptation to the hot period of summertime. The winter chill should not be regarded as a problem which calls for unconventional solution; because when the temperature falls below what is physically pleasing we can elevate it using any kind of heating or by putting on warm clothes. In contrast, if the temperature rises **above** what is physically pleasant, we are still lacking any resolution for the matter. Although there is hope that by the end of the [Second World] War artificial cooling will solve the climatic problem at least in the apartments of the wealthy, for the wide masses such a solution remains a dream. (Wittkower 1943b)

After defining the main problem posed by the climate of Palestine, Wittkower moved to describing the current state of the art in local design habits:

> One single idea dominates today the design of houses, cities and settlements in Palestine: **the wind**! Great efforts are made in order to introduce more and more wind into the house; they all serve a single end: to use the "draft", which at times can become an annoyance by its own right, to refresh the human body that would have otherwise been defeated by the heat. The wish to introduce overwhelming quantities of wind into the house is the reason, almost without exception, for all our habits in the design of houses and for all our living routines inside the apartment, when they are linked to questions of climate. (Wittkower 1943b)

According to Wittkower, the outcome of this design approach appeared to be almost negligible: during the height of summer, and especially during the season's evenings, apartments remained exceptionally hot. The reason, argued Wittkower, was the neglect of other factors which affect the "human comfort sensation", namely the indoor temperature and air humidity. Therefore, "the shortcoming of the conventional building method lies in its very basics, since it takes into consideration only the problem of air movement and does not even attempt to affect the indoor temperature of buildings. Moreover, even the problem of indoor air movement has not been approached until now following a systematic scientific approach". Wittkower added that the critical lack in scientific approach applied also to the question of human comfort, and therefore "the architect should learn from the physician and the hygiene expert what is really comfortable for man based on scientific and objective research" (Wittkower 1943b). He then referenced Walter Strauss' article from 1941, and concluded that the healthiest way for the human body to remove excess heat is by radiating it to the surrounding cooler surfaces (walls, ceiling, and floor). Thus, added Wittkower, "the main purpose of apartment building in our country is maintaining cool indoor surfaces.

Only when it is impossible to keep indoor surfaces cool enough we are allowed to be assisted by the movement of air" (Wittkower 1943b). This conclusion was revolutionary for the time and place.

Having stated that, Wittkower argued that it is important to determine what should be the maximal indoor surface temperature under which comfort conditions would still exist, but since accurate scientific answer which applies to the local climate was still missing at that time, he allowed himself to rely on his own experience in order to determine numerical values (24.5°C-25°C and about 70% relative humidity for the Coastal Plain, and 25.5°C-26°C for the internal and less humid parts of the land). On the other hand, since indoor movement of air was more researched, Wittkower argued that based on experiments done by Strauss in Berlin, one can rely on "very light air movements" that are evenly distributed around the room for removing the "envelope of hot air" which surrounds the human body (Wittkower 1943b). Therefore,

> Now it is clear what the duties of apartment builders in Palestine are:
>
> 1) The main goal: indoor wall surface temperatures that will not exceed 24.5°C.
> 2) When it is impossible to keep the temperature below the above level (as is the case for several weeks during the height of summer in most of the country), the main goal should be the creation of light turbulences of air inside the rooms. (Wittkower 1943b)

From here, Wittkower continued to a theoretical examination of the ways in which external wall temperature is affected, namely by "conduction and radiation". When dealing with conduction, he argued that the best practice should be opening the windows during nighttime only, which "will bring the internal surfaces of the walls in contact with the cool night air"; this mode of window operation, when coupled with protection from the sun's radiation, should keep indoor temperatures below 25°C during the whole year, except for 4-6 weeks. Therefore, "a complete protection of the internal wall surfaces from the impact of sun beams" was necessary. In order to minimize the heating up of walls, three measures should be taken:

> a) The maximal intensification of the radiation reflected from the wall and the radiation of the wall itself;
> b) Removal of the layer of hot air adjacent to the wall;
> c) Prevention of the conduction of heat through the wall. (Wittkower 1943b)

These principles called for some practical advice: painting the walls with bright colours (white, for instance) would intensify the reflected radiation; building clear, smooth and simple wall surfaces would increase the radiation of heat from the walls to the outdoor air; planting trees and vegetation that cover the ground surface would also create "comfortable radiation conditions"; "creation of wind and convection flows" would remove the layer of hot air adjacent to the wall; and using proper insulating materials would minimize heat conduction (Wittkower 1943b).

These conclusions led Wittkower to suggest some general design recommendations. The most important of them was the preferred orientation of buildings. Here, Wittkower proposed – in direct contrast to the local custom of that time – to orient the main facades to the north and south, while minimizing the building's envelope exposure to the east and the west.[3] This recommendation was based on a simple reading of the sun position during summertime; according to Wittkower, the northern facade is allegedly "shaded throughout the day", while the southern facade could be shaded easily because of the high position of the southern sun. For shading the southern facade, Wittkower suggested an intricate

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[3] The preference of the southern exposure was not something completely new; in fact, in Xenophon's *Memorabilia*, dated after 371 BC, Socrates is quoted as saying: "It is pleasant to have one's house cool in summer and warm in winter, is it not? […] Now, supposing a house to have a southern aspect, sunshine during winter will steal in under the verandah, but in summer, when the sun traverses a path right over our heads, the roof will afford an agreeable shade, will it not? If, then, such an arrangement is desirable, the southern side of a house should be built higher to catch the rays of the winter sun, and the northern side lower to prevent the cold winds finding ingress; in a word, it is reasonable to suppose that the pleasantest and most beautiful dwelling place will be one in which the owner can at all seasons of the year find the pleasantest retreat, and stow away his goods with the greatest security" (Xenophon 1909, 51).

construction of detached shading ledges, positioned about 20 cm away from the wall, thermally insulated in their lower and lateral parts, with an inclined upper surface. This special arrangement was believed to prevent (or at least minimize) the conduction of heat from the shading ledges into the external wall they were designed to protect. To that Wittkower added the careful treatment of roofs: in horizontal roofs he recommended the use of plant-covered pergolas for shading (or at least the application of whitewash for reflecting sunlight) while keeping their parapets low in order to increase the wind's effect of heat removal; in tiled-covered pitched roofs he argued that special care should be given to proper ventilation of the attic (Wittkower 1943b).

Wittkower did not limit his analysis to construction details, and tried to formulate general recommendations for different building types and street layouts, separating between rural and urban settlements. Rural houses, he argued, should orient their main facades to the north and south; kitchens, which are used mainly during the first half of the day, should face the west. Following a similar logic, bedrooms, which are mainly used during the night, should face the east, taking advantage of the nighttime eastern winds which, added Wittkower, are quite common in the land's Coastal Plain during the summer. The eastern walls should be well insulated and protected from the sun by using trees and creeper plants, while the southern walls should be shaded using the roof's deep overhang. Wittkower also recommended that the settlement's layout would base itself on the north-south building orientation and that the main streets would be lined with trees (Wittkower 1943b).

The same principles were used by Wittkower to suggest a new scheme for urban design, which also reflected his implicit criticism of local town planning trends (especially in Tel Aviv, the fastest developing city of that time). His short description of the problem is particularly interesting because it links the climatic design of a single building to the climatic design of the entire city:

> The best solution for urban settlements is long rows of buildings, whose main facades are facing north and south.

The residential streets are, therefore, perpendicular to the sea, i.e. passing from east to west. I think no argument compels us to pave the whole area of these streets. Several paved "strips" for the movement of vehicles and narrow sidewalk on one of the street sides would satisfy the transportation demands. The remaining surface should be planted with trees and vegetation, which means that the residential street would become a garden.

[...]

The traffic arteries, with no buildings on their sides or built at most with single-story retail shops, run perpendicular to the residential streets. These arteries should have genuine roads and sidewalks.

Such urban settlement would have many advantages over existing cities. Vital breeze would flow in it, day and night, along the residential streets, cooling the facade walls. Pedestrians would enjoy the shade of trees in the residential streets that became gardens, much like Rothschild Boulevard in Tel Aviv; but contrary to this boulevard, direct sea breeze would constantly surround them. In such a city the senseless gaps between buildings, ranging from 4 to 6 m, would disappear. There is no doubt that the average temperature in such a city would be lower than the temperature in contemporary Tel Aviv, for example.

[...]

I would not elaborate here on questions of plan design of the long eastern-western rows of buildings. Each architect should resolve this issue following his own talent. I would only convey my opinion that possible good solutions are innumerable. A pronounced distinction between the northern and southern facade should not be made; but it

> should be said that the southern facade should be given preference for living purposes, since during summer it is not less cool than the northern facade (because of the attached shading ledges), while in winter it enjoys the sun beams in spite of the shading ledges, since the sun position is lower then. (Wittkower 1943b)

Here it should be noted that the modern urban scheme of Tel Aviv, an outcome of a 1925 plan by the renowned Scottish town planner Patrick Geddes (1854-1932) updated throughout the 1930's, based itself on somewhat similar street hierarchy, but at the same time followed a totally different building layout, in which each building maintained a minimal gap of 3-5 m between its facades and the plot borders.

Wittkower concluded his article with a short reference to the second duty "of apartment builders in Palestine", namely "the creation of light turbulences of air inside the rooms" when wall temperature reaches a higher-than-desired level. He admitted that because of the lack of "any special studies and measurements" it is hard to suggest specific design recommendations in this area, but added that his own experience taught him that drafts passing through the upper part of the room (above the height of a person who is seated or lying) should create turbulent and strong movement of air in its lower part that would be refreshing enough without causing discomfort. In any case, Wittkower reiterated that the common wish of designers to enhance the effect of "drafts" is wrong (Wittkower 1943b).

Wittkower's article was revolutionary in more than one sense. As already mentioned, this was the first time a local architect published a systematic analysis of the effects of the local hot weather on buildings in Palestine, and probably also the first time an architect chose to openly reject the total reliance on natural wind for securing indoor thermal comfort. Wittkower tried to persuade his readers that the irradiation of walls by sunlight is the most important factor in the overheating of buildings in Palestine, and that the designer's role is, above all, to minimize it as much as possible. This led him to formulating a new recommendation on preferred building orientation (main facades should face north and south). As was later indicated by Hashimshoni (Hashimshoni 1962, 129), this recommendation later became a widely accepted design rule, at least in theory.

2.5 The first monitoring programs

Although remarkable in its analytic clarity, Wittkower's article still lacked the backing of actual thermal monitoring of buildings – a weak spot which he openly acknowledged. He mentioned that the theoretical calculation of the potential cooling effect of night ventilation, which allegedly proved that this ventilation strategy could keep indoor temperature below 25°C for most of the year, was done by a fellow engineer named E. Katz (Wittkower 1943b), but this conclusion was not backed by actual measurements. Moreover, it seems that Wittkower's argument was based on simplistic and somewhat inaccurate readings of the sun's path in the sky, not on precise calculations, since Wittkower mistakenly argued that the northern facade is fully-shaded throughout the whole day even in summer.

The sun's effect on differently-oriented built surfaces was already locally researched to some extent since the second half of the 1930's. Dov Ashbel (1895-1989), professor of meteorology and climatology at the Hebrew University in Jerusalem and a pioneer of meteorological observations in Palestine, was probably the first to measure the actual solar irradiation of walls in different positions and orientations. He summarized his findings, which were based on systematic monitoring that took place in Jerusalem, in his seminal book on climatology, published in Hebrew in 1940 (Ashbel 1940, 39-40), and then again in a book published in 1942, which was dedicated only to the question of solar radiation in Palestine (Ashbel 1942a). On the same year and following the work of Ashbel, engineer Shragga Irmay from the Technion in Haifa published a three-part article on "orientation of buildings in Palestine and solar radiation" in which he included detailed calculations of the seasonal sun's position in the sky and the daily illumination times of different facades and roof surfaces. Irmay argued that his calculations were meant

> [...] to provide the builder, the meteorologist, and the hygienist the required data related to illumination of buildings and their heating by sun beams, following experimental data from the measurements of Dr. Ashbel which were adapted by the author. In this way the local

> builder receives a new working tool, which enables him to approach the question of orientation rationally, standing on scientific and experimental grounds, with a lesser need for methods of trial and error or sheer reliance on common beliefs. (Irmay 1942)

Notwithstanding his proclaimed intention, Irmay's elaborated account lacked practical advice for architects, engineers, or builders, at least not of the kind that resembled Wittkower's decisive opinions on preferred building orientation. Irmay also limited himself to questions of "outdoor climate", leaving behind any discussion of "indoor climate" and the way the sun leaves its effects on it (Irmay 1942). This made his article less practical than might have been originally intended.

Irmay's article was meant to be published as a supplement to the book by Ashbel on the effect of solar radiation, but was not included in the book because of technical reasons. However, in the beginning of the 1940's Ashbel was much more engaged than Irmay in questions of climatology and building. In 1942, alongside his book on solar radiation, Ashbel published an article on "orientation of buildings in Palestine" which was dedicated only to questions of natural ventilation and included detailed results of recent measurements of wind speed and direction across the country. This somewhat narrow viewpoint on the question of building orientation, which totally ignored the effects of solar radiation, led him to the conclusion that along the Coastal Plain the main facade should be directed to the east or west, while in the mountain areas, where Ashbel argued that the introduction of winds into the buildings is unwanted, it was recommended to orient the main facade to the north or south (Ashbel 1942b). Here, the dissimilarity between the richness of the observed meteorological data and the simplistic understanding of its application for building design was striking: Ashbel, who by then had already measured sun radiation on different surfaces in local conditions, addressed the question of building orientation without any reference to the sun's effect on building envelope, indoor temperatures, or indoor thermal conditions, blindly accepting the common belief that the wind is the most important factor in climatically-aware building design. As we already saw, by then this belief was already put into considerable doubt.

In the following year Ashbel published an article on the "natural cooling in- and outside buildings", which was mainly dedicated to the description of equipment for measuring air cooling power (kata-thermometer and frigorimeter). Since the same equipment could also be used for assessment of climate conditions inside buildings, Ashbel referred also to issues of indoor thermal comfort, writing that

> Measurements inside buildings with different wall thickness and wall composition, buildings which are oriented in accordance with the sun beams and the local prevalent winds, are a vital necessity in all regions, particularly in places of harsh climate as the Jordan Valley and Beisan [today's Beit She'an].
>
> Therefore, a rigorous methodology for the execution of planned and thorough observations should be prepared without delay.
>
> A proposal was made, alongside some attempts, to measure the temperature inside rooms and walls. The question should be raised: why only the temperature, is it the sole climatic factor of the human reaction to the difficulties of climate, do other factors bear lesser importance?
>
> The means should be found for a suitable operation, on a scale that will enable the conduction of simultaneous measurements in several locations and not "one by one", i.e. in one place under certain seasonal conditions and in another place under totally different conditions. (Ashbel 1943)

Ashbel's call was answered early than he was probably expecting. His article was published in June 1943; during August and September of the same year an intensive monitoring campaign took place under the auspices of the relatively new Building and Technical Research Institute (BTRI) of the Engineers', Architects' and Surveyors' Union of Palestine (EASUP). The Union came into being in April 1941 as a national trade union representing employees in the fields of engineering, architecture, and surveying, and was part of the powerful *Histadrut* (the General Federation of Jewish Labour in Palestine). The same meeting that endorsed the union's establishment also voted for the creation of a subsidiary research institution dedicated to the production and circulation of professional knowledge in the field of building and construction (Davar 1941, Central Committee of the Engineers' 1941, 3). Although a trade union whose main concern was the employment conditions of engineers and architects, the Union was interested from its very beginning in the promotion of research in the field of building and construction. This interest reflected the Union's aspirations for professional prestige, but also a pressing need for a much wider knowledge base in technical issues pertaining to the field of construction. As was explicated in a 1945 official document of the Union,

> The usual obstacles in the execution of technical projects in general and construction projects in particular increase in our country because of the special conditions under which they materialize. The problems related to these special conditions (like climate, local materials, different working methods, social questions pertaining to the different settlement forms, etc.), whose solutions require a special approach adapted to the special conditions of the land, with no option of relying only on experience gained abroad – all these problems require that the designers and executioners study the conditions and opportunities of the land, as well as the current state, in order to learn and conclude, one time after another.
>
> […]
>
> In order to prevent the future recurrence of scattering of efforts and errors of individuals, the Central Committee decided to establish the Building and Technical Research Institute, whose role is to gather works of individuals, to put

> them into the discussion of professionals, to study yet unresolved problems, to tackle new problems, and to look for new solutions, permanent or temporary in nature, while cooperating with all stakeholders and following the means and needs. (Central Committee of the Engineers' 1945, 10-11)

The BTRI, which held its first meeting on 13 June 1942 (Building and Technical Research Institute 1942), was the first research institution of its kind in Palestine. No other official body ever showed interest in the creation of a permanent framework dedicated to research in the building sector, even not the main professional body of engineers and architects, the well-established Association of Engineers and Architects in Palestine (AEAP), which was founded in 1922. The establishment of the EASUP was justified by the need to secure better employment conditions for its members, a task which allegedly was not well addressed by the AEAP; yet the central position it gave to its Research Institution indicated that it aimed much higher and planned to become a professional alternative to its predecessor, probably as an attempt by the socialist *Histadrut* to increase its influence within the building sector. Similar intentions were behind the great effort made by the Union to make its research activities well-publicized: instead of the low-distribution medium of internal reports, the studies financed by the Union were published between 1942 and 1946 in two books and five compilations of papers, creating a high quality alternative to the professional journal of the AEAP, which had been published almost regularly since December 1936. Research had thus clear political goals, which justified its financing by the *Histadrut* through the budgets of its executive committee and Unemployment Fund, in addition to membership dues, and funds from the Jewish Agency (which was then controlled by the socialist party *Mapai*) and building contractors. In 1944 this budget covered the full-time employment of five employees of the BTRI, as well as other 80 workers in part-time positions (Central Committee of the Engineers' 1944).

The organizational scheme of the new Institution was based on the creation of special committees nominated for the study of specific research questions. Originally, a committee was assigned for each of the following subjects: building in the *Kibbutzim*, urban and rural workers housing, the local Arab building traditions, professional education, building quotas and products, engineering archive, and a future exhibition (Building and Technical Research Institute 1942). Nevertheless, when actual work began, it was decided to leave out the committees on professional education and the future exhibition, and to add two new committees: one dedicated to research on local building materials, the other to "problems of climate in building". The appointment of a committee dedicated only to questions of climate and building reflected the growing interest in the scientific research in the field, as well as the acknowledgment of the problematic lack of knowledge in the field:

> The work of other committees of the Institution could be assisted, in a known manner, by the results of the experience gained in our country, and in many cases could even continue along a research path which has been already paved. This does not apply to the problems of compatibility between building and climate conditions – here it was required to begin almost everything from nothing. The committee for the study of problems of climate in building set itself a goal to first study the effect of building orientation on its indoor temperatures, a problem which has a crucial effect on the design of new settlements and neighbourhoods.
>
> [...]
>
> The next subjects of study will be: wall materials, the shape of openings, the problem of ventilation, etc. (Central Committee of the Engineers' 1944)

The committee on problems of climate in building was headed by Ashbel, and its members were engineer Asher Allweil (1908-1994), architect Ze'ev Rechter (1899-1960), Walter Strauss, and Werner Joseph Wittkower.

Given the committee's line-up, its focus on systematic measurement of temperature and air humidity inside buildings is well-understood. As mentioned above, monitoring took place in August and September 1943. An article summarizing the committee's work was included in the second book of studies published by the BTRI in 1944; it opened with a short description of the motivation behind the study, stressing once again the lack of scientific data on climate and building:

> The climate and its effects on man are the most important elements of a rational and hygienic design of residential buildings. This is the reason why people here acknowledge the need to take the climatic element into account in the general design of new settlements and in the development of existing ones. This calls for thorough study and research that will enable to resolve the question of building adaptation to climate conditions relying on scientific and objective data.
>
> For this reason the Building and Technical Research Institute of the Engineers', Architects' and Surveyors' Union of Palestine found it suitable to give this question an adequate treatment. For that purpose, a joint monitoring campaign with the Department of Meteorology at the [Hebrew] University and the technical department of the Jewish Agency was initiated in the summer of 1943 and was already completed in Ashdot Ya'akov (the Jordan Valley), Ein Shemer (the Coastal Plain), Tel Aviv (a coastal city), Hadar HaCarmel (a coastal-mountain city), Jerusalem and Safed (mountain cities). Monitoring was conducted inside rooms located in buildings differing in their orientation, height, building material, roof shape, etc. (Ashbel et al. 1944, 97)

Although exceptionally extensive in its scope, the monitoring campaign lacked a coherence needed for drawing specific design recommendations. The indoor temperatures and relative humidity levels were monitored in buildings which had almost nothing in common. In Tel Aviv the observations took place in a two-story stone building from the 1910's and in the third and upper floor of a public housing project located on the other end of the city, made out of concrete and calcium-silicate bricks; in Hadar HaCarmel a relatively new multi-story residential building made out of stone was used; in Safed temperatures and humidity levels were monitored inside a corridor in a hospital building and in a traditional stone house; in Jerusalem several premises of the university were used for observations, most of them relatively modern but one was of a traditional "Arab" type; Ashbel's own apartment in a new building in Jerusalem was also used. Ashbel admitted that "the material from all these locations is still too little to be used for the extraction of final conclusions" but insisted that some general lines can be drawn from the results (Ashbel et al. 1944, 97-98). Nevertheless, the abundance of raw figures which were presented in the paper was in sharp contrast to the limited analytical discussion of the data and the over-generalized conclusions which totally neglected questions of building orientation, opening of windows, and the precise thermal properties of the external walls. Therefore, the conclusions were limited to a general formulation of the relation between indoor and outdoor temperatures in the different regions in Palestine:

> In the Coastal Plain region – where the windows are open all day long and during most of the night, the difference between temperatures inside and outside the house in the summertime is smaller than the difference during the winter, since during the cold season the windows are usually closed. The actual difference in the conditions is manifested in a higher outdoor temperature during the day and a lower **outdoor** temperature during the night throughout the year, although in cases of storms and rainfalls or under cold eastern wind the outdoor temperature might also be lower than the temperature inside the house **during the day**.
>
> In the mountain region – the temperature of a summer day is higher outside the house than inside it and lower during nighttime. During the winter the temperatures inside the

> mountain houses are usually higher than the outdoor temperatures also during the day, apart from **calm** sunny days, in which the outdoor temperature rises above the indoor temperature and every healthy human being wishes to spend some hours in the sun. During summertime every healthy human being wishes to hide from the sun during the midday hours.
>
> In the Jordan Valley – there is no doubt that outdoor temperature is lower than indoor temperature during the night throughout the whole year, even during the summer. Nevertheless, during the day the outdoor temperature is **higher** throughout the whole year, except very cold winter days which are few in number. (Ashbel et al. 1944, 100)

These conclusions must be regarded as disappointing, taking in mind that Wittkower and Strauss, who were already conceptualizing far more complex building design questions that related to different climatic factors, were involved, at least formally, in the formulation of the committee's framework. It seems as if the main figure behind the campaign was Ashbel, a climatologist, who was the most experienced person in meteorological measurements among the members of the research committee; nevertheless, it seems that he was more interested in mapping the different climatic zones of Palestine, using building type "generic" to each region, than resolving specific design uncertainties by the use of scientific tools. The large dissimilarities between the monitored buildings made it impossible to test the effect of certain building properties (orientation, window location and size, thermal capacity of the envelope, shading devices, etc.) on indoor climate. Therefore, and contrary to the proclaimed motivation to "study the effect of building orientation on its indoor temperatures" (Central Committee of the Engineers' 1944), it was impossible to translate the results into clear design guidelines nor to understand the climatic consequences of building orientation.

2.6 The monitoring campaign of the Meteorological Research Council

In March 1944, about half a year before the publication of the second book of the Building and Technical Research Institute, the Engineers', Architects' and Surveyors' Union of Palestine published its fourth compliation of professional articles in matters of building and engineering, titled *Engineering Survey*. Two articles on questions of climate and building were included in the compilation: the first, "The Climate and Town Planning" was written by Wittkower; the other, "The Residential Flat in the Climate of Palestine" was written by a physician, Dr. Theodor Gruschka (1888-1967), who came to Palestine from Czechoslovakia in 1939 and was at that time the general manager of Hadassah Hospital in Tel Aviv. The two articles demonstrated a much higher degree of analytical capabilities when compared to Ashbel's discussion of his monitoring campaign, representing a point in time in which the theoretical analysis of climatic questions reached a point of ripeness.

Wittkower's article developed some of the points already discussed in his 1943 article, published in JAEAP (see above, section 02.4), but mainly addressed the subjects of "microclimate" and outdoor thermal comfort in cities. Like his previous article, this was another pioneering analysis which was based on his 1942 manuscript, this time of climatic aspects of urban design that were never before considered to such an extent by local planners. Wittkower was much ahead of his time; it took more than two decades before architect Michael Boneh (1929-2002) readdressed a similar issue in his study on the microclimate of Tel Aviv, published in January 1967 (Boneh 1967).[4] Wittkower's motivation for addressing the issue was directly linked to questions of indoor climate. As he candidly wrote,

> The climatic conditions inside internal rooms depend heavily on the climatic conditions of the close environment of the buildings. We should therefore pay attantion – when

---

[4] Boneh's personal archive, including his study on the microclimate of Tel Aviv, is kept at Israel Architecture Archive.

> we begin to repair the climatic condition of the internal rooms in our country, and mainly in our attampt to lower the temperature – also to the climatic conditions of the direct environment of the buildings, those referred to as "micro-climate".
>
> The micro-climatic conditions of a house, street, or city ususally show significant differences when compared to the general climatic conditions of the rural environment, the "macro-climate". Our efforts are directed to cases where the average temperature in the micro-climatic space is higher than that of the macro-climatic space. As everybody knows from his own experience, the average temperatures of our cities are much higher than in the adjacent villages; our role in new design and in expansion of cities would therefore be to keep the average temperature of the urban area low, in a way that it would not be higher than the temperature of the rural environment, or at least not much higher.
>
> Climate – which also means temperature – of a city includes the micro-climates of isolated streets. Examination of urban temperature therefore means: examination of street temperature; our attempt to reduce the urban temperature is an attemp to reduce street temperature. (Wittkower 1944b)

The rest of Wittkower's article was dedicated to an analytical description of the main elements that contribute to the increase in urban temperature. Above all, he stressed the role of solar radiation and proposed to use street shading by trees, to keep side streets unpaved, to keep the area in front of the buildings slanted (in order to reduce solar reflection), and to prefer long and continuous facaded facing the street (instead of the common habit in local town planning to maintain a gap of some metres between the side facades of buildings). Unlike questions of indoor climate, especially in hot countries, which were almost totally underresearched at that time, the special properties of the urban microclimate, including the recorded phenomenon of higher temperatures inside cities (the so-called "urban heat island"), were already well-known to meteorologists by the beginning of the 1940's. Wittkower must have been aware of the rich microclimatic background of the contemporaneous German town planning methods, which epitomized in Albert Krazer's seminal book, *Stadtklima* (Hebbert and Mackillop 2013). In particular, he referred to *Wie atmet die Stadt?*, a German book by J. Goldmerstein and Karl Stodieck published in 1931 and which, according to Wittkower, emphasized the importance of natural "convection flows" (in contrast to local winds) in releasing the absorbed urban heat during the night.

Gruschka, like Strauss, was an hygiene expert. His article reiterated Strauss' main arguments: that "what is functional in Vienna, Prague, Geneve, cannot be functional for Tel Aviv, and vice versa" and that one should first understand "how to design an apartment which provides the optimal conditions for 'cooling' the human body". Acknowledging the works of Strauss, Ashbel, and Wittkower alike, Gruschka followed Wittkower's analytical logic and provided figures measured by Ashbel of the insolation of walls oriented in different directions, as well as temperatures of walls of different orientations measured by (Richard) Flügge in Berlin. Like Wittkower, Gruschka concluded that northern and southern rooms perform much better than western rooms, and stressed that "the orientation to the west misses the goal, and we must open a comprehensive discussion and move to experimental examination on the size of windows, the shape of a window, the distribution of windows, and the direction of wind through the inner walls of the house" (Gruschka 1944). Wittkower, so it seemed, found an open ear for his way of thinking, though not in his own professional milieu.

By the end of 1944, the new, scientific approach to climate and building in Palestine was consolidating. Interestingly enough, except Wittkower, all major figures advoacting scientific research in the field were not architects. Wittkower, like his fellow architects and much unlike the hygiene experts who were more interested in the general concept of human thermal comfort, was still preoccupied with the question of ideal building orientation. Ashbel's monitoring campaign failed in providing a clear answer to this question, leaving Wittkower without experimental grounds for his theories. Since the Building and Technical Research Institute ceased to initiate new studies, Wittkower had to find another public institution that could support a better-designed monitoring campaign. It turned out that this institution would be the local Meteorological Service.

From the scant available sources it is hard to perfectly reconstruct the exact circumstances that led Wittkower to cooperate with the Meteorological Service. In his 1984 retrospective paper, Wittkower wrote that he assembeled "a team of specialists", which included Strauss and Gruschka, as well as Emanuel Goldberg (1881-1970), a briliant Jewish chemist and inventor who was removed by the Nazis from his high position in Zeiss Ikon company and settled in Tel Aviv in 1937, as well as Rudolf Feige (1889-1948), the director of the local Meteorological Service who fled from Nazi Germany to Palestine in 1935. In converstions with Uzi Agassi, who curated an exhibitions on his works in 1992, Wittkower argued that he helped Feige to receive his position as the head of the Meteorological Service (Agassi 1993, 34), though Feige, who had a long and prosperous carreer in Germany as a meteorologist and aviation enthusiast, was probably professional enough to be selected in 1936 by the British to establish the local meteorological service even without Wittkower's intervention.

A correspondence between Wittkower and Feige from late 1943 reveals that Wittkower sent Feige his *Bauliche Gestaltung* manuscript and was interested in receiving Feige's comments on it (Wittkower 1943a). Feige replied that he had read the manuscript "with great interest" and that he would like to discuss with Wittkower "some points which I have marked on the respective margins" (Feige 1943). Another document found in Feige's archive is a five-page "Arbeitsprogram betr. Bauforschung" that was written by Wittkower, probably in 1944, and referes in places to his manuscript. In the document, Wittkower outlined three complex experiments: the first aimed at revealing whether the use of normal building materials in Tel Aviv, while closing the windows with shutters during daytime and opening them for ventilation during the night, can produce the minimum indoor temperature as predicted by his calculations; the second aimed at exploring the thermal effect of unconventional building materials and constrcutions (double glazed windows, double windows, external walls of different thicknesses, external walls with thermal insultaion on their inner or outer side, external walls with inner air gaps with or without insulation); and the third was designed to examine the effect of the soil around a building (exposed, paved, covered with vegetation, shaded by trees, fully horizontal or slanted) on indoor temperatures. Wittkower also briefly mentioned future fields of research, refering his readers to his manuscript for details on the main points of interest: the effect of solar radiation (direct or reflected) in relation to external colour of walls and their orientation; the effect of certain features of the built environment (block orientation, tress, vegetation, pavement, facade smoothness) on outdoor temperature; and the physiological effects of different climatic factors like temperature, humidity, and wind, and their relation to thermal comfort (Wittkower 1944a).

Wittkower's efforts to convince Feige to cooperate in building research were eventually successful. Working under the "Meteorological Research Council" (Feige 1947), they gathered enough resources for conducting an experimential monitoring campaign in September-October 1946 which was much more modest than what was proposed by Wittkower to Feige, and was limited to the fundamental question of building orientation. To their team Feige and Wittkower recruited Walter Koch (1909-1967), a Viennese-born Jewish physician who escaped Vienna right after the Anschluss (leaving a position of division chief in Internal Medicine at the University of Vienna) and held a position in the department of Hygiene at the Hebrew University in Jerusalem, and Jehuda Neumann (1915-1993) from the Meteorological Service. A full report on their findings was put in print only six years after the conclusion of the campaign (Feige et al. 1952), four years after Feige's tragic death during the 1948 War, though a short report on the program was already published in October 1947 in *Nature* (Neumann 1947).

According to the report, the main purpose of the 1946 program was "to compare indoor climate elements of two apartments the outer walls of which were oriented to N and to S, in one case, and to E and to W, in the other case. The walls in the remaining directions were inner walls" (Feige et al. 1952, 2). The apartments, which had an identical layout, were located in a newly-built public housing block in Tel Aviv's Yad Eliyahu neighbourhood. Both apartments were located on the first floor above ground, below another upper floor. The comparison was based on monitoring the indoor air temperature and humidity, black-globe thermometer temperature, and cooling rate (using a frigorimeter). Different modes of windows operation (opened throughout the day or closed during daytime) were applied during the ten monitoring days. The collected data was used to calculate an effective temperature, air velocity, and mean radiant temperature of the walls. Outdoor air temperatures and humidity levels in the apartments' vicinity were also measured. Since reading of the measuring instruments took place during daytime only (six times between 06:00-17:00), nighttime effect of the apartments' orientation was not taken into account.

The 1946 observations found a direct correlation between insolation of certain building facades and higher indoor air temperatures (Figure 2.6 and Figure 2.7), and therefore concluded that "dwelling houses or office or school buildings with the longer walls facing north and south offer a higher degree of climatic comfort than similar buildings with the longer walls facing east and west" (Feige et al. 1952, 10). This conclusion was also supported by the already known fact that during summer and spring daytime hours "winds have an important northerly component, while the nighttime land breezes have a prominent southerly component". Although pretty rudimentary in nature, this conclusion bore much significance, since it was the first time in which experimental grounds were given for the claim that the orientation of the main facades in Palestine has a direct effect on indoor thermal comfort during summertime.

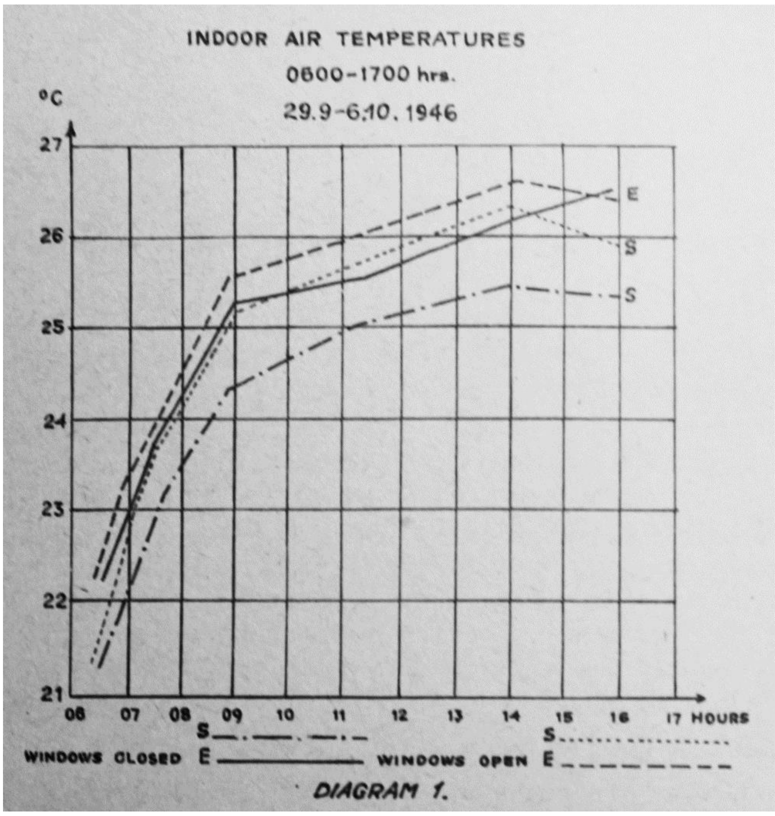


Figure 2.6: The 1946 monitoring campaign: comparison of room air temperatures in rooms facing south and east (Feige et al. 1952, 4)

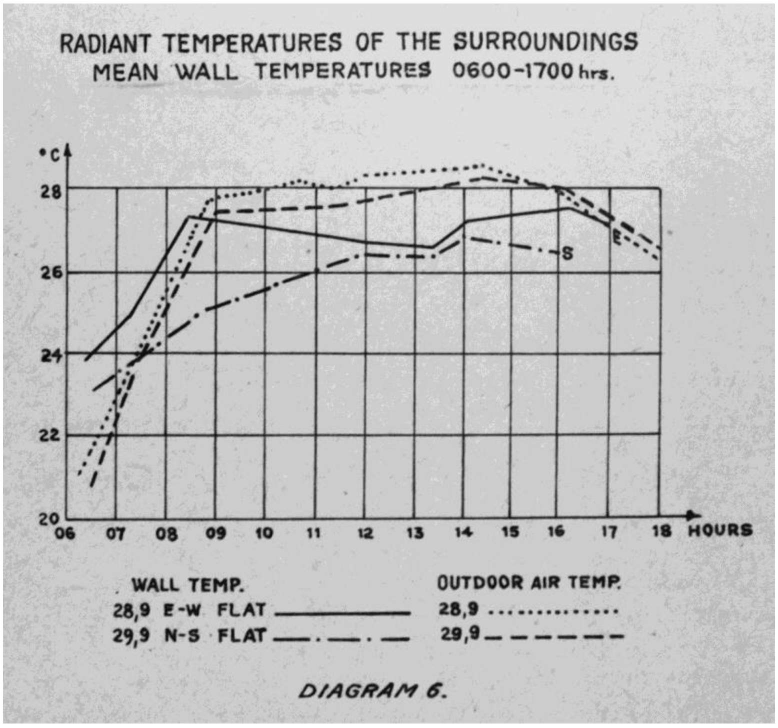


Figure 2.7: The 1946 monitoring campaign: mean wall temperatures of southern and eastern walls, derived through globe thermometer measurements and compared with outdoor air temperatures (Feige et al. 1952, 7)

2.7 The Board for Scientific and Industrial Research

The official body which directed the monitoring campaign of 1946 was the Meteorological Research Council, which cooperated with the Standards Institution of Palestine (Feige 1947). This was not an optimal choice, since the Meteorological Service did not occupy itself with questions of building climatology on a regular basis; and one can only guess that this unusual cooperation stemmed mainly from the personal acquaintance of Wittkower and Feige. The ad-hoc nature of the whole enterprise meant that constant developments in research were still waiting for a much more permanent framework that could guarantee continuing support.

At that time, research activities in Palestine began to be directed by the Board for Scientific and Industrial Research (BSIR), established in April 1945 as a successor of the Scientific Advisory Committee of the Palestine War Supply Board formed in 1942 (Nature 1948). The Board was engaged in organizing and financing several studies, all directed by ad-hoc sub-committees, in a variety of subjects, including water supply, construction materials, and agriculture. Its executive secretary was Samuel Sambursky (1900-1990), a mathematician and physicist from Königsberg (today's Kaliningrad) who came to Palestine in 1924 to become a professor at the Hebrew University. During the second half of 1946, while Feige and Wittkower were engaged in their own study, Sambursky received a research proposal from Rudolf Bloch (1902-1985), a Jewish-German chemist who was active since 1936 as a senior researcher at the Palestine Potash Company. Bloch, whose company's activities were all concentrated in the Dead Sea area, suggested to conduct research on "houses under sub-tropical conditions, and their cooling"; not having any professional relation to the fields of construction or physiology, his interest in the subject was probably a result of the extremely hot climatic conditions affecting the workers of Palestine Potash. On the other hand, Bloch's interest was not limited only to building in the Dead Sea area, as reveal the first paragraphs of his short proposal:

> During the next ten years there will be in Palestine a very heavy expenditure on the building of new houses.

> Comparatively little has been done in order to ascertain in a scientific way the most suitable constructions for the climate.
>
> It would be advisable to do such research extensively by putting up in the two most characteristic climates of the country an experimental house each. One should be constructed in the Jordan Valley, and one in the coastal plain near Tel Aviv. (Bloch 1946)

Bloch suggested that the experimental houses were to be built as "frames" into which any type of wall construction could be inserted. Moreover, these structures were supposed to include also "refrigeration equipment" imported from abroad, as well as built-in "structural elements" that would be used for refrigeration, following a method for solar cooling patented by (Edmund) Altenkirch. Sambursky presented Bloch's proposal to officials in the Colonial Office while visiting London, and received the impression that "the general opinion was that this project is of the greatest importance. As it is of interest to other parts of the Empire as well, Mr. Carstairs pointed out that special funds could be obtained for it" (Sambursky 1946b). Moreover, Benjamin Stanley Platt (1903-1969), a scientific advisor to the Colonial Office and a member of Britain's Medical Research Council, suggested Sambursky to consult a British physician posted in Nigeria, William Strachan Simpson Ladell (1912-1970), in respect to the proposed research.

The Colonial Office was probably considering the invitation of Ladell to Palestine even before Sambursky's trip to London. With a specific research being put in discussion, his visit could now be directed to practical matters. On 10 December 1946 Ladell sent a letter to Sambursky, informing him that his trip to Palestine will take place in January 1947 (Ladell 1946). Sambursky telegrammed Ladell that he is looking forward to his visit, and added in a letter sent on 19 December that

> As our board is at present considering the whole problem of adequate building in hot climates, we intend to discuss with

> you not only the physiological aspects, but the thermo-dynamical, structural and other related problems as well. One of the practical results of our meeting should be the formation of a suitable ad hoc committee here, which will later keep in constant touch with you and your colleagues. (Sambursky 1946a)

Ladell arrived in Palestine by plane from London on 7 January 1947 (The Palestine Post 1947). The day before, a first meeting of the "Sub-committee for Indoor Climate" was held. It seems that the sub-committee was hastily formed because of Ladell's visit. Its members were Rudolf Bloch, Walter Koch, Rudolf Feige, Marcus Reiner (1886-1976) from the Standards Institution, and Werner Joseph Wittkower; its chairman was the director of the Standards Institution, Arnold Arnstein (1901-1958, later changed his last name to Arnan). Following the meeting it was decided to produce three preliminary reports summarizing "the physiological, thermo-dynamical and structural aspects of the problem of indoor climate" commissioning Koch, Bloch, and Wittkower with their preparation (Anonymous 1947). While Bloch's membership in the committee was directly related to his research proposal, the inclusion of Feige, Koch, and Wittkower was not based on any past involvement with the BSIR, and was probably an outcome of the involvement of the Standards Institution in the formation of the sub-committee.

As mentioned above, the Standards Institution was part of the 1946 monitoring campaign in Tel Aviv. It is not clear whether the Institution approached Wittkower, requesting for a proposal for another research, or vice versa. In any case, on 12 December 1946 Wittkower sent a letter to Reiner proposing such follow-up research. Written in German, the letter was kept among other documents of the BSIR sub-committee in Israel State Archives, though without the proposal which was originally attached to it. Wittkower's main concern in his letter was to secure the status of his fellow-researchers (Feige, Koch, and Neumann) in any future research, reminding Reiner that "Bevor solch ein Program herausgeht, waere es notwendig, dass die Herren Feige und Koch quasi offiziell ihre

Zustimmung geben; wichtig ist auch eine Abmachung betr. Herrn Neumann. Privat an mich ist dies alles schon geschehen – nun muesste dies quasi offiziell an das Standard Institution bestaetigt werden" (Wittkower 1946). One can assume that Sambursky consulted the Standards Institution on the formation of the sub-committee, and only then, because of the recent personal contact between Wittkower and Reiner, Wittkower, Feige, and Koch joined Bloch as its members.

The sub-committee's second meeting was held on 13 January 1947 at the offices of the Standards Institution in Tel Aviv and was attended by Ladell and Sambursky. Having spent some days in the country, Ladell argued that "it was probably more important to concentrate on more warmth in winter than on less heat in summer" and added that "suffering from cold reduced a person's heat accommodation in summer". His insight must have surprised his listeners, who were much more concerned about summer conditions, including Bloch. After Feige presented Ladell the 1946 monitoring campaign, it was agreed that "measurements on indoor temperature, humidity and air movement should be continued by the scientists who had already started such work and that in addition, the problem, of the effect of wall temperature on globe thermometer reading, should be studied" (Sub-committee for Indoor Climate 1947a).

Ladell returned to Nigeria after completing an eight-day visit to Palestine. While working on his report on heat physiology in Palestine, which was to be submitted to the Colonial Medical Research Committee, the members of the BSIR sub-committee were separately developing their own research proposals. As it turned out, Koch had split ways from Feige, Wittkower, and Neumann, and prepared a proposal on "precursors, signs and avoidance of heat-strain". Koch's main interest in his study was the development of a new method and new measuring instruments for estimating mean radiant temperature and wind speed, in order to calculate an estimated heat strain produced by certain indoor conditions. Instead of a globe thermometer, Koch suggested to build and use an instrument which "consists of a copper sphere, inserted into a rock-salt cube; this in turn is sealed to a handle filled with a getter"; instead using a kata thermometer or frigorimeter, Koch proposed a new instrument for direct reading of wind speed:

> Two small metal spheres, highly polished, contain thermocouples. While one sphere can be heated by a constant current, the other one remains on room-temperature. As both spheres are polished, heat loss occurs mainly by convection, the temperature difference between both spheres being a measure of wind-speed. (Koch 1947b)

At that time, Koch was preoccupied with measuring indoor thermal comfort. Several months earlier, he published an article in JAEAP in which he described a small monitoring experiment, in which effective temperatures, following the method suggested by Yagloglou (1927), were calculated for northern and southern rooms in a building at the Hebrew University campus on Mount Scopus. Monitoring was done around the year, with four readings daily. Monthly average heat strain in each room was calculated by comparing the deviations of the measured effective temperatures from the upper and lower comfort limits of effective temperatures according to Yagloglou. Results showed a higher heat strain in the southern room throughout the year (Koch 1946). Several months later, Koch published a paper in an international Journal, *Acta Tropica*, with a proposal for a modified kata thermometer for better accuracy of wind speed calculations (Koch 1947a). This proposal was very different from the instrument suggested by Koch in his research proposal some months later.

Meanwhile, Ladell finished a draft of his report, which was sent to Sambursky in April 1947. Following his initial impressions, his recommendations put much more stress on winter conditions:

> Whether the summer lassitude and the inability to sleep have a real clinical and physiological basis or not measures of amelioration are required. First the population should be educated to realise that being too cold in winter is as physiologically undesirable as being too hot in the summer.

> Houses should be designed to keep warmth in and not only to keep heat out; small wood burning stoves or other means of heating should be installed in the settlement houses in the cold weather; floors should be insulated from the earth and be of warmer material than concrete. Small ventilating bricks could be inserted to allow some air exchange or small extractor fans might even be fitted; this would avoid the difficult choice between lukewarm 'fug', with the windows closed, and chilly, rapidly moving, fresh air, with the windows open. It is desirable in the winter to have the sun shining onto the walls and into the rooms, but the present wide verandah [sic.] roofs prevent this; instead of heaving the verandah roof permanent, something on the lines of a Venetian blind might be fitted, which could be rolled up out of the way in the winter, when it is not required. (Ladell 1947)

Although Ladell included some recommendations on cooling (application of white paint to buildings; the use of simple evaporative air coolers), his emphasis on winter conditions, which could have resulted from the simple fact that he visited Palestine in the height of winter after spending some time in equatorial Lagos, was not left unnoticed by members of the Sub-committee for Indoor Climate. Thus, Feige's proposal for "Research on Indoor Climate", which was certainly written in cooperation with Wittkower, opens with reference to Ladell's argument for not ignoring winter conditions (since, as Ladell wrote, "when an individual has become adjusted to a low thermal comfort standard, a rise in air temperature hardly noticed by someone on a higher standard will strike him as being most uncomfortable"), but at the same time implicitly criticized his views, arguing that

> [...] the optimal house will be one that will undergo little upheating in summer just as well as avoid undue cooling in winter. But it must be borne in mind that it is comparatively cheap to keep a room sufficiently warm in winter (e.g. with a

> rather cheap kerosene stove, where central heating is not provided). On the other hand artificial cooling of an overheated room in summer by means of air-conditioning is not yet an economical proposition for an ordinary dwelling house.
>
> To find a general solution for an "all-weather" house that will suit under all climatic conditions, however cold or warm they may be, without costly technical devices, will be impossible. What we can do is to investigate the possibility to construct our houses in such a way as to eliminate the detrimental influence of the climate, if not fully then at least to the greatest possible extent. (Feige 1947)

Having stated his case for keeping research efforts directed to summer conditions, Feige suggested an experiment which would focus on the effect of several building features (orientation, roof composition, surface treatment, shading devices, wall construction, fenestration, and ventilation) on daytime as well as nighttime comfort. Monitoring was proposed to be conducted in two pairs of "houses of similar construction", one pair oriented with north-south exposure, the other with east-west exposure. Within each pair, one house was supposed to remain unchanged, while the other house was to be gradually modified in terms of roofing, surface treatment, shading, and wall construction (Feige 1947).

Feige's proposal was discussed during the third meeting of the Sub-committee for Indoor Climate on 22 May 1947. It was decided that the proposal will be redrafted in a way that "the specific problem of the influence of orientation of houses on indoor climate should first be investigated" (Sub-committee for Indoor Climate 1947b). The modified version, signed by Feige, Neumann, and Wittkower and titled "An Investigation into the Influence of the Orientation of Houses on the Indoor Climate", removed the reference to roofing, surface treatment, and wall construction, but emphasized the way windows and shading devices might, in addition to orientation, affect indoor climate. This was meant to be achieved by applying different use scenarios, as follows:

(a) Windows will be closed from sunrise to sunset.
(b) Windows to be closed from sunrise to about 3 pm when outdoor temperatures decrease and the sea breeze is fairly strong.
(c) Shutters and windows closed by day.
(d) Shutters closed, but windows open by day.
(e) Mosquito netting fitted in the windows and windows kept open or closed.
(f) Shadowing plates placed above windows. (Feige et al. 1947)

It was added that the scheme was "met with the full approval of Mr. A. F. Dufton of the [British] Building Research Station, Department of Scientific and Industrial Research at Carlton (near London) when it was presented to him by Mr. R. Feige on the occasion of a visit to London and has also found the keen interest of Prof. G. P. Crowden [from the London School of Hygiene]" (Feige et al. 1947).

On 7 August 1947, the revised research proposal of Feige, Wittkower, and Neumann was presented to the sub-committee and was recommended for the approval of the BSIR. Koch's proposal, on the other hand, received much lesser support, since he suggested to conduct his experiment on measuring instruments in existing buildings, in a way that resembled too much the proposal of Feige, Wittkower, and Neumann (Koch 1947b). Therefore, Koch was asked to provide an alternative proposal, this time "on the comfort range in Palestine" (Sub-committee for Indoor Climate 1947c). Only five days later, Koch presented the Sub-committee with a research proposal titled "Requirements for Thermal Comfort in Palestine", in which he suggested to extend Thomas Bedford's scale of Equivalent Warmth (Bedford 1936) to Palestine by combining monitoring with comfort voting by users of indoor spaces (Koch 1947c). This time the sub-committee agreed to recommend the proposal for the BSIR approval (Sub-committee for Indoor Climate 1947b).

In spite of the recommendations on the two research proposals, the deteriorating political stability in Palestine had its negative impact on their prospects of realization. Since February 1947 it was clear that the British government wished to end its Mandate over Palestine and to pass its responsibilities to the United Nations. On 13 November, 16 days before the resolution on the partition plan for Palestine was approved by the UN's General Assembly, Britain informed the UN that it will withdraw its troops from Palestine by 1 August 1948. Less than a month later, the British cabinet decided to officially end the Mandate on 15 May 1948 (Morris 2008, 37-38, 52, 74). This gave a final blow to the already diminishing chances for the realization of the recommended studies. During the following months, Sambursky was occupied in a haste publishing of a report on the completed studies of his Board (Nature 1948), as well as Ladell's report which was printed in late April 1948 (Ladell 1948). By then, parcel mail services between Palestine and the United Kingdom were abruptly cut, leaving Sambursky unable to send its copies even to the report's initiator and funder, the Colonial Medical Research Committee in London (Sambursky 1948).

2.8 Conclusion

Building climatology research in Palestine emerged during the 1940's in an almost accidental manner. Although climate was a central theme in the writings of Jewish architects in Palestine since the 1920's (if not earlier), interest in scientific research on the relation between climate and building was almost totally absent from professional discussions. The first actual research efforts were initiated by climatologists and physicians who were disappointed by the poor summer thermal performance of modern buildings in Palestine. Nevertheless, these efforts were not primarily directed to the formulation of recommendations that could be used for architectural design. With a single exception of the activities of Werner Joseph Wittkower, the local architectural milieu was pretending to take great concern of climate, but actually did so in a totally superficial manner.

Wittkower can be regarded as the unrecognized father of building climatology in Mandatory Palestine, and later on in Israel. His analytical and practical works in the field during the 1940's had no precedent, as well as no contemporary equivalents. As an active architect, Wittkower was aware of the need to produce specific design solutions which will have their impact both on indoor as well as on outdoor climate. This is why he found the question of building orientation important enough to be the first to be addressed by experimentation: building orientation is perhaps the most basic design decision taken by an architect during design, and its effect on indoor climate is fundamental. Wittkower was the first architect in Palestine to advocate, and then to test, the orientation of buildings according to wall insolation, leading him to approve the north-south orientation over the east-west one because of the much lesser insolation of northern and southern walls during summer. This sharply contrasted with the existing habit among local architects of orienting the main facade to the prevalent western winds. Wittkower, though, did not limit himself only to the basic question of orientation, and formulated a whole set of questions to be answered. The only drawback in his systematic approach was the lack of institutionalized support for his experiments which prevented him from realizing most of his plans.

Building research efforts during the 1940's were sporadic in nature, preventing any chance for a gradual accumulation of knowledge. This was mostly evident in the field of climatic research, where past knowledge was virtually non-existent. While the need for building research was already acknowledged in architectural circles, the central government of Palestine, which was dominated by British civil servants and military officers, had little interest in vast and coordinated efforts for the promotion of local building research, unlike, of course, the British government in the UK which established a national Building Research Station, the first of its kind worldwide, already in 1921 (Swenarton 2007). Therefore, even though efforts to scientifically develop the understanding of the relation between climate and building continued throughout the 1940's, these activities were few in number, and had to rely on the dedication and decisiveness of a handful of individuals who had to struggle one time after the other for securing minimal funds and institutional backing. This trend was wholly transformed when the State of Israel came into being.

3 BUILDING CLIMATOLOGY RESEARCH IN ISRAEL: INSTITUTIONALIZED RESEARCH, 1948-1965

3.1 Introduction

The establishment of the State of Israel on 14 May 1948 was a defining moment not only in the long history of the Jewish people, but also in the short history of building climatology in Palestine. During the British Mandate for Palestine scientific exploration of the relations between climate and building concerned much more the growing Jewish population of the country than its British governors. Although the Colonial Office was responsible for Ladell's visit to the country, this was done because Palestine was seen as a suitable laboratory for experiments which could be beneficial to other parts of the British Empire. This was also openly stated in the concluding paragraph of Ladell's report:

> Palestine's climatic problems are duplicated in other tropical and sub-tropical countries. Work on tropical housing and on palliative measures against the heat will be of interest and of use in many places in Africa and Asia where similar conditions prevail. Academic work will also have a general application outside Palestine, especially in connection with alterations in heat tolerance; if means were to be found of influencing such changes for the better, it might be possible, on the one hand, to open up for European Colonisation territories at the moment closed, and on the other, to increase the efficiency of the indigenous population. Much of the research that may be done, therefore, under the auspices of the Palestine Board for Scientific and Industrial Research on climatological and comfort problems will be of general interest, and may, if the results are properly disseminated, bear fruit elsewhere. (Ladell 1948, 21)

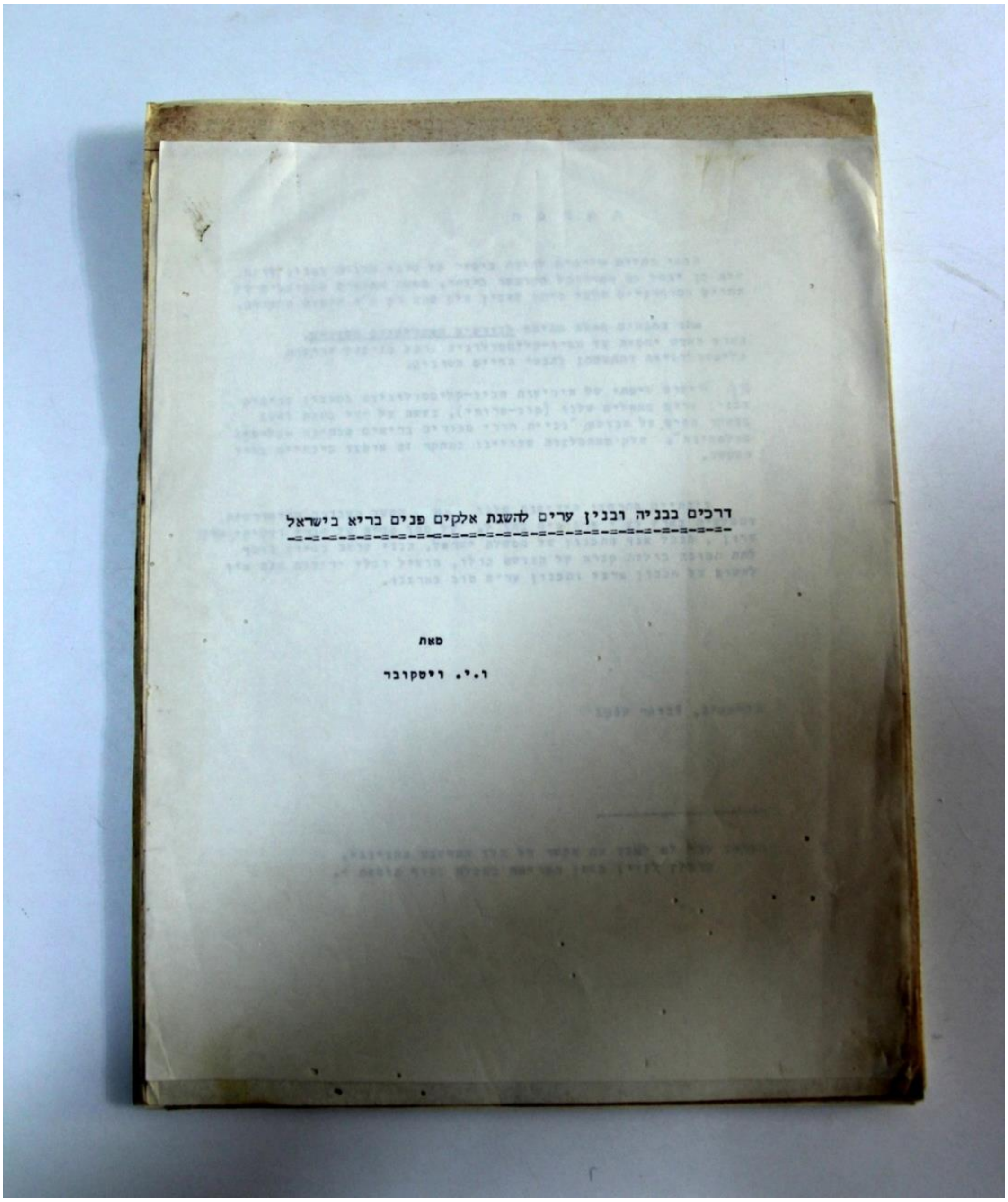
During the British Mandate, building activities, especially for housing, were not part of the government's duties. While the British created a new system of modern planning administration, their involvement in the design of buildings was negligible, which can explain their relative indifference to the development of building research in general and building climatology in particular. The new Jewish State held a totally different position. Not only did the state take responsibility for the construction of public housing, the very limited resources it had access to called for much more care and premeditation in the execution of mass-housing projects. For the first time in the history of modern Palestine/Israel, the local government had a clear interest in a continued and reliable promotion and funding of building research.

3.2 Wittkower at the service of the new state

Before further research could be initiated, some reliance on past achievements must have been looked for. On 19 August 1948, much before the 1948 War officially ended, Mordechai Bentov, the Minister of Labour and Construction, announced that architect Arieh Sharon was appointed the head of a new department named the "Planning Administration". This new body was responsible for planning the construction of tens of thousands of new housing units across the country in order to absorb the expected waves of immigration to the new Jewish state (Davar 1948, Hatzofeh 1948). As noted above (section 2.2), Sharon was one of the few Jewish architect in Palestine to publicly address questions of climate and building; his new responsibilities and past awareness probably led him to approach Wittkower, asking for his advice. The outcome was a 41 page guide by Wittkower on "building and town planning recommendations for achieving a healthy indoor climate in Israel" which summarized more than a decade of his work (Figure 3.1). In its preface, written in January 1949, Wittkower briefly referred to its purpose:

> An attempt for a systematic application of bioclimatic knowledge in the design of buildings and in town planning in our climate (sub-tropical) was done by me in 1941 in a comprehensive study on the subject: "Building Climatically Healthy Dwellings in Palestine" [see above, section 02.4]. Some of the recommendations included in that study were meanwhile adopted in practice.
>
> Meanwhile our knowledge has expanded through an ongoing theoretical and practical work executed in our country, as well as through publications from abroad. Based on a request from my friend and colleague, Arieh Sharon, the director of the Planning Division of the Israeli government, I am making another attempt to give a concise outlook on the subject as a whole, since without this knowledge one cannot

> contemplate a good national planning and town planning in our country. (Wittkower 1949, preface)



דרכים בבניה ובנין ערים להשגת אקלים פנים בריא בישראל

מאת

ו.י. ויטקובר

Figure 3.1: The cover page of Wittkower's 1949 guide; its only surviving copy is kept by Uzi Agassi (photograph by the author, 2014)

Wittkower's guide was not officially published; it was probably meant to be an internal document to be used only by workers of the Planning Administration (which changed its name to the Planning Division in the beginning of 1949). Much like with Wittkower's 1942 manuscript (*Bauliche Gestaltung Klimatisch Gesunder Wohnräume in Palästina)*, we know of its existence only due to a fortunate coincidence: a copy of it was kept by

Uzi Agassi (b. 1951), an art historian and curator who curated a retrospective exhibition on Wittkower's works in 1992. Agassi received the document from Wittkower while working on the exhibition and mentioned it briefly in its catalogue (Agassi 1993, 34). He was kind enough to allow me to photograph it at his home in Ra'anana.

Wittkower's unbound document was produced with a simple typewriter, and seems to be a final draft, since it contains some hand-written additions and corrections. It contains ten figures and tables in German with Hebrew translation, few of which were already included in Wittkower's 1942 manuscript. Wittkower's document was written as a basic guide to planners and designers in Israel. Its opening paragraphs state its purpose:

> This booklet summarizes the ways in which building design and town planning should proceed in light of the climatic conditions of our country, in order to achieve, using natural means, the best indoor conditions, for securing health and good feeling.
>
> Professionals are mainly aware of the conditions securing maximal health and good feeling inside indoor spaces.
>
> Based on these facts, which are known to the professional practitioners, it is necessary that professionals in the field of building make sure that the internal faces of walls, ceilings, and floors (and therefore the temperature of the indoor space) are cool as possible. If keeping adequate lower temperature is not possible, we are given another role – to make sure that suitable air movement is maintained in the indoor space. (Wittkower 1949, 1)

The guide generally repeats the main analytical discussions and recommendations which already appeared in Wittkower's 1942 manuscript as well as in his published articles from the 1940's, with some additions, including a reference to the 1946 monitoring campaign. In addition to its main prescriptive part, it included four short theoretical appendices on the effects of climate on indoor space and the ensuing conclusions regarding building construction; the effect of solar radiation on the temperature of indoor spaces; the effect of effective ventilation on indoor room temperature, excluding the effect of radiation; and an extended glossary of important terms like heat transfer, heat convection and conduction, radiation, etc.

Wittkower divided the main part of his document into two: the first addressed the issue of maintaining low temperatures of the building envelope, the second dealt with the creation of "an efficient movement of air" in indoor spaces. Both parts relate to issues of microclimate and building design alike. Once again, Wittkower put emphasis on the role of solar radiation, and suggested ways to ameliorate its effects both on the urban scale (shading streets using vegetation, painting facades in white, reducing the use of outdoor paving, orientating streets along the east-west axis, avoiding the design of gaps between single buildings) and building scale (securing night cooling through natural ventilation of rooms, securing cross ventilation and ventilation of roof attics, painting facades and flat roofs in white, orientating the main facades to the north and south, designing shading ledges, constructing double-layered flat roofs with ventilated middle layer). As for ventilation, Wittkower argued that window orientation does not have to be perfectly aligned with the prevalent wind direction, and that the main challenge of ventilation is securing cross ventilation of indoor spaces (Figure 3.2). Moreover, in order to prevent discomfort caused by strong drafts, Wittkower suggested to design windows with two operable parts, the lower edge of the upper one be 1.35 m or 1.85 m above floor level (Figure 3.3), depending on the expected type of activity in the room (whether people are mainly seated or standing). These recommendations, added Wittkower, needed to be verified through controlled experiments, since they were based only on his own experience as a designer of buildings.

Wittkower concluded his guide with an outlook on "what can be achieved" by design and planning according to his recommendations. While admitting that "it would be welcomed to obtain a larger number of details on measurements" he added that "these measurements would not produce anything fundamentally novel". Therefore, he summarized his main guidelines in the following way:

> The sun radiates heat; the eastern and western facades together receive from June until August almost 13 times more radiation than the northern and southern facades together (with a shaded southern side) – and therefore, a group of buildings with facades to the north and south is cooler than buildings with east-west facades. White paint ensures almost 100% reflection of radiation – and therefore it is cooler in a house with a roof painted white than in a house with a roof painted grey or unpainted roof covered with asphalt. Leaves and grass absorb part of the radiation without transforming it into heat – vegetated areas are therefore cooler than those without vegetation. Wind moves hot air away – and houses exposed to wind and to a windy road are cooler than those without winds. Nighttime air is cooler than daytime air – well-ventilated rooms at night are cooler than rooms ventilated mainly during the day. Shaded areas are cooler than exposed areas – thus shaded houses and roads are cooler than those without shade!
>
> Although we could imagine, following the above mentioned criteria, to what extent our cities and houses could be cooler, we do not yet know anything in a precise manner. We only know that the means that we counted would produce greater cooling.
>
> My opinion is that there is no excuse for avoiding the use of the better, only because we do not precisely know to what extent it is better! (Wittkower 1949, 16-17)

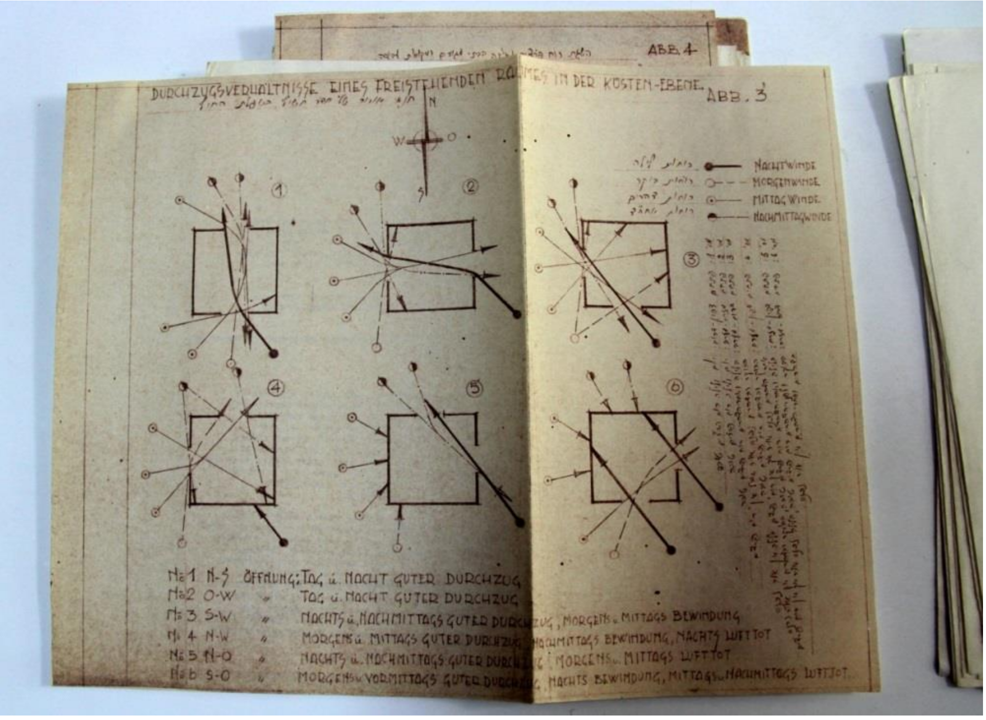


Figure 3.2: Wittkower's schemes of cross ventilation options in rooms with windows directed in different orientations as appeared in his 1949 guide (Wittkower 1949)

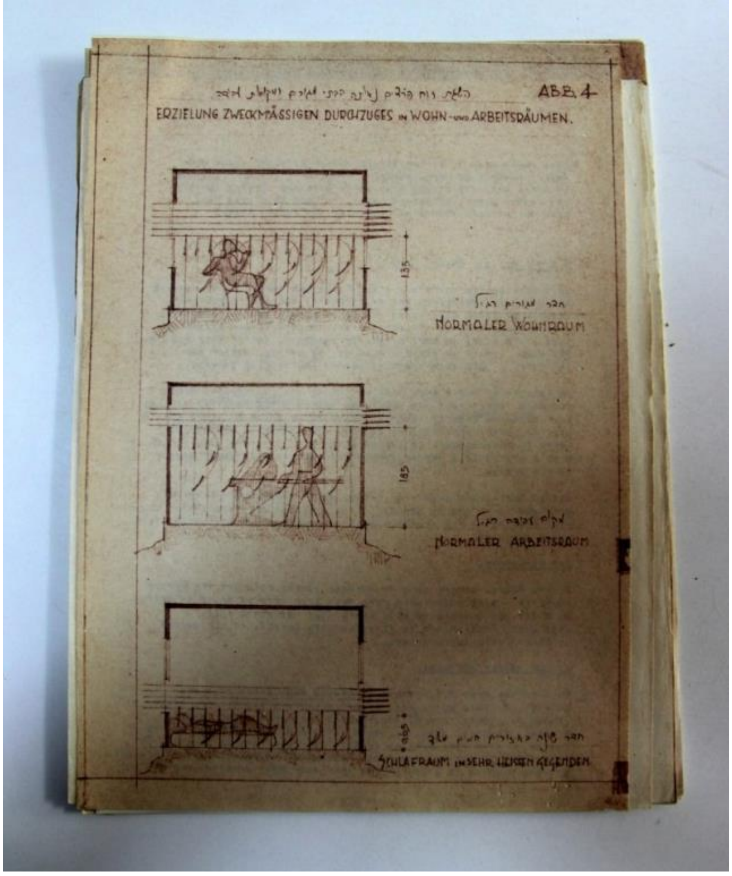


Figure 3.3: Wittkower's schemes for window design for preventing discomfort from excessive cross air movement as appeared in his 1949 guide (Wittkower 1949)

3.3 The Research Council of Israel

It is hard to determine whether Wittkower's guide was indeed distributed and used by members of the Planning Administration. Nevertheless, Sharon's interest in the dissemination of climatic knowledge was indicative for the future relations between governmental housing authorities and the development of local scientific research in building climatology. As we shall see, housing authorities in Israel had an important role in the promotion and funding of research in building climatology, though the application of its results in actual design and planning was much less successful than originally intended.

In terms of funding and coordination of local research, the most important governmental body of the first half of the 1950's was the Research Council of Israel, which originated from the Mandate's Board of Scientific and Industrial Research. Although the end of the British Mandate terminated the Board's activities, its executive secretary, Samuel Sambursky, was eager to "incorporate the Board in the Government of Israel", as he wrote to Ladell in August 1948 (Sambursky 1948). He eventually succeeded: in April 1949 a new governmental body, named the "Research Council of Israel", came into existence under the auspices of the Prime Minister's Office, with Sambursky serving as its general director (Herut 1949, Nature 1949). Its roles were "to serve as an advisory body for the government in matters of scientific research for the development of the country's resources, the promotion of agriculture and industry, and the improvement of public health" (Anonymous 1955b). The Council consisted of 18 members, all scientists except its chairman, who was the prime minister, and its vice-chairman, who was the Minister of Education. Like its predecessor, the Council's main activities took place in professional committees, appointed to discuss research proposals submitted for funding or to initiate and promote research programs in certain fields. In that sense, the council served mainly as a coordinating apparatus for research activities, while actual research continued to be performed by other institutions.

The Council's first meeting took place on 1 June 1949, during which it was decided to appoint five professional committees in basic science, agriculture, industry, building, and food (Davar 1949). The appointment of a Building Research Committee was a good indication to the central position the field of construction held in the young state, but at the same time revealed the urgent need for widening the knowledge base in one of the principal industries of Israel at that time. The first meeting of the Building Research Committee took place on 19 June 1949, headed by Arnold Arnan (Arnstein), the director of the Standards Institution of Israel. Its members were: Dov Ashbel from the Hebrew University, Avraham Baniel (b. 1919) from Israel Mining Institute, Ya'akov Ben Sira (1899-1994) from the Building and Technique Research Institute at the Association of Engineers and Architects in Israel (not to mix with the 1940's Building and Technical Research Institute of the Engineers', Architects' and Surveyors' Union of Palestine), Michael Fuchs from the Department of Public Works, Shmuel Rosenkranz from Solel Boneh construction company, Marcus Reiner from the Technion, Heinrich Neumann (1888-1955) from the Technion, Asher Allweil from the Ministry of Labour, and Shlomo Ettingen (1897-1963) from the Technion. Ashbel and Baniel resigned in November 1950 and were substituted by E. Nesher, an engineer, and Meir Tanny from the Standards Institution. During 1951 Rahel Shalon (1904-1988) from the Technion took Ettingen's seat. The roles of the Building Research Committee were to discuss research proposals in the field of construction, to prioritize them, to follow their execution after their approval, and to recommend them for publication (Anonymous 1955a).

Issues of climate and building did not occupy much of the Committee's time. Most of the studies approved during its meetings were in the fields of building materials and construction techniques, an inclination which was also reflected in the Committee's composition. Nevertheless, in its first meeting the Research Council decided to continue all the studies that were already approved by the Mandatory Board, including a "research on the problem of indoor climate", while another proposal on indoor climate by Wittkower, Neumann, and Koch was waiting for approval (Building

Research Committee 1949a). Moreover, during the committee's third meeting on 4 August 1949, four proposals pertaining to climate and building were presented. Therefore, it was suggested by Arnan that such studies will be discussed in a special sub-committee for indoor climate (Building Research Committee 1949b), which had much in common with the similar sub-committee that worked under the former Board for Scientific and Industrial Research: besides Arnan, who was again the head of the sub-committee, it included Wittkower, Koch, and Bloch. Its other members were familiar faces: Mordechai Gilead, the director of Israel Meteorological Service (who replaced Feige), Ashbel, and Heinrich Neumann, a distinguished professor of civil engineering from the Technion. Later on three members were added to the sub-committee: Jehuda Neumann from the Meteorological Service (who took part in Wittkower's 1946 monitoring campaign), Mordechai Peleg (1901-1977) from the Technion, and Joseph Frenkiel (b. 1919) from the Research Council, who was also the sub-committee's secretary (Frenkiel 1955).

During the first phase of its work (until 1952) the Sub-committee approved five studies: a study on "heat storage in houses" by Bloch; a study on thermal comfort by Koch; a study on "indoor climate" by Heinrich Neumann; a study on solar collectors by Levi Yissar (one of the forefathers of solar water heating in Israel); and another study on "indoor climate" by Wittkower, Jehuda Neumann, and Frenkiel (Building Research Committee 1955a). Each of the studies was backed by a different public institution: Bloch came from the Palestine Potash Company (which was nationalized in 1953 and renamed Dead Sea Works); Koch held a position at the Hebrew University; Neumann was a professor at the Technion; Yissar worked for the Standards Institution; and Wittkower, who was an independent architect, teamed with Neumann from the Meteorological Service. This scattering of efforts resulted from the nature of developments in the area until that time, which relied mainly on the sporadic interests of individuals in questions of climate, not on well-established methodologies and research traditions.

The five studies approved by the sub-committee were discussed during meeting held in 1949 and 1950. As time went on, the initial enthusiasm seemed to decline. The studies of Bloch and Koch were never completed. Moreover, the Building Research Committee, which was responsible for coordinating all building research in Israel, did not convene at all between October 1952 and April 1954, after holding almost monthly meetings until the middle of 1952. Even afterwards its meeting were not held on a regular basis. As a result, only four new studies were approved by the Committee during 1953, a number which declined to only two in 1954, in comparison to 35 studies approved between 1949 and 1952 (Building Research Committee 1955a).

One of the reasons for the declining influence of the Building Research Committee was its dwindling financial resources: in the fiscal year of 1954-1955, the Research Council allocated only 5,000 Israeli Pounds for building research (Building Research Committee 1954). This lack of funds sparked discontent and bitterness among the committee's members. On 3 February 1955 the committee convened with Sambursky to discuss the pressing budgetary problem. Rahel Shalon, who was the head of the committee since April 1954, asked whether building research should at all be "attached" to the Research Council, since

> [...] in other fields there are funds and additional funding resources while building research has no other custodian. This means that the mere fact of its attachment to the Research Council is a hindering factor. The Council should consider one of the two alternatives and decide to act accordingly: either it should step back from its role as a custodian, enabling to work in another direction, or it should gather the money required for effective research. This can be done through levying construction works, in a rate of one per mill for an hour, which can grow in two or three years to three per mills. (Building Research Committee 1955b)

When referring to "another direction", Shalon was probably hinting to the concentration of building research in Israel under a national building research institution, whose establishment was being discussed by members of the Research Council throughout 1952. The discussions exposed some tensions between the Technion and other stakeholders like the Standards Institution and the Association of Engineers and Architects in Israel; two competing proposals for the organization of the national research body were submitted to Sambursky in November, one written by Ben Sira and Arnan, and the other by Yaakov Dori (1899-1973), the president of the Technion (Ben-Sira and Arnan 1952, Dori 1952). Since the differences in content were not fundamental, it seems that matters of personal and institutional prestige prevented the successful realization of the idea. Replying to Shalon during the March 1955 meeting, Sambursky argued that "a building research station is a question of millions" and that while not objecting the idea, he could not see it materialize in the near future. What seemed more plausible, in his opinion, was external funding, like a sum of 18,000 Israeli Pounds which was recently allocated for research by the Housing Division (Building Research Committee 1955b). In the end, it was decided that a delegation should meet Golda Meyerson (Meir), the Minister of Labour (under which the Housing Division worked at that time), in order to petition for additional funds for building research. Members of the delegation (Shalon, Allweil, Arnan, Ben Sira) held another meeting on 13 March and decided that "on the first phase, budget for building research should be based only on governmental building activity. The demand is for three per mill of the total expenditure, that is: around 300,000 Israeli Pounds" (Building Research Committee 1955c).

Although a meeting with the Minister of Labour did take place, it had no effect on the 1955-1956 budget, in which only 8,000-10,000 Israeli Pounds were allocated for building research (Building Research Committee 1955d). In April 1956 Sambursky left his position as the general director of the Research Council, and was replaced by the Berlin-born geographer David Amiran (Kelner, 1910-2003)(Herut 1956). This, however, did not serve well the cause of building research. On 26 July 1956, during a meeting of the Building Research Committee, Frenkiel, the committee's secretary, informed that after Amiran assumed office it was decided to divide the fiscal year into two: for the first three months 6,750

Israeli Pounds were allocated, but because of shifts in the budget the sum of 15,000 Israeli Pounds that Amiran promised to allocate to building research was transferred to other fields of research. For the members of the committee, this was the last straw. Shalon did not waste words; she revealed that after the meeting with the Minister of Labour the members of the committee decided to resign if their demands were not accepted, and added

> The Ministry of Labour now allocates money for building research and its distribution is done by a committee of the Building Council at the Israel Institute of Productivity, which was appointed without informing the Building Research Committee of the Research Council. This is really improbable, and our committee should resign, not only because the allocated sums for its activity are miniscule in comparison to the dimensions of building activity, and not only because of the cancelled allocations from the budget of the Research Council, but also because of the appointment of that committee. (Building Research Committee 1956)

All members of the committee then agreed to resign, except the representative of the Ministry of Labour. Amiran, who was abroad at the time of the resignation, tried to reallocate funds for building research but failed. On 25 March 1957 he wrote to Rahel Shalon that he had no other choice but to accept the committee's resignation (Amiran 1957).

3.4 The Meteorological Service as promoter of building research

The resignation of the Building Research Committee was the culmination of a process that began already in 1952. Contrary to the original intentions of the committee's founders, the committee failed to perform as a national advisory body for building research not only because it could not financially support studies, but also because other, more direct, channels for funding and research initiation were developing simultaneously, especially through the work of the Housing Division (see below, section 03.7). This meant that "outsiders" like Wittkower, researchers who were not part of the academic milieu, were destined to step aside.

As mentioned above, Wittkower still managed to execute one last monitoring campaign with the funding of the Research Council during 1950 and 1951. Contrary to the original proposal by him, Feige, and Neumann, the second campaign did not address the question of "ideal" building orientation but examined the thermal properties of apartments with different roof constructions. As with his first monitoring campaign, Wittkower cooperated again with the Meteorological Service. He also managed to convince Tel Aviv Municipality to let his team monitor newly built and unoccupied two-storey houses in Nahalat Yitzhaq neighbourhood. Monitoring took place between late August and late October 1950, and then again (in some of the same houses) in August and September 1951. Preliminary monitoring was done in Holon in the summer of 1949, revealing that the temperature gradient "from a small distance above the floor to a small distance underneath the ceiling" is negligible. Therefore, and since roof construction was of main concern, thermometers were placed in 1 mm distance from the examined ceilings. Other thermometers were used for measuring the outdoor air temperature. Reading of the thermometers was done in two-hour intervals between 07:00 and 19:00, with some additional nighttime readings for a few days. A report summarizing the study's results, written in English, was published by the Research Council in December 1953 (Wittkower et al. 1953).

All in all, eight types of common roof constructions were compared, five of them of flat roof constructions and three of tiled roof, as follows:

> Flat Roofs
>
> 1. Ordinary reinforced concrete roof (solid concrete roof or solid roof, in brief) 12 cm thick, and a layer of 'hot' asphalt (approximately 1 cm thick);
> 2. Ordinary hollow-block roof (hollow-block roof, in brief), 14+6=20 cm thick and a layer of 'hot' asphalt (approximately 1 cm thick);
> 3. Roof as in No. 2, but instead of hollow blocks, full 'Betkal' (foam concrete) blocks, 14+6=20 cm thick and a layer of 'hot' asphalt (approximately 1 cm thick);
> 4. Ordinary hollow block roof as No. 2, but covered by a 'Betkal' insulating layer;
> 5. Roof with ventilating channels, 14+6=20 cm thick and a layer of 'hot' asphalt (approximately 1 cm thick).
>
> Tiled roofs (sloping roofs)
>
> 1. Ordinary tiled roof, ceiling-plaster on expanded metal;
> 2. Tiled roof with ventilation slits, 'Celotex' ceiling;
> 3. Tiled roof with extra large ventilation slits; ventilation lantern at top; 'Celotex' ceiling.
>
> The tiles were made of concrete about 1.5 cm thick. They were pink in colour. Whitewashed and non-whitewashed flat roofs were also compared. (Wittkower et al. 1953, 5)

The wide range of roof constructions enabled to produce practical and detailed recommendations for roof construction in Israel's Coastal Plain. As the authors remarked:

> Observational work also indicates that it is possible to choose between different types of roof construction in accordance with the purpose of use of the room or of the house. If the building is used for dwelling and is principally occupied from the afternoon hours to the early morning

> hours, one should avoid using extra insulating materials in the roof. Insulating materials will make it difficult for the roof to cool after sunset and will thereby maintain high ceiling temperatures for the night. On the other hand, if the building is a place of work or study, mainly occupied from the morning to the afternoon, the use of insulating materials in the roof may ensure relatively low ceiling temperatures for the period of occupation of the room. (Wittkower et al. 1953, 15)

Moreover, the monitoring enabled Wittkower to establish his argument on whitewashing of flat roofs, recording a reduction of indoor temperature of up to 6°C during the height of summer when a roof is whitewashed (Figure 3.4). Whitewashed flat roof produced lower indoor temperatures also when compared to tiled roof. Contrary to the authors' expectations, though, tiled roof with ventilation stilts did not produce lower indoor temperatures than normal tiled roofs. Their explanation for the recorded phenomenon was that nighttime wind was not strong enough to introduce effective ventilation into the roof space (Wittkower et al. 1953, 17-18). In the end, while the study provided designers some clear answers regarding the effect of the most common roof construction on indoor temperatures during summer, its main significance is the scientific affirmation it gave to the common practice of whitewashing flat roofs.

The Meteorological Service's involvement with Wittkower was not its only effort to promote local research in building climatology. In the summer of 1953, the Israel Meteorological Service invited George V. Parmelee (1910-2002), a research associate of the American Society of Heating and Ventilating Engineers (ASHVE) from Cleveland and an expert in solar radiation and building cooling, to Israel as an advisor on problems of indoor climate. The visit, which lasted from 4 August to 28 September, was funded by the United Nations Technical Assistance Administration (Hatzofeh 1953, Parmelee 1990).

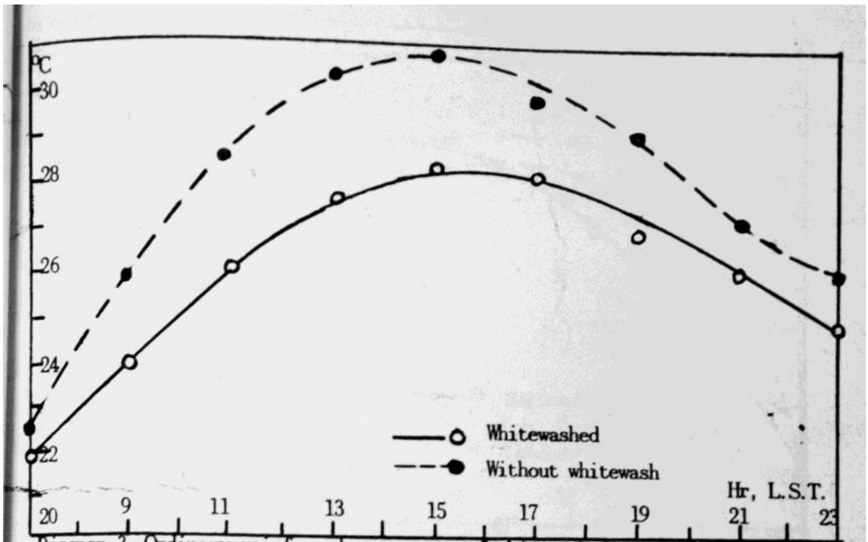


Diagram 3 Ordinary reinforced concrete roof whitewashed vs. ordinary reinforced concrete roof without whitewash. Period: 15/9–25/9/50

Diagram 4 Hollow-block roof whitewashed vs. hollow-block roof without whitewash. Period: 22/9–25/9/50

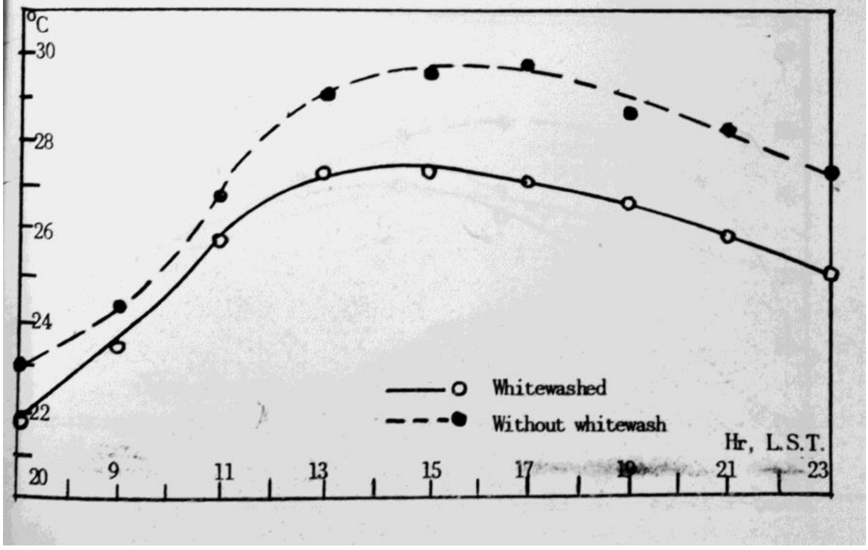


Figure 3.4: Wittkower's 1950-1951 monitoring campaign: a comparison between indoor temperatures under whitewashed and non-whitewashed flat roofs (Wittkower et al. 1953, 23)

Parmelee toured Israel, met with professionals in the field of indoor climate, demonstrated the use of different measuring instruments to members of the Meteorological Service, gave four public talks, and held a seminar of two-hour lectures on indoor climate research in Tel Aviv. In addition, He deposited "80 pieces of US literature pertaining to the field" in the Library of the Meteorological Service (Parmelee 1954, 2). In the opening paragraph of his report on his visit, Parmelee described the circumstances of his arrival to Israel in the following way:

> In recent years, particularly since the foundation of the State of Israel, the Meteorological Service has been confronted with numerous requests for assistance in siting, orientation, and design of projected buildings in Israel, in order that they might be adapted to the climate. And at various times the Service has carried on investigations in the field of indoor climate to seek answers to some of the questions. In order to provide more effective service, a request was made to the World Meteorological Organization for the assistance of an engineer in the field of indoor climate.
>
> In accordance with an agreement between the United Nations and the Government of Israel, the Technical Assistance Administration, in consultation with the World Meteorological Organization, appointed an expert who was to:
>
> 1. Advise in matters of siting, orientation, and design of buildings, and in the best use of buildings and insulation materials for maximum human comfort indoors in summer, and
> 2. To advise with respect to air cooling methods. (Parmelee 1954, 1)

Parmelee's visit calls to mind Ladell's visit to Palestine in January 1947. Nevertheless, unlike Ladell, who was a physician interested in questions of thermal comfort, Parmelee was an engineer whose expertise was the climatic conditions created by buildings. Moreover, having experienced the Israeli summer, Parmelee was mainly concerned with summer conditions, unlike Ladell who unexpectedly stressed the importance of thermal comfort during winter. Parmelee's long stay enabled him to study many aspects of local building customs, and to produce not only a list of recommendations but also a detailed outline for a future research program for improvement of summer indoor climate. His impression from the current state of typical building in Israel was far from being positive:

> Although man is incapable of modifying to any great extent the outdoor climate, through building he can exercise some control over its effects on his comfort. A brief study of the climatological data of Israel shows that careful attention needs to be given to details of building construction, if the most desirable indoor thermal environment is to be obtained. A housing unit is normally a permanent affair and if construction is to continue at the current rate of about 50,000 room units per year, Israel cannot afford to fail in making the best possible adaptation of new construction to her climatic conditions. Consideration should also be given to methods of improving conditions in existing housing. The need for better adaptation is shown by:
>
> 1. the unsatisfactory indoor living conditions in existing housing in many areas. This was learned by the expert in his travels in the country and by discussions with residents of the buildings and with others.
> 2. the considerable amount of experiment and investigation that is being carried on to improve the thermal performance of housing units.
> 3. the great number of questions directed to the expert as to how to improve building design, natural ventilation methods, and use of material to obtain more satisfactory indoor living conditions. (Parmelee 1954, 2-3)

Following this short analysis, Parmelee proposed a three-part comprehensive research program that should have created a satisfactory knowledge base for climatic design. The first part was a short term program that was intended to answer two questions: how can roofs be designed in a way that will improve indoor climate (whether by ventilating, insulating or whitewashing the roof; Parmelee was aware of the monitoring campaign of Wittkower, Frenkiel, and Neumann, but thought it should be expanded to measurements of the thermal performance of a whole building); and what are the thermal time lag and decrement factor of certain wall or roof constructions. The second part was field trials of simple mechanical aids, mainly fans and evaporative cooling devices. The third part was a long term program which was to include "a detailed study of the influence of living space ventilation on thermal performance and on living space air motion, of the effect of building materials, of the effect of sun-shading, and of mechanical aids". The proposed program was meant to enable to determine, among other things, an optimal air change rate, a minimal capacity of fans that could provide indoor comfort, a satisfactory degree of thermal circulation of air during the evening, thermal properties of common building materials, a minimal capacity of satisfactory evaporative cooling system, and the effect of shading on thermal performance and ventilation (Parmelee 1954, Appendix D).

Parmelee's visit, as well as his report and proposed research program, could have held a genuine significance for the study of what was called at that time "indoor climate". His outline for the research program was much more detailed than anything discussed by the committees of the Research Council and could have been used for further development of the field by following a structured program. Yet Parmelee arrived in Israel in a time when the Building Research Committee was beginning to lose its ability to fulfil its role as a national coordinator of research in the field, not to mention its almost inactive sub-committee on indoor climate. Although the sub-committee decided during its meeting from 21 July 1955 to use Parmelee's proposal as a basis for the preparation of a new program of indoor climate research, the decision was never implemented. A month later, Allweil, as the manager of the Engineering Department of the Housing Division, sent a letter to Sambursky with 15 building research proposal to be submitted to a representative of United States Operations Mission (USOM) in order to receive funding for their execution. Among the proposals, Allweil included a "research to improve indoor climate" which admittedly copied the first and second parts of Parmelee's proposed program (Allweil 1955). As with the intentions of the Sub-committee for Indoor Climate, this initiative was nothing but another dead letter. Eventually, research on indoor climate in Israel continued by following ad-hoc needs (mainly of governmental bodies), not a general program.

3.5 The Technion's Station for Technical Climatology

While the Research Council was struggling to maintain its authoritative position in the field of building research, the Technion, Israel's oldest higher education institution, was beginning to pave its own way in the same field. Its activities during the first half of the 1950's created an alternative centre of gravity for local building research activities and secured its leading position in the field for years to come. This was done while representatives of the Technion continued to attend (and even chair) meetings of the Building Research Committee, allegedly accepting the higher authority of the Research Council. In reality, the same figures who took active role in the committee's meeting were also very active in establishing research bodies, the most important of all was the Building Research Station, that were eventually meant to diminish the committee's influence on local research.

By the beginning of the 1950's, a major part of the Technion's activities was dedicated to building and construction. Until 1953, for example, out of 1552 graduates of the institution since its establishment, 784 were civil engineers and 174 were architects (Shoval 1953). The Technion's interest in becoming the main building research authority in Israel is therefore understandable. The establishment of the Building Research Committee of the Research Council in June 1949 did not support this interest, since it distributed research activities among other, sometimes competing, bodies, like the Standards Institution, the Building and Technique Research Institute, and the Meteorological Service. When Yaakov Dori, Israel's first Chief of Staff, was appointed the president of the Technion in late February 1951, the institute embarked on a new way where research was to occupy a central position. In a press conference held in Haifa on 23 May 1951, Dori announced that

> In order to exploit the country's natural resources and reduce expenditure there will be a need to train cadres of researchers who will dedicate themselves to the study of natural sciences. Until now, very little has been done in the field of research in our country, because of the lack of proper

> personnel and technical equipment. In the future, the Technion's executive management will put efforts in recruiting personnel and equipment for research.
>
> Following this trend, the Technion will establish departments for mathematics, physics, and chemistry. Until now these fields were taught only as aiding tools for engineers and technicians who needed them for daily use, not as an independent theoretical field. In the future the departments of the natural sciences will provide theoretical training aimed at research.
>
> Effectively, the Technion will resemble more a university, in which the trend is more theoretical and abstract [...] (Herut 1951a)

In the field of construction, a Building Materials Laboratory existed in the Technion since 1931. Its head, Heinrich Neumann, was appointed in 1951 as one of the three members of the new Station for Technical Climatology, whose main task was research on the influence of climate on local industries, and especially on building and indoor climate (Herut 1951b). Neumann's partners were Mordechai Peleg, a civil engineer who was also the Station's director, and Nathan Robinson (1904-1964), a physicist. As mentioned above, in October 1949, even before the station was established, Neumann, who was a member of the Building Research Committee, received a grant from the Research Council for a study on "indoor climate". This was in fact a monitoring experiment conducted between June and September 1950 on 0.8 m^2 mock-ups of different wall and roof constructions that were erected in Kibbutz Maoz Haim in the Jordan Valley. Report on the experiment, signed by Neumann, Peleg, and Robinson, was first published in 1952, and then was reedited and published again a year later.

The aim of the Maoz Haim experiment was to determine the effect of the extremely hot climate of the region on wall temperatures, and to conclude which type of wall composition, orientations, and treatment (plaster, whitewash, shading by ledges) results in lower wall temperatures. It was shown that given a wall thickness of 22 cm or more, orientation had almost no effect on wall temperature, while whitewashing walls had a marginal effect on wall temperatures as wall thickness increases. For wall thickness of 22 cm or more, no substantial difference in temperature was found between all the monitored wall constructions, which included concrete, hollow concrete blocks, calcium silicate bricks, hollow burnt clay blocks, concrete bricks, expanded concrete blocks, no-fines concrete, and rammed earth. At the same time, differences were found in the daily amplitude of the walls' temperatures: thicker walls showed lower maximum temperatures and higher minimum temperature when compared to "thin" walls of 10.5 cm. This led the authors to the counter-intuitive conclusion that in hot climate a thick wall is not the right solution for a house, since nocturnal indoor temperatures are expected to be higher in such a house when compared to a house with thin walls (Neumann et al. 1952b, Neumann et al. 1953, 8-21).

In the 1953 publication on the Maoz Haim monitoring, the authors included a report on an experiment conducted at the Technion in August and September 1941, which was not publicized before. The 1941 experiment had many similarities with the 1950 monitoring campaign, including the use of mock-up installation. Wall compositions were less varied and included only concrete, calcium silicate bricks, and hollow burnt clay blocks. Unlike the Maoz Haim experiment, in Haifa whitewashing lowered the difference between maximum and minimum temperatures by half. In addition, north-south orientation resulted in lower wall temperatures than east-west orientation (Neumann et al. 1953, 2-7).

The Maoz Haim experiment was the only study of the Station for Technical Climatology to receive the funding of the Research Council. Nevertheless, the Station continued its activities by cooperating with two other semi-governmental bodies: the Amidar housing company and the Jewish Agency. In both cases the Station was asked to examine the thermal performance of certain housing types. The first monitoring campaign, commission by Amidar, took place in the winter of 1950 and the summer of 1951. It compared indoor temperatures of two four-unit houses, one built from concrete in a conventional technique, the other by using a Tournalayer machine, a machine consisting of a mobile form for concrete casting invented by R.G. LeTourneau. The houses were not identical: except minor differences in their layout, the thickness of the unplastered walls of the Tournalayer house was 12.5 cm, compared to 15 cm plastered walls of the conventional concrete house. The Tournalayer house was built from denser concrete with extra reinforcement. The results showed no real difference in indoor temperatures between the two houses (Neumann et al. 1952a).

The second monitoring campaign was conducted in the winter of 1952 in a transit camp for new immigrants near Haifa. The Station was asked to monitor the temperatures inside unoccupied four light structures typical of similar transit camps: wooden barracks, huts of wooden frames covered with aluminium sheets, similar huts covered with canvas, simple tents. The results showed that the "thermal sensitivity" (the ratio between the daily range of indoor and outdoor temperatures) of all the light structures was higher than houses of solid structure. With windows closed, the sensitivity was above 1.0, meaning that the light structures performed worse than solid structures; light absorbing colour of the light structure was found to worsen indoor conditions during daytime (Neumann et al. 1955a).

The fourth and last published monitoring experiment conducted by the Technion's Station for Technical Climatology took place in September 1954 at the Technion. Its aim was to compare "several ways of protecting concrete roofs against heat gained through insolation". The experiment used an existing 8 cm thick concrete roof slab of 12x9.6 m which was divided into 20 fields of 2.4x2.4 m; on each field a different type of protection was applied (Ytong blocks, burnt clay hollow blocks, hollow concrete blocks, sea shells bedding, wooden boards, calcium silicate bricks, vermiculite concrete, and whitewash). These protection types were meant to represent three different protection strategies: solar reflection (whitewash), reduction of thermal conduction, and shading combined with air-circulation above the concrete slab. The temperature of the lower side of the concrete slab was measured, in the middle of each of the 20 fields, from 6:00 to 18:00. Contrary to what was expected, all protection types showed an almost similar effect in lowering the maximum daily temperature, except whitewashing which produced the greatest reduction of maximum temperature. The authors speculated that the reason for the unexpected result was a very thin layer of air (1 mm thick) that allegedly separated the applied protection from the roof slab, thus preventing both conduction and convection of heat (Neumann et al. 1955b). This contrasted with the declared intentions of the authors to examine the effect of reduction in thermal conduction of a roof slab; in other words, the experiment failed due to its unsuccessful set-up. For unknown reasons, the authors did not refer to the 1950-1951 monitoring campaign of Wittkower, Frenkiel, and Jehuda Neumann, which examined a somewhat similar research question through different experimental setting and arrived at different results.

The last study of the Station was theoretical and was published by Peleg alone in 1956, after Heinrich Neumann's death. It presented a mathematical method for the calculation of wall insolation, given the values of incident solar radiation and reflecting the wall's location and position. As with all the other studies performed by the Station for Technical Climatology, the application prospects of the study's results in architectural design were very limited. In that sense, the two monitoring campaigns initiated by Wittkower with the cooperation of the Meteorological Service produced recommendations much more applicable for design, probably because their initiator was an active architect who set his research questions in direct relation to common design problems. Wittkower monitored actual residential buildings built in Tel Aviv, which represented well a substantial part of the contemporaneous building types; the Station, on the other hand, monitored esoteric structure types (like the Tournalayer house or the light weight huts used for temporary purposes) or avoided monitoring real buildings at all, focusing only on the narrow perspective of wall or roof composition. Its experiment in Maoz Haim, while being extensive in its scope, had very little relevance for most of the public building that took place at that time, which was concentrated in areas with utterly different climatic conditions. Nevertheless, since the Station had the backing of the Technion, it was much easier for it to pursue its activities even without the support of the Research Council, a situation far different from that of Wittkower.

3.6 The establishment of the Technion's Building Research Station

The establishment of the Station for Technical Climatology in 1951 was only a first step in a much more daring initiative by the Technion to occupy the leading position in building research in Israel. As already mentioned (see above, section 3.3), during 1952 discussions were held between the Technion and the Research Council on the establishment of a national Building Research Institution. These discussions followed a position paper written by Arnan, the director of the Standards Institution, in November 1951. According to Arnan, the main reason behind the need to establish a national "building research station" was the lack of "permanence and programatization" in past research efforts in the field. He envisioned a "central laboratory for building research in which the architect, engineer, physicist, chemist, and geologist cooperate and which maintains a constant contact with the builder", as was already done in other countries. Following preliminary discussions among members of the Research Council, Arnan visited similar research institutions in England, Sweden, the Netherlands, and France, and concluded that the proposed research station should be a national institution under the auspices of the Research Council, to be established in Tel Aviv in cooperation with the Standards Institution (Arnan 1951).

Arnan was probably too naïve to blatantly suggest his Standards Institution as the host of the national building research station. On 14 February 1952 a large meeting was held at the Research Council offices in Tel Aviv to discuss the establishment of the station, attended by high officials in the building industry, as well as members of the Building Research Committee. Dori, the president of the Technion, was also present; following Sambursky's opening words, in which he expressed his opinion that the station should be established in Haifa in order to benefit from the Technion's personnel, he presented a gentle ultimatum:

> The institution will have to train people in order to provide its needed personnel. If the Technion should fulfil its mission, then it could not restrict itself only to educational

> teaching, but develop continuing education programs and provide its graduate with the option to focus on research. Among other fields, the Technion will not be able to give up building research, even if the government had decided to establish a building research institution in another place. (Research Council of Israel 1952)

Many of the speakers agreed with Dori, though Arnan, Ben Sira, and Allweil were not pleased with the idea of the affiliation between the new station and the Technion and called for its independence. Meetings on the issue continued in the following months, until eventually a compromise was forged. Instead of a single national building research station, it was suggested to establish a national institution that will be composed of two separate bodies: a national council on improving the efficiency of the building industry, and a building research station. The council was to represent all stakeholders in building and construction and to direct research activities, while the building research station at the Technion was to be engaged in actual research. Nevertheless, as mentioned above, persistent differences in opinion on the extent of the Technion's share in the council's composition between the Technion, the Standards Institution, and the Association of Engineers and Architects in Israel failed the entire initiative (Ben-Sira and Arnan 1952, Dori 1952).

The failure did not stop the Technion from establishing its own Building Research Station (BRS) in late 1952, headed by Rahel Shalon (Davar 1953), as a direct outcome of the Technion's new emphasis of research activities. It is unclear whether the real promoter of the idea was Shalon herself or not; in any case, Shalon's determined character transformed the Station into the most important building research body in Israel until its reorganization as the National Building Research Institute in 1988. Shalon was a remarkable person: the first female civil engineer in Palestine and later the first female professor in Israel, she was born in 1904 in Kalisz, a town in the Russian-ruled part of Poland, and came to Palestine in 1925, enrolling to the recently formed Department of Civil Engineering at the Technion. She graduated in 1931 and quickly joined the

Department of Civil Engineering, becoming an internationally renowned expert on cement and concrete (Cohen 1960, Jaegermann 1984). All through her career, Shalon was an ardent advocate of building research, repeatedly arguing that in a country like Israel, where building and construction constitutes one of its main industries, the spending on building research is only "meagre" (Haelyon 1966a).

In a newspaper interview in March 1955, Shalon referred to the establishment of the BRS using the following words:

> Past research conducted in our country was limited in its scope and with no proportion to the scope of building. Therefore the Technion decided to accept the burden of multifaceted and systematic research.
>
> The first step was the establishment of the Building Research Station, about two years ago. Its basic roles are: research, the distribution of research results among the builders, and advisory services for anyone concerned with questions of building in fields where enough expertise is lacking, like the use of new materials, the problem of preventing dampness in buildings, the effect of seawater on concrete pipes, exploitation of natural resources, etc. The existing laboratories of the Technion do not enable research to take place at the required extent. Therefore construction works on the first laboratory of the Station will begin in the upcoming weeks. It will be constructed based on a donation of 100,000 Israeli Pounds by the estate of Michael Polack, founder of the cement factory Nesher, and will be named after him. (Talmi 1955)

Shalon gave the interview a short time after the decision of the Building Research Committee to meet Golda Meyerson, the Minister of Labour, in order to protest the lack of funds for local building research. Therefore, it is not surprising that Shalon ended her conversation with the reporter by referring to the issue of research funding, saying

> Other countries interested in improving building and lowering its price are very much concerned with funding research. In most of the countries, the governments directly allocated substantial funds for building research, though there are also other funding resources. In Sweden, for example, there is a law according to which three per mill of building costs must be allocated to research institutions. And in France the biggest building research institution was established by the contractors association, which equipped it and supports it. (Talmi 1955)

The March 1955 interview was published in *Davar*, the mouthpiece of *Mapai*, Israel's omnipotent ruling party of that time. There is no doubt that it was used by Shalon as another way of putting pressure on Meir, who was a senior member of the party. At the same time, it is not clear what type of funding Shalon was lobbying for. Being both the chairwoman of the Building Research Committee and the director of the Building Research Station, she must have sensed the conflict of interests between receiving limited funds for the BRS through the Research Council and receiving much larger funds directly from the government to a Building Research Station that was intended (at least by her) to become the central building research body in Israel.

Even before the 1955 budgetary crisis of the Building Research Committee, the Technion was working in other directions to secure the leading position of the BRS. In April 1954, Mejse Jacobsson (1911-1966), a Jewish-Swedish expert and the director of the Swedish State Committee for Building Research (*Statens Kommitté för Byggnadsforskning*), arrived in Israel as a delegate of the United Nations Technical Assistance Administration, following an official request from the Israeli government. His task was to "work with the Technion, Israel Institute of Technology in advising, and planning a building research station to be built on the new Technion site [the new Technion campus]. The planning is to include a building programme, assembly of equipment and organization of activities" (Jacobsson 1954, 2). As a guest of the Technion, Jacobsson was very unlikely to compose a report that would not recommend the development of the BRS as the main building research body of Israel.

In order to suggest a national program for organizing building research, Jacobsson first mapped the local bodies occupied in any type of building research, which already included the BRS, as well as the Technion's Station for Technical Climatology. On their professional level, Jacobsson wrote

> Activity is limited owing to lack of means, space and equipment. This statement is valid for each of the above-named institutions. If research activities are expressed in costs per inhabitant or as percentage of the total building activity, figures obtained will without doubt be considerably lower than for most Western European countries, even the small ones. (Jacobsson 1954, 3)

He then considered two alternatives for organizing building research in Israel, as follows:

> <u>Alternative 1</u> – It was suggested that a National Building Research Board should be set up. This Beard should raise funds, determine policy, consider legislation, indicate priority of research projects, organize large-scale field observation and laboratory tests and coordinate the work of all existing centres of building research activity in the land.
>
> <u>Alternative 2</u> – It was suggested that the above-named agencies (p.11.14) should If necessary, be reorganized in order to be more capable of fulfilling their aims. They should be provided with necessary means, personnel and equipment.
>
> Especially should the Building Research Station considerably extend its present activities beyond the field of materials and structures and also treat the questions mentioned under

> 21, e.g. accoustics [sic.], heat insulation, space utilization and economics.
>
> Conclusion – At the first sight, alternative 1 above seems to give the greatest advantages. Probably it would be able to determine more accurately the needs of the industry and could more impartially compare different research projects. This way has recently been entered upon in Denmark, Norway, Sweden, Canada and U.S.
>
> After having thoroughly considered the question, however, it seems likely to me that research activities in Israel will not in the near future be extended to such a degree that a separate body with its own staff is needed only for organization and coordination.
>
> As the personnel and financial means are limited, the conclusion could also be expressed in these words: The needs for extended research are greater than for coordination. It should also be mentioned that a coordinating body does not assure coordination. If people do not wish to collaborate, no organization whatsoever can force them to do so.
>
> This solution however, presupposes a powerful extension of activities of the Building Research Station of the Technion. It is in this case necessary that it should serve the whole country as a central research body.
>
> Recommendation 3 – Existing research organizations should extend their field of activities so that all suitable phases of building research are covered. Especially should the Building Research Station be built and equipped to enable large scale laboratory and field research.
>
> No national building research board should be set up in the near future. (Jacobsson 1954, 4-5)

Jacobsson's conclusions were supplemented by a detailed program for the organization of the BRS, as well as of its activities, among which he stressed the importance of indoor climate, relying also on Parmelee's report on the subject (see above, section 03.4). Jacobsson argued that

> The question of indoor climate is one of the most important of present building problems. Its outstanding importance has been expressed by nearly all building people I have met in Israel. Among special problems mentioned are best insulation and heat capacity of walls and roofs, humidity transmission, general layout and orientation of the building, as well as colour and texture of surfaces. (Jacobsson 1954, 6)

Jacobsson's report suited well the intentions of the Technion. It also suggested a financing scheme to support the development of the BRS by inducing a tax of 1 per mill of all building costs whose revenues would be directed to a "special fund for building research" (a proposal later repeated by Shalon in more than a single occasion). Yet Jacobsson's opinions were not welcomed among other stakeholders, who must have felt driven out of the game. This feeling was expressed by Sambursky in a personal letter to Frenkiel, stating that "it seems to me that in several chapters, for example on indoor climate research which he [Jacobsson] also emphasizes, the result is a one-sided outlook. The study conducted in Tel Aviv with our support [by Wittkower, Frenkiel, and Neumann] is not taken into consideration" (Sambursky 1954). This was probably not a coincidence, since when the results of Wittkower's study on roof compositions were presented to the Building Research Committee, Heinrich Neumann and Shalon refrained from joining the strong compliments it received from the other members of the Committee and expressed a somewhat hostile attitude towards the research methodology and experiment set-up (Building Research Committee 1952). It seemed as if the Technion's determination to occupy a leading position in local building research left very little space for other initiatives, especially in the young field of indoor climate.

3.7 First steps in indoor climate research under the Building Research Station

The first study in indoor climate that was taking place under the name of the Building Research Station was a study on "the influence of ceiling height in dwelling houses", published in 1957. It came into being following a commission from the Housing Division in late 1954 to study the "optimal height" of rooms, allocating 10,000 Israeli Pounds for its execution (Tanne 1954). Formed in August 1949, the Housing Division in the Ministry of Labour was responsible for the actual design and construction of public housing (Shadar 2014, 15). The director of its Engineering Department, Asher Allweil, was the driving force behind the long standing promotion of building research by the Division, including many studies in indoor climate and building climatology. Allweil, who was a member of the Building Research Committee, later admitted that after the dissolution of the Committee "the Housing Division in the Ministry of Labour took upon itself to promote the existing local research institutions in the field" (Allweil 1961). The study on ceiling height was thus not only the first indoor climate research done by the BRS, but also a precursor for a pattern of cooperation without whom building climatology research in Israel would not have existed at all.

The motivation behind the study was mainly economic. Until that time, the common ceiling height was 3.0 m, dropping to 2.75 m in some public housing projects. The Housing Division was interested to know whether the lowering of ceiling heights, which reduced building costs, would not negatively affect indoor climate. In order to answer that question, it was proposed to measure indoor temperatures in five two-storey buildings, each consisting of four housing units, which would be constructed with different ceiling heights in each apartment. Ceiling heights were to be set to 2.86, 2.68, 2.50, and 2.32 m, with roof construction varying between flat concrete roof and tiled pitched roof. A detailed research program was sent by Shalon to the Building Research Committee on 21 March 1955 (Shalon 1955) and was presented to the Research Council's Sub-committee for Indoor Climate a month later (Sub-committee for Indoor Climate 1955). This was mainly a formal procedure which had no effect on the study's design; since the study was already funded by the Housing Division, the BSR did not need it to be officially approval by the Research Council.

Execution of the study was relatively rapid. Monitoring took place between 3 July 1955 and 30 March 1956 in test houses which were built in the small town of Tirat Hacarmel near Haifa. During the monitoring period, changes were made in the roofs' composition in order to examine the effect of whitewashing, Celotex insulation, and pitched roof ventilation as well. Different scenarios of window opening were also compared. Results showed that for ground floor apartments, 2.5 m ceiling height produced lower indoor temperatures than higher ceiling heights. As for upper floor apartments, depending on their roof type, differences between 2.5 m ceiling height and higher ceilings did not usually exceed 0.5K. This led to the final conclusion that lowering of ceiling height to 2.5 m did not negatively affect indoor climate, at least not in the climatic conditions typical to Israel's Coastal Plain. In addition, once again the importance of whitewashing of flat roofs was affirmed by monitoring. It was predicted that lowering of ceiling height from 3.0 to 2.5 m could cut 5% of total building costs for typical housing projects (Shalon et al. 1957).

The monitoring in Tirat Hacarmel was perceived as a success. For the first time in Israel, a study on indoor climate had direct and practical implications which could also be translated into savings in construction costs. This success led to the extension of the study to another geographical region (the northern Negev), and a similar monitoring campaign was executed in Be'er Sheva during the summer of 1957, leading to similar results (Givoni and Shalon 1962). These conclusions satisfied the Housing Division, and new housing projects commissioned by the Division began to be constructed with ceiling heights of 2.5 m. Nevertheless, high officials in the Ministry of Health, including Walter Strauss who was now the director of its Department of Preventive Health Care (Strauss 1959), protested against the Division's decision (Tanne 1959c), claiming that the decision ignored important considerations (Barzilai 1959). After negotiations between the Ministries of Labour, Health, and Interior, it was decided to add a representative of the Ministry of Health to the former research team and to reassess the conclusions of the study. The additional examination did not, however, produce different conclusions, and in June 1961 the Ministry of Interior officially set the minimum allowable ceiling height to 2.5 m in all residential units in Israel (Herut 1961).

3.8 Baruch Givoni and the BRS Department of Indoor Climate

The study on ceiling heights was officially conducted by a team led by Shalon which included architect Al Mansfeld (1912-2004) and ventilation expert Rudolf Landsberg, assisted by the technical help of the Station for Technical Climatology. The team's secretary was a new recruit to the BRS, an architect named Baruch Givoni, who was then at the beginning of his long and exceptional academic career.

Givoni (Figure 3.5) was born on 16 February 1920 in Jerusalem and was raised in Haifa. As a young man he was one of the founding members of Kibbutz Hamadia in the Beit She'an Valley. After the 1948 War he decided to pursue higher education. Being attracted to landscape architecture, he became an architecture student at the Technion, graduating in 1953. After graduation he worked for a year in an architecture office in Haifa, and then moved to Be'er Sheva and worked there as an architect for the Housing Division. In 1956 he was approached by Shalon, who knew him from his studies at the Technion, and was offered to become her assistant in the BRS. In 1958, after serving two years as her assistant, Shalon told Givoni she was planning to open an indoor climate department at the BRS and proposed him to become its head. Givoni told Shalon he needed more training to assume the proposed position, and Shalon agreed to send him to a one-year training in the Research Laboratory of the American Society of Heating and Ventilating Engineers (ASHVE) in Cleveland under the direction of Burgess Hill Jennings (1903-1996).

According to Givoni, he was first accepted as an unpaid assistant of a physiology expert. Arriving in Cleveland, Jennings told Givoni that the physiologist unexpectedly left the Laboratory after receiving a large inheritance, and that in the meantime, until a new physiologist is recruited, he is encouraged to go over the literature in the field he was supposed to work on. In Givoni's words,

> The field of research was the relative effect of temperature, humidity, and wind in the physiological and sensorial sense.

> So he told me, read the literature, here you have the lab, you can do experiments on yourself like a guinea pig, take the right measurements, so that when the physiologist arrives, you will be more ready. So I played with it for about two months, and then he came and said, we do not find a physiologist, and I see that you are already in business, do you mind to do the research by yourself? I said, we can try. It turned out to be a very good study, and we published it. This attracted me to the subject of environmental physiology and I thought it to be a great addition to the design of buildings, in order to design buildings adapted to human needs. (Givoni 2012)

Figure 3.5: Baruch Givoni in an interview with the author, Tel Aviv, December 2012

After completing the training in Cleveland, Givoni asked Shalon for an extension of another year in order to do a Master's degree under the direction of Harwood S. Belding (1909-1973), Professor of Environmental Physiology at the University of Pittsburgh, who was at that time a leading researcher in his field. Shalon had her doubts regarding the possibility that an architect could be accepted to studies dominated by physiologists, but Givoni managed to persuade Belding, based on his recent work with Jennings, to let him join the program. He graduated in 1960 with an MA in Public Health (Environmental Physiology) and returned to Israel to assume the position of the head of the Department of Indoor Climate at the BRS. His first major work, which was first published in 1963 as a doctoral dissertation submitted to the Faculty of Medicine at the Hebrew University, was the development of a new thermal comfort index for Israel which would later become the basis for Givoni's famous bio-climatic chart (Givoni 2012). For his work, Givoni used a special laboratory built at the BRS (Nesher 1962). Ironically, in 1958, the same year that Givoni left for the US, Walter Koch, who in the beginning of the 1950's worked on similar issues, left the Hebrew University and immigrated to Chicago, seeing no professional future for himself in Israel.

Givoni's return to Israel marked a new chapter in local building climatology research. For the first time, a permanent research body was dedicated only to questions of climate and building. Givoni's own varied personal experience, which combined architecture, physiology, and climatology, as well as his close cooperation with the Ministry of Housing (which replaced the Housing Division in 1961) contributed to the direction of indoor climate research towards practical problems of building design. Among the subjects Givoni worked on during the first half of the 1960's were building and window orientation, natural ventilation, roof and wall composition, thermal comfort, curtain walls, and effectiveness of shading devices. The latter work, completed in 1964, was the first study in which Milo Hofmann (b. 1931), who replaced Givoni as the head of the Department of Building Climatology in 1977, participated. Hoffman, a physicist, was not the only recruit to Givoni's team, which in times also included a psychologist, a sociologist, and a physiologist (Hoffman 2014); but his contribution to the development of the Department was most valuable, especially in the fields of thermal insulation, natural ventilation, urban microclimate, and later on also in thermal simulation.

Maybe the most important work of the Department during the first half of the 1960's, in term of its applicability to architectural design, was a series of studies on building and window orientation, which were summarized in a report published in 1965. As already mentioned, the question of building and window orientation was probably the most discussed climatic question in Mandatory Palestine and Israel since the mid-1930's. It was also the one that attracted the most heated debates. In their final report, Givoni and Hoffman put an end to the long-lived discussions, and concluded that a clear-cut answer to the question of orientation cannot be given, since it relies on a combination of several thermal factors. Moreover, Givoni and Hoffman established through monitoring that "good ventilation conditions could be obtained in a wide variety of orientation angles to the wind" and that "ventilation conditions depend more on the location and design details of the windows than on their orientation". Thus

> The current study enables to understand the mechanism of the effect of orientation and its dependence on different factors. It should be taken into account that the thermal load on a room oriented in a certain direction is composed of two independent components: the course of outdoor air temperature and the course of radiation intensity on the vertical surface. The effect of the course of outdoor air temperature is almost uniform in all directions (excluding the intensity of the wind striking the walls). The absolute effect of the course of radiation intensity depends on the external colour of the walls and the shading conditions on the windows and walls. The lighter the colour and the more effective the shading, the effect of radiation declines. The relative duration of the course of radiation in respect to the course of outdoor air temperature is dependent upon the material of the walls and ventilation conditions. The thicker the walls, the higher their thermal resistance, and the better the ventilation conditions, the lower the significance of

> radiation in comparison to the significance of outdoor temperature, since the air penetrates through the openings and directly affects indoor conditions, while circumventing the walls resistance.
>
> Therefore it seems that when the walls' external colour is light, their thermal resistance is relatively high, the windows are shaded, and indoor space is effectively ventilated, the differences in indoor conditions between the different orientations decline, and can reach a negligible degree for practical purposes.
>
> The results of this study can lead to the conclusion that the question of orientation should be reformulated: instead of asking which orientation is preferable, one should ask how to design the building and select the building materials in a way that on each orientation the most comfortable indoor conditions, given the specific climate, are maintained. In practical terms, with each orientation one should examine whether the design of the system of openings genuinely enables effective ventilation, the windows are shaded in a way suitable for the specific orientation, and the selection of external colour and material of walls prevents overheating created by intensity of radiation on the walls. (Givoni and Hoffman 1965a, 29-30)

By the middle of the 1960's, research work done by the Department of Indoor Climate enabled local architects to obtain fuller understanding of the climatic implications of their designs. Backed by Allweil's practical approach to research questions (Hoffman 2014), Givoni's work focused on answering basic design questions which could have had a direct effect on indoor climate: the orientation of walls and openings, the massing of the building, the articulation of shading devices, the use of external colour, and the composition of walls. The answers, though, were never given in a fully prescriptive (not to say dogmatic) manner, but promoted a holistic approach where an architect can consciously chose between several alternatives, each with its own positive and negative climatic aspects. As it turned out, the rapid development in local building climatology research since the beginning of the 1960's, after almost two decades of struggles and difficulties, only led to another, much more difficult, challenge: convincing architects to become attentive to the new body of knowledge and to use it for their own designs.

3.9 Israeli building climatology research in 1965: a situation report

In April 1962, a symposium on "climate and man in Israel" was arranged by the Team for Human Environmental Physiology of the National Council for Research and Development (NRCD), a governmental body which replaced the Research Council of Israel in 1959. The team was formed in 1960, and was composed almost entirely of physiology experts, including Baruch Givoni. One session of the symposium was dedicated to questions of architecture and engineering, during which Givoni lectured on the climatic effect of building and window orientation. The other presenter in the session was architect Avia Hashimshoni, then the Dean of the Faculty of Architecture at the Technion, who spoke on the "climatic problems from the architect's point of view". Hashimshoni's presentation consisted of a historical appreciation of past developments and future prospects in the field of climate and building.

Hashimshoni opened his talk by describing the historical development of climatic building solutions in Mandatory Palestine and Israel:

> If we set the beginning of new Israeli building to 1920, and the time when the current building method took its final shape to 1950-1960, we will find a time period of around forty years between the beginning of the development and the time when this development gained its full hold.
>
> We will inspect also the time scope of different stages within this process:
>
> 1. During the early 1920's the importance of orientation to the wind began to be noticed, though orientation of buildings to the prevalent wind direction was accepted as a general rule only during the mid-1930's;
> 2. The comprehension that one should not make do only with orientation to the wind, but also secure cross ventilation, consolidated during the early 1930's and became a common practice only by the end of the 1940's;

> 3. The growing preference for the northern and southern directions became gradually established from the early 1930's to the early 1950's;
> 4. 25 years passed between the time of the first use of shutters for balconies (by the late Krakauer, in the Bonem House in Jerusalem) and the common use of asbestos shutters for the protection of balconies. (Hashimshoni 1962, 128)

Following the historical review, Hashimshoni added his own appreciation of local climatic design:

> As mentioned above, it is possible to view the achievements of climatic design in Israel in positive light, and the general solutions arrived at as fitting.
>
> Throughout the years the main climatic conditions became known, and ways for their correct utilization were found; the value of wind as a factor of climatic wellbeing was understood, shading of buildings was enhanced by a correct orientation and the use of sun-shading shutters, and some of the design problems in hot regions, especially in the Negev, were solved.
>
> In contrast, one can remember cases in which people hastily jumped into "pseudo-scientific" conclusions based on partial or incomplete data. One negative example, which was mentioned above, is that, for quite a long period, people made do with orienting the rooms to the wind without securing cross wind flow. Another example is the many cases in which the shading of buildings was calculated only according to the data of the months of December and June, without controlling the situation during the rest of the year. Differences in wind directions in adjacent regions were not given attention. Another source of errors was the use of methods of heat stress evaluation, which resulted in the

> assertion that 70% of the heat losses of the body are coming into being in the form of radiation, etc.
>
> It is important to prevent dangers of wrong interpretation by the designer. Therefore, it is important to supply precise data and to prefer a smaller number of precise basic principles over the use of numerous instructions which are not fully tested, and even if tested, might lead in more than a few cases to contradictory solutions. (Hashimshoni 1962, 128-129)

Hashimshoni was keen on the development of climatic research in Israel, especially for confronting the changes in building technology and the effect of high-rise building in urban centres. Research, he thought, should be directed to three major fields: physiological hygiene, meteorology and climatology, and technical climatology; the latter was described by him as "the necessary link between the fundamental questions and their manifestation in design". Therefore, "Research in this area should be focused on its central purpose, which is equipping the designers with the possibility to predict the microclimatic conditions created in the area of his design, and mainly to provide them with the ability to adjust these conditions in advance" (Hashimshoni 1962, 133).

Hashimshoni concluded his talk with an optimistic tone, expressing his belief in the application of the results of climatic research in the common design habits of local architects:

> A systematic teaching of the fundamentals of architectural climatology was included in local architecture studies about ten years ago; since then the scope of this kind of teaching has been growing. Study begins now already in the first year, and the architect receives the climatological basis even before practical design begins. This systematic teaching will prevent the future architect from tackling the difficulties of his predecessor; the latter arrived at the appreciation of the

> climatic element through self-teaching, which resulted in certain limitations.
>
> In the current works by students one can sense a tendency for arriving at a comprehensive solution for building climatology through a consistent and powerfully-expressed method. (Hashimshoni 1962, 134)

Yet Hashimshoni's hope for the future generations of architects was probably too optimistic. His promotion of scientific education for architecture students as the Dean of the Faculty of Architecture at the Technion confronted strong opposition, which led to a full-fledged academic mutiny of fellow-professors during 1965. The opposition group, led by architect Al Mansfeld, claimed that architecture teaching should be based on the syntactic studio system which allegedly mimics an actual design process, not on structured teaching of separate and detached subjects (Haelyon 1965, Alpert 1982, 336-338). The conflict was not fully resolved, and Hashimshoni, who was probably the most ardent promoter of the application of climatic knowledge into design among the Faculty's senior members, was eventually forced to step down from his position as the Faculty's Dean.

While education of future generations was still under debate, the practices of the present generation of local architects proved to be less ideal than in Hashimshoni's description from 1962, at least when analysed by Givoni. A clear sense of frustration from local design habits and the neglect of climatic knowledge was already beginning to infiltrate his answers to members of the press at the same time of Hashimshoni's proud presentation on the advancements in local climatic architectural design, claiming that "many architects see their profession as art and not as science" (Nesher 1962) and that "in many cases we do not [build reasonably][...] we could have been a more productive and healthier nation, had we built better houses" (Pundak 1963). Givoni's attempts to change the state of affairs were directed to harnessing governmental authorities for the modification of design customs, probably as a result of lack of genuine cooperation from within the Technion, his own academic home.

As mentioned above, Givoni's expertise in physiology led to his inclusion in the NRCD's Team for Human Environmental Physiology. During the team's meeting on 28 July 1964, Givoni announced that "following previous decisions to establish a sub-committee for [building issues], and after meeting with members of the National Council for Research and Development, it was suggested to establish a committee which include members familiar with building, building research, physiology, and meteorology" (Human Environmental Physiology Team 1964). In spite of its alleged resemblance to the Sub-committee for Indoor Climate of the 1950's, the new committee was not established in order to approve specific research proposal, but as an advisory body which would promote research in unaddressed problems. Givoni was selected as the chairman of the committee, whose original composition included Rahel Shalon, Ezra Zohar (1922-2014, an expert on physiology from Tel Hashomer hospital), Michael Fuchs, Asher Allweil, and Arie Ron from the NRCD. During the second meeting, Mordechai Gilead, the director of Israel Meteorological Service, was added as a member.

The first meeting of the Committee for Building-Climate (as it was named), which was active until the end of 1965, was held on 31 August 1964. Givoni tried to describe the Committee's mission in the following way:

> a. To find out to what extent climatic aspects are considered in town planning and building.
> b. To present those active in planning and responsible for building with the results of the physiological studies and the resulting conclusions pertaining to planning. In addition, to find out what are the climatic problems they face during planning and which of them call for research.
> c. To recommend the National Council for Research and Development on required studies for securing healthy

> and comfortable conditions in places of dwelling and work. (Committee for Building-Climate 1964a)

Givoni's first two points implicitly indicated that he sensed a problem in knowledge dissemination. Zohar was much more outspoken, and argued that

> The current state of the subject of building-climate in our country is not proportional to the results of the studies and the great amount of knowledge that has been accumulating here on the subject. One of the missions of the committee should be the translation of this knowledge into reality, by convincing the people who are actually practicing it. Possibly, it is worthwhile to establish here a professional institution, like the Building Research Station, which will control all governmental building and local town planning. In times to come private building will also apply for the approval of such institution. The institution will examine a building proposal only from a climatic point of view. (Committee for Building-Climate 1964a)

Eventually, the members of the committee agreed on two missions: studying the research needs and the current adaptation of building to climate, and consulting the relevant ministries on promoting the climatic adaptation of buildings. It was also decided to add an architect to the team; on the committee's next meeting on 28 October 1964 Givoni recommended Wittkower, "who has been interested in problems of building-climate for many years", and his proposal was approved. Among other issues, the discussion addressed the problem of the "introduction of indoor climate-related knowledge in building to the minds of architects and shapers of building" in Israel. Four suggestions were presented: to use the BRS bulletin (*Bisde Habniya*, lit. "In the Field of Construction") as a publishing tool; to arrange a conference for architects on these issues; to use the public media for dissemination of knowledge; and to require architects of public projects to consult the committee in questions of climate (Committee for Building-Climate 1964b).

The third meeting of the Committee, which was held on 20 January 1965, was dedicated to the relations between the Ministry of Housing and the Department of Indoor Climate at the BRS. The meeting took place in the offices of the Ministry of Housing in Tel Aviv and was attended by high officials in the Ministry: architect Alexander Piekarczyk (1909-1996), architect Hanan Martens (1912-1982), architect A. Robinson, architect M. Yaron, and engineer M. Strum. This was an unusual occasion: Givoni had the opportunity to present his dissatisfaction with the application of climatic knowledge in front of the main culprits, as Allweil, the main promoter of climatic research in the Ministry, watches. The discussion exposed the intrinsic difficulties building climatology research in Israel faced during the mid-1960's in a way that could be regarded as emblematic to the relation between architectural practice and scientific knowledge in general.

Allweil opened the meeting and suggested to discuss the initiation and implementation of climate-building research by the Ministry of Housing. He told the participants that "the Ministry of Housing promotes actions of building research via a special budget, of which problems of climate-building occupy a major part", and then asked Givoni to describe the relation between the BRS and the Ministry of Housing. Givoni came prepared, and read a written review whose draft is kept in Israel State Archives:

> The relation between the Building Research Station and the Ministry of Housing in problems pertaining to climate conditions in buildings is manifested in two ways:
>
> a. Studies commissioned to the Station by the Ministry of Housing.
> b. Consultancy in climatic problems for planners of the Ministry of Housing.

Studies

The subjects of the studies conducted on behalf of the Ministry of Housing are (according to the studies list):

1. The influence of ceiling height in dwelling houses.
2. Location of openings in dwelling houses.
3. Influence of roof type and construction on indoor thermal conditions.
4. Preliminary study [of the influence] of window orientation on indoor climate.
5. Influence of building orientation in Eilat on indoor temperature and the inhabitants' sensations.
6. Internal ventilation of bathrooms.
7. Effectiveness of shading devices.
8. Problems pertaining to design of buildings with different climatic orientations in the Negev.
9. Comparison of wall types in Jerusalem.

The application of research results was not done on a regular basis. Studies which had an effect on construction savings, like the possibility to lower the ceiling height, had an immediate application. In respect to other studies, which require special acquiring of knowledge and a careful design of building details, there was a more significant difficulty in actual use of the research results. This was manifested, for example, in the application of the research results on problems of orientation, which do not lead to conclusive recommendations, but suggest different directions for solution finding according to the selected orientation.

There were also cases in which research results contradicted common practices, for example in respect to the prefabricated building method in Eilat, and it seems that they were effectively disregarded.

Consultancy

An attempt was made to create a regular system of consultation in climatic problems for planners of the Ministry of Housing. This attempt was unsuccessful. The failure was an outcome of several reasons. In some cases consultancy was asked in subjects requiring preliminary research, and when the planner did not receive an immediate advice to such problems he lost interest in further consultation. There were planners who thought that such procedure complicates their work and therefore, since there was no formal obligation to take climatic elements into account, were not inclined to it in the first place. There were cases in which architects were offended by criticism of their disregard for climatic factors and it seems that the Ministry of Housing probably did not find a way to push them in that direction.

On the other hand, it should be noted that there were departments in the Ministry of Housing which showed interest in climatic consultation and used it on an ongoing basis.

A year ago the arrangement was changed and the Ministry of Housing asked for separate consultancy on any problem the planner finds appropriate for such consultation. The departments that in the first place showed interest in climatic problems continue to ask for consultancy and receive it according to the new arrangement. Other departments totally refrain from approaching the Station in such issues.

Summarizing the past experience, it seems to me that if one wants to arrive to a point of real application of research results, two problems should be addressed:

a. If possible, research results should be formulated as legally-binding obligations, for instance in respect to insulation capacity in different [geographical] regions, shading of windows, etc. As for the Ministry of Housing, there is a possibility to first set internal guidelines by the Ministry without official approval, which will be tested in reality and gradually improved, until they could become a basis for official legislation.

b. To find a procedural arrangement that will secure preliminary examinations, the formulating of recommendations, and examination of plans during the different stages of planning.

Proposals for the team on building and climate:

Setting formal and technical procedure for the following subjects:

a. Preliminary meteorological examinations, towards planning in new regions. Maximal and minimal temperatures in summer and winter, summer and winter winds, precipitation amounts and distribution, humidity.

b. Contact with planners in respect to general planning (town planning): street orientation, building orientation, gaps between buildings.

c. Climatic examination of new building types: building materials, sun penetration, ventilation, condensation, rain penetration.

d. Special problems like prefabricated building.

Regarding each subject:

- Pointing out the bodies with whom contact should be made
- The formal arrangement of the contact

- Discussion on whether the required knowledge is available for providing consultancy in the subject
- Recommendations on the necessary studies for acquiring missing knowledge
- Examination whether the subject could be subjected to legislative requirements (Givoni 1965)

Following this review, Givoni presented another paper, written in cooperation with Gilead, on the "Climatological basis for Planning New Towns in our Country". New towns or settlements were not an uncommon sight in Israel of the 1960's, and the paper had therefore great relevance to actual planning initiatives. Gilead and Givoni suggested to conduct a preliminary meteorological survey, and to use its results for preparing a list of climatic guidelines on "the size of the building blocks, the height of the buildings in the different blocks, distances between buildings, parks, orientation and width of the main streets, and transportation". The last step would be the setting of guidelines for building design which will address issues like building materials, building orientation, opening size and orientation, balconies, and shadings (Gilead and Givoni 1965).

Allweil was the first to respond to Givoni's criticism. He argued that "the planners cannot be accused" since in many issues the only available knowledge is outdated, and mentioned the lack of data on the climatic effects of common building materials. Wittkower expressed his opinion that the problem lies in the translation of knowledge to design, and suggested to set an "information service" for architects, to provide meteorological data for planners, and to distribute knowledge through bulletins. Martens admitted that a problem exists, but argued that "the problem is educational, and does not concern only architects [...] the problem exists during preliminary planning". Shalon was less confident that architects could really solve the problem; she said that "we all know, based on our experience, that an architect lacks fundamental knowledge in climatology". She then suggested that any plan should be submitted to the examination of climatologists. Piekarczyk was much more optimistic, and argued that "today the indoor climate of an apartment is less and less dependent on the outdoor weather. Not far from today it will be possible to install cooling and ventilation in the streets, as is now customary in houses". Allweil ended the discussion by agreeing that a climatologist should be added to the planning team on an early stage. The meeting adjourned with a decision to arrange another meeting with planners of the Ministry of Housing from the different districts (Committee for Building-Climate 1965). Such a meeting never took place.

The Committee's meeting gave Givoni an opportunity to express his frustration from the design and planning practices of local architects and planners. Contrary to Shalon's ongoing complaints on the lack of funding (Haelyon 1966a), Givoni's criticism showed that even when budgets are allocated and research produces useful results, its application is partial, if not lacking at all. The cooperation with the Ministry of Housing was vital for the research achievements of the 1960's, but while research in building climatology during Givoni's years as the head of the Department of Indoor Climate (which changed its name to the Department of Building Climatology in 1966) have progressed in giant leaps when compared to the research activities during the 1940's and 1950's, it still had a minor effect on common design practices. As already mentioned, in interviews to the press during the 1960's Givoni recurrently expressed his discontent from local design habits (Nesher 1962, Pundak 1963, Haelyon 1966b); the picture remained quite the same some years later, leading Givoni to the conclusion that "unfortunately, local architecture is perceived mainly as art, and its scientific sides are almost entirely ignored" (Magen 1974). Like a voice crying in the wilderness, research continued to produce knowledge while its application was lagging far behind.

3.10 Conclusion

Building climatology research in Israel was perceived as a crucial area of concern since the very first days of the state. This was a result of the bitter failures of the past, enhanced by the urgent need to build new housing in extents never before realized in Palestine. The errors of the past, the unsatisfactory indoor climate conditions created by uncalculated and uninformed architectural design, were now regarded as a potential nightmare for the present and future living conditions. The urgency was felt, but the means to overcome the fears were poor and insufficient.

After a decade of slow beginnings and lack of minimal support by the central government during the 1940's, one could have expected that the establishment of the new state would transfer building research in general and building climatology in particular to a new era. Yet organizational problems, as well as unhealthy competition on the relatively limited resources allocated to building research, resulted in almost a decade of standstill. The same power struggles resulted in the distribution of research effort in a way that prevented gradual accumulation of knowledge. In spite of the external help provided by the UN in matters of research organization, the potentially useful advice of foreign experts failed to be implemented mainly because too many elements were trying to secure their position in the field of building research. Wittkower, at that time the only true experienced architect in the field of building climatology, was left outside, lacking any affiliation to any centre of power, and especially not to the evolving centre of power at the Technion. As a result, building climatology's potential to affect local design practices still remained relatively limited. The theoretical guidelines and conclusions presented by Wittkower in his 1940's articles were still the most productive reading material in building climatology for local designers and planners even by the end of the 1950's.

What eventually enabled a breakthrough in building climatology research in Israel was a joint effort of determined individuals (Rahel Shalon, Asher Allweil, and Baruch Givoni) who held key positions in the establishment. Shalon founded and developed the Building Research

Station in spite of her continuing complaints on the lack of public funding; Allweil was the de-facto coordinator and promoter of building research in Israel since the mid-1950's, harnessing the resources of the housing authorities for developing research; and Givoni, with his expertise in architecture, physiology, and climatology, was the right person to fuse theoretical and practical research with concrete design questions to create a solid basis for climatically-aware architectural design in a relatively short time.

Probably the most significant contribution of Givoni's work to local building design until 1965 was the end it put to three decades of somewhat simplistic discussions on a "preferable" building orientation. Givoni attacked the problem from a holistic point of view, reformulating the question of orientation as a question of the cumulative effect of several factors which include wall insolation, wall rendering, wall thickness and composition, wall and window shading, window size and shape, and natural ventilation. Thus, instead of prescriptive solutions, Givoni's approach mandated that architects acknowledged that climatic building design calls for an analytical synthesis of different climatic factors, and that the design solution can only be determined by the full consideration of all climatic factors. This systematic and integrative outlook proved to be even less successful than the prescriptive approach in its common application by architects since it required them to acquire more than a superficial understanding in the climatic aspects of building.

Givoni's revolution in local building climatology research finally exposed what until then was only implied: that architects in Israel, while securing a central rhetoric position for the notion of climate, were never genuinely interested in scientific research of its relation to building, nor in the intelligent application of the products of such research. Architects, so it seemed, were interested in climate as a general idea, not as a factual reality that could determine central design features. By the mid-1960's, when climatic knowledge and understanding gained maturity, it was suddenly realized that the knowledge barrier that once existed was far more easy to cross than the barrier of old professional habits.

4 THE GILMAN BUILDING, TEL AVIV UNIVERSITY

4.1 Historical background

The Gilman Building at the heart of the Tel Aviv University campus (32.112 N, 34.805 E, 39 m above sea level, Figure 4.1) is the main building of the University's Faculty of Humanities. It was originally built with two main floors, each of about 3500 m², and a basement floor of about 3100 m²⸴ and consisted of two rectangular wings, northern and southern, connected by a single corridor (or a "bridge"); each wing was arranged around two non-identical rectangular courtyards. A third floor, which was only designed in 1972, was built on top of the second floor in 1974-1975, following the same layout of the original floors.

Figure 4.1: Gilman Building (in the centre) in a contemporary aerial photograph (gisn.tel-aviv.gov.il)

4.1.1 The designers of the Gilman Building

The Gilman Building was designed during 1963 and built between 1964 and 1965 by architect Werner Joseph Wittkower and his partner, Erich Baumann, with architect Israel Stein (b. 1934) as the office's architect in-charge. Wittkower was also, alongside with three other architects (Dov Karmi, Arieh El-Hanani, and Nahum Salkind), a member of the planning committee who developed the master plan for the university campus. It was the third building to be built in the University's new campus and the completion of its southern wing marked the campus' official inauguration, celebrated on 4 November 1964 (Davar 1964b).

Scarcity of archival materials renders a precise reconstruction of the design process of the building impossible. Original architectural and HVAC plans are kept at the Engineering and Maintenance Unit of the Tel Aviv University, but there is a real shortage in other types of supporting documents (correspondences, protocols, programmes) that could help in shedding light on the motivations and considerations behind the design. At the same time, the remaining evidence, as well as several personal interviews conducted by the author with Stein during 2012, is rich enough to enable a reliable analysis of the climatic facets of the design.

While Wittkower, a local pioneer of building climatology (see above, section 2.4 and on), is commonly and officially recognized as the building's architect, Stein was arguably the key figure behind many features of the design, including those affecting the building's thermal performance. In all conversations we had, Stein, who later became Wittkower's partner, expressed his deep respect for Wittkower and was quite careful not to leave any impression that the design should be solely attributed to him. Yet Stein's name and the title "participating architect" do appear on the original architectural plans of the building, and the official sign at the construction site did indicate him as the "junior architect" of the project (Figure 4.2). These facts, as well as his thorough and lucid description of the design decisions half a century after they were taken, can indicate that Stein was much more than a humble draftsman in this project.

Stein was a young architect at that time. He was born in Poland and miraculously survived the Second World War under Nazi occupation. After the war Stein and his parents immigrated to Belgium, and from there, in 1949, to Israel, where he studied architecture at the Technion in Haifa between 1955 and 1959. Following his graduation, Stein worked for a year for Sharon-Idelson architects, one of the prominent architecture firms in Israel at that time. In 1961 he spent several months in France after receiving a grant for advanced studies in town planning. The next year, he joined Wittkower-Baumann. According to Stein, he favoured the idea of joining Wittkower's office for two reasons: first, Wittkower knew how to constantly draw in big commissions; and second, besides Wittkower, he was at that time the only certified architect in the firm, which meant bigger responsibility (all other members in the office, including Baumann, had no formal training as architects). As Stein put it, he and Wittkower shared "good chemistry" and Wittkower "liked things that I have done, liked my attitude" (Stein 2012b). This probably led to the relative freedom given to Stein as a designer. As Stein himself wrote years later, "Wittkower knew how to give his younger partners a free hand in developing the idea through individual interpretation. This way enables mutual fertilization and enrichment" (Stein 1993). This "mutual fertilization" included Wittkower's long-time interest in building climatology; in Stein's words, Wittkower's "main influence" on him "was that I had internalized the importance of the climatic issue, and this manifested itself mainly through sun protections, because an architect has little control, to say the least, over building orientation" (Stein 2012b).

Figure 4.2: The official sign at the Gilman Building construction site indicating the names of the general contractor, architects, and engineers. Photograph by Isaac Berez (Tel Aviv University Archive). Stein's name appears (in Hebrew) next to the names of Wittkower and Baumann, with the title "junior architect"

4.1.2 Architectural shading design in Israel of the 1950's and 1960's

THE INVENTION OF THE *BRISE-SOLEIL*

Stein's interest in sun protections was not uncommon among Israeli architects of the 1950's and 1960's. Architectural shading was attracting a considerable amount of international attention during the same years, and local architects, who were always very receptive to external influence, made it a fertile ground not only for climatic enhancement of buildings but also for aesthetic experimentation. In that sense, Israel's shading idioms were primarily developing under the direct influence of imported trends, mainly that of the *brise-soleil* (French for "sun breaker") idiom of the contemporaneous Brazilian architecture, and not as a purely original response to local climate conditions.

The story behind the invention of the *brise-soleil* is closely related to the innovative use of glass in architecture which was promoted by Le Corbusier and others after the end of the First World War. Le Corbusier was particularly interested in what he called *pan de verre* ("Glass Wall"), which meant the application of glass as a main cladding material for facades. The fully-glazed curtain wall came into being when a solution was searched for the alleged health risk of the lack of natural light in residential units. Yet, after the application of the radical solution of the fully transparent facade in several projects, and mainly in a Salvation Army hostel named *Cité de Refuge* in Paris (1932-1933), Le Corbusier arrived at the conclusion that "the summer solstice and the dog days with their unbearable temperatures make the sun, our friend, a fierce enemy; during these hot hours, the need becomes imperative: the windows must be obstructed, the glass wall must be 'diaphragmized'" (Le Corbusier and Boesiger 1946, 104). In other words, the emergence of the glazed curtain wall created the need for efficient sun control in order to regulate the sun's direct penetration into the building, since the amounts of solar radiation absorbed in this way by the structure during the hot season resulted in an uncontrollable overheating of the indoor spaces (Banham 1984, 151-158). This problem had even graver consequences in a world in which air conditioning had yet to become an integral part of the expected services in common buildings.

The solution, as devised by Le Corbusier, was to screen the curtain wall with an additional structural layer of "sun breaking" elements, horizontal or vertical, that besides their climatic role entirely transformed the aesthetic impression left by the facade. Instead of the two-dimensional, uniform, and immaterial transparency of the glass wall, Le Corbusier introduced a three-dimensional, complex, and sculptural array of thin surfaces. His first opportunity to examine the new invention on real ground was in Brazil: in June 1936 Le Corbusier arrived in Rio de Janeiro to consult a group of local architects (headed by Lúcio Costa and Oscar Niemeyer) during the design of the Ministry of Education and Public Health Building. One result of this encounter can be seen in the distinct difference between the building's cool, southern facade, which was sealed by a glazed curtain wall, and its northern facade, which was exposed to direct sun light and therefore received a supplementary shading array. It was constructed of concrete-cast horizontal and vertical surfaces which divided the facade into identical rectangular fields (a pattern which will later be nicknamed "egg crate"). Blue horizontal Eternit (asbestos cement) louvers were installed on the upper part of each rectangular field and could be mechanically adjusted in response to the changing position of the sun (Laar 2001, Barber 2012).

According to the official Corbusian historiography, the seed of the *brise-soleil*, planted by Le Corbusier in 1936, sprouted almost overnight as a creative gush of an original variety of structural shading solutions that Niemeyer and his contemporaries were applying in Brazil. Niemeyer himself included *brise-soleil* arrays in several projects that were completed even before the inauguration of the Ministry of Education and Public Health Building in 1943, among them a day nursery (*Obra do Berço*) built in Rio in 1937, the Brazilian Pavilion in New York World's Fair of 1939 (designed in cooperation with Costa) and the yacht club in Pampulha, completed in 1942. The extrovert use of structural shading elements gave the young Brazilian modernism a distinctive character, which began to attract international attention.

In January 1943, while the battles of the Second World War were at their utmost intensity in Europe, North Africa, and Asia, an exhibition named *Brazil Builds* opened at the Museum of Modern Art (MOMA) in New York, curated by architect Philip Goodwin. In the book accompanying the exhibition Goodwin did not hesitate to claim that

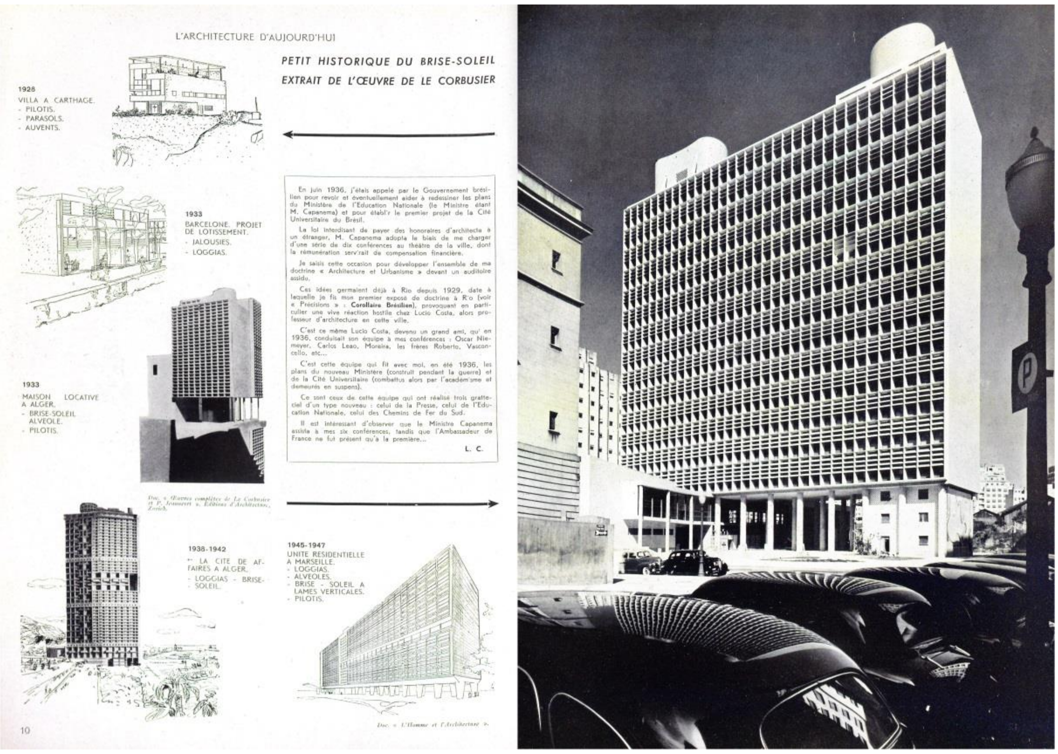
> [Brazil's] great original contribution to modern architecture is the control of heat and glare on glass surfaces by means of external blinds. North America has blandly ignored the entire question. Faced with summer's fierce western sun, the average office building is like a hot-house, its double-hung windows half closed and unprotected. The miserable office workers either roast or hide behind airless awnings or depend in the feeble protection of Venetians blinds, – feeble because they do nothing to keep the sun from heating the glass. It was curiosity to see how the Brazilians had handled this very important problem that really instigated our expedition [to Brazil]. (Goodwin 1943, 81, 84)

Four years later, the leading French architecture magazine *L'Architecture d'Aujourd'hui* dedicated most of its September 1947 issue to the modern architecture of Brazil. The review opened with a double-page spread which tried to epitomize Brazil's genuine contribution to modern architecture: to the left, a text by Le Corbusier describing "a little history of the *brise-soleil*", accompanied by an illustrated genealogy of some of his own non-Brazilian projects; to the right, a spectacular photograph of the northern facade of the Ministry of Education and Public Health Building (Figure 4.3). On the cover of another issue dedicated by *L'Architecture d'Aujourd'hui* to Brazil (August 1952) appeared an illustration showing schematic sun beams intercepted by shading louvers (Figure 4.4).

Albeit the tremendous proliferation of the *brise-soleil*, in the eyes of Le Corbusier there was at least one flaw in the way his idea was interpreted in Brazil. As he wrote some years later

> The Ministry of Education and Public Health [...] offers the first example of the use of brise-soleil in modern architecture. But a mistake was made. The horizontal panels of the brise-soleil are movable. The real principle is this. It is the sun which does the moving, never once occupying the same place in the sky for 365 days. A scheme can therefore be devised based on precise data: a) the course of the sun on every day of the year; b) problems of the latitude of the place under consideration. (Le Corbusier 1960, 111)

Le Corbusier's insistence on the unmovable version of the *brise-soleil* seems a matter of private tendency to total control, not a genuine performance issue, since his own argument actually contradicts his conclusion. Contrary to Le Corbusier's belief, during each year the sun's daily course is repeated twice, not once, except from the solstice days of the 21st of June and the 21st of December. Therefore, unmovable *brise-soleil* which will break the sun beams during the hot months of August and September (as it is in Israel), should also break the same sun beams during the much cooler months of April and March (Mackenzie 1993, 72). Such a result is undesirable, at least in the eyes of the common user. Unmovable shadings have two main advantages which have nothing to do with their climatic role: the much lesser maintenance needed for them, and the unchangeable nature of their appearance, which prevents the users from altering the visual impact of the facade. The latter must have been the real motivation behind Le Corbusier's somewhat dogmatic imperative.



L'ARCHITECTURE D'AUJOURD'HUI

PETIT HISTORIQUE DU BRISE-SOLEIL
EXTRAIT DE L'ŒUVRE DE LE CORBUSIER

1928
VILLA A CARTHAGE.
- PILOTIS.
- PARASOLS.
- AUVENTS.

1933
BARCELONE. PROJET DE LOTISSEMENT.
- JALOUSIES.
- LOGGIAS.

1933
MAISON LOCATIVE A ALGER.
- BRISE-SOLEIL ALVEOLE.
- PILOTIS.

Doc. « Œuvres complètes de Le Corbusier et P. Jeanneret », Éditions d'Architecture, Zurich.

En juin 1936, j'étais appelé par le Gouvernement brésilien pour revoir et éventuellement aider à redessiner les plans du Ministère de l'Education Nationale (le Ministre étant M. Capanema) et pour établir le premier projet de la Cité Universitaire du Brésil.

La loi interdisant de payer des honoraires d'architecte à un étranger, M. Capanema adopta le biais de me charger d'une série de dix conférences au théâtre de la ville, dont la rémunération servirait de compensation financière.

Je saisis cette occasion pour développer l'ensemble de ma doctrine « Architecture et Urbanisme » devant un auditoire assidu.

Ces idées germaient déjà à Rio depuis 1929, date à laquelle je fis mon premier exposé de doctrine à Rio (voir « Précisions » : **Corollaire Brésilien**), provoquant en particulier une vive réaction hostile chez Lucio Costa, alors professeur d'architecture en cette ville.

C'est ce même Lucio Costa, devenu un grand ami, qu'en 1936, conduisait son équipe à mes conférences : Oscar Niemeyer, Carlos Leao, Moreira, les frères Roberto, Vasconcello, etc...

C'est cette équipe qui fit avec moi, en été 1936, les plans du nouveau Ministère (construit pendant la guerre) et de la Cité Universitaire (combattus alors par l'académisme et demeurés en suspens).

Ce sont ceux de cette équipe qui ont réalisé trois gratte-ciel d'un type nouveau : celui de la Presse, celui de l'Education Nationale, celui des Chemins de Fer du Sud.

Il est intéressant d'observer que le Ministre Capanema assista à mes six conférences, tandis que l'Ambassadeur de France ne fut présent qu'à la première...

L. C.

1938-1942
← LA CITE DE AFFAIRES A ALGER.
- LOGGIAS - BRISE-SOLEIL.

1945-1947
UNITE RESIDENTIELLE A MARSEILLE.
- LOGGIAS.
- ALVEOLES.
- BRISE - SOLEIL A LAMES VERTICALES.
- PILOTIS.

Doc. « L'Homme et l'Architecture ».

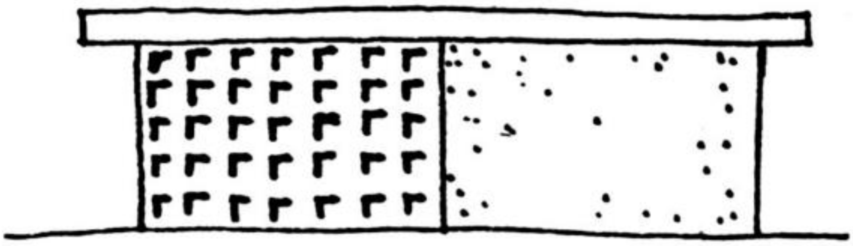
10

Figure 4.3: The opening double-page spread of the "Brazilian" section of the September 1947 issue of *L'Architecture d'Aujourd'hui*

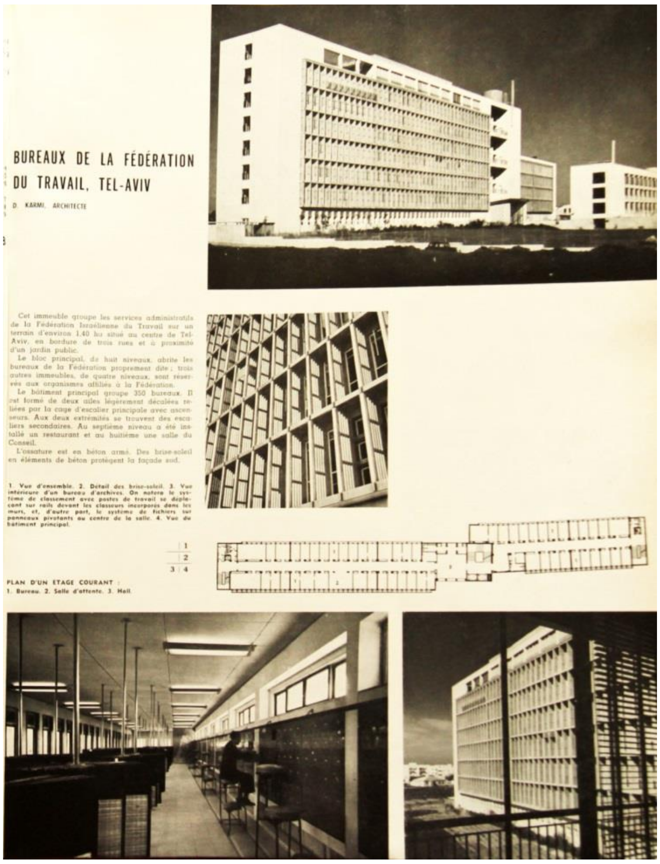
Figure 4.4: Cover of the August 1952 issue of *L'Architecture d'Aujourd'hui*

BRAZIL OF THE MIDDLE EAST

The architecture of Brazil immigrated to the young state of Israel in the beginning of the 1950's (Elhyani 2002, 40-43). Except from David Reznik, who came to Israel from Brazil in 1949, real Brazilian architects did not design actual projects in Israel, but a continuing flow of professional books and magazines, in which the Brazilian shading devices still received considerable attention, facilitated the absorption of Brazil's unique idiom of *brises-soleils*. A rather amusing description of the trend is given in Israel Goodovitch's 1967 book *Architecturology*, in a section dedicated to his architecture studies at the Technion in Haifa:

> February 1954
>
> After the first term vacation, we are assigned our year's project: a forest-keeper's cabin. Pretty soon I could not find most of the students in the drafting rooms – everybody was in the library. It was here, on the shelves, that one was literally suffused by the terrific abundance of the latest information; the newest criteria of beauty; the most recent achievements. *Les Magazines!*
>
> By the time I found out that we were living and creating in the "Brazilian Period" (according to the magazines) – it was already too late.
>
> 
>
> The "variations on the Brazilian Theme" overshadowed any individual searchings. (Goodovitch 1967, 10)

The replication of the Brazilian shading devices in new Israeli projects was usually given a climatic justification, as if it had only a minor relation to the current fashion in the world of architecture. Thus, architect Dov Karmi, one of Israel's most brilliant architects who designed an intricate precast concrete shading array for the southern facades of his Headquarter of the *Histadrut* project in Tel Aviv (1949-1955, Figure 4.5), argued in 1953 that the sun breakers (which he also called "Brazil shutters") "will be able to make it possible to adjust our building to our nation's climate and the designs of the planners". Karmi also found an alleged connection between local shading solutions and the Brazilian examples, claiming that "the source of the ray-breaker is the Near East, and we may find proof of this in the shutters and pergolas of the Old City of Jerusalem, which are built of thin wooden slats in a wrap and weft pattern, while the steep walls and parapets are built from pieces of ceramic pipes" (Karmi 1953, 14).



BUREAUX DE LA FÉDÉRATION
DU TRAVAIL, TEL-AVIV

D. KARMI, ARCHITECTE

Cet immeuble groupe les services administratifs de la Fédération Israélienne du Travail sur un terrain d'environ 1,40 ha situé au centre de Tel-Aviv, en bordure de trois rues et à proximité d'un jardin public.

Le bloc principal, de huit niveaux, abrite les bureaux de la Fédération proprement dite ; trois autres immeubles, de quatre niveaux, sont réservés aux organismes affiliés à la Fédération.

Le bâtiment principal groupe 350 bureaux. Il est formé de deux ailes légèrement décalées reliées par la cage d'escalier principale avec ascenseurs. Aux deux extrémités se trouvent des escaliers secondaires. Au septième niveau a été installé un restaurant et au huitième une salle du Conseil.

L'ossature est en béton armé. Des brise-soleil en éléments de béton protègent la façade sud.

1. Vue d'ensemble. 2. Détail des brise-soleil. 3. Vue intérieure d'un bureau d'archives. On notera le système de classement avec postes de travail se déplaçant sur rails devant les classeurs incorporés dans les murs, et, d'autre part, le système de fichiers sur panneaux pivotants au centre de la salle. 4. Vue du bâtiment principal.

PLAN D'UN ETAGE COURANT :
1. Bureau. 2. Salle d'attente. 3. Hall.

Figure 4.5: An article on Dov Karmi's *Histadrut* Headquarters in Tel Aviv, as it appeared in the December 1956 issue of *L'Architecture d'Aujourd'hui*

While Karmi more than welcomed the new Brazilian idiom, another leading architect of that era, Arieh Sharon, had more doubts regarding the possibility of proper incorporation of the Brazilian idiom into local architecture. In his words,

> During the recent years architects [in Israel] have been experimenting with climatic problems, not without the influence of Brazilian architecture and the advantages and disadvantages linked with the foreign. There are many treatments that are purely formal, using a decorative texture of elevation by means of hollow bricks, multi-form concrete blocks, and various, occasionally rich, colour schemes.
>
> The climatic approach is basically correct, but the problem is to differentiate between mere fashion and the organic solution. The search for ways of providing climatic protection has to be varied according to the different parts of the country. I have already mentioned the extensive use of terraces in urban and public buildings. These have a functional purpose besides that of effective climatic protection. In most rural buildings it is possible to provide natural and inexpensive protection by planting various kinds of trees at suitable distances, and in spots which need to be secured from heat or winds. Effective experiments of this kind have been made in various collective settlements in the sub-tropical Jordan Valley.
>
> In several multi-storey public buildings climatic protection has been provided through vertical or horizontal *brissoleil* [sic.] shutters movable according to the direction of sunrays and prevailing breeze. It would be of interest in this respect to follow the old forms and patterns of climatic protection, which were often used in the Middle East and to develop them according to our new technical possibilities. (Sharon 1956, 55)[5]

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[5] I am indebted to Zvi Elhyani, founder and director of Israel Architecture Archive, for referring me to this valuable article.

Sharon himself was one of the greatest promoters of the use of movable *brises-soleils*, and his works from the 1950's and 1960's exhibit a clear influence of Brazilian modernist architecture. One of the finest examples for this preference is the Lessin House-Hamlin House project in Tel Aviv (built in two stages between 1952-1956), in which movable and vertical asbestos cement *brises-soleils* covered the fully glazed western facade (Figure 4.6), while parts of the southern facade (Figure 4.8) received some similar horizontal *brises-soleils*, in a manner that more than reminds some of Niemeyer's projects of the 1930's and 1940's (Figure 4.7 and Figure 4.9). This was not just a blind act of mimicry: Sharon and Idelson described in detail the climatic considerations behind the design of each facade in an article which appeared in the *Journal of the Association of Engineers and Architects in Israel*, stressing that the "all-sided orientation called for an individual solution for each facade, in accordance with the directions of the sun and the wind, and the function of indoor spaces that are protected by the different facades" (Sharon and Idelson 1955, 3).

Figure 4.6: Arieh Sharon and Benjamin Idelson, the western facade of Lessin House, Tel Aviv, 1956 (www.ariehsharon.org)

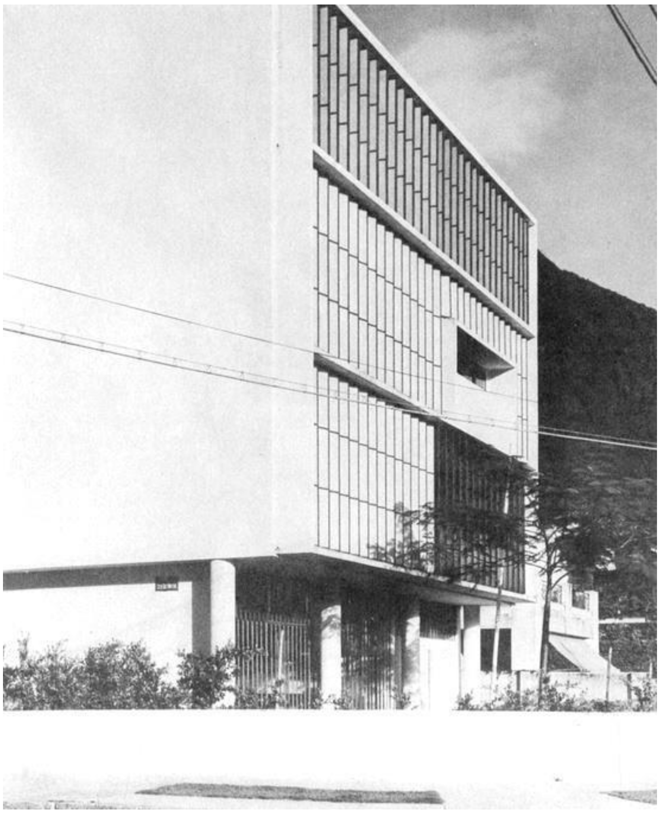


Figure 4.7: Oscar Niemeyer, *Obra do Berço* day nursery, Rio de Janeiro, 1937, western facade (Olgyay and Olgyay 1957, 154)

Figure 4.8: Arieh Sharon and Benjamin Idelson, the southern and western facades of Hamlin House and the western facade of Lessin House, Tel Aviv, 1956 (www.ariehsharon.org)

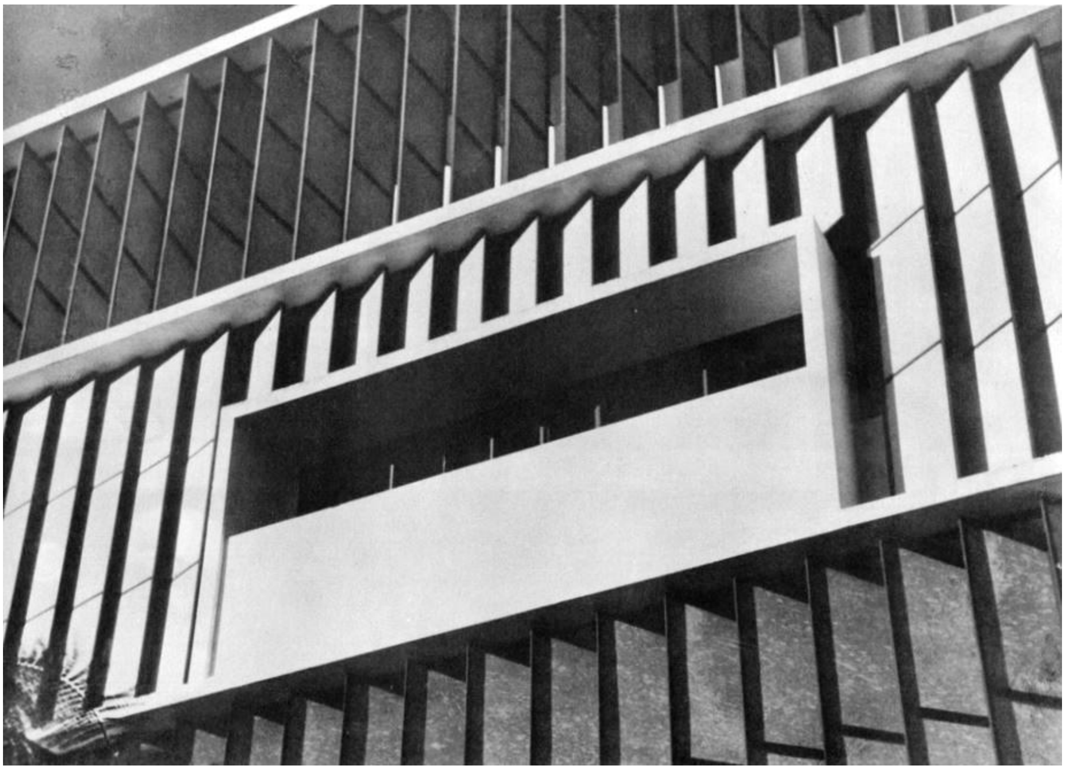


Figure 4.9: Oscar Niemeyer, *Obra do Berço* day nursery, Rio de Janeiro, 1937, detail of the western facade (Olgyay and Olgyay 1957, 155)

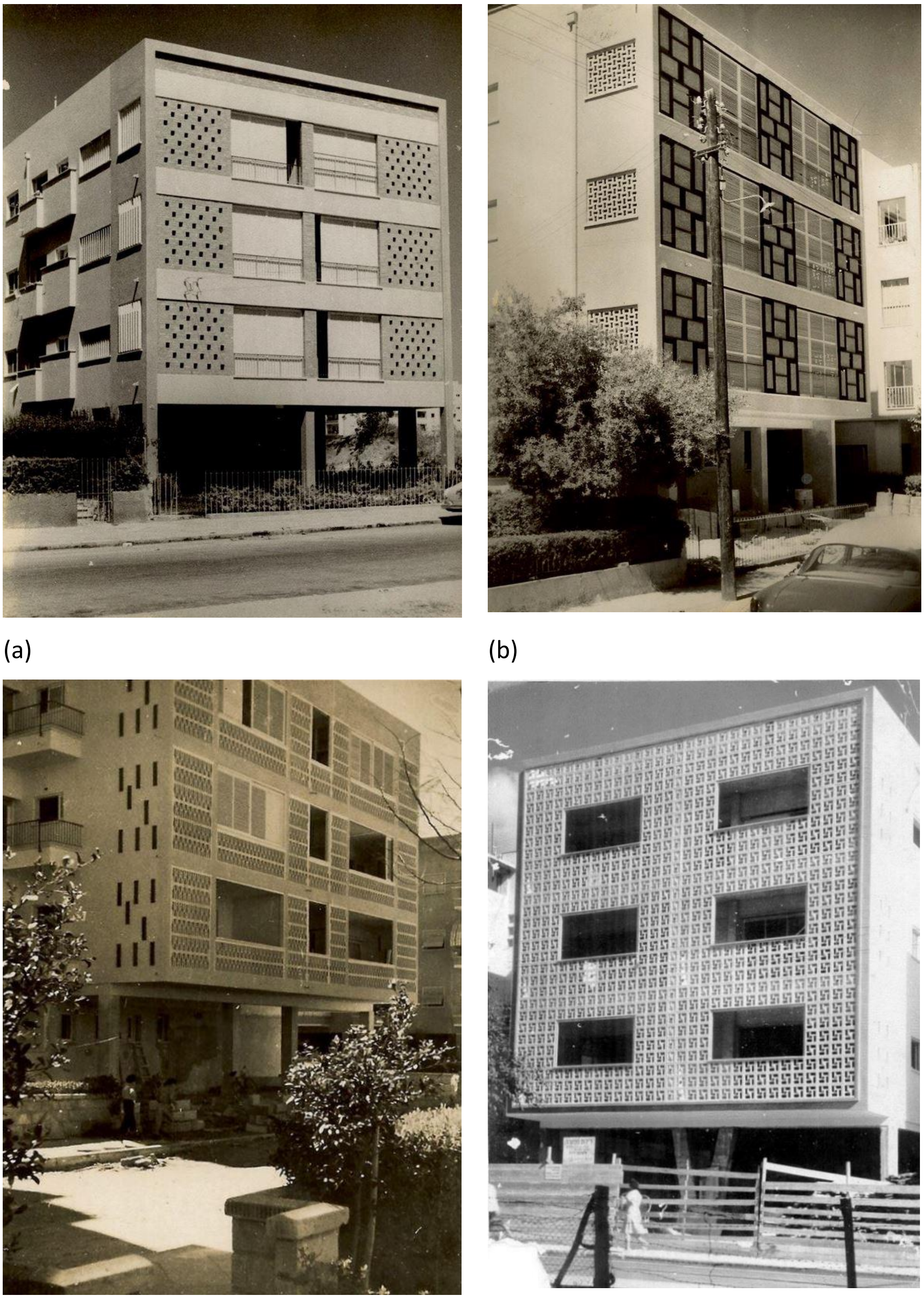
The immediacy in which the Brazilian shading language was adopted in Israel was not only a result of the search for bettered climatic design, but also of the ability to mimic the slick international images appearing in the imported architectural magazines by using the limited local technological means. In Israel during the 1950's, concrete was regarded as the most prominent local building material, and the more it was used the more the working methods with it improved, both in on-site casting and in prefabrication of building elements (precast concrete). The new shading idiom could not have developed into its later sophisticated form without the support of skilled factories, who knew how to cast hollow bricks, concrete panels or asbestos cement louvers thin and precise enough to create the desired "lattice effect" (Efrat 2004, 863-870). In a certain sense, we may describe the renewed architectural interest in the concept of shading as part of a more elaborate journey to exhaust the gamut of precast concrete products for detailing the building envelope.

The most pronounced influence of the Brazilian fashion on Israeli architecture can be traced in typical residential buildings, mainly in the area of Greater Tel Aviv, where the street-facing facades became a fertile ground for the development of a local ornamental idiom, rich and new, which had some loose relation to climatic concerns. This came as a clear shift from the orthodox modernist design preferences of the 1930's and 1940's, under which a building was shaped as "the masterly, correct and magnificent play of masses brought together in light", to borrow Le Corbusier's famous words (Le Corbusier 1931 (1927), 29). This led to the development of local style based on the abolition of any form of explicit ornament and the articulation of the building as a composition of basic geometrical solids and voids (Figure 4.10). In comparison, the 1950's typical residential building had its main facade entirely flattened, and the protruding balconies of the 1930's and 1940's were now replaced by introvert deep "loggias" which were partly hidden behind a rich variety of masking screens (Figure 4.11). The shading devices, mainly patterned hollow precast blocks, were now performing also as filters of the human gaze. The facade was divided into rectangular fields of two kinds: open fields, which were left free of any element, and closed fields, which were filled with perforated inlays of fixed elements. The result was a facade that was initially designed as a two-dimensional framed composition of abstract geometric patterns.

The precast screens and climatic efficiency had in many times only a loose connection. Screens were designed for northern facades, where the additional shading was almost useless; densely perforated precast elements that were fit for shading the eastern and western sun were used for screening southern facades, resulting in excessive dimness of the interiors, especially during winter; and more loosely perforated elements suited for southern facades were placed in eastern and western facades (Figure 4.12). Identical precast elements were sometimes used in corner buildings in both facades facing the street in spite of the clear difference between them in the incidence angle of the sun.

Figure 4.10: Typical 1930's and 1940's residential buildings in Tel Aviv (Chen Boulevard), 1952, photograph by Rudi Weissenstein (Pri-Or Photohouse)

Figure 4.11: Typical 1950's residential buildings in Tel Aviv (39-49 Be'eri Street, all by architect Meir Horman), 1958, photograph by Rudi Weissenstein (Pri-Or Photohouse)



(a) (b)

(c) (d)

Figure 4.12: Residential buildings of the 1950's in Tel Aviv, all designed by architect Aharon Doron, one of the most prolific residential architects of that era (Aharon Doron Collection, Israel Architecture Archive). (a) 31 David HaMelech Street, southern facade; (b) 5 Wilson Street, eastern facade; (c) 8 'azarya Min HaAdumim Street, northern facade; (d) 58 Pinsker Street, south-western facade

This inclination to pure ornamentation was not a unique Israeli invention: one of the most renowned examples of this treatment of residential facades was Lúcio Costa's buildings around the edge of Parque Eduardo Guinle in Rio de Janeiro (1948-1954). In Costa's project, in clear opposition to the technical truth of shading, identical precast screens were used in facades facing west and north (Figure 4.13). Contrary to Costa's project, in which a fully glazed wall separated the screened loggias from the indoor spaces, in Israel the solid wall remained the most common type of partition between room and loggia, and the relatively small openings in it usually received an additional shading layer of sliding wooden shutters.

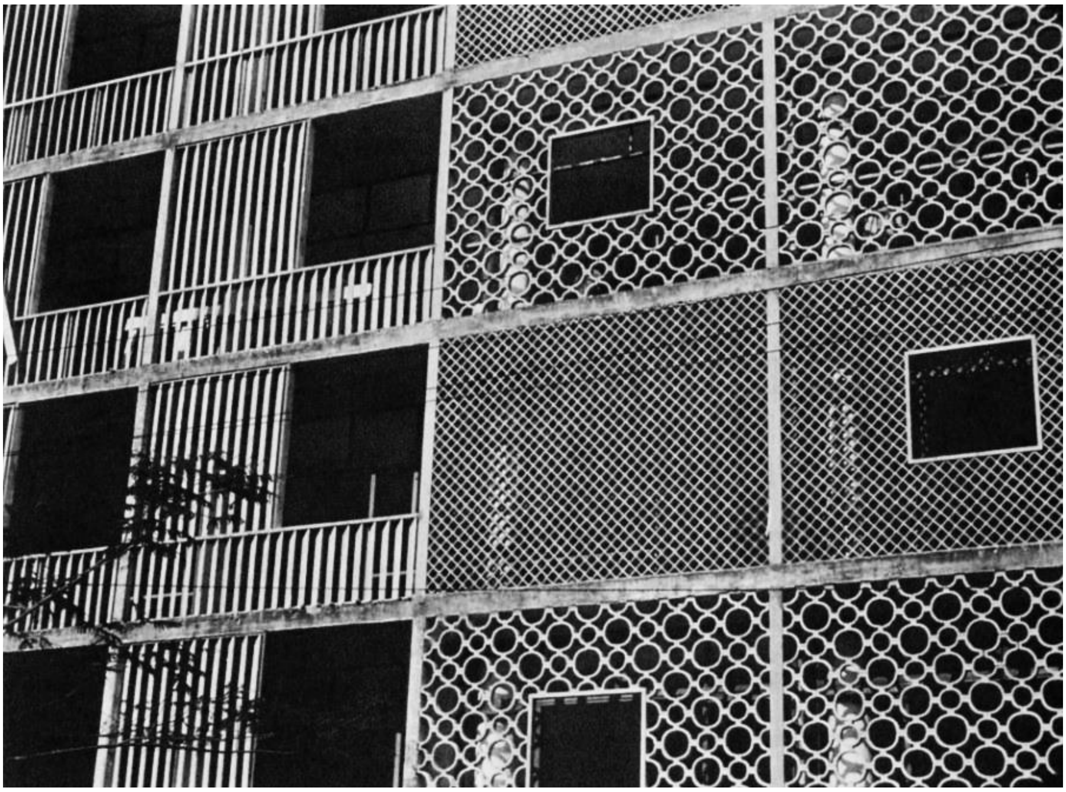


Figure 4.13: Lúcio Costa, Parque Eduardo Guinle residential blocks in Rio de Janeiro, 1948-1954 (Olgyay and Olgyay 1957, 176). The same shading elements were used for both the western and northern facades

ORNAMENT AND CLIMATE

In light of the functionalist atmosphere of the era, the local inclination towards the ornament was far from being welcomed. Local critics were reluctant to acknowledge at least the visual achievements of this new local architectural idiom and the inventive exploitation of the limited local means of production. A fine example of this approach can be found in an article by architect and critic Avraham Erlik, which appeared in 1955 in the *Journal of the Association of Engineers and Architects in Israel*. His description emphasizes the discrepancy between architectural fashions and functional common sense while focusing on a single building element, the window:

> In recent years we witness an inclination towards the enlargement of glazing surfaces, which become wider and taller, an inclination that did not skip our country. We often see windows transforming entire walls into continuous glazing surfaces. Let us consider the suitability of such windows to the two fundamental functions – light and ventilation. Under our local sunlight, a lighting area of about 10% of the floor area is usually enough […]. If we design a window whose area is substantially larger, the indoor light during summer might be too strong, especially when the window is higher than 2.00 m, thus resulting in glare. During times of direct sun penetration, the protection against it is very hard and requires shutters which are expensive due to their size. In many cases we see windows stretched to the full width of the room and in front of them fixed concrete shutters (since movable shutters are too expensive) – the result is paradoxical: insufficient light during all day, during the main working hours – except from the afternoon hours (in west-facing rooms).
>
> As for ventilation: opening up the entire wall is impossible, since the open window requires wall area of similar size as its own. Of course, wings on regular hinges could not solve the issue unless opened outwards, an uncommon solution in different countries where not only shutters are used but also fly screens – and a hard and almost impossible solution here, where shutters and fly screens are compulsory.

> When using common sliding windows this design leaves an area of fixed glazing, while it is already known for quite a while that fixed glazing in our climate is far worse than a solid wall in terms of the heat transferred through it into the room. A glazing surface from which only a small part can be opened for ventilation is fine for a climate in which light and sun are scarce and ventilation does not form a problem, as it is in England or Scandinavia, but we are standing on the opposite side. One can place in front of the fixed glass a "Brazilian" shutter, yet this shutter will be an artificial solution to the problem: had we designed the window by its proper size for light and ventilation, the problem would not have arisen as well as the need for a solution (see *Forum*, September 1953, on the windows in the United Nations Headquarters which are constantly screened halfway by shutters "to heap [sic.] out the glare"[6]). The "Brazilian shutter" makes its appearance here, in most cases, as a purely decorative motif, with no relation at all to actual function.
>
> That this shutter originated from a search for an answer to a genuine functional problem should not make any difference. Almost any ornament comes into being as a functional or structural element. The transplanting of such architectural elements from one country to another and their distribution as a matter of fashion blurs the special character of the local architecture. (Erlik 1955)

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[6] Erlik is referring to an article from the September 1953 issue of the *Architectural Forum*. The quote is inaccurate. The original text reads as follows: "In the UN, the same architects not only ran the window clear to the ceiling but also built in a recessed pocket to house the retracted Venetian blind so it would not block any daylight. As a surprise, however, workers kept their blinds at half-mast most of the time to block sky glare" (Architectural Forum 1953, 110).

Another prominent architect and critic of that era, Aba Elhanani, held similar views on the vices of ornament. In 1957 he published an article in the daily newspaper *Haaretz* in which he described the new local idiom of shading devices. His description is telling since it encompasses the whole array of shading options which were in common use at that time in Israel, some of them much older than the newly imported *brise-soleil* from Brazil. It is therefore worth citing it here almost in its entirety:

> Closing loggias in diverse and new methods and materials is becoming more and more common in our cities. This trend is not a matter of a passing fashion, but a natural expression of our self-protection against the negative effect of the hot climate.
>
> The method opens up many architectural horizons, and it is therefore worthwhile to examine the different ways of screening the loggias, as seen in new buildings.
>
> **The Bris-Soleil (wind sun)** [sic.]
>
> This name, which originates from French, describes a method aimed at resolving the problem of shading without affecting the ventilation. Some of the diverse installations that were designed following this principle are simple and cheap, while others consist of complex and expensive technical arrangements. They enable **the blocking of sunlight while keeping an optional penetration of air and wind**. Most of these arrangements can be divided into two major types: the precast elements screen and the slats screen.
>
> **The precast elements screen**
>
> A precast element is an element cast in concrete beforehand. Nevertheless, this word, "precast", which indicates a very wide variety of precast concrete elements from which the precast elements of the loggias are only one and less

important type, is now commonly used in the market of residential buildings to describe the elements which create the loggia screen even if they are not precast at all. These blocks or concrete boards are built, or should be built, in a way that will block sunlight from entering the loggia at least during the hours in which the loggias are commonly in use, while letting the flow of air and wind through it all around the clock.

Since the sun path is different in the east, west, and south, the shape of the precast elements or the way they are laid must be different in balconies facing different directions. Indeed, the correct application of precast elements demonstrates this difference explicitly.

It might be worth mentioning that in a northern loggia there is no need, in terms of shading, for installing such a screen. At the same time, the issue can be resolved in southern loggias only by using a projecting awning which could shade the entire area of the loggia, since the southern sun is "high".

The slats screen

A slat is a thin piece of wood ("plafon" in European languages), and the folding cabled shutter [roller shutter] is constructed of wooden slats, just as the Venetian blind (which we call *Tzelon* after the name of the local factory who chose to use this name to describe its products) is constructed of very thin aluminium slats.

When we talk about a slats screen we talk about all kinds of shading arrangements in which the main element is the slat, be it made out of wood or any other material.

Thus, first and foremost we know the normal shutter which is constructed out of wooden slats (in Tel Aviv and several other places) or tin slats (in Haifa, Jerusalem, etc.). The shutter can be foldable or opened through hinges, or it can slide in parallel to the surface of the wall, into the wall, or in front of another shutter. In all of these shutters the slats can be fixed or rotating. The rotation of the slats has a clear advantage, since it enables an easy and comfortable adjustment of the penetration of sun beams, light and wind. In normal or sliding shutters there is no difficulty to enable the slats to rotate, and this arrangement is commonly known as a "Haifa shutter" for one reason or another. The architect S. Rosoff issued a patent some years ago on a foldable shutter with rotating slats. Unfortunately, this patent, though being easy to use, did not catch on in the field of construction.

Here we should emphasize the salient advantage of the openable shutter in comparison to the fixed shutter. During the evening hours we do not need to adjust the air, yet we are in a grave need for wind and therefore it is more than desirable to open up, as much as possible, the loggia's walls in order to gain direct contact with the surroundings.

We would like to remind here another mode of opening a shutter, which is, for some reason, uncommon in our country – that is the opening on a horizontal axis. This type of opening transforms the open shutter into an extension of the loggia's awning, which is desirable especially in south-facing balconies. This solution makes it possible to save the arrangement of the rotating slats, which causes the shutter to be a bit more expensive.

Besides the various shutters, a slats screen can be built from fixed or rotating slats made out of wood, precast concrete, asbestos or any other suitable material. These slats will be deeper than those installed in shutters. These arrangements, of course, which are heavier, will no longer "travel" along the

> balcony wall. But since the deep slats rotate, this enables a reasonable opening of the loggia.
>
> [...]
>
> **Aesthetic considerations**
>
> Looking from within the apartment, the aesthetic "gain" is clear. The smaller rooms are "deepened" along the full length of the loggia by applying glass doors between the room and the loggia. Space becomes more agreeable and richer.
>
> Regarding the external look, the precast elements and slats could have "tranquillized" and "pacified" the facades of our houses by minimizing the plethora of window and railing shapes, yet to our disappointment this simple and effective element has regretfully become a zone for competition and for a fruitless search after ornamentation; while many architects aspire, for some reason, to emphasize their own personality by inventing different and complex forms of precast elements in a myriad of pale colours
>
> Buy pursuing this external and tasteless decoration, engineers and contractors tend to forget the point – the purpose and function of the "precast" wall, which is the shading of the loggia (this process is known in all ages, when a functional element is transformed into a decorative element by gradual oblivion of the function!).
>
> Nevertheless, one can still find in the city [Tel Aviv] more than a handful of buildings which demonstrate in an efficient and fine manner the functional and aesthetic use of this simple and good idea. (Elhanani 1957)

THE COMMON SHUTTERS

What is clearly revealed through Elhanani's detailed description is that besides the Brazilian-influenced shading devices, local architects could have chosen a rather different, conservative direction of using "small-scale" shading options as means of protecting the indoor spaces. These include mainly the wide range of shutter types which were already in common use for some decades before the advent of the Brazilian idiom and were all made out of wood. In sharp contrast to the *brise-soleil*, they were commonly seen by local architects as standard technical equipment attached to the building and not as an architectural element which requires their attention. The *brise-soleil* created an opportunity for substituting the old forms of shadings with a more visually-attractive and "architectural" mode of expression; its climatic reputation provided the pretext for indulging in forbidden ornamentation.

As implicated by Dov Karmi's article from 1953, shutters in Palestine have a much longer and richer history than one would expect from the rapid adoption of the Brazilian shading idiom during the early 1950's, though until the end of the 1950's it was based mainly on wooden devices. Plain solid wooden wing shutters can be seen in the first photographs of Jaffa from the 1860's (Figure 4.14). About a decade and a half later, photographs documented wing shutters with wooden slats (Figure 4.14). In some cases it was possible to rotate the slats using an internal vertical rod and specialized hinges, an invention probably imported during the 1870's by the first Templer settlers from Germany, who had been immigrating to the Holy Land, including the three main cities of Jerusalem, Jaffa and Haifa, since 1869 (Figure 4.16). This shutter type later received the name "Haifa shutter" (Figure 4.18).[7] Wing shutters with (usually fixed) slats became a common feature in many local houses since at least the turn of the 20th century.

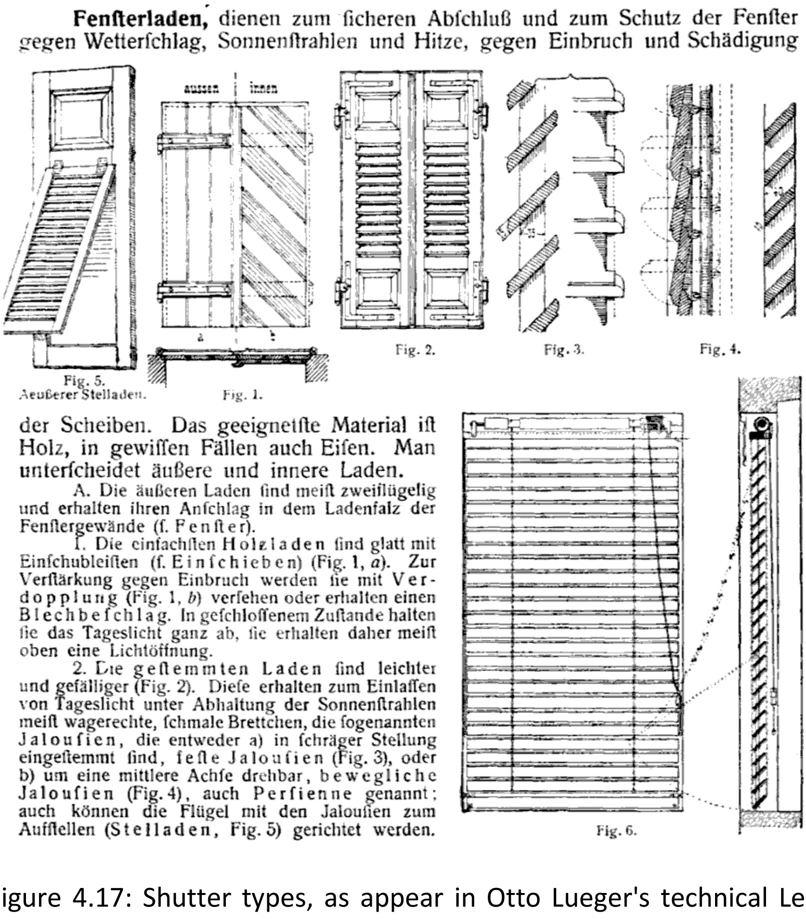
---

[7] It is hard to determine the exact origin of this type of adjustable shutters, but its existence in the buildings of the German Templers and the fact that it was common in German speaking countries at least "since the Baroque", according to Hänel and Hänel (2005, 85), make it more than probable that the Templers served here as the main promoters of this shutter type in Palestine. This type of shutter also appears in Otto Lueger's Technical lexicon, published in 1904 (Figure 4.17).

Figure 4.14: Jaffa, 1860, photograph by Louis Vignes, a detail showing solid wooden wing shutters (gallica.bnf.fr, id: ark:/12148/btv1b6939949t)

Figure 4.15: Jaffa from the sea, the 1870's, photograph by Felix Bonfils (Institut national d'histoire de l'art, bibliotheque-numerique.inha.fr, id: PC 42970 Don), a detail showing solid and adjustable wing shutters installed in many residential buildings

Figure 4.16: Friedel Family house in the German Colony of Jaffa, ca. 1890, a detail showing wooden shutters with rotatable slats (Eisler 2012, 46)



Fenſterladen, dienen zum ſicheren Abſchluß und zum Schutz der Fenſter gegen Wetterſchlag, Sonnenſtrahlen und Hitze, gegen Einbruch und Schädigung der Scheiben. Das geeignetſte Material iſt Holz, in gewiſſen Fällen auch Eiſen. Man unterſcheidet äußere und innere Laden.

A. Die äußeren Laden ſind meiſt zweiflügelig und erhalten ihren Anſchlag in dem Ladenfalz der Fenſtergewände (ſ. Fenſter).

1. Die einfachſten Holzladen ſind glatt mit Einſchubleiſten (ſ. Einſchieben) (Fig. 1, *a*). Zur Verſtärkung gegen Einbruch werden ſie mit Verdopplung (Fig. 1, *b*) verſehen oder erhalten einen Blechbeſchlag. In geſchloſſenem Zuſtande halten ſie das Tageslicht ganz ab, ſie erhalten daher meiſt oben eine Lichtöffnung.

2. Die geſtemmten Laden ſind leichter und gefälliger (Fig. 2). Dieſe erhalten zum Einlaſſen von Tageslicht unter Abhaltung der Sonnenſtrahlen meiſt wagerechte, ſchmale Brettchen, die ſogenannten Jalouſien, die entweder a) in ſchräger Stellung eingeſtemmt ſind, feſte Jalouſien (Fig. 3), oder b) um eine mittlere Achſe drehbar, bewegliche Jalouſien (Fig. 4), auch Perſienne genannt; auch können die Flügel mit den Jalouſien zum Aufſtellen (Stelladen, Fig. 5) gerichtet werden.

Figure 4.17: Shutter types, as appear in Otto Lueger's technical Lexicon (Lueger 1904, 695). A cross section of a shutter with rotatable slats is drawn in Figure 4

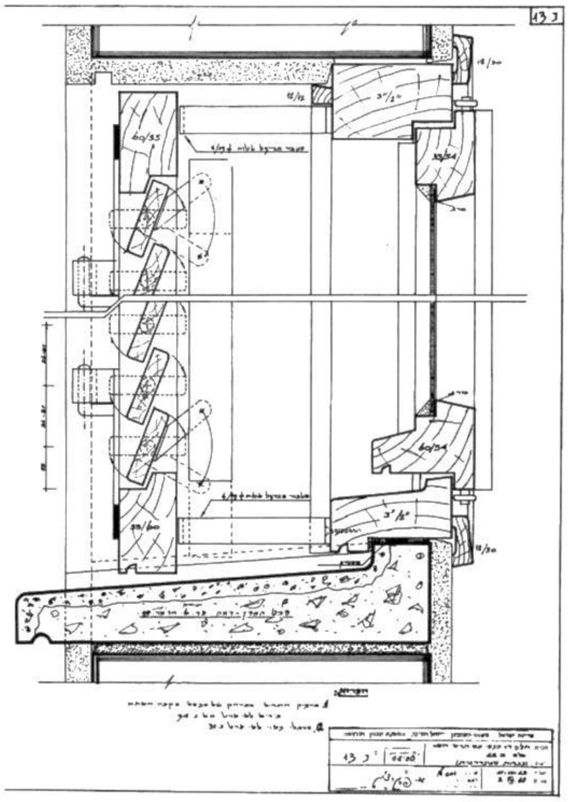


Figure 4.18: A cross section of a "Haifa Shutter", as appeared in a manual of standard building details for residential buildings published by Israel's Ministry of Housing, 1963 (Efrat 2004, 882)

In 1925 a new factory in Tel Aviv began to manufacture wooden roller shutters ("folded" of "folding" shutters, as they were called then), probably the first of its kind in Palestine (Figure 4.19). This shutter type, again an invention imported from Europe, became popular among the local proponents of the International Style, in part because it suited well the horizontal proportions of the strip windows typical of the style (Figure 4.20). At the same time, as architect Dov Karmi admitted later, "the folding shutter that became so common in our country does not function properly [...] its main disadvantage [...] is that one cannot use it to prevent, on the one hand, the penetration of sunrays into the room during summer [because the light penetrated through the cracks between the slats], and on the other hand, to fully open the window for ventilation, even in cases in which the shutter is equipped with a frame that opens it outwards" (Karmi 1946, 11). A way for overcoming this flaw led architect Shmuel Rosoff to develop in 1954 a roller shutter in which the slats were loosely knotted to each other and thus could also be rotated to a horizontal position when the shutter was fully down (Figure 4.21). As mentioned in Elhanani's article quoted above, this new invention did not gain much popularity.

מכנוז
ארץ־ישראלי
ראשון
לתעשית תריסים מהופלים

ערבות שלמה
ניתנת עבור העבודה
ממדרגה ראשונה
ע"י
האחים הכ
ושות'
מרכז-מסחרי תל-אביב
9680

Figure 4.19: A newspaper ad enouncing the opening of the "first Palestinian workshop for the industry of folded shutters" (*Doar HaYom*, 8.2.1925, p. 1)

IMMEUBLE BOULEVARD ROTSCHILD
ARCHITECTE : ZEV RECHTER.

Photo Kalter

Figure 4.20: Engel House, Tel Aviv, designed by architect Ze'ev Rechter following the Corbusian famous five points of architecture (the supports, the roof garden, the free design of ground plan, the horizontal window, the free design of the facade), photograph by Itzhak Kalter (*L'Architecture d'Aujourd'hui*, September 1937, p. 14). The roller shutters seen here, which could also be tilted outwards when rolled down, were a perfect solution for the use of horizontal windows, dictated by Le Corbusier

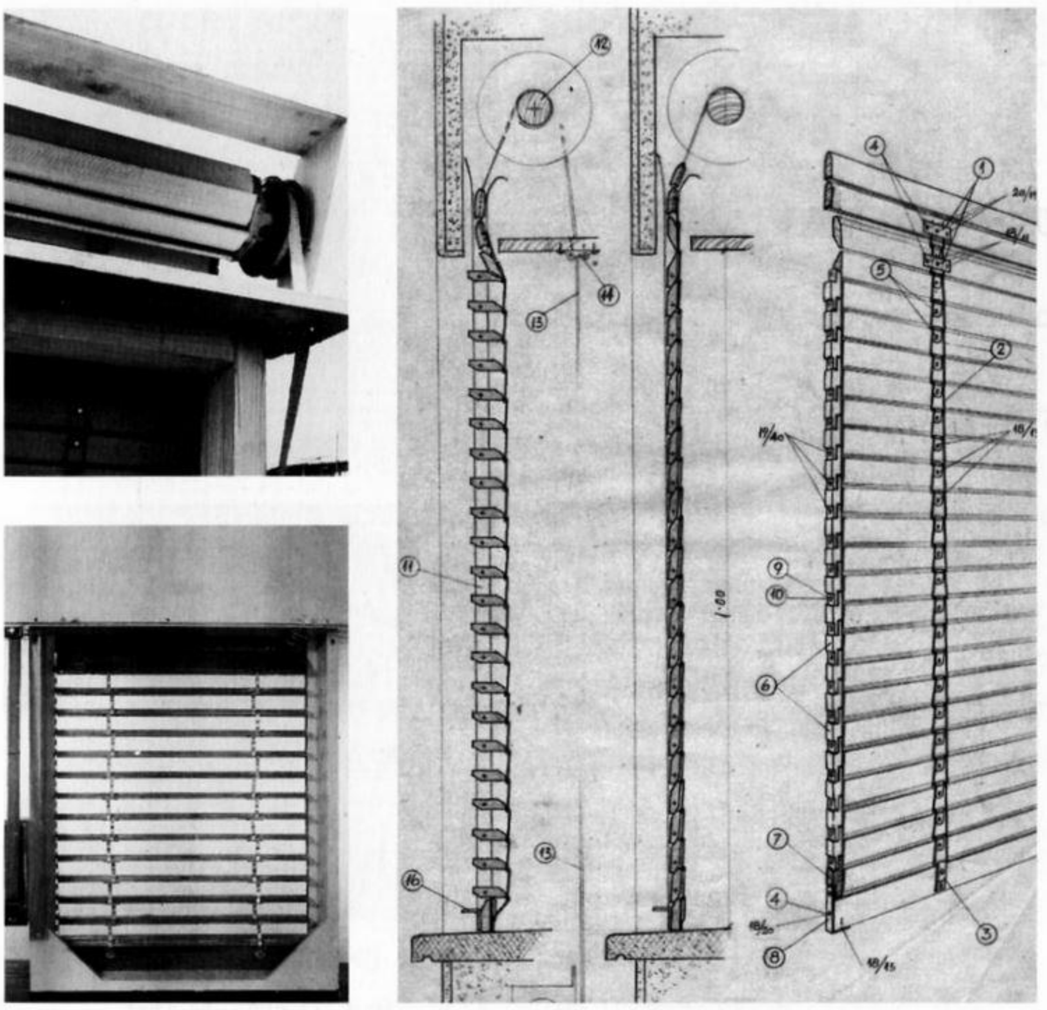


Figure 4.21: *Brisol*, a roller shutter with rotating slats invented by architect Shmuel Rosoff, Israeli Patent 5874 (Efrat 2004, 883)

Dov Karmi was probably one of the more inventive Israeli architects to experiment with all modes of shading devices, including different types of wooden shutters. In his 1946 article he told his readers that

> I recently experimented with the installation of normal shutters which open up by sliding into the wall. The sliding act is easier than setting the folding shutter in motion. Moreover, the shutter's slats [...] can be rotated up to 90 degrees. This enables adjustment to a certain degree. The slats can block the sunlight from penetrating the room while facilitating the ventilation movement indoors; this is their greatest advantage over the folding shutter. In addition, they

> do not require any "covering plates", shutter boxes, etc. which are essential in the case of folding shutters.
>
> It is evident that the installation of sliding shutters results in the installation of sliding windows and the construction of double walls in the house. Under the current construction prices, these arrangements mean very high expenses. Unfortunately, I cannot advise how to build cheaply, but one should remember the saying, that in the end a cheap building is dear and a dear building is cheap. (Karmi 1946, 11)

The adjustable sliding shutter started to gain some prominence in Israel during the 1950's, especially in residential buildings for the well-to-do. In some cases a precast screen was used for concealing the sliding shutter behind it (Figure 4.12 (a) and (c)). Karmi himself used it in an inventive way for screening the entire main (southern) facade of Orenstein House (1955) in Tel Aviv (Figure 4.22), where large sliding slatted wooden shutters enabled the full opening of two-thirds of the loggia's width (above railing height). A few years later (Elgazig House in Tel Aviv, 1959-1962), Karmi used wooden shutters with fixed slats in large panels which could be rotated and fixed in several angles until an almost fully horizontal position, thus opening up the southern facade to an almost full extent while keeping the loggia shaded (Figure 4.23). A somewhat similar approach was adopted by Karmi in Bar Shira House in Tel Aviv (1958-1959), though this time the shading elements were made out of asbestos-cement: the railing was filled with tiny vertical *brises-soleils* whose rotation enabled the free flow of air, while large square solid panels above them could be rotated horizontally, providing overhang shading to the southern facade when in full horizontal position (Figure 4.24). All these experiments demonstrated Karmi's concern with the provision of a wider range of intermediate positions between full closure and full openness of the main loggias. At the same time, his solutions, while having a clear aesthetic appeal, became more and more complex and sometimes even awkward in their daily operation, in a way that affected the actual exploitation of this wide range of possible uses.

Figure 4.22: Dov Karmi and Hever Architects, Orenstein House, 3 Rosenbaum Street, Tel Aviv, 1955 (photograph by the author, 2003). The facade to the street is covered with slatted shutters, of which the bigger panels are sliding one behind the other and the smaller panels are fixed and used as railings

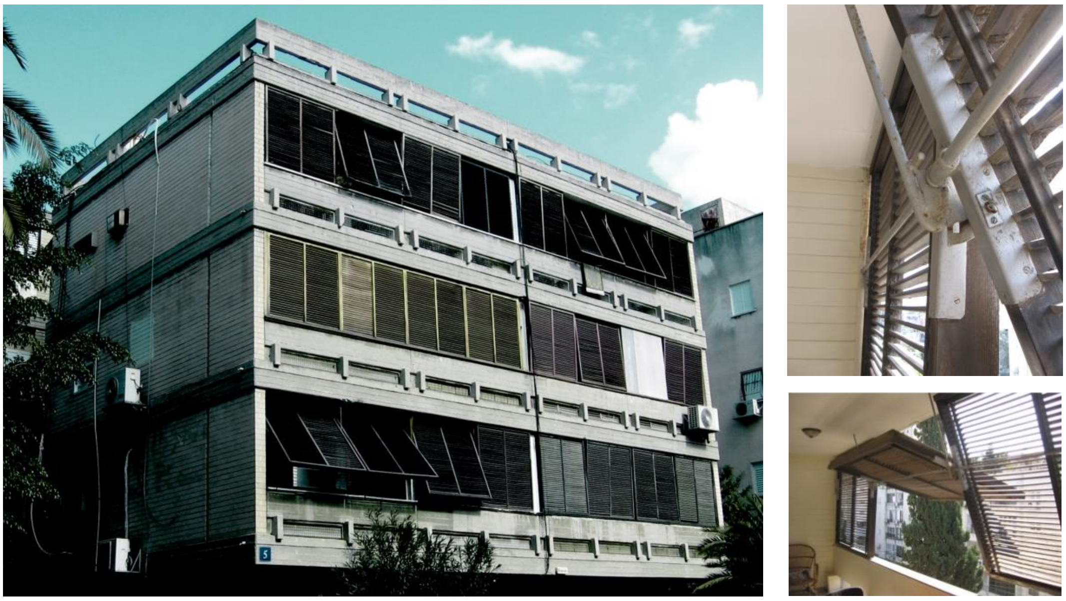


Figure 4.23: Dov Karmi, Zvi Meltzer and Ram Karmi, Elgazig House, 5 Zlocisti Street, Tel Aviv, photographs taken by architect Naama Shabtai-Cyzer in 2006 showing the original details of the rotating shutter panel mechanism (Shabtai-Cyzer 2006)

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Figure 4.24: Dov Karmi, Zvi Meltzer and Ram Karmi, Bar Shira House, 33 Ben Gurion Boulevard, Tel Aviv, photograph by Julius Shulman, 1959 (www.getty.edu/research, Shulman Collection, Job 2790: 15)

THE INVENTION OF THE *TRISOL* AND THE PVC SHUTTERS

While Karmi was struggling to enrich the range of the intermediate positions of his shutters, a much simpler yet revolutionary invention emerged, pairing the Brazilian thin asbestos cement *brise-soleil* with specialized and clever fittings. In spite of Le Corbusier's open criticism of the adjustable *brise-soleil*, the asbestos cement shutters which could be rotated along their longer axis shared a common quality with Le Corbusier's fixed "egg crates": they left an almost identical visual impression in any of their tilting position. In practice, the alleged movability of the asbestos cement shutters was very limited, thus giving the users only little freedom in operation. The shortcoming was evident: an opening which was screened with rotatable asbestos cement shutters could not be genuinely reopened to its full extent.

Israeli patent number 10575, "Improvements in and relating to shutters of the sunbreaker type", was granted on 19 December 1957 to engineer Ram Ben-Tal. The innovation of Ben-Tal was related to the fittings and movement mechanism of vertical asbestos cement panels that enabled their collection into a single group at one side of the opening, thus leaving the rest of the opening free from any obstruction.[8] The aim of the patent was not inherently different from an earlier patent by the architect Moshe Kubowitzki (Israeli patent number 7795 granted on 27 October 1954), but contrary to Kubowitzki's invention, Ben-Tal suggested an easy and smooth collection of high and heavy shutters like the asbestos cement *brises-soleils*. In an interview with the author, architect Nahum Zolotov argued that he was the one who challenged Ben-Tal to overcome the inherent inflexibility of the *brise-soleil*. In his words,

> During those years they invented the brise-soleil in Brazil. It could be rotated, but it could not be folded. I had a friend who graduated with me from the Technion, an engineer by the name of Ram Blatt [Ram Ben-Tal]. He would visit my office, which was then located on Bloch Street in Tel Aviv, almost every day. He would sit with me and say, “what am I going to do? Am I going to be just another run-of-the-mill engineer? Help me. You built houses from asbestos in Narharyia for the Isasbest [local factory for asbestos cement building product] manager, maybe you can help me find something in asbestos”. I told him, Ram, that precast element they make in Brazil, if you find a way to fold it, you have a job, you have a livelihood, you have a factory. (Zolotov 2013)

---

[8] Contrary to what is argued by Zvi Efrat (2004, 869), Ben-Tal's innovation was not related to the ability to rotate an asbestos cement shutter around its longer axis, a feature already existing by that time in some Israeli projects (as in Sharon-Idelson's Lessin House, see Figure 4.6) and which was an integral part of the invention of the *brise-soleil* in Brazil. Ben-Tal's genius was the transformation of the rotatable *brise-soleil* into a **collectable** *brise-soleil* which could easily almost "disappear" from sight.

Figure 4.25: Nahum Zolotov, 79 Ben Yehuda Street, Tel Aviv, 1958, the western facade showing the *Trisol* shutters in their full operational range between total closure and total openness. The facade's windows received sliding wooden shutters with rotatable slats. Photograph by Nahum Zolotov (Nahum Zolotov Collection, Information Center for Israeli Art, The Israel Museum)

Ben-Tal's invention, nicknamed *Trisol* (a portmanteau of the Hebrew word for shutter and the French *brise-soleil*) gave birth to a shading device which was flexible and rigid at the same time. The success was rapid, and the new product was welcomed by local architects. Zolotov himself was one of the first, applying *Trisol* shutters in the western facade of his 1958 "high rise" (eight storeys) residential building in Tel Aviv. The new flexibility in the use of the loggias encouraged him to design a fully glazed wall between the loggias and the main living rooms, while the *Trisol* shutters performed as a light removable wall which could perfectly block the direct western sun yet open up almost to its full extent in order to receive the western breeze (Figure 4.25). A similar contemporary use of *Trisol* shutters can be found in another high rise residential building in Tel Aviv by Avraham Yasky and Amnon Alexandroni, completed in 1962 (Figure 4.26).

Figure 4.26: Avraham Yasky and Amnon Alexandroni, a residential building in 24 Lipsky Street, Tel Aviv, 1961-1962, photograph by Avraham Yasky (Rotbard 2007, 393). The western facade of the building consisted of a long strip of balconies, all originally closed by *Trisol* shutters

While architects were guardedly experimenting with the new invention, the *Trisol* gained a much bigger success among ordinary people who wished to transform their balconies and loggias into a more versatile living space than the one designed by the architects (Davar 1960b). The growing number of local manufacturers aggressively marketed their shading products as primarily fit for this specific purpose, keeping in mind the local tradition of building balconies almost unprotected from direct sunlight. With no real regulations against it, balcony and loggia closing became a common habit, and this, in turn, expedited the development of new types of shutters with new materials (Figure 4.27). By 1960, PVC slats started to replace the wooden slats in roller shutters, making them less expensive than their wooden counterparts (Davar 1960a). Then, in 1962 (Porat 1962), the most important shading invention in local history was out: the adjustable sliding shutter made out of aluminium frames and PVC slats. This was a new, less expensive and more versatile version of the old wooden "Haifa shutter" (Figure 4.28). An enhanced version of the PVC-aluminium shutter type replaced the PVC slats with aluminium slats, but this new product gained less popularity probably due to its higher price.

The PVC-aluminium shutter was easier to handle and maintain than the original asbestos cement *Trisol*, and soon afterwards it replaced it entirely, even in places were *Trisol* shutters were originally installed (like the buildings of Zolotov and Yasky-Alexandroni mentioned above). Although actual statistics is lacking, one can argue that it is the most common shutter type in Israel even today.

Figure 4.27: Actor Audie Murphy on a terrace at 8 Epstein Street, Tel Aviv, during the shooting of the film *Einer spielt falsch*, 1966 (Photograph by David Ulmer). One can clearly spot that many balconies in the surrounding were already closed by their owners using all kinds of shading products available at that time, thus compromising the intended uniformity of the exterior look prescribed by the architects

Figure 4.28: A newspaper ad illustrating the product range of the shading devices company Isratris, marketing side by side asbestos cement and PVC-aluminium shutters (*Davar Supplement for the Levant Fair*, 24.6.1964, p. 19)

Figure 4.29: A frame from the Israeli comedy *Rak BeLira* ("One Pound Only"), directed by Yoram Gross, 1963, showing the newly built residential blocks at 51-57 David HaMelech Street in Tel Aviv, designed by architect Aharon Doron. The main balconies of the buildings, completed in late 1962, were all originally closed using sliding PVC-aluminium shutters

Contrary to the precast shading elements and even the *Trisol* shutter, the PVC-aluminium shutter was only reluctantly endorsed by local architects. Its somewhat flimsy appearance, the use of an "inferior" material as extruded plastic, its reputation as a cheap solution for closing a balcony, all made its integration into high-end architecture projects almost unimaginable. At the same time, architects could not resist domestic clients who wanted to be able to use their balconies in a much more varied way than enabled by any fixed shading elements, and did use the PVC-aluminium shutters in new residential buildings (Figure 4.29). In public and commercial buildings, where the individual end user traditionally had a much lesser influence on the architect's choices, the idiom of fixed precast concrete elements for shading remained intact (Efrat 2004, 870), developing through the 1970's into a new mode of expression, that of deep and in times sculptural overhangs (Figure 4.30).

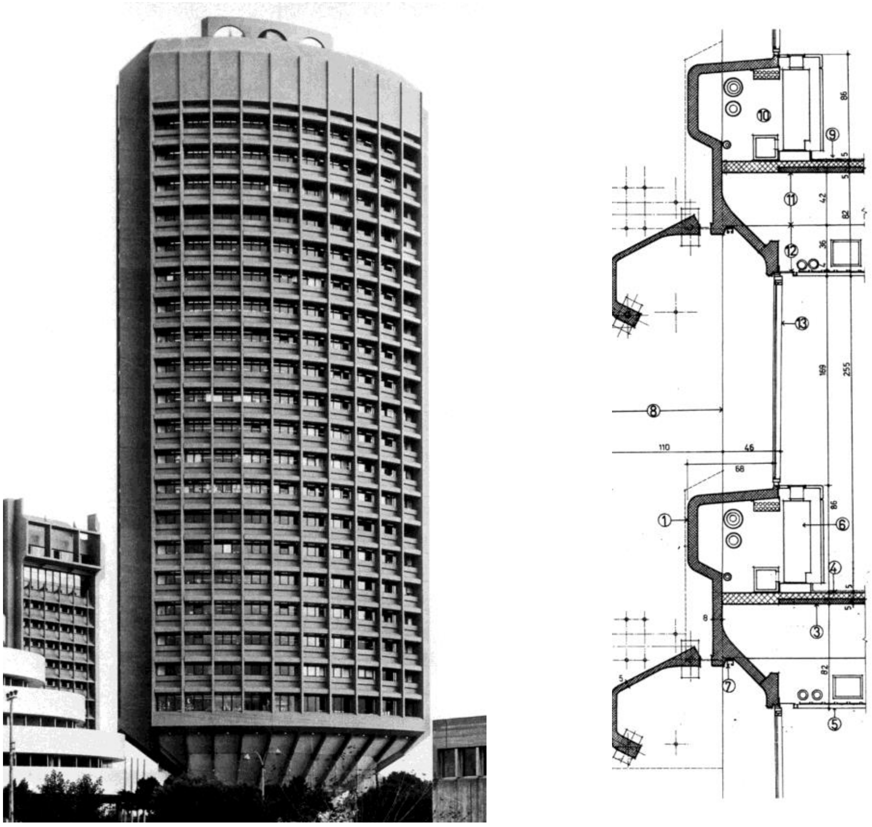


Figure 4.30: Yasky-Gil-Sivan, IBM Building, Tel Aviv, 1978, western facade (left, photograph by Ran Erde) and a typical facade cross section showing a precast sun breaker designed for the project (right, indicated by the number 2). In the back of the photograph appear two other office buildings from the same era (Asia House and America House) which employed a similar shading strategy of deep and solid overhangs (Rotbard 2007, 826, 829)

4.2 Climatic design in the Gilman Building

4.2.1 Building orientation of the Gilman Building

The orientation of the Gilman Building was dictated by the University campus master plan. A preference for a north-south orientation clearly dominated the plan: most of the buildings were designed as perfect slabs orienting their longer facades to the north and south (Figure 4.31), an orientation eagerly promoted by Wittkower since the early 1940's, based on climatic considerations (see above, section 2.4). Nevertheless, for the Gilman Building a totally opposite orientation was selected, with the building's longer facades facing east and west.

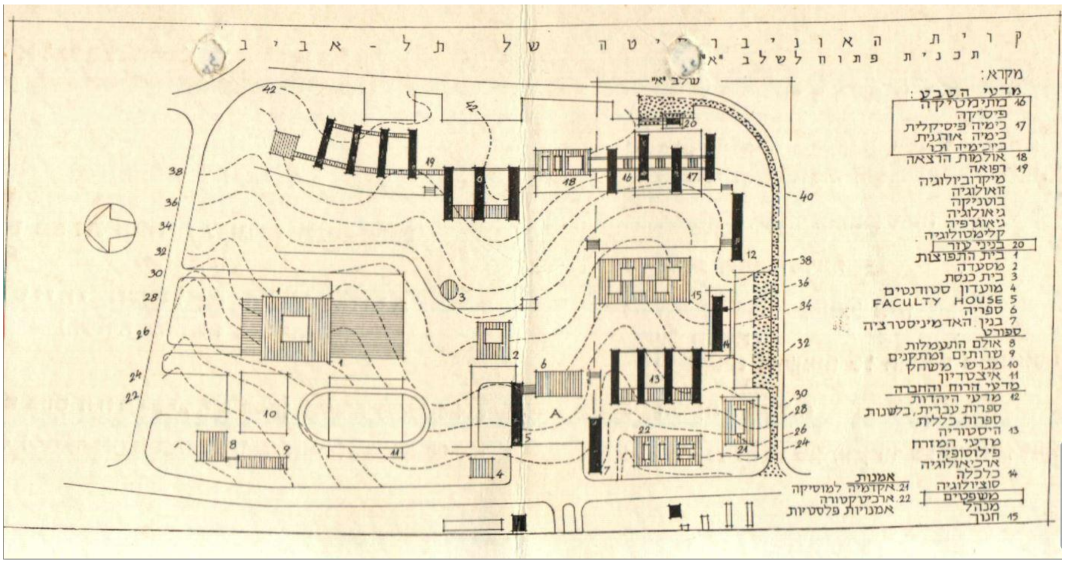


Figure 4.31: The master plan of Tel Aviv University campus in Ramat Aviv as was attached to an invitation to the graduation ceremony of academic year 1961-1962 (Anonymous 1962)

Taking in mind that it is the overheating of buildings which was (and still is) perceived as the main climatic challenge in Israel, the east-west orientation meant that excessive and undesirable heat gains would ensue during the hot season. Its application to several buildings of the Tel Aviv University campus had probably little to do with indoor climate and was much more influenced by a wish for better defining the outdoor spaces between the campus' buildings, spaces that might have been much duller with all building oriented similarly. The negative climatic effects of this design decision were not left unnoticed, and the planners, so it seems, developed a general strategy to overcome them by arranging the east-west buildings around courtyards or "patios". This architectural feature, which was applied systematically to all large-scale east-west buildings in the master plan, enabled to maximize the number of rooms that could face the preferable directions of north or south, while leaving spaces of lesser importance to the eastern and western facades. The courtyards were used to transform the generic rectangular slab into an articulated set of perpendicular "stripes", while maintaining a neat and continuous external exterior.

The east-west orientation of the Gilman Building was thus a given limitation that the building architect had to accept and solve by architectural means. As Stein described it,

> Since we had a long 'sausage' where the longer facades face east and west, the design as a whole used the courtyards to split it to separate wings inside which every wing of classrooms has a northern or a southern facade [...] Regarding the eastern and western facades, I used them as follows: to the east mainly toilets and stairwells on both sides, and to the west, where you had deeper classrooms, I placed small classrooms, rooms for the teachers, or seminar rooms.[9] (Stein 2012b).

Stein's solution for the spatial arrangement of the building mass was clearly different from the one which appeared in the original master plan, in a way which reveals an original interpretation of the design principles set by Wittkower's master plan. The original massing, as appeared in the master plan, defined Gilman as a long rectangular box perforated from within by five small patios arranged in a checkerboard-like pattern (Figure 4.32). Stein decided to divide the building into two separate rectangular masses (or wings), each one arranged around two non-identical courtyards (Figure 4.33), and to connect them through a long and

---

[9] This scheme applies to the southern wing of the building. For the northern wing, an opposite scheme was used, since its eastern side is deeper than the western, and the toilets and the smaller rooms were facing west.

wide corridor (or a "spine"). In that way, Stein managed to orient all classrooms and lecture halls to the north or south (Figure 4.34). The division of the building into two separate masses also facilitated the division of construction works into two phases, a demand set by the University in order to expedite the building's partial occupation even before the completion of the whole project. Effectively, the southern wing of the building was inaugurated in October 1964, while the construction of the northern wing continued until the summer of 1965.

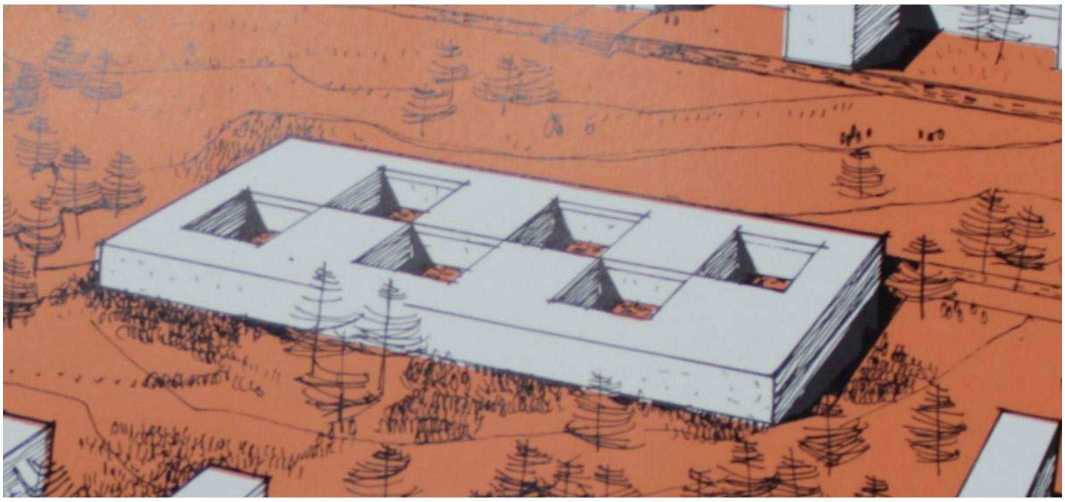


Figure 4.32: Gilman Building as it appeared in an artist rendition of the proposed Tel Aviv University campus (Tel Aviv University 1962)

Figure 4.33: Aerial view of the Gilman Building during construction of its northern wing, 1965, a detail of a larger photograph (Tel Aviv University Archive)

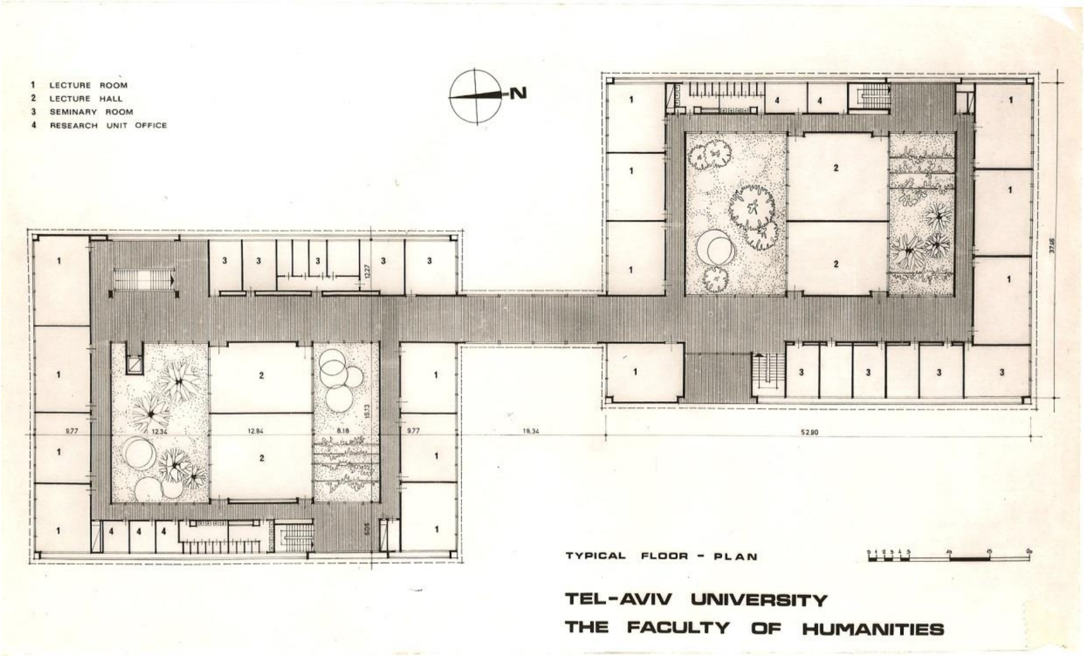


Figure 4.34: Typical floor plan of the Gilman building, a presentation plan, 1963 (Israel Stein Collection)

4.2.2 Sun protections in the Gilman Building

The transformation of the original slab into two smaller masses still resulted in large surfaces of the envelope facing east and west. In his 1955 paper on "ventilation and insulation", Wittkower wrote that

> If one cannot escape the orientation of the main facades to the east and west, it is possible to well protect these facades using horizontal or vertical sun protectors – which are called Brise Soleil in our professional jargon. It is very much recommended that the sun protectors should protect the entire facade and not only the windows, in order to prevent the heating up of the entire wall. Vertical sun protectors, which could be rotated and adjusted, are without doubt an ideal solution, since they assist in capturing the drafts and in directing it through the building. (Wittkower 1955)

Stein followed Wittkower's prescription, and dealt with the challenge by designing an intricate system of fixed sun protections. His idea was to create an additional wall in front of each of the eastern and western facades which would be composed of hollow concrete blocks (in the southern wing) or precast concrete "shelves" or "fins" (in the northern wing). Both the blocks and "fins" were diagonally oriented to the north in a way that blocked the exposure of the wall behind them to direct western and eastern sunlight (Figure 4.35, Figure 4.36, and Figure 4.37). An air gap between the screen of sun breakers and the building wall facilitated the movement of cooler air behind the shading blocks, thus releasing some of the heat stored in them outdoors.

Figure 4.35: Gilman Building, the concrete sun breakers of the western facade of the southern wing, 2012 (photograph by the author)

Figure 4.36: Gilman Building, the concrete sun breakers of the eastern facade of the northern wing, 2012 (photograph by the author)

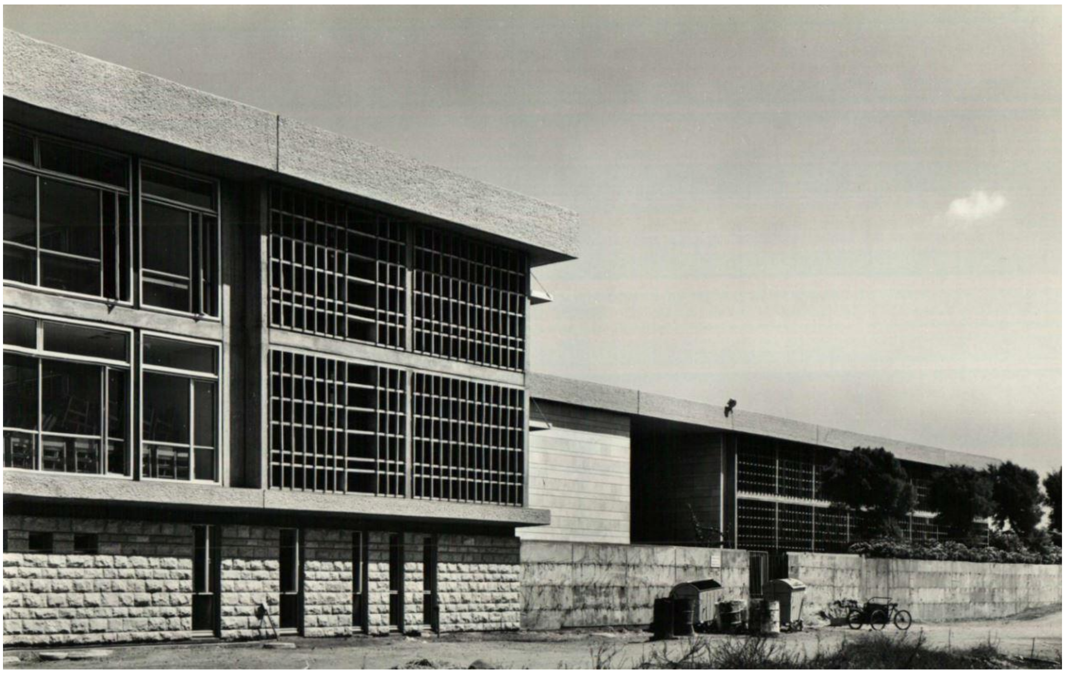
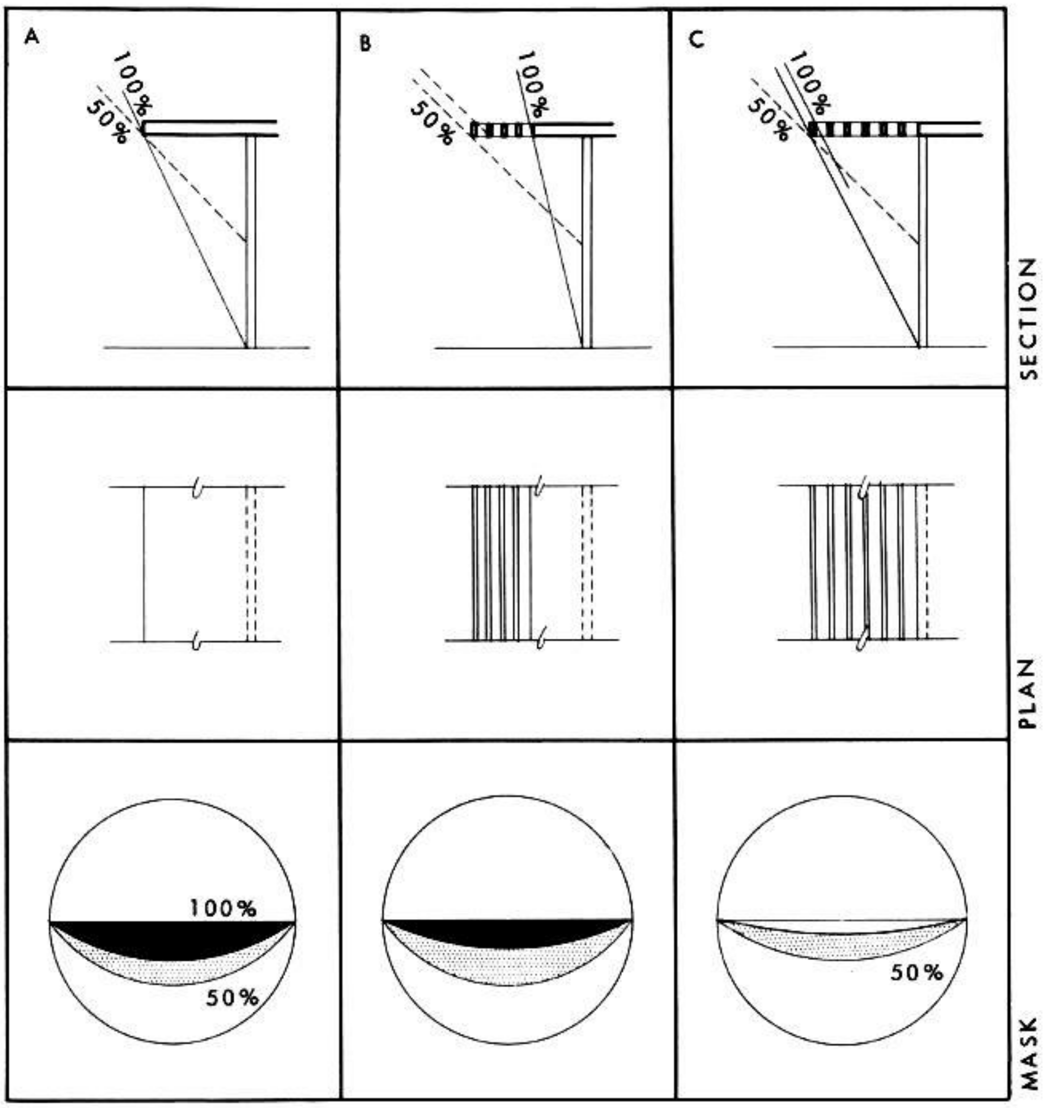


Figure 4.37: Gilman Building, the western facade showing the two types of the precast concrete sun breakers, ca. 1965 (Israel Stein collection)

The "sun breakers" solution was not unique for the time and place, although its articulation had some original inventiveness, as we shall see later. As elaborated above (section 4.1.2), "screening" the facades with unmovable and perforated concrete elements was already quite common in Israel for about a decade. The wide array of shading solutions that were available at that time in Israel gave an intelligent architect proper tools to optimize the use of sun protection for enhancing the indoor climate, mainly during summer.

To this availability of material resources one could add the scientific method of shading calculations which was developed and introduced by the Olgyay brothers (Figure 4.38) in their seminal work *Solar Control and Shading Devices* (Olgyay and Olgyay 1957). Olgyay's work reached Israel upon its publication and was even used by some local architects for designing *brise-soleil* (Figure 4.39 and Figure 4.40). Stein, on the other hand, admitted that he did not hear about the book nor employed Olgyay's shading calculation method (Stein 2014). Nevertheless, his design of the building's sun protections took great care for the functional aspects of their details, employing distinctively different types of sun protections in windows oriented to different directions.

HORIZONTAL TYPES



176. A. Solid horizontal overhang with 100% and 50% segmental mask.

B. Overhang partially solid, partially louvered.

C. Louvers parallel to wall, which do not secure 100% shade, therefore the mask shows only 50% shading.

Figure 4.38: A schematic example of Olgyay and Olgyay's "shading mask" method for calculation of the effective shading of different shading devices (Olgyay and Olgyay 1957, 88)

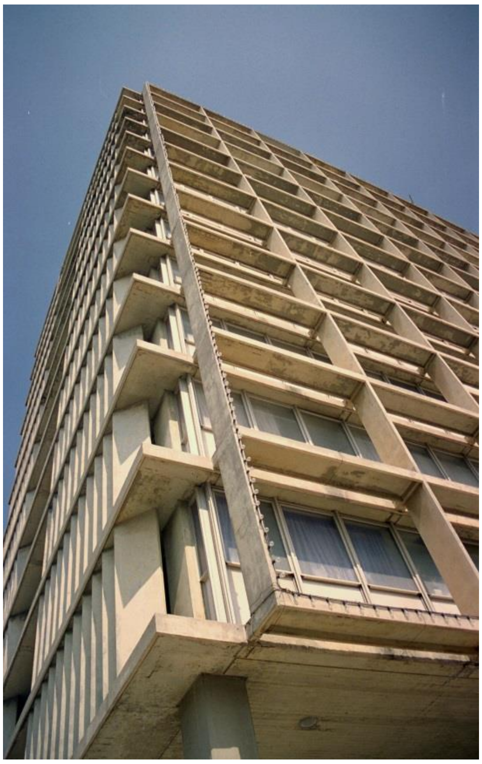


Figure 4.39: Menachem Cohen, the south-western corner of Tel Aviv City Hall (1957-1965), showing the "egg crate" shading array for the southern facade and the vertical shading elements for the western facade, 2001 (photograph by the author). The original shading elements of the southern facade were replaced during a recent renovation of the building by a new construction which unsuccessfully tried to mimic the original design

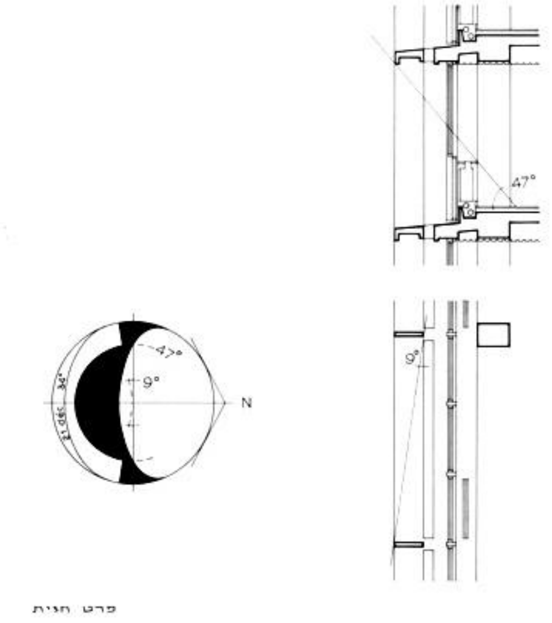


Figure 4.40: Menachem Cohen, shadow mask calculation for the southern facade of Tel Aviv City Hall, ca. 1960 (Menachem Cohen Collection, Israel Architecture Archive)

In his interviews with the author, Stein argued that the choice of precast elements for sun protection was influenced, among other things, by maintenance considerations, since "it is quite clear that under the local maintenance conditions, a movable thing [sun protection] will not survive beyond the contractor's warranty, so we used precast elements. There was a wall of windows, a narrow path in front of it, and an external wall that protects it" (Stein 2012b). At the same time, screening the facades from direct sunlight by an array of identical precast elements enabled Stein to create, in addition to its climatic qualities, a harmonized external image for the building even when the location of the openings in the rear walls produced a visual composition which tended to be less than satisfactory. In Stein words,

> It is a representative building. In my opinion, the function that is hidden behind it [behind the precast screen] cannot appear on the facade, having windows of toilets, and then two windows of two teacher rooms, and then a stairwell. This was not an option. So I was searching for an aesthetic solution which would enable me to resolve the facade in a pretty monumental way. You can see that the accent, not only at the entrance but also in these facades, is a two-storey accent […] So, in that sense, I was a formalist. I searched for its external expression, beyond the functions. I did not find it too exciting to put on the outside what you need inside. (Stein 2012b)

Stein words echo Le Corbusier's famous dogma, "the plan proceeds from within to without; the exterior is the result of an interior" (Le Corbusier 1931 (1927), 5), while refusing to take it at face value. The unmovable precast elements screen, originally a Corbusian invention, was used here in order to conceal some of the visual effects of the functions of the building, which should have been, according to Modernist values, exposed to the eye through the building's external skin. Two corner rooms, which face more than a single direction, received a solid wall with no openings at all in their eastern or western walls, following a clear climatic logic but probably also because of a wish to diversify the facade's appearance.

Notwithstanding aesthetic considerations, the sun protections in the Gilman Building were still designed in a way that could be directly related to the function of the space they were protecting and its orientation. Thus, while precast elements were covering most of the eastern and western facades of the building, the openings which led to the main corridors of each floor were left with no sun protection at all, reflecting a different type of use and needs (Figure 4.41). The northern and southern external facades, which were fully glazed, received a louvered aluminium overhang shading about one meter deep (Figure 4.42). The northern shading elements were identical to the ones used for the southern facades; the similarity allegedly stemmed from their similar function as glare protection, though in the southern facade they were also intended to block the penetration of direct solar radiation (Wittkower 1965). A narrow strip of about 80 cm above the aluminium overhang louvers was sealed using glass in the northern facades and fixed aluminium louvers on the southern facades; this also reflected Stein's inclination to place solar protection only where it was actually needed.

Originally, the facades of the corridors to the courtyards were left free of any solid walls and glazing, and received a shading layer of common sliding PVC-aluminium shutters. The area above the recessed ceiling of the corridors near the classrooms was closed by a fixed version of the same shutter type (Figure 4.43). Since PVC-aluminium shutters were a relatively new invention which was mainly intended to residential uses, it seems that its application here was due to its practicality and relatively low price and less because of any aesthetic consideration. When asked, Stein argued that he did not remember whether he was involved in specifying the type of shutters to be used or not (Stein 2014). The movable shutters proved to be a maintenance disaster: as early as January 1967, Chana Shlomi, the secretary of the Faculty of Humanities, reported that "many of the shutters facing the patio have been broken for a long time now" (Shlomi 1967). As a result, Wittkower and Stein were asked to design a solid closure for the corridors' facades to the courtyards. The new design consisted of large opaque thin wall constructions, with an external face made out of whitewashed asbestos cement panels, combined with mainly narrow windows, some of them openable. In the northern and southern corridor facades the area above the recessed ceiling was now closed using perforated metal sheets. Replacement of the original PVC-aluminium shutters was completed first in the beginning of the 1970's in the southern wing of the building; in the northern wing it took place only after the construction of the additional third floor (Doron 1975).

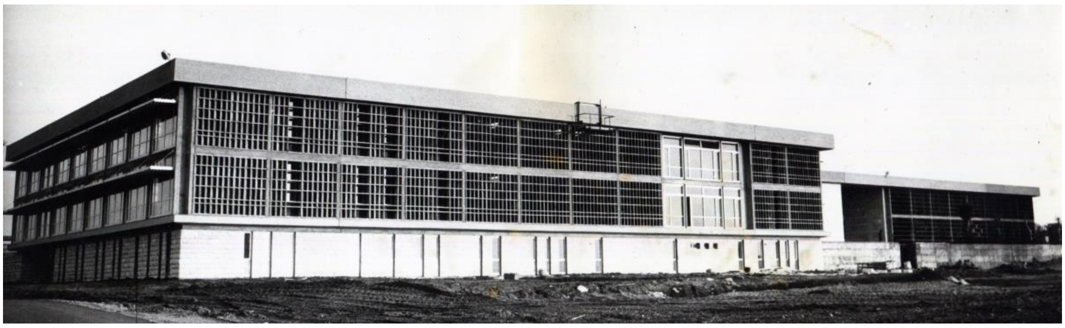


Figure 4.41: Gilman Building, the western facade, ca. 1965 (photograph by Isaac Berez, Tel Aviv University Archive)

Figure 4.42: Gilman Building, the western facade of the connecting "bridge" between the northern and southern wings, ca. 1966 (Israel Stein Collection). Similar louvered overhang shadings could be seen on the southern facade of the northern wing and on the northern facade of the southern wing. The glazed western wall of the "bridge" received no shadings, functioning as an open corridor

Figure 4.43: Gilman Building, the smaller courtyard of the southern wing, looking east, ca. 1966 (Israel Stein Collection). The corridor facades, here facing north and west, were screened with sliding aluminium panels of rotatable PVC slats

Figure 4.44: Gilman Building, the smaller courtyard of the southern wing, looking east, 2014 (photograph by the author). The original PVC-aluminium shutters were replaced during the 1970's with opaque panels made out of asbestos cement and metal, combined with narrow windows

4.2.3 Roof composition in the Gilman Building

Although proper documentation of the roof composition of the Gilman Building is lacking, it is still possible to reconstruct its exact composition based on several partial sources. In the original architectural sections the second floor's floor slab appears to be 38 cm thick (without indoor plaster), from which 7 cm were dedicated to flooring layers (cement floor tiles laid over sand). The second floor's roof slab had the thickness of 31 cm. In each wing, the roof above the upper lecture halls between the courtyards had the thickness of 40 cm. These figures indicate the use of horizontal ribbed slab of reinforced concrete as the structural composition of the roof and ceiling (Figure 4.45 and Figure 4.46).

The exact composition of the inlay material of the ribs is not indicated in any of the original plans; nevertheless, a single photograph that was taken during the construction of the northern wing of the building clearly shows that Ytong blocks were used for the construction of the ceilings (Figure 4.47). Ytong blocks were produced in Israel since 1953 (Shadmi 1953) and by the beginning of the 1960's became a common component of ribbed slab constructions, in spite of being substantially more expensive than their common alternative, hollow concrete blocks. This can be attributed in parts to their much lower weight (with a density of about 450 kg/m^3, in comparison to 930 kg/m^3 of hollow concrete blocks).

As mentioned above (section 3.4), one of the two monitoring campaigns initiated by Wittkower during the 1940's was meant to determine which type of roof construction is favourable under local climatic conditions. Based on results obtained from monitoring residential buildings in Tel Aviv during 1950 and 1951, Wittkower concluded that for the summertime in Israel's coastal plain,

> […] the best roof is the hollow-block roof whitewashed, without the addition of insulating materials. This roof is only slightly better than the ordinary reinforced concrete roof whitewashed, but when winter conditions are also considered, then the hollow-block roof is likely to afford greater protection in the cold season. It is worthy of note

> that the air temperature near its ceiling was never higher during any hour of the day than the outdoor temperature, while in the morning hours it was frequently 4° below it.
>
> [...]
>
> In cases where the house is solely used between the morning and afternoon hours, it is advantageous to add an insulating layer to the hollow-block roof [...] and paint the roof white from above. Daytime temperatures will be relatively low under such a roof. (Wittkower et al. 1953, 16-17)

These conclusions were highly relevant also for the Gilman Building, especially since the building was not meant to be used during nighttime. The "insulating layer" Wittkower was using for his monitoring campaign was made out of "Betkal", an Israeli brand name for foam concrete which was used also for creating the drainage gradients necessary in flat roofs. It seems than foam concrete was indeed applied on the roof of the Gilman Building: when construction of the third floor began in 1974, one of the first actions was the removal of the layer of "Betkal" before the construction of the upper floor's walls (Gur 1974). At the same time, it is not clear whether the foam concrete was applied to the roof because of Wittkower's awareness to its thermal properties, or only for creating drainage gradients. A similar doubt can be cast on the use of Ytong blocks; in spite of their much higher thermal resistance (Ytong's typical thermal conductivity is 0.11 W/mK, in comparison to 0.86 W/mK of hollow concrete blocks), it is possible that they were primarily used because of structural (low weight), rather than thermal, reasons. Nevertheless, the outcome was an almost optimal roof composition also in terms of its thermal performance.

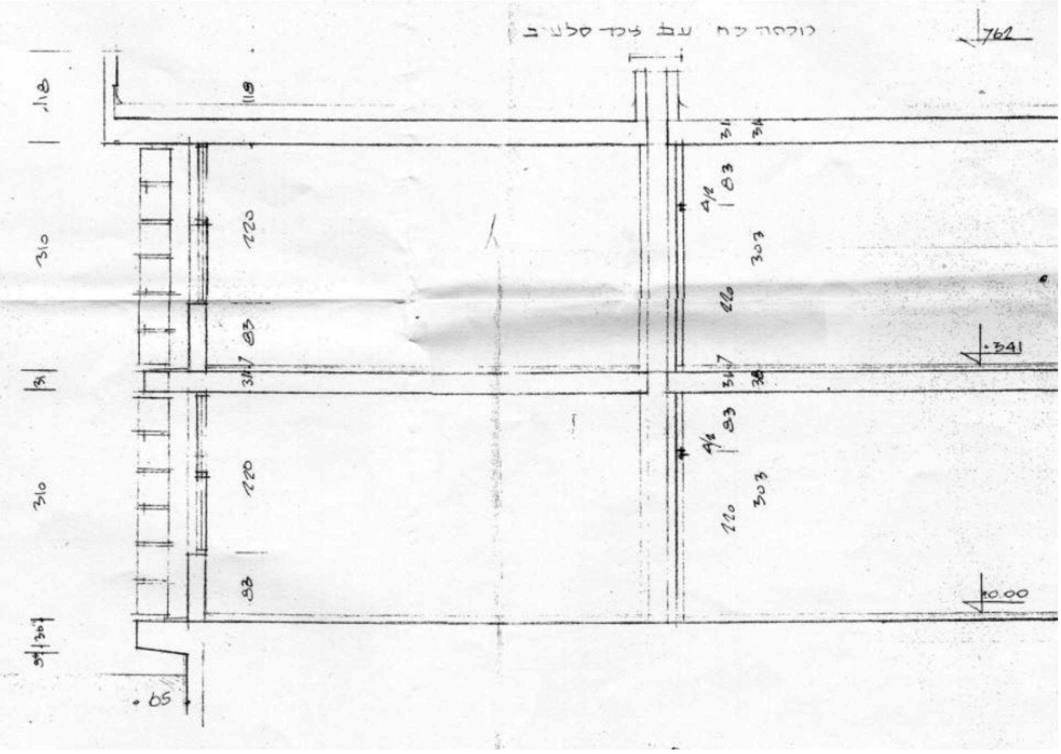


Figure 4.45: Gilman Building, original architectural plans, a detail of an east-west cross section of the southern wing showing a section through the peripheral rooms and the corridor

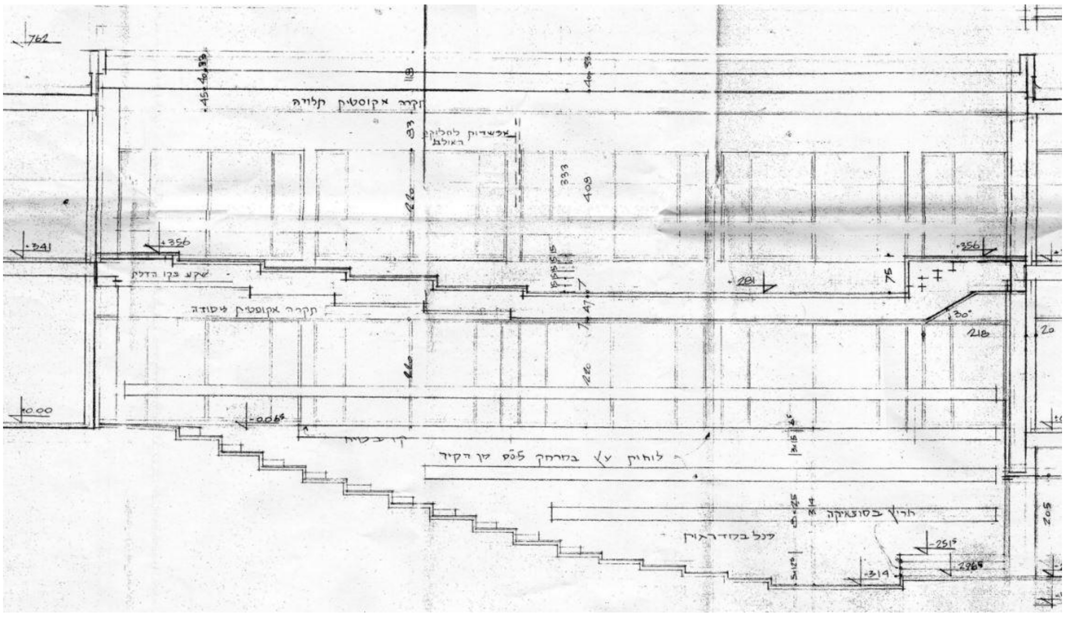


Figure 4.46: Gilman Building, original architectural plans, a detail of an east-west cross section of the southern wing showing a section through the central lecture halls

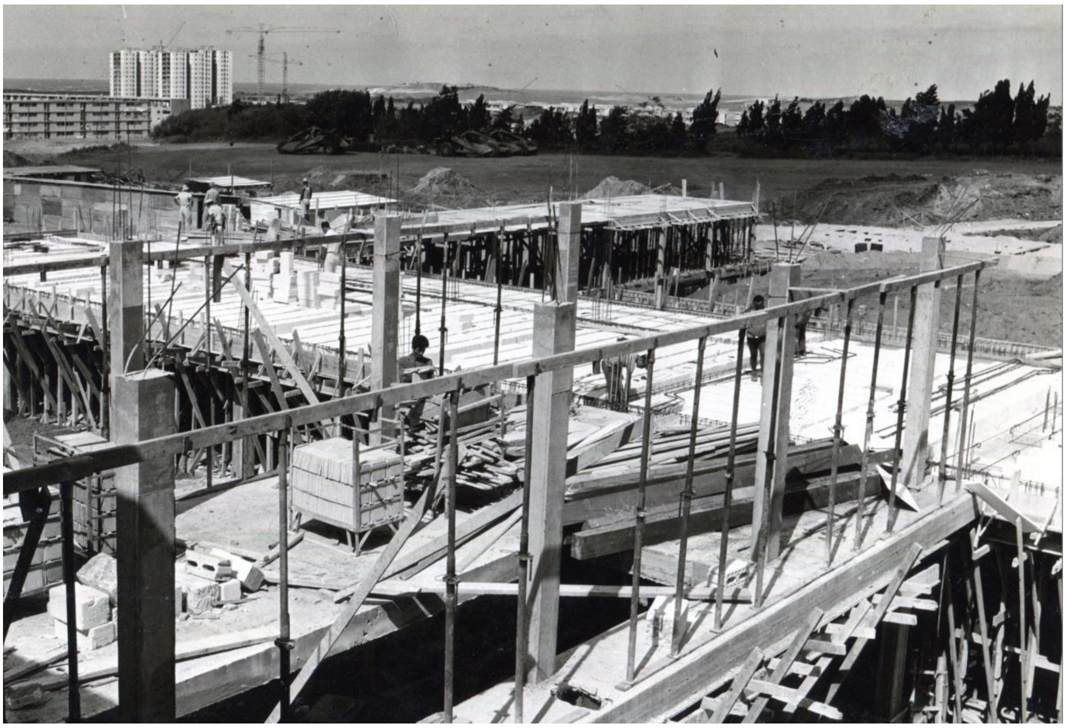


Figure 4.47: Gilman Building, laying Ytong blocks for the casting of the ceiling above the basement of the northern wing, 1964 (photograph by Isaac Berez, Tel Aviv University Archive)

4.2.4 Natural ventilation in the Gilman Building

The Gilman Building was originally designed to be air conditioned. A set of HVAC plans for a central air conditioning system, dated from 1963, was part of the original tender. According to the plans, the main air handling units should have been located in dedicated motor rooms in the basement of each wing, from which air should have been supplied to the rooms through ducts. The ducts were designed to be installed above a recessed ceiling along the corridors and above the central lecture halls of each of the two floors. This scheme was never realized, since the University decided to halt the execution of the HVAC plans for economic reasons (Stein 2012b). Although definitive historic documentation is lacking, it seems that from the 1970's on, small air handling units started to be sporadically attached to the building in order to air condition some of its rooms. This sporadic trend became a general rule, and today all the rooms of the Gilman Building are air conditioned following the same type of solution. The method left its mark on the courtyard facades, now covered with external channels housing coolant pipes which run from units placed mainly on the building's roof (Figure 4.48).

Figure 4.48: Gilman Building, the southern wall of the northern courtyard (northern wing) showing external coolant pipes running from air handling units on the roof and an old window air-conditioner, 2012 (photograph by the author)

Although air conditioning was an integral part of the original design, Wittkower and Stein did pay close attention to naturally ventilating the building. This was not exceptional at that time, and reflected an understanding that many users were used to control their work environment by opening and shutting windows at their own will. The building's location was almost ideal for natural ventilation: on one of the highest points in northern Tel Aviv, with very little obstruction from adjacent buildings. Thus, the arrangement of spaces around courtyards was not only intended to mitigate the effects of solar exposure but also to enable the cross ventilation of rooms through the spaces above the recessed ceilings, going from the courtyards, crossing over the corridors and entering the classrooms, where a window could be always opened. Stein described this scheme in the following way:

> On the side of the corridor there is the problem of noise coming from the corridor. In schools, shutters were placed [in the classrooms doors] facing the corridor, because between the breaks there is no problem of acoustic

> disturbance. In the Gilman Building [where you do not have simultaneous breaks in all classrooms], we tried to resolve this by using a recessed ceiling in the corridors, and shutters in the classrooms [Figure 4.49] were opened to the space above the corridor. The corridors themselves were closed, above and below [the recessed ceiling], by shutters [which enabled the free movement of air; see Figure 4.43]. Here we had a really bad surprise, acoustically speaking. I innocently thought that if you build panelled ceiling and apply mineral wool on top of it the penetration of noise into the classrooms is prevented. It turned out that mineral wool did not prevent the penetration of noise. What does help is mass, so in later years they substituted the dropped ceilings with Rabitz ceilings. (Stein 2012b)

Figure 4.49: Rare original ventilation shutters, now unused, inside a classroom in the Gilman Building, leading to the air space above the adjacent corridor that connects to the facade to the courtyard, 2014 (photograph by the author)

The replacement of the flimsy shutters in the courtyards' facades during the 1970's put an end to a real possibility of cross ventilating the classrooms during lessons. The corridor openings above the recessed ceiling level were now closed with perforated metal sheets (Figure 4.50), which were probably designed to allow the infiltration of fresh air into the building, but invalidated the original natural ventilation scheme. Limited cross ventilation could still be achieved through a simple opening of a classroom door, assuming that the corridor and classroom windows are open, but this applied only for the short breaks between lessons.

Even after the closing of the corridors to the courtyards, the Gilman Building, especially in its circulation spaces, was relatively open to the outside. Windows in all rooms and corridors could be easily opened by the users. Moreover, the large glazing areas of the northern and southern facades, as well as the main connecting corridor, were constructed of only one layer of plain 4 mm glass, which resulted in considerable heat loss. This combination made the thermal performance of the building during winter a soft spot. In an academic institution in which the lion's share of lessons take place during the cooler season this could be a problem, but, as Stein admitted, the issue of low indoor temperatures during winter was not even considered, since

> […] during the 1950's and 1960's the main concern was protection against heat. The subject of chill was absolutely not among the design considerations […] it turned out that the subject of the winter months was not at the top, and even not at the bottom, of the architectural [attention] during those years. (Stein 2012a)

Figure 4.50: Gilman Buildings, a detail of a corridor wall facing the northern courtyard of the northern wing, 2012 (photograph by the author). The area above the recessed ceiling of the corridor was closed with perforated metal sheets upon the replacement of the original sliding shutters

4.3 Simulating the thermal performance of the Gilman Building

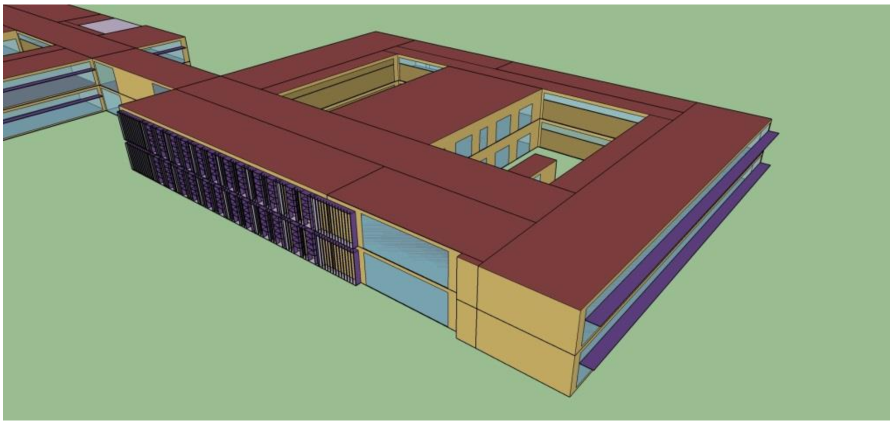
In spite of the attention that was given to climatic issues during the design of the Gilman Building, its actual thermal performance was probably less than ideal. A major issue was the coldness of indoor spaces during winter, which attracted much attention soon after the full occupation of the building. In November 1965 Daphna Cohen-Mintz from the secretariat of the Faculty of Humanities approached Shlomo Rakabi, the Faculty's administrator, and asked about heating provisions for the upcoming winter in classrooms and offices alike. Rakabi referred the letter to Aharon Doron, then the University's executive director, adding the following comments:

> We have no provision for winter heating in the classes. As you know, air conditioning was not installed. Last year we passed the winter without heating, and it seems that this year we have no other choice as well. Heating in offices is paid for from the budgets of the departments (electric heaters). Not everybody has budgets for it. (Cohen-Mintz 1965)

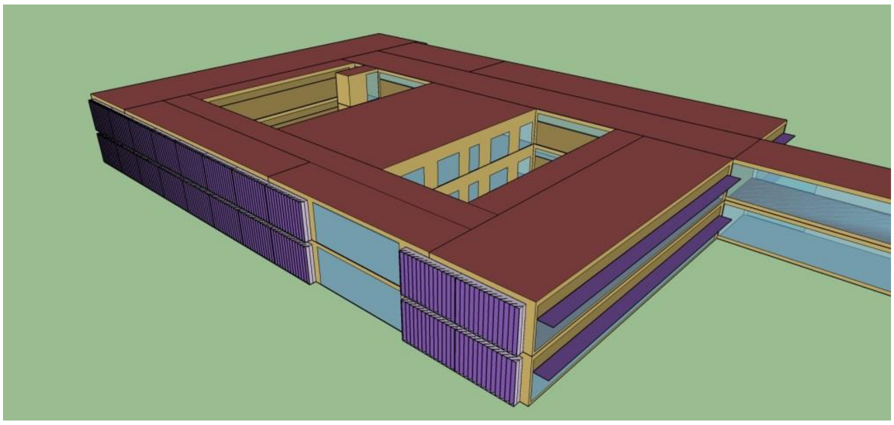
The indoor chill of the Gilman Building during its first years of operation was probably worsened because of the choice of sliding shutters (instead of glazed windows) for closing the corridors' facades to the courtyards, since their deteriorating condition, with broken slats left unfixed, exposed the corridors to chilly winds and rain. Yet the problem of chill was not the only recorded complaint on the building's indoor climate: it seems that summer conditions as well left some users unsatisfied. Thus, in July 1973 Daniel Carpi, the Dean of the Faculty of Humanities, wrote a letter to the University's president, rector, and executive director, urging them to approve the installation of (central) air conditioning in the building. Carpi's justification for his request was short: he argued that "the building was originally built for teaching under conditioned atmosphere, and therefore the heat during the months of teaching is greater in comparison to a normal building, and this negatively affects both teachers and students" (Carpi 1973). The fact that the letter was written in the hot and humid month of July may shed some doubts on Carpi's climatic appreciation of the building's thermal performance as worse than that of a "normal" building.

A closer look into the thermal performance of the original design could help to correctly assess whether indoor conditions were as grave as claimed by some of the building's users, and to understand whether the original design resulted in worse-than-expected indoor climate or rather in an optimal climatic solution that actually prevented much worse conditions. Since the Gilman Building went through substantial transformations throughout the years, the only way to make such an assessment is by employing thermal building simulation, conducted here with version 8.1 of the EnergyPlus simulation engine (U.S. Department of Energy 2013). The building was simulated in its original state (i.e. without the third floor which was constructed in 1974-1975), including the original sliding shutters installed in the corridors' facades to the courtyards. Since the original architects designed and oversaw their replacement by windows and light walls during the 1970's, a preliminary assessment of the impact of this improved design on indoor temperatures was conducted. The results led to the conclusion that the new design produced almost similar indoor temperatures as the original design (summer and winter alike), when assuming similar air change rates, and therefore could be ignored for the purpose of the current study. Renderings of the simulated models appear in Figure 4.51. A list of the applied simulation scenarios appear in Table 4.1 (further details can be found below). For the sake of simplification, adjacent rooms facing a similar direction were analysed as a single thermal zone.

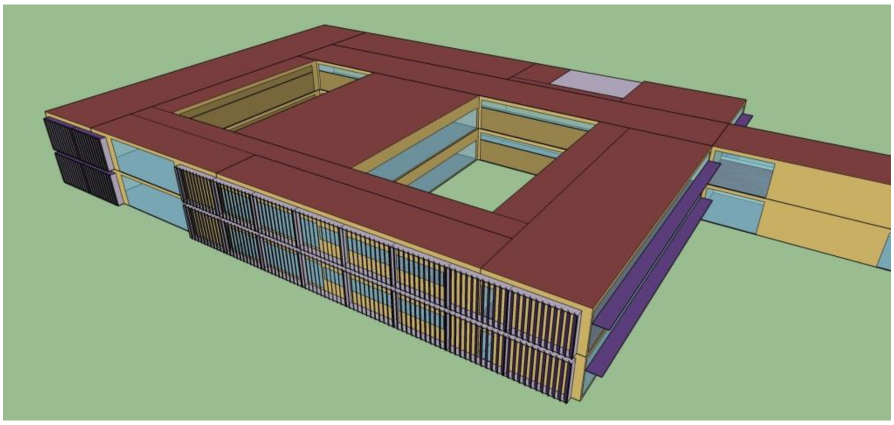
Northern Wing, North-Eastern Corner



Northern Wing, South-Western Corner



Southern Wing, North-Eastern Corner



Southern Wing, South-Western Corner

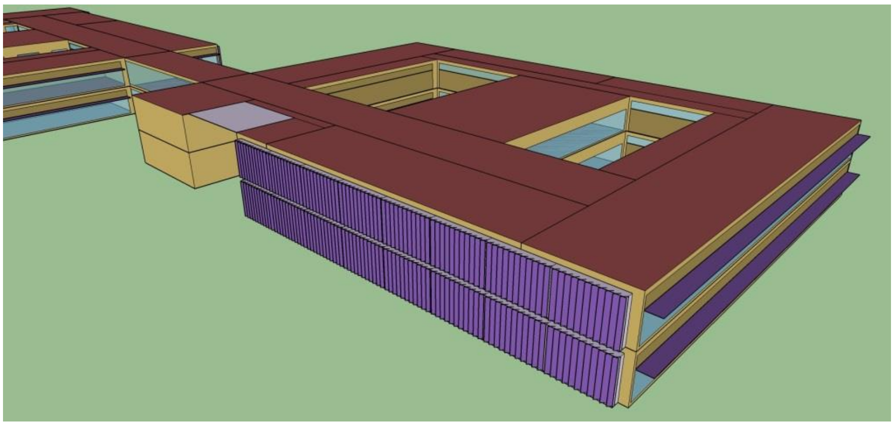


Figure 4.51: Renderings of the simulation model

Table 4.1: Simulation scenarios for evaluating the effect of building orientation

Scenario Name	Description
BS	The building as built
BSNS	The building as built, no sun protections
BSCB	The building as built, concrete blocks inlay instead of Ytong blocks in the roof construction

Although historic or contemporary documentation of building materials in the Gilman Building does not exist, it was possible, based on the original architectural plans, historic photographs, and on-site survey, to reconstruct a full material list of the main building components (Table 4.2). Physical properties (thermal conductivity, density, specific heat, and solar absorptance) of the building materials were extracted from existing literature (Table 4.3 and Table 4.4). Physical properties of windows (U-value, solar heat gain, visible transmittance) were calculated using version 7.2 of the WINDOW software (Lawrence Berkeley National Laboratory 2014b). Weather file of a sample year was created using Version 7.0 of the Meteonorm software (Meteotest 2012), based on monitored historic weather (from the years 1961-1990) and solar radiation (1981-1990) data. For the sake of simplifying the simulation process, a constant rate of 3.0 ACH per hour for summer (naturally ventilated) and 1.0 ACH for winter (windows closed) was calculated (Table 4.5), based on the values given in the CIBSE guide for environmental design (CIBSE 2006, 5-8). Internal loads (Table 4.6) were simulated based on typical occupancy schedules for weekdays and Saturdays (Figure 4.52 and Figure 4.53). On Sundays[10] it was assumed that no activity was taking place in the building.

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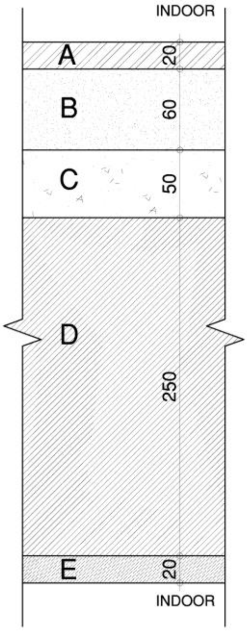
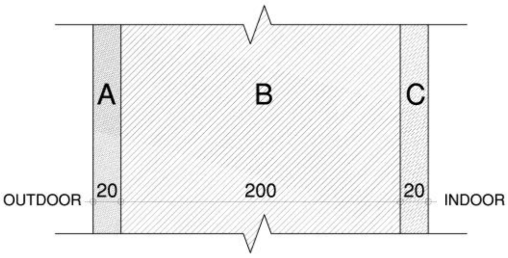
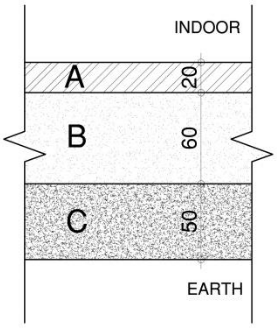
[10] The Israeli working week starts on Sunday and ends on Thursday. The university campus is open on Fridays until the early afternoon hours, which means some activity can take place in its buildings. Since EnergyPlus does not have an option of designating alternative days of a working week, the standard Monday to Friday scheme was used.

Table 4.2: Main building materials of the Gilman Building

Building Element	**Typical section (dimensions in mm)**	**Materials and resultant U-value**
Ceiling between floors		A: Cement floor tiles B: Sand C: Reinforced concrete D: Ytong blocks E: Indoor plaster
External doors	-	Non-painted aluminium frame, 4 mm single plain glass sheet
External wall		A: External plaster B: Hollow concrete block C: Indoor plaster **U value: 2.00 W/m^{2}K**
Floor		A: Cement floor tiles B: Sand C: Concrete screed

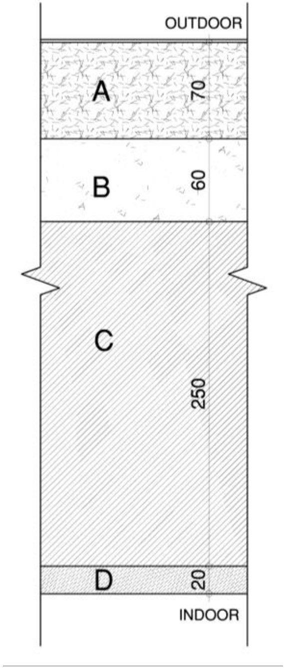
Building Element	Typical section (dimensions in mm)	Materials and resultant U-value
Roof		A: Foam concrete, whitewashed over sealant asphalt layer B: Reinforced concrete C: Ytong blocks D: Indoor plaster **U value: 0.28 W/m^2K**
Windows	-	Non-painted aluminium frame, 4 mm single plain glass sheet

Table 4.3: Thermal and physical properties of simulated materials

Material	Thermal Conductivity (W/mK)	Density (kg/m^3)	Specific Heat (J/kgK)	Source
Aluminium fixed shutters	45	7680	420	(CIBSE 2006, 3-34)
Cement floor tiles	1.1	2100	840	(CIBSE 2006, 3-37)
External cement-based plaster	0.72	1860	840	(CIBSE 2006, 3-36)
Foam concrete	0.07	320	920	(CIBSE 2006, 3-37)
Hollow concrete block	0.86	930	840	(CIBSE 2006, 3-37)

Material	**Thermal Conductivity (W/mK)**	**Density (kg/m^3)**	**Specific Heat (J/kgK)**	**Source**
Indoor plaster	0.22	800	840	(CIBSE 2006, 3-36)
PVC shutters	0.16	1380	1000	(CIBSE 2006, 3-34)
Reinforced concrete	1.9	2300	840	(CIBSE 2006, 3-37)
Sand	1.74	2240	840	(CIBSE 2006, 3-35)
Ytong block (standard)	0.11	450	840	(Xella UK 2011, 4)

Table 4.4: Solar absorptance properties of simulated exterior materials

Material	**Solar Absorptance**	**Source**
Aluminium fixed shutters	0.65	(CIBSE 2006, 3-42)
External cement-based plaster	0.73	(CIBSE 2006, 3-43)
PVC shutters	0.50	(Assumed)
Reinforced concrete (exposed)	0.73	(CIBSE 2006, 3-43)
Whitewash	0.35	(Givoni 1998, 75)

Table 4.5: Simulated ventilation rates (in ACH)

Daily Hours	**Summer**	**Winter**
	1.5-31.10	**1.11-30.4**
07:00-19:00 (day)	3	1
19:00-07:00 (night)	3	1

Table 4.6: Internal loads used for the simulation

Type	Value for Maximal Occupancy
People	0.1 person/m^2, 115 W/person (64 met)
Electric equipment	1 W/m^2
Lights	1 W/m^2

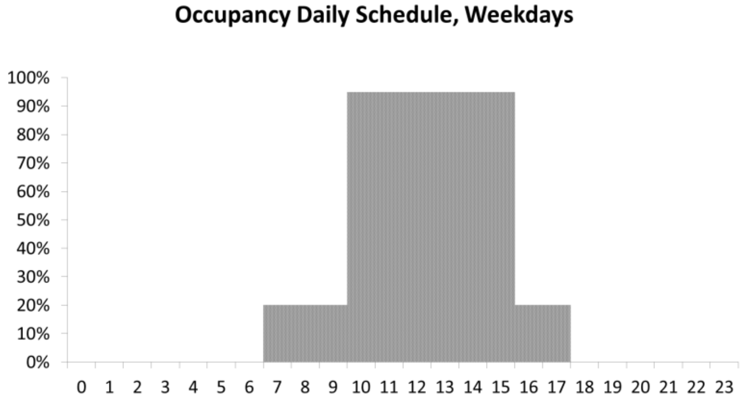


Figure 4.52: Occupancy schedule for weekdays

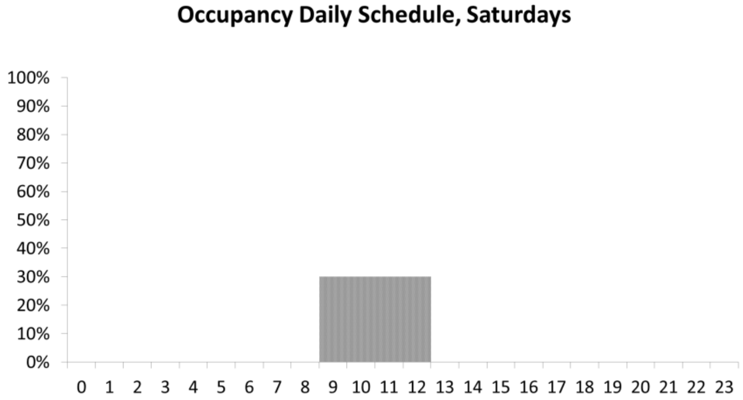
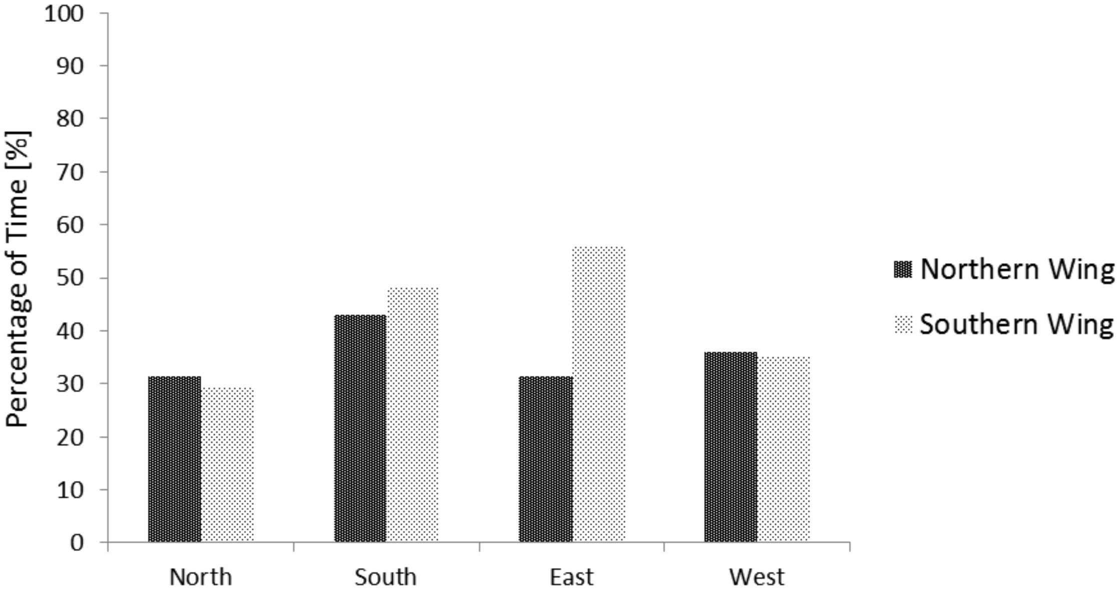


Figure 4.53: Occupancy schedule for Saturdays

4.3.1 Effect of building orientation

Werner Joseph Wittkower, the architect-of-record of the Gilman Building, had a long history not only of awareness to the theoretical aspects of building climatology but also of scientifically research in the field. Between 1946 and 1951 he was involved in two monitoring campaigns, the first addressed the question of preferable building orientation while the latter examined the thermal effect of different roof compositions on indoor climate during summer. One of his main arguments was that protection of indoor spaces from direct sunlight is the primary strategy for lowering indoor temperatures in the Israeli summer (Wittkower 1942b, Wittkower 1943b). In the Gilman Building, Wittkower, alongside his future partner Israel Stein, had to deal with a building orientation which was in total contrast to what he has been recommending throughout his career. The problematic orientation called for an extensive exploitation of the concept of shading. As mentioned above (section 4.2.2), Stein himself saw shading as the most effective climatic tool in the architect's arsenal. Thermal simulation of the Gilman Building should therefore first examine the effects of the far-from-optimal orientation of the building, and then help in analysing the ways in which shading devices were applied to overcome the expected negative effects of the building's orientation. At the same time, the simulation should also examine the possible effects of other factors on the building's indoor climate.

Since shading devices vary in the Gilman Building from one facade to another (thus having a non-uniform impact on the building envelope), it is required to simulate the building without its shading devices (scenario BSNS) in order to examine the effect of orientation on indoor temperatures. Assessment was done by calculating "overheating rates" (defined as the percentage of hours with indoor temperatures above 27°C) for the different rooms during daytime (07:00-19:00) only, since the building was not meant to be occupied during nighttime. Average results for the summer months (July-September) in both wings and floors are shown in Figure 4.54. In addition to overheating rates, indoor temperatures of a typical summer day (calculated as the mean dry-bulb temperature of each hour separately between 1 July and 30 September) were calculated and compared with the corresponding outdoor temperatures (Figure 4.55 and Figure 4.56).



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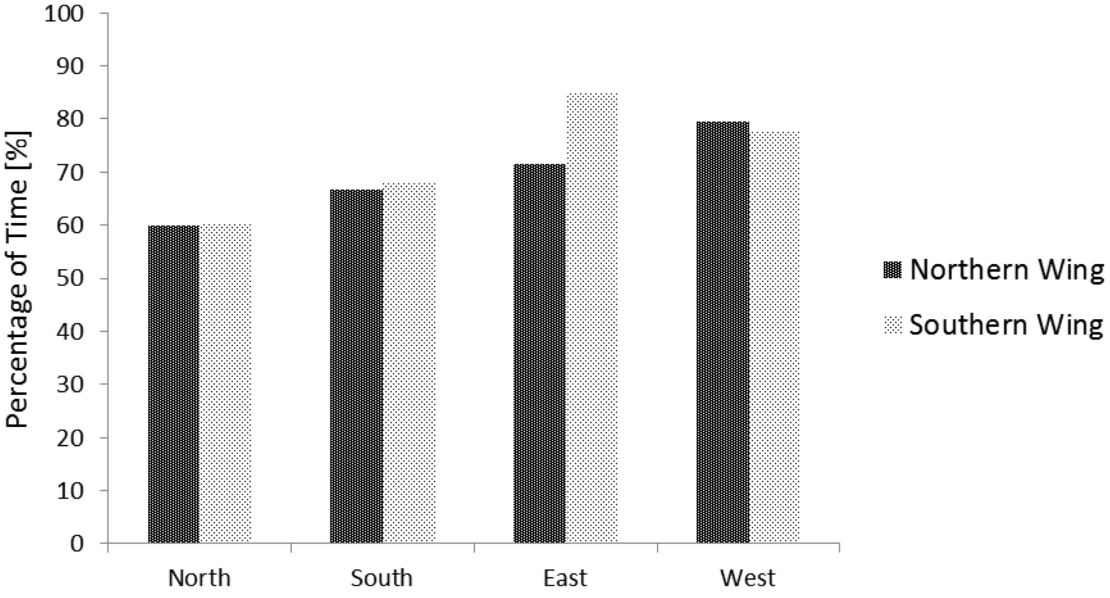
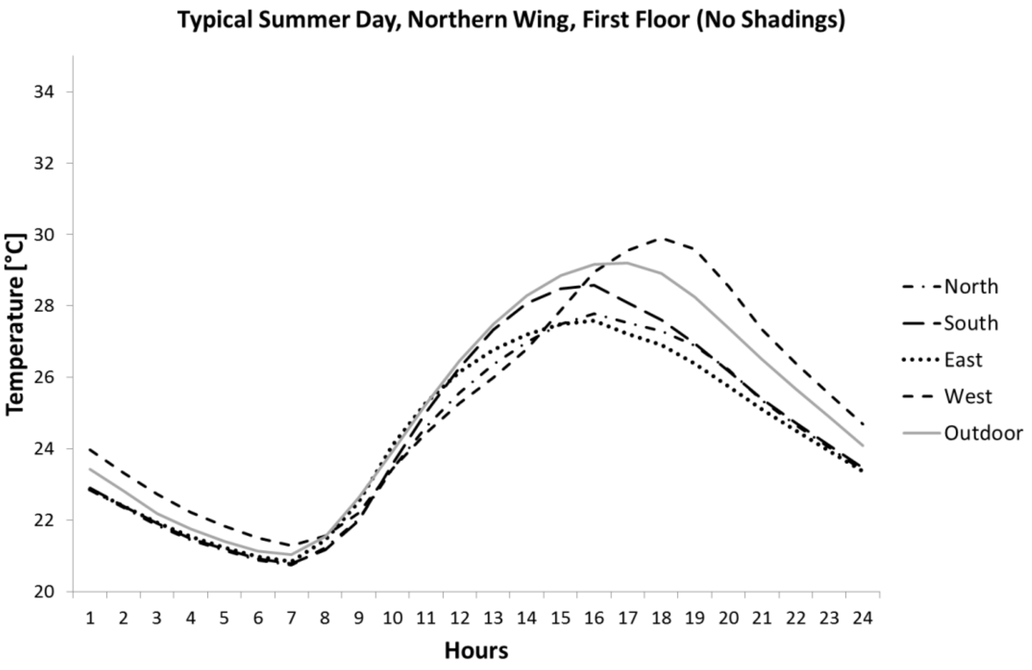


(b)

Figure 4.54: Summer overheating rates of rooms oriented differently, the first (a) and second (b) floors of the southern wing (scenario BSNS)



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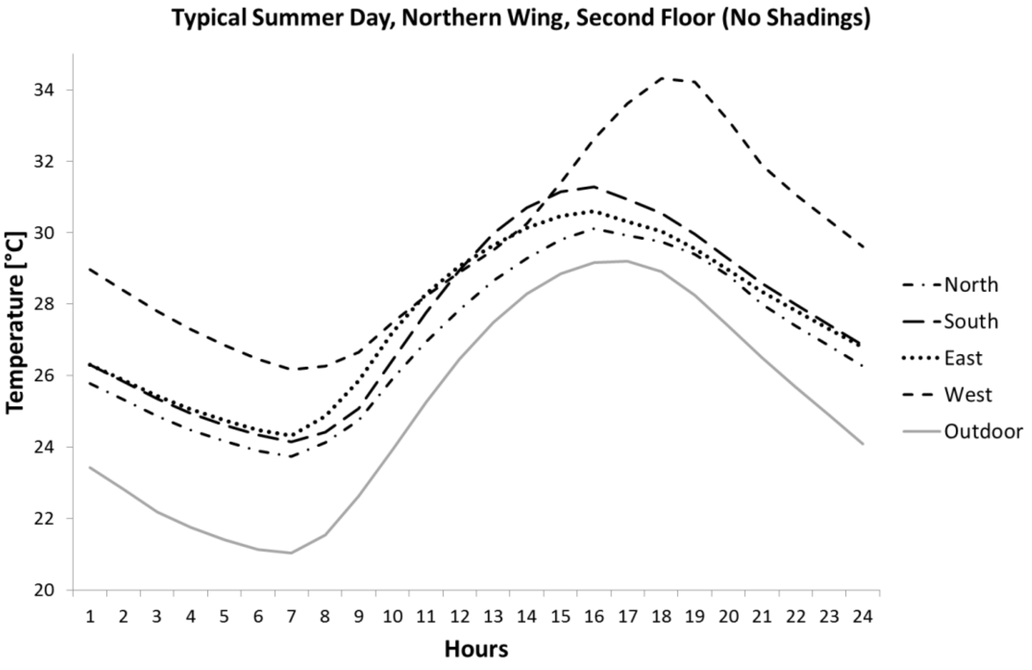
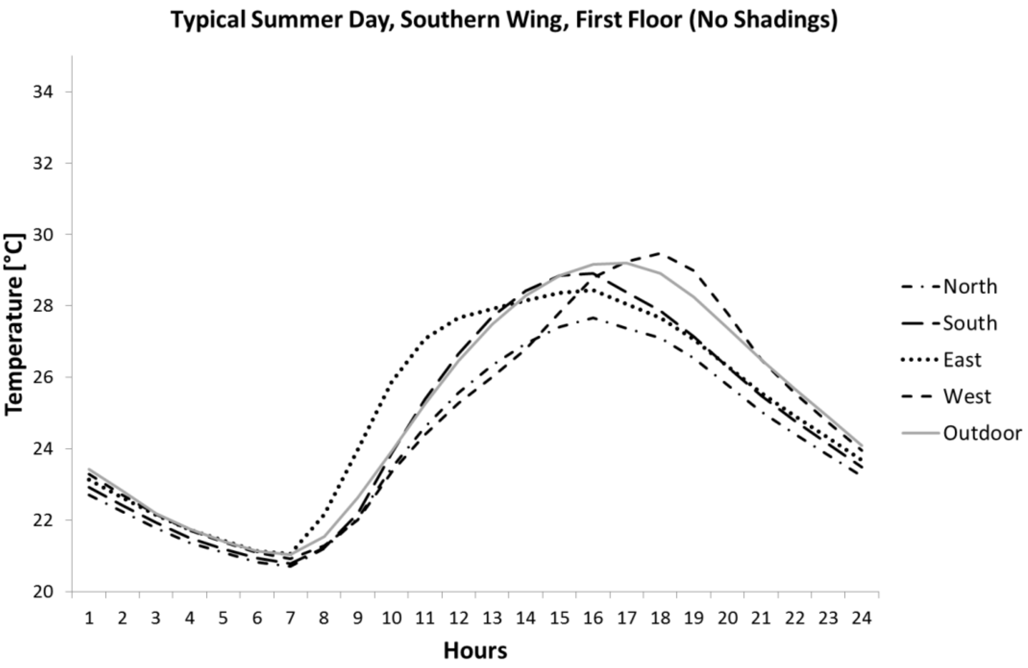


(b)

Figure 4.55: Simulated indoor temperatures for a typical summer day (July-September) of rooms oriented differently, the first (a) and second (b) floors of the northern wing (scenario BSNS)



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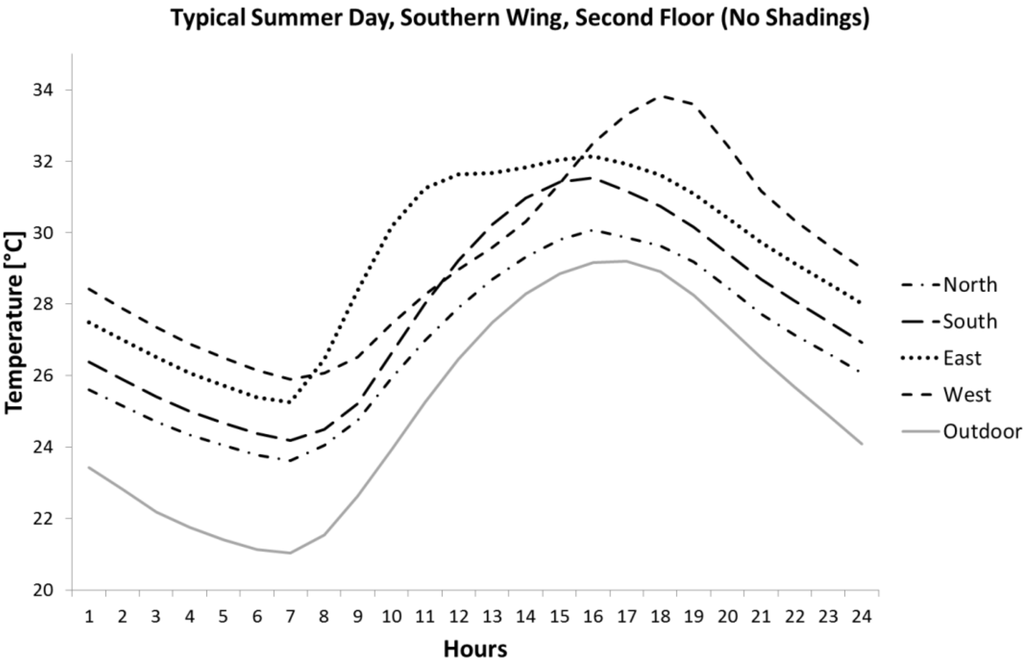


(b)

Figure 4.56: Simulated indoor temperatures for a typical summer day (July-September) of rooms oriented differently, the first (a) and second (b) floors of the southern wing (scenario BSNS)

The simulation results showed that in both floors and wings, overheating rates during daytime cannot be solely explained by reference to the rooms' orientation alone, though it can be argued that northern room were generally cooler than all other rooms. In other words, indoor temperatures depended on other factors than mere orientation, mainly the glazing to wall and glazing to floor ratios (indoor air temperatures increased as wall glazing to floor area ratios increased, see Table 4.7). This is best manifested in the results for the eastern rooms (Figure 4.58): the eastern rooms of the southern wing were the coolest of all, while the eastern rooms of the northern wing were the warmest of all. This result can be explained based on the much higher glazing to floor area ratio of the eastern rooms in the southern wing, compared to the similarly oriented rooms in the northern wing.

Table 4.7: Wall glazing to floor area ratio for all rooms

	Northern rooms	**Southern rooms**	**Eastern rooms**	**Western rooms**
Northern Wing	0.38	0.27	0.11	0.30
Southern Wing	0.41	0.28	0.35	0.27

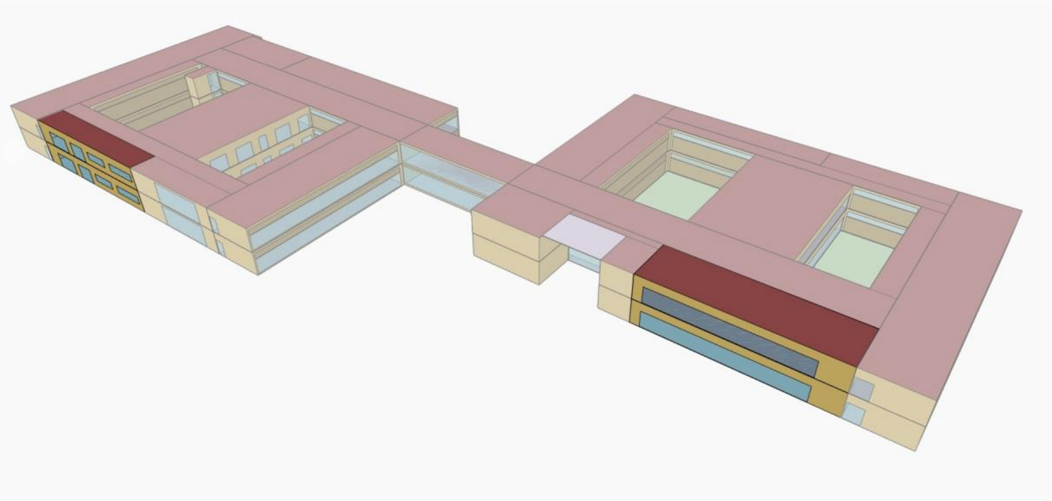


Figure 4.57: Simulation model of the Gilman Building with no shadings (scenario BSNS), in which the western rooms are highlighted in the northern (left) and southern (right) wings

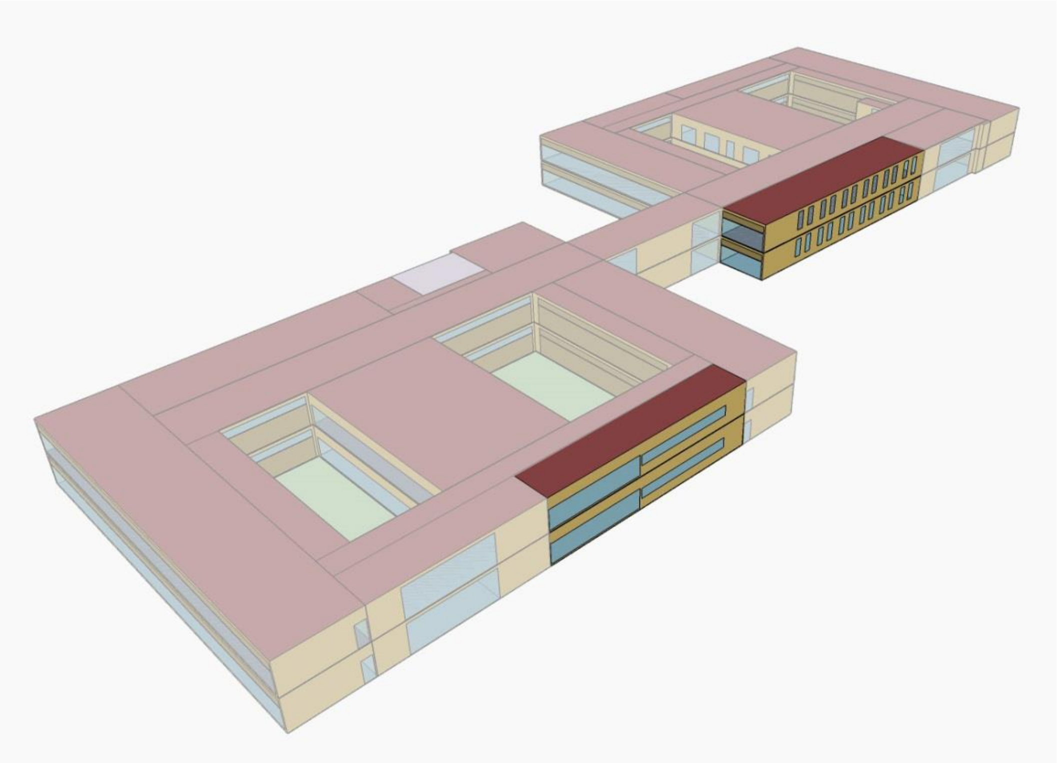


Figure 4.58: Simulation model of the Gilman Building with no shadings (scenario BSNS), in which the eastern rooms are highlighted in the northern (right) and southern (left) wings

4.3.2 Effect of sun protections

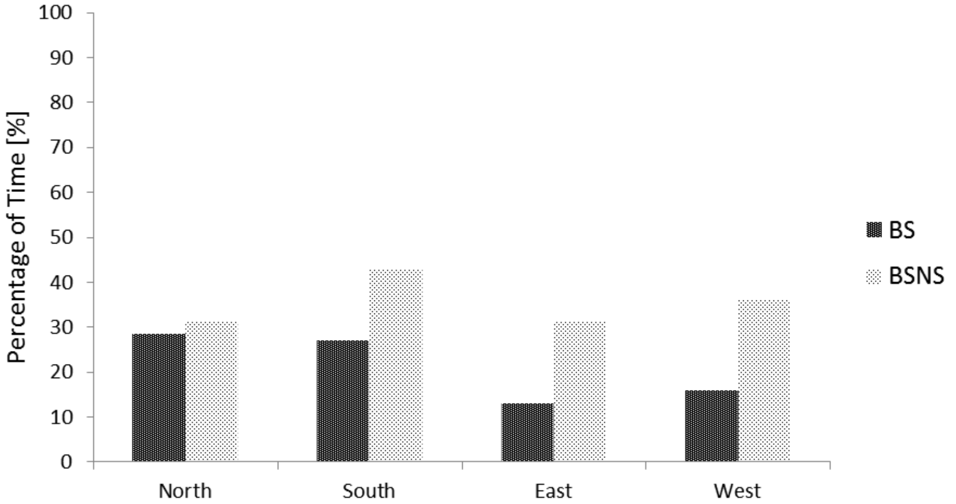
The efficacy of shading devices in the Gilman Building was evaluated by comparing two simulation scenarios: the original state of the building (BS) and the building stripped of its shading elements (BSNS). Overheating rates for daytime hours only were calculated for the summer months (July-September) and are shown in Figure 4.59; the cooling effect of the shading devices, expressed in temperature difference of the maximum daily temperature for a typical summer day between the two scenarios, is shown in Table 4.8. The results lead to the conclusion that the precast concrete elements were responsible for a substantial lowering of indoor temperatures in both eastern and western rooms. The horizontal shading overhangs of the southern facades helped in lowering the indoor temperatures during daytime, though in a relatively moderate way. As expected, the horizontal shading overhangs of the northern facades had almost no effect on indoor temperatures.

What is clear from the calculation of overheating rate, as well as from comparison of indoor temperatures of a typical summer day (Figure 4.60 and Figure 4.61), is that the eastern and western rooms were cooler than the northern and southern rooms. Thus, it can be argued that the shading devices for the eastern and western rooms overcame their initial disadvantage caused by their orientation. At the same time, it can also be argued that in the southern rooms summer temperatures could have been slightly lower with an alternative design of shading devices. In the end, the shading devices in the Gilman Building played an effective role on lowering summer indoor temperatures and in a way that kept indoor spaces relatively cool at least in the building's first floor.

Notwithstanding their effective role during summer, it is interesting to examine whether the shading devices had a negative impact on indoor winter temperatures by blocking solar radiation that could have increased indoor temperatures. To answer this question, "underheating rates" (defined as the percentage of hours with indoor temperatures below 20°C) were calculated for the different rooms during daytime (07:00-19:00) only; the results for the BS and BSNS scenarios were then compared (Figure 4.62). The cooling effect of the shading devices, expressed in temperature difference in maximum daily temperature for a typical winter day, is shown in Table 4.9. The results show that for the eastern and western rooms, the fixed precast shading elements prevented a proper exploitation of solar radiation for passive heating during winter. A somewhat more moderate effect was also simulated in the southern rooms, though even with their shading devices temperatures in these rooms were still relatively high (Figure 4.63), making them much less dependent on additional heating than rooms oriented to the north, east, and west. These results indicate that the design of shadings in the Gilman Building, while providing excellent summer solar protection, was not optimized for absorbing solar radiation inside the rooms during winter.

Table 4.8: The cooling effect of shading devices for different room orientations, expressed as the difference between the maximum temperatures of scenarios BSNS and BS for a typical summer day

		Northern rooms	Southern rooms	Eastern rooms	Western rooms
1st Floor	**Northern Wing**	0.14	1.04	0.77	3.08
	Southern Wing	0.22	1.11	1.31	2.51
2nd Floor	**Northern Wing**	0.21	1.38	1.26	5.13
	Southern Wing	0.27	1.48	2.55	4.30



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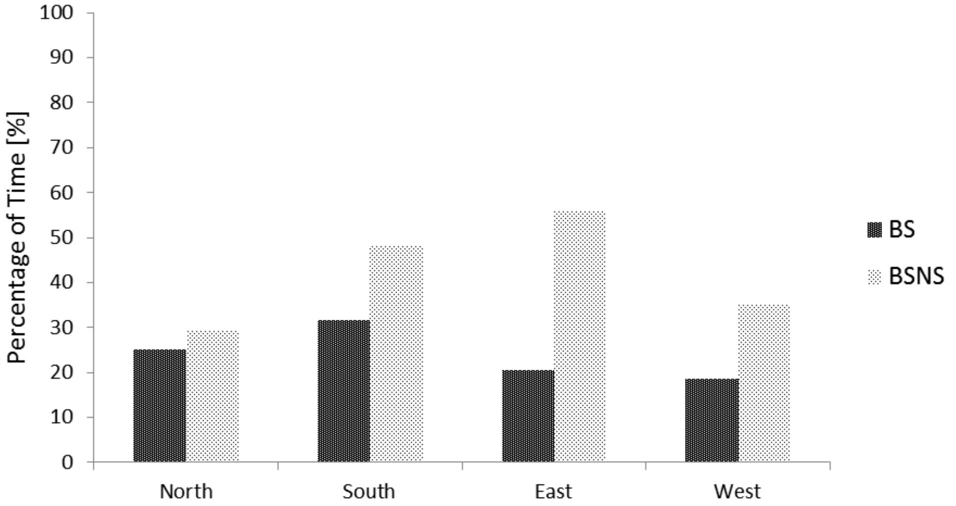
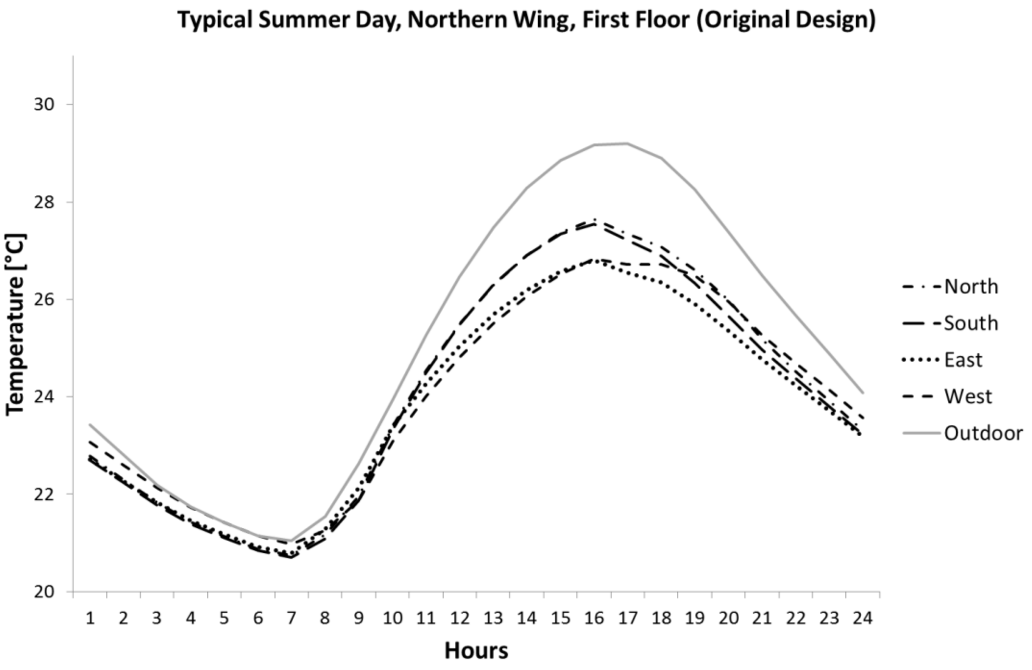


(b)

Figure 4.59: Summer overheating rates of rooms oriented differently, the first floor of the northern (a) and southern (b) wings (scenarios BS and BSNS)



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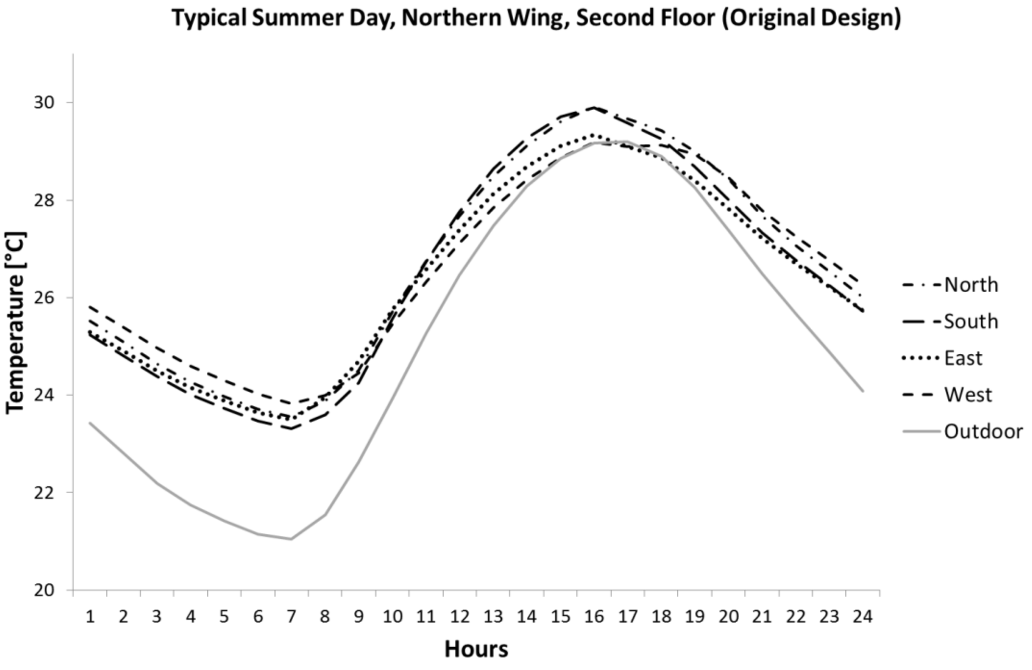
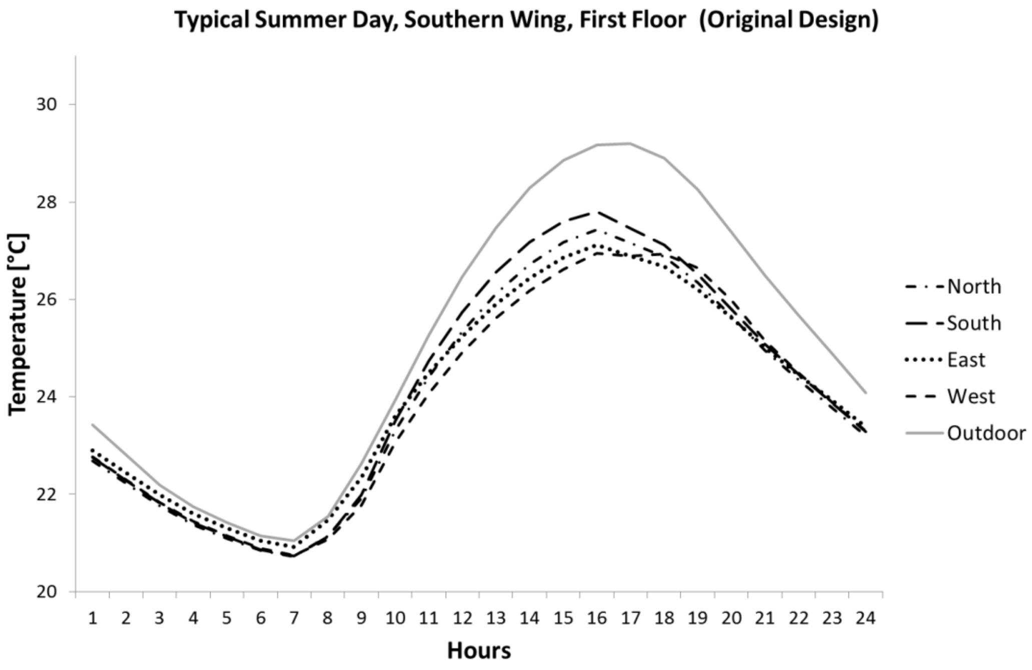


(b)

Figure 4.60: Simulated indoor temperatures for a typical summer day (July-September) of rooms oriented differently, the first (a) and second (b) floors of the northern wing (scenario BS)



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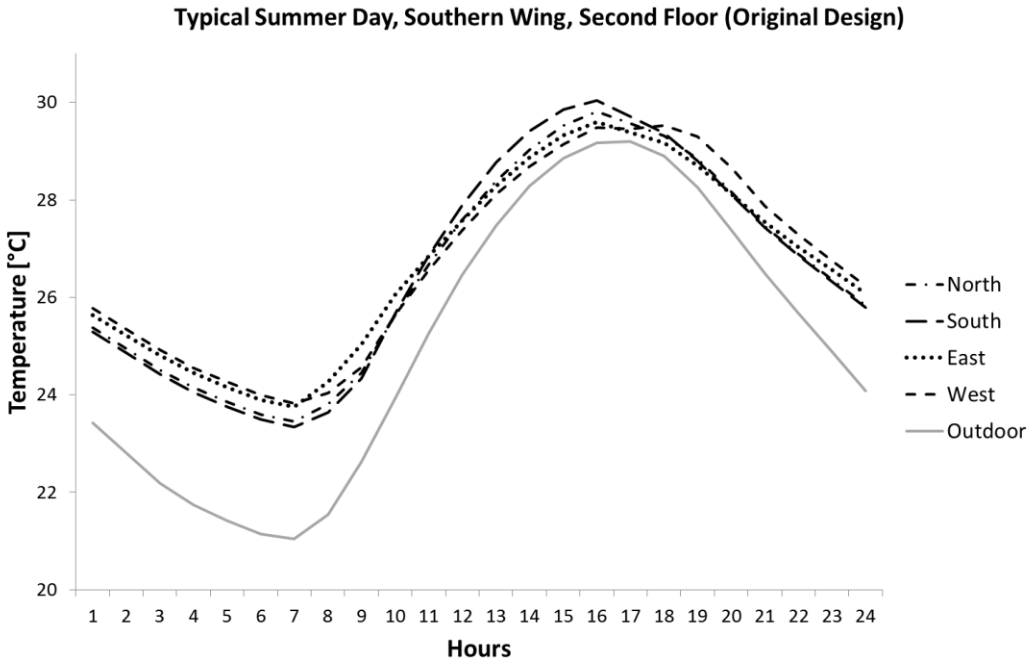


(b)

Figure 4.61: Simulated indoor temperatures for a typical summer day (July-September) of rooms oriented differently, the first (a) and second (b) floors of the southern wing (scenario BS)

Table 4.9: The cooling effect of shading devices for different room orientations, expressed as the difference between maximum temperatures of scenarios BSNS and BS for a typical winter day

		Northern rooms	**Southern rooms**	**Eastern rooms**	**Western rooms**
1st Floor	**Northern Wing**	0.18	1.22	0.67	2.24
	Southern Wing	0.25	1.28	1.13	1.88
2nd Floor	**Northern Wing**	0.31	2.18	1.39	3.89
	Southern Wing	0.35	2.26	2.13	3.65

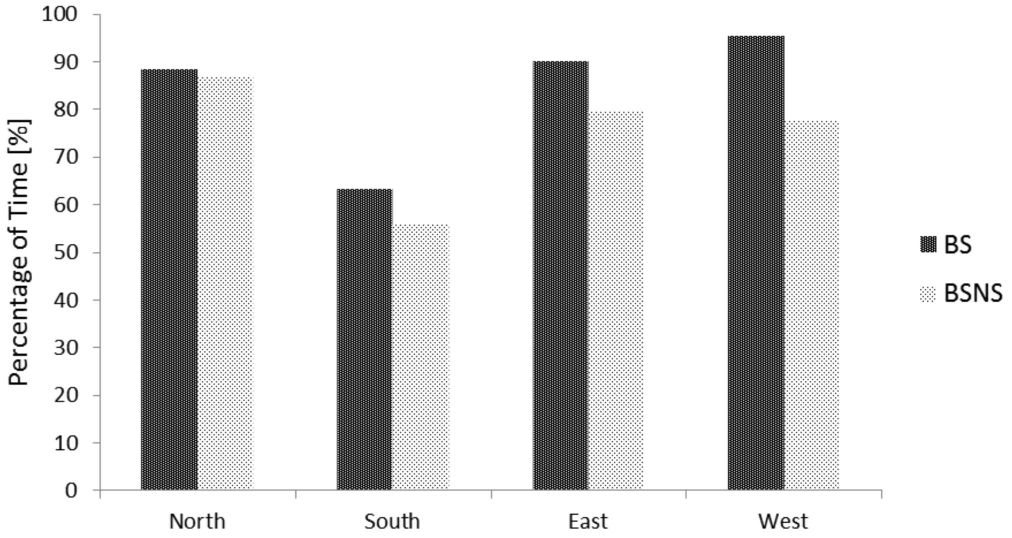


Figure 4.62: Winter underheating rates of rooms oriented differently, the first floor of the northern wing (scenarios BS and BSNS)

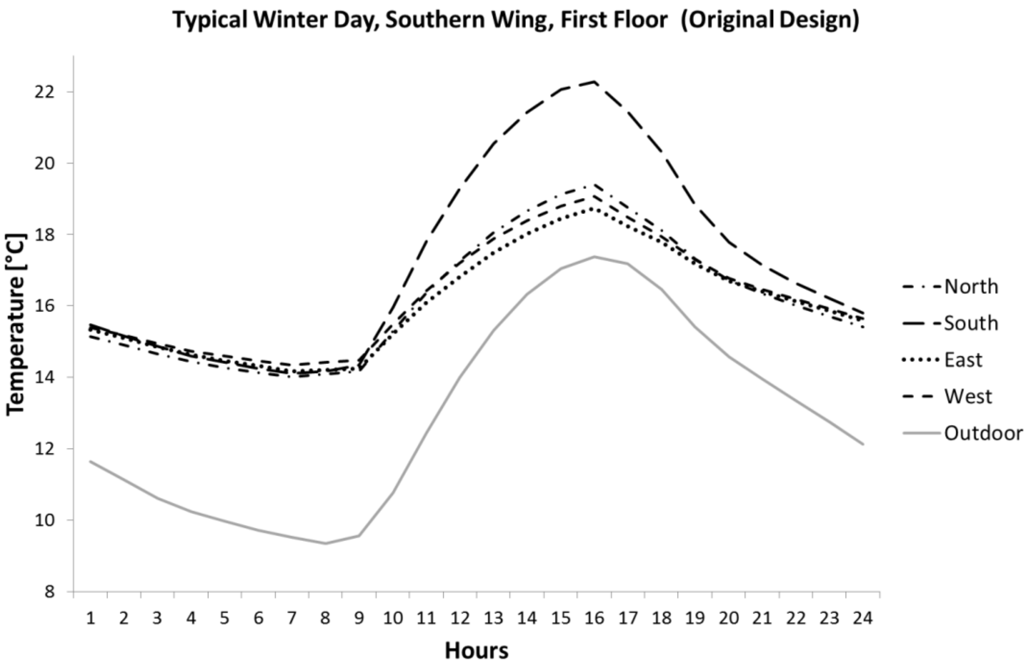


Figure 4.63: Simulated indoor temperatures for a typical winter day (December-February) of rooms oriented differently, the first floor of the northern wing (scenario BS)

4.3.3 Effect of roof composition

As can be seen in Figure 4.60 and Figure 4.61, simulated indoor summer temperatures in the second (upper) floor were consistently higher at about 2-3K than room temperatures in similarly-oriented rooms in the first floor. Since the first and second floors of the Gilman Building are identical in their layout and facade design, this difference must be attributed to the direct exposure of the second floor's ceiling (i.e. the building's roof) to solar radiation and outdoor air temperatures. Rooms directly below the roof were warmer than outdoor conditions, while rooms below them were cooler.

The roof composition of the Gilman Building was almost optimal in terms of its thermal performance, with a total thickness of 40 cm and a U-value of 0.28 W/m²K. It was also congruent with the climatic recommendations of Wittkower's 1950-1951 experiment. The only minor exception was the application of Ytong blocks instead of hollow concrete blocks, which, because of their much better thermal resistance (0.11 W/mK, in comparison to 0.86 W/mK of hollow concrete blocks), could have had a negative effect on the upper rooms' ability to cool down during nighttime.

In order to evaluate the potential improvement in indoor temperatures, a comparison was made between the original roof composition and a scenario where hollow concrete blocks replaced the Ytong blocks in the roof construction (scenario BSCB). Calculation of summer overheating rates (Figure 4.64) showed that the application of hollow concrete blocks could have produced a reduction of 3-5% of overheating rates. In terms of temperature reduction, hollow concrete blocks kept indoor temperatures cooler by about 0.5K in all orientations (see for example Figure 4.65). During winter, and in spite of the lower U-value of the hollow concrete blocks roof (0.65 W/m^{2}K), there was almost no difference in indoor temperatures between the two scenarios, though rooms with roof consisting of Ytong blocks were slightly warmer in all orientations (see for example Figure 4.66).

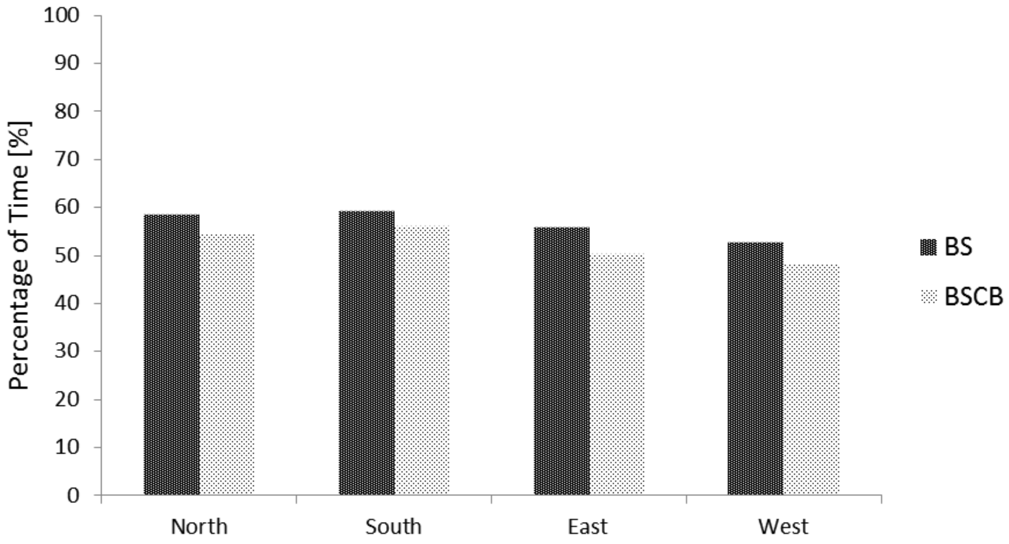


Figure 4.64: Summer overheating rates of rooms oriented differently, the first floor of the northern wing (scenarios BS and BSCB)

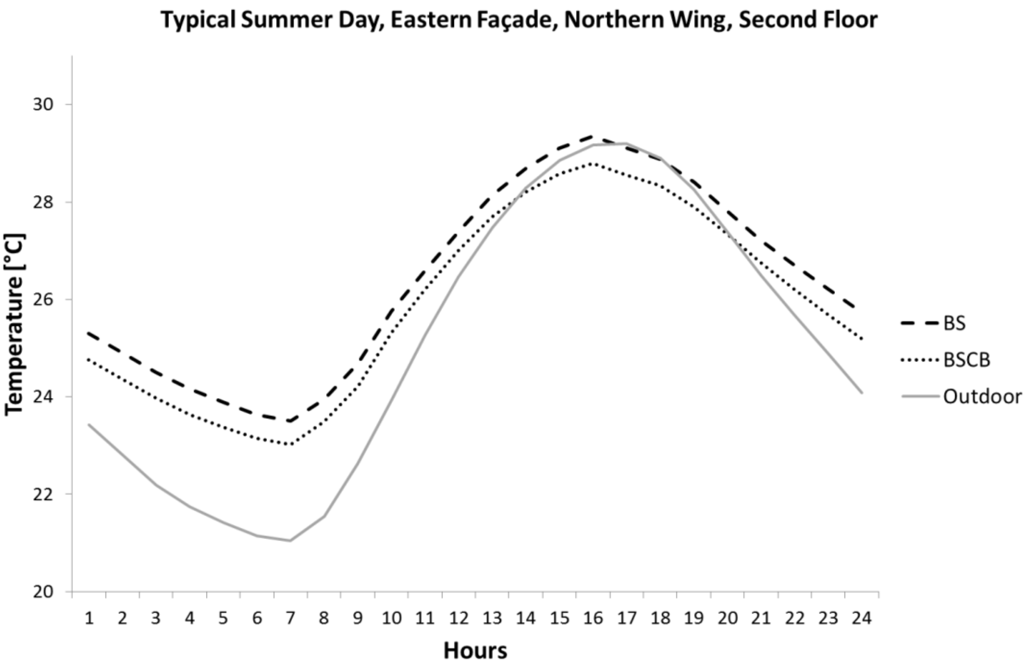


Figure 4.65: Simulated indoor temperatures for a typical summer day (July-September) of eastern rooms, the second floor of the northern wing (scenarios BS and BSCB)

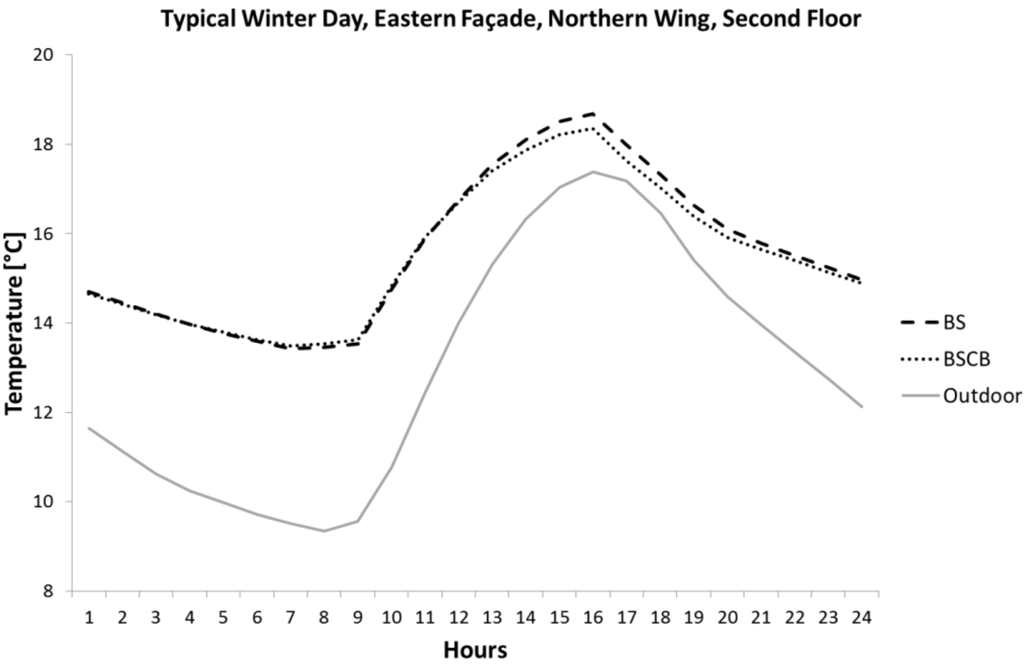


Figure 4.66: Simulated indoor temperatures for a typical summer day (December-February) of eastern rooms, the second floor of the northern wing (scenarios BS and BSCB)

4.3.4 Discussion

The main climatic challenge of the Gilman Building was perceived by its designers as its undesirable orientation, with its longer facades facing east and west. From this perspective, the design proved to be effective since it maximized the exposure of the building's main spaces to the north and south and secured agreeable summer indoor conditions in its first floor. This implicitly demonstrated that the prescriptive attitude to the question of orientation so common in Israel of that time was not fully justified: with intelligent building massing and sun protection, problems emanating from orientation could be resolved or at least ameliorated given the right design.

Besides the clever massing of the building, the application of shading devices had a major effect on the building's indoor climate. Their design was the main reason behind the cooler indoor conditions of the eastern and western rooms during summer: while the eastern and western facades were almost entirely masked from direct sun penetration, shading of the warmer southern rooms was less effective. This treatment of the facades, which gave much more emphasis to the protection of the eastern and western facades from direct solar radiation, corresponded to the climatic views expressed by Wittkower since the beginning of the 1940's.

The relatively agreeable summer indoor conditions were not an outcome of a special attention given to the composition of the external walls. Walls in the Gilman Building were constructed in the most conventional way for that time (plastered hollow concrete blocks). A non-conventional design might have resulted in higher thermal resistance and thermal capacity of the walls, but such an enhancement had little sense in a building that was designed for natural ventilation. Some improvement could have been achieved during wintertime, but since winter conditions were not seen by the architects, as well as their contemporaries, as a genuine climatic challenge, it is hard to criticize their final choice of wall composition.

In contrast to its walls, the roof of the Gilman Building was designed with much more care to its composition. The result was a roof with a relatively high U-value, as well as a relatively high albedo. Nevertheless, the roof still proved to be a major weak spot in the thermal performance of the building during summer, with indoor temperatures in the upper floor 2-3K higher than first floor temperatures. Not much could have been done to overcome this inherent deficiency, at least not in terms of common practice of that time; and while natural ventilation might have helped to reduce discomfort during the height of summer, one could not but understand why a demand for air conditioning was expressed by the highest rank of the building's users.

4.4 Conclusion

The Gilman Building is a fine example of an intelligent design that successfully and systematically integrated knowledge in building climatology into architectural design. Three major climatic concerns, in descending order of importance, were given close attention during the design: the first and foremost was building orientation and the ensuing wall insolation; the second was the need for sun protections, especially against the direct penetration of sunlight into indoor spaces; and the third and the relatively less discussed was the composition of the building envelope and its insulating capacities.

Building orientation posed the first difficulty for the designers. The orientation of the main facades of the Gilman Building to the east and west was dictated by the master plan for the university campus. This orientation was in complete contrast to what was regarded then in Israel as the preferable building orientation and to what the building's architect-in-charge, Werner Joseph Wittkower, was publicly recommending since the early 1940's. Although no historical documentation enables to definitely determine what was the planning team (which included Wittkower) trying to achieve by selecting a climatically-undesirable orientation, it can be assumed that the main concern was the spatial definition of outdoor areas rather than its climatic effects.

Facing the pre-defined problematic orientation, Wittkower and Israel Stein, the architect in-charge at Wittkower's office, conceived a creative way for overcoming the orientation-induced climatic shortcomings of the future building. The separation of the building mass into two detached wings and the arrangement of each wing around courtyards enabled them to orient the most important spaces of the building – namely, the lecture halls and classrooms – to the north and south, while arranging the service areas and smaller rooms (seminar rooms and offices) along the eastern and western facades. Nevertheless, since the smaller rooms were still exposed to the eastern and western sun, the effective spatial layout of the building had to be supplemented by a careful design of proper shadings.

The Gilman Building was designed in an era in which a plethora of shading options and styles were regularly available for use by Israeli architects. Israel of the 1950's and 1960's was an effervescent field of experimentation and innovation in shading elements of different types and effects, and local architects were keen on exploiting the field of solar protections for developing a new local architectural idiom (in spite of being consciously inspired by the modern architecture of Brazil). At the same time, this richness of possibilities led in times to excessive use of shading elements for purely ornamental purposes, which had very little in common with the technical purpose of sun protection.

Three different types of shading elements were used in the Gilman Building: fixed precast concrete elements forming an external screen of shading which covered most of the eastern and western facades; fixed horizontal louvered elements made out of aluminium which were installed in the northern and southern facades; and sliding PVC-aluminium shutters with rotatable slats which screened some of the facades to the courtyards. The latter devices proved to be unsuitable for their purpose, being too flimsy for being installed in the public areas of the building, and were eventually replaced a few years after the building's completion.

Based on the thermal simulation of the building, it can be argued that while the eastern and western precast screens of shading elements were very effective in lowering the indoor temperatures of the eastern and western rooms, the southern horizontal louvers had a much lesser effect; the northern louvers, which had practically no thermal effect on the northern rooms, were designed from the first place only for preventing glare. The positive effect of the shading screen of the eastern and western facades had its price, both in the permanent blocking of view from the eastern and western rooms and in lowering of indoor winter temperatures. These undesirable effects could have only been resolved by using movable shading elements, but this, in turn, would have probably created additional maintenance issues which the architects tried to avoid.

More than with any other building component, the application of shading elements in the Gilman Building exposed an inherent tension between aesthetics and performance. Stein admitted that his shading solution for the eastern and western facades had also a purely aesthetic role, which was to "unify" the expression of the facades while concealing a less attractive arrangement of windows behind the shading screen. Since the design proved to work well, at least during the summertime, it could be seen as a noteworthy achievement of coupling optimal performance with preferable aesthetics. At the same time, the use of identical shadings for the southern and northern facades reveals a much lesser coherence of design, mainly because the similar form of the elements contrasted with their dissimilarity in function (solar protection in the southern rooms, glare prevention in the northern rooms).

While the horizontal shadings of the southern facades provided adequate (although not fully optimal) protection against the summer sun almost without blocking the welcomed solar radiation during winter, the full glazing of the southern facades created a problem of overheating which made the southern rooms remarkably warmer than all other rooms. Thus, the ingenuity of the spatial scheme of the building, which enabled the orientation of some of its main spaces to the preferable south, was not exploited to its fuller potential because of the decision to use large glazing surfaces in the southern facades. In addition, since the applied shadings did not perfectly block direct south-eastern and south-western solar radiation, the negative effect of glazing was further aggravated by the application of shadings of limited capacities.

The selection of materials for the building envelope had also some negative consequences which could have been avoided, although this applied mainly to the use of large glazing areas. This is best demonstrated by looking into the indoor temperatures of the eastern rooms, which were constantly lower than temperatures in the southern and northern rooms during the warmer half of the year, in spite of the fact that eastern facades receive much greater amounts of direct solar radiation. The effect is a result of the combination between effective sun protection (the external shading screen) and a relatively low wall glazing to floor area ratio. A more moderate use of glazing should have lowered the indoor temperatures in the southern and northern rooms below the indoor temperatures of the eastern rooms.

Glazing, on the other hand, had a positive effect during winter, leading to agreeable indoor temperatures in the southern rooms. While the northern, eastern, and western rooms were simulated as being relatively cold during winter (supporting the documented occupants dissatisfaction with the winter indoor conditions), southern rooms showed a relatively good equilibrium between summer and winter conditions. This, however, was probably not an outcome of deep calculated thinking, since summer, and not winter, conditions were regarded as the main (and even the only) climatic challenge in Israel of the 1960's, as also acknowledged by Stein. For a similar reason the negative effect of the eastern and western shading screens on indoor winter conditions should be judged with less severity.

The other clear effect of the choice of envelope materials was the much higher indoor temperatures of the second (upper) floor of the building, a result of the direct exposure of the roof to solar radiation and outdoor temperatures. Contrary to the decision to fully-glaze the southern and northern facades, here the gamut of alternative materials and constructions was quite limited, and it can be argued that even the application of the best common strategy for roof composition at that time could not have prevented the overheating of the spaces located below the roof. Possibly the only viable way of overcoming the problem would have been the addition of an upper layer of horizontal shading above the concrete roof (a "double roof"), which could have protected the concrete roof from direct sunlight while enabling the flow of cooler air across it. This solution was (and still is) more than rare in Israel and was not applied in any major public building of that era, probably because of economical and practical considerations. Therefore, it can be argued that the design decision regarding the roof composition was optimal and more than reasonable. More than anything else, the indoor climate it produced demonstrated the known fact that there are times in which passive means alone cannot bring the thermal performance of a building to a desirable level.

5 THE MODEL HOUSING ESTATE, BE'ER SHEVA

5.1 Historical background

The Model Housing Estate in Be'er Sheva (Beersheba) (31.250 N, 34.778 E, 276 m above sea level, Figure 5.1) is a residential neighbourhood of 826 housing units built by Israel's Ministry of Housing. It was designed during 1958-1959 and constructed between 1960 and 1964 over a total area of about 13 hectares, separated into two square spatial units of about 300 x 300 m and 200 x 200 m. The neighbourhood was designed by a team of young architects led by architect Avraham Yasky (1927-2014). Although not executed to the full extents of its original plan (Figure 5.2), it is still regarded today as one of the most daring and successful urban projects in the history of Israeli architecture.

Figure 5.1: The Model Housing Estate (in the centre) in a contemporary aerial photograph (www.govmap.gov.il)

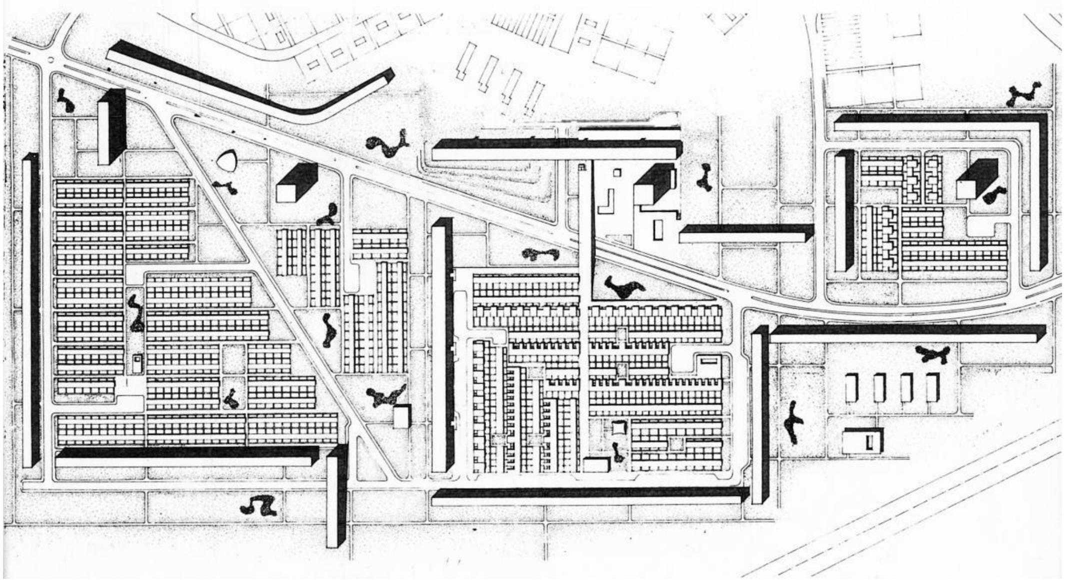


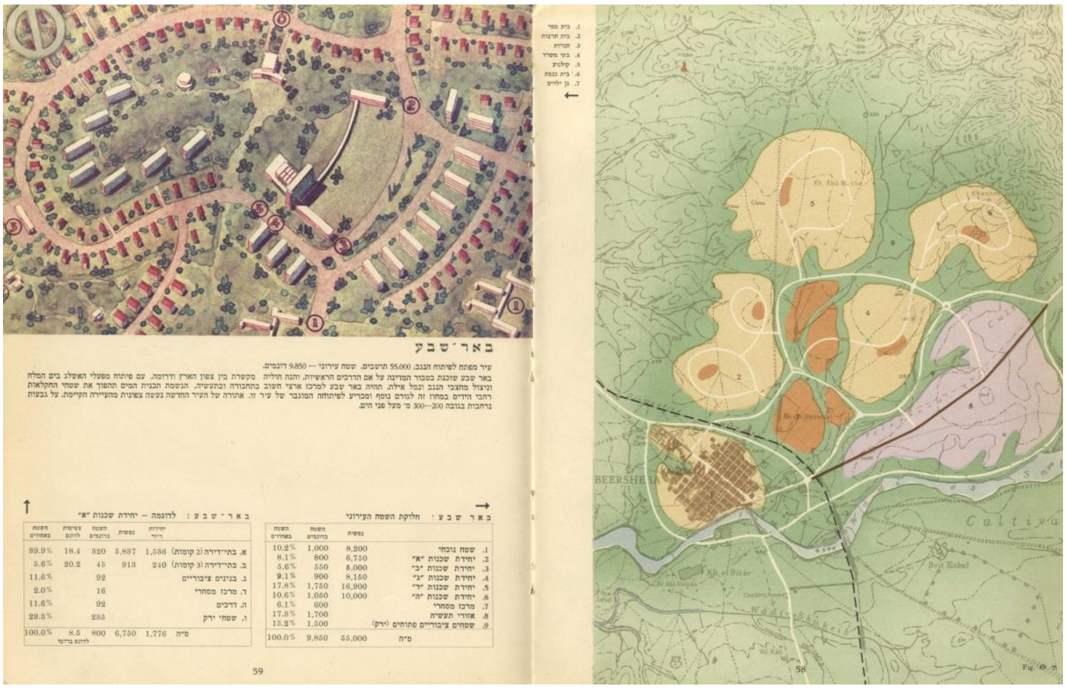
Figure 5.2: Model Housing Estate, Be'er Sheva, original master plan (Hirsch and Szereszewski 1968). The larger spatial unit of about 400 x 400 m (left), as well as all the high-rise buildings and some of the residential blocks, were never built

5.1.1 Public housing in Israel of the 1950's

The full uniqueness of the Model Housing Estate in Be'er Sheva can only be understood when put in the wider context of public housing in Israel of the 1950's and 1960's. As a young immigrant country, population in Israel grew rapidly since its establishment in May 1948, rising from 872,700 by the end of 1948, to 1,669,400 by the end of 1953, and 2,031,700 by the end of 1958. The massive immigration waves of Jews, many of them refugees from Europe, North Africa, and the Middle East, created within a short span of time an acute housing shortage which was at first partially relieved by provisional camps and reuse of the "deserted property" of about 700,000 refugee Palestinian Arabs who were not allowed to return to the Jewish state after the end of Israel's War of Independence.

In spite of the provisional solution devised during the first immigration wave, the need for mass housing for the new immigrants was clear to the Israeli government early on, and since 1949 it empowered the Housing Division, a specialized unit in the Ministry of Labour, to design and execute a wide range of housing projects for the masses. This included the building of numerous new towns and neighbourhood, in a premeditated attempt to "spread" the population across the country in order to mitigate what was regarded as the anomaly of the concentration of

Jewish population in the Greater Tel Aviv area. These new settlements were usually planned as "garden cities" (Figure 5.3), showing a clear and conscious influence of the contemporary trends in the United Kingdom, and especially of its post-war "New Towns" (Shadar 2014, 14-37). Most of the building was done following a small set of standardized building plans, without real adjustment or reference to actual building sites (Figure 5.4). Thus, a certain building type could be identically realized in locations with different climatic or topographic properties, and be perpetually reproduced when a new neighbourhood was built (Efrat 2004, 167-185, 565-605, Shadar 2014, 39-51).



1. בית ספר
2. בית תרבות
3. חנויות
4. בתי משרד
5. קולנוע
6. בית כנסת
7. גן ילדים

באר־שבע

עיר מפתח לפיתוח הנגב. 55.000 תושבים. שטח עירוני — 9.850 דונמים.
באר שבע שוכנת בטבור המדינה על אם הדרכים הראשיות, והנה חוליה מקשרת בין צפון הארץ ודרומה. עם פיתוח מפעלי האשלג בים המלח וניצול מחצבי הנגב ונמל אילת, תהיה באר שבע למרכז ארצי חשוב בתחבורה ובתעשיה. הגשמת תכנית המים תהפוך את שטחי החקלאות רחבי הידים במחוז זה לגורם נוסף ומכריע לפיתוחה המוגבר של עיר זו. אתורה של העיר החדשה נעשה צפונית מהעיירה הקיימת, על גבעות נרחבות בגובה 200—300 מ׳ מעל פני הים.

באר שבע: חלוקת השטח העירוני

	נפשות	השטח בדונמים	השטח באחוזים
1. שטח נוכחי	8,200	1,000	10.2%
2. יחידת שכנות ״א״	6,750	800	8.1%
3. יחידת שכנות ״ב״	5,000	550	5.6%
4. יחידת שכנות ״ג״	8,150	900	9.1%
5. יחידת שכנות ״ד״	16,900	1,750	17.8%
6. יחידת שכנות ״ה״	10,000	1,050	10.6%
7. מרכז מסחרי		600	6.1%
8. אזורי תעשיה		1,700	17.3%
9. שטחים ציבוריים פתוחים (ירק)		1,500	15.2%
ס״ה	55,000	9,850	100.0%

באר־שבע: לדוגמה – יחידת שכנות ״א״

	יחידות דיור	נפשות	השטח בדונמים	צפיפות לדונם	השטח באחוזים
א. בתי־דירה (2 קומות)	1,536	5,837	320	18.4	39.9%
ב. בתי־דירה (3 קומות)	240	913	45	20.2	5.6%
ג. בנינים ציבוריים			92		11.6%
ד. מרכז מסחרי			16		2.0%
ה. דרכים			92		11.6%
ו. שטחי ירק			235		29.3%
ס״ה	1,776	6,750	800	8.5 לדונם ברוטו	100.0%

Figure 5.3: First master plan for Be'er Sheva after 1948, as appeared in Arieh Sharon's book on the general planning of the young State of Israel (Sharon 1951, 58-59). To the left, an aquarelle rendition of a typical new neighbourhood, rich in open green areas. Be'er Sheva was intended to become the capital city of the Negev, Israel's vast desert region

Figure 5.4: Newly-built housing projects in Nazareth Illit, ca. 1960 (photograph by Amiram Erev)

5.1.2 The Model Housing Estates – a response to increasing criticism

Architecture historians Zvi Efrat and Hadas Shadar date the history of the Model Housing Estate in Be'er Sheva back to the Interbau exhibition in West Berlin, which took place between June and September 1957 (Figure 5.5). David Tanne (1909-1973), The head of Israel's Housing Division in the Ministry of Labour (later to become the Ministry of Housing), visited the exhibition and was impressed by the idea of building a new neighbourhood by commissioning a number of architects to contribute different designs of residential buildings (Efrat 2004, 331-332, Shadar 2014, 62-63). Returning to Israel, he decided to implement the idea by constructing "model housing estates". The first was planned during 1959 and built in Ramat Aviv (northern Tel Aviv) between 1960 and 1962 (Figure 5.6). As with the Interbau project, the vast majority of the buildings in Ramat Aviv were designed by well-established architects of that time who were active in the local arena since the 1930's (Robert Bannet and Itzhak Perlstein, Werner Joseph Wittkower and Erich Baumann, Munio Weinraub and Al Mansfled, Arthur Glikson, Rechter-Zarchi-Rechter architects, Arieh Sharon and Benjamin Idelson), with only one exception (Itzhak Yashar and Dan Eiten).

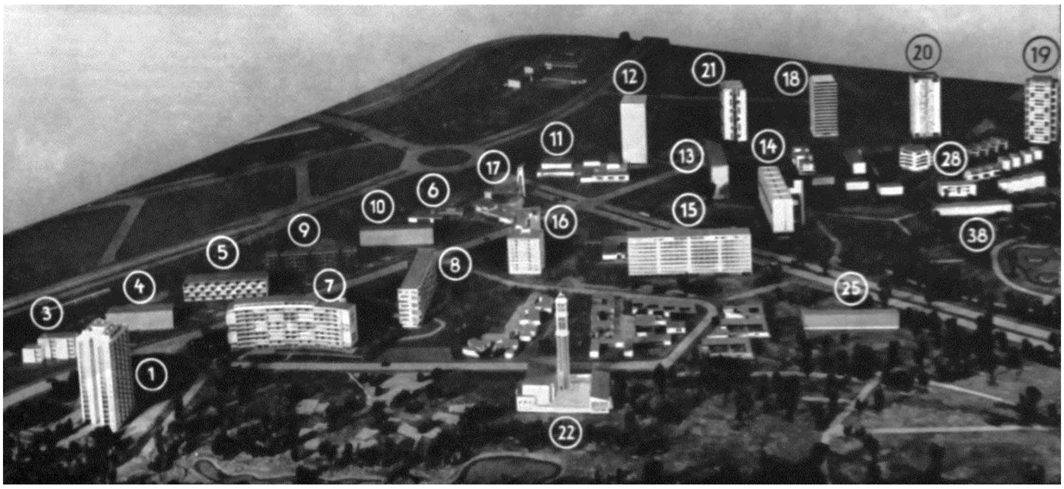


Figure 5.5: A model of the buildings of the Interbau exhibition in Berlin's Hansaviertel, 1957 (*L'Architecture d'Aujourd'hui*, December 1957-January 1958, p. 7)

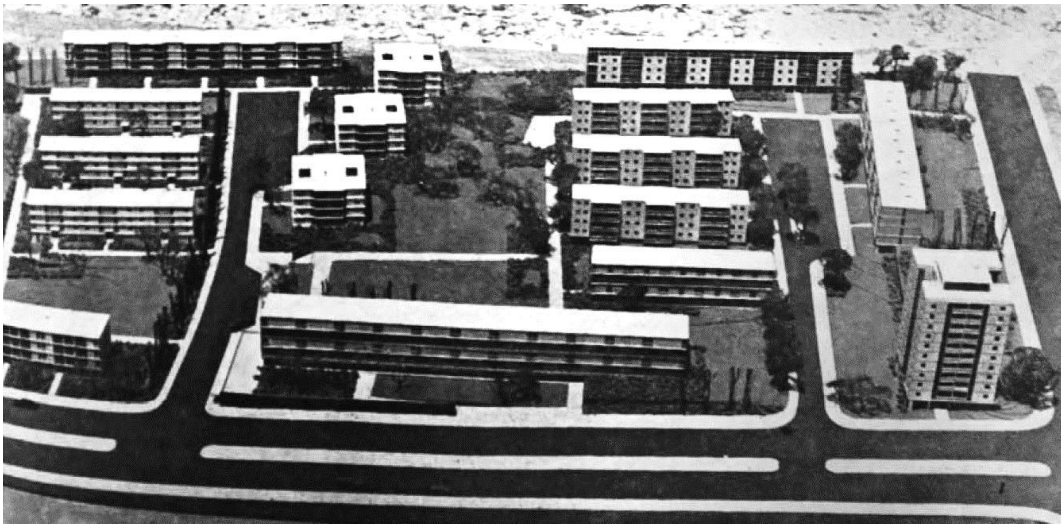


Figure 5.6: A model of the Model Housing Estate in Ramat Aviv (*Journal of the Association of Engineers and Architects in Israel*, July-August 1959, p. 180)

While the Interbau model had certainly its effect on the idea of gathering a set of designs by well-accomplished architects on a single location, it seems that the main motivation behind Tanne's initiative had much more to do with local pressures of public opinion, as a way of fending off increasing discontent and criticism. A decade of intensive construction for housing resulted in a total number of 200,000 new public housing units in permanent constructions, which constituted 73% of the total construction for housing during that period (Tanne 1959a). The results were omnipresent and could not escape criticism, which was in times harsh, be it from local journalists or planning professionals. Although the limited material means and the pressing time frames were well understood, it was argued that much better, and even aesthetically appealing, results could have been achieved by involving private-sector architects (instead of architects which were employed directly by the government) in the design process. This view was eloquently expressed in 1955 by journalist Arie Gelblum (1921-1993), who bitterly attacked the dull and monotonous aesthetics of public housing:

> Let us put aside the housing frenzy that we indulge in (even the one who lives in a good, inexpensive but old apartment must put himself under heavy debts in order to fulfil the Commandment of Housing), and refrain from the question of the quality of construction, which effectively means that millions of pounds will be spent on the maintenance and perpetual-repair of all the housing projects that were built in that certain way because of "economic reasons"; and let us agree that they were built so not because of deceitfulness but because we build with limited financial means (though in the urban housing projects for the middle class, executed by the big housing companies, the means are not entirely limited); we still could not understand and never will, why it was necessary to give our places of residence such a <u>form</u>.
>
> A concentration of dense and grey boxes is given the name *Hadar Yosef* [literally, the Splendour of Yosef], and in the entrance to Tel Aviv, next to Mikveh Israel [an agricultural school], stands a nightmare called *Kiryat Shalom* [literally, the town of peace]. Here was once a big area of open plane, ideal for efficient and beautiful planning, where contractors and other "private initiative speculators" were left out; here

building was done by a "public element", the one and only *Histadrut* [Israel's powerful Trade Union Federation]. What was the outcome? "Housing project for the veterans", houses for thousands of families which are the spitting image of one another, each one is nothing more than a box pierced by doors and windows, everything has the same size, same form, same colour, one house after another, hundreds of houses which copycat each other, and in which all details are identical. Were this only a once-in-a-lifetime incident we could have thought that not architects were responsible for its creation, but the janitors in the architectural office of the *Histadrut*'s housing company; for children in their games build nicer things.

Our mayors recently returned from a conference in Italy and "discovered" that Italians have a law that prohibits the construction of two neighbouring houses which are identical. In America one can see numerous popular housing projects, the most inexpensive among them cost less than ours, but nevertheless, within the general form, one can always find several types of houses, freedom of colour and decoration for all, and this creates diversity within unity. The way human beings understand life and create their habits is affected by their environment, and an environment as the one of Kiryat Shalom could not evoke in them or in their children any sense of beauty, or initiative, or individualism. It was justly said that in this project a certain joke could become reality, the one about the guy who returns home from work in the evening, enters the house, takes a bath, changes, eats dinner, and falls asleep, only to discover in the next morning, when he finds next to the door a newspaper other than the one he is used to read, that this was not his but his neighbour's home. Yet this is only an illustrative example for the hundreds of housing projects

> that were and are still being constructed following the principle of the uniform and dull equality which turn the land into a landscape of totalitarian foolishness.
>
> Housing projects of ugliness were surely constructed in other countries as well, in periods of sudden development or when population rapidly grew, but this was the work of private speculators who aimed only at profits and escaped any form of governmental inspection. Yet here, most of the building is done by the government, and by a government which advocates planning. The Ministry of Labour builds the neighbourhoods of the popular housing. Why should commissions for their execution be determined only from the financial perspective, without considerations of plan, form, and beauty? Why is it impossible that the Ministry of Labour will search for the advice and inventiveness of the best architects we have, instead of relying only on its functionaries, lest the former will find ways to make the neighbourhoods popular in their prices without looking like concentrations of large stables? Since in some places the Ministry of Labour learned how to give a sense of beauty to its inexpensive buildings by "small" things, as a free play in exposed bricks or the painting of balconies and shutters with lively colours, without compromising the financial principle, one should realize how much wrong has this Ministry done while creating the form of the State of Israel. (Gelblum 1955)

Two years later, Shabtai Teveth (1925-2014), another leading journalist, published his own take on what he described as "the ugly face of the housing projects". Teveth was even less restrained than Gelblum:

> [...] for nine years the public builders, persistent and diligent, committed a crime, with no one to disturb. The public builders built one horror after another [...] They spread sulphurous acid on the face of towns, they tormented

> the dwellers of the housing projects until their souls were lost (now they live there without them), they marked half of the population of Israel with hot branding iron of nervousness and narrow-mindedness, and no one stopped them.
>
> [...]
>
> For heaven's sake, is there a place on earth where the beauty of housing and society is left in the hands of technicians? Since paramedics are not allowed to operate the nerve system, so it should have been forbidden to entrust the technical offices with public building. It is an irony that the new, bold patterns of town planning and neighbourhoods were created in other countries by governments and local authorities who hired the greatest minds of architecture for the service of the commons. The housing project of the government employees in Marseilles, for example, was built by the great Le Corbusier. In Israel the opposite is the rule. The private building is the one that enjoys the best architects. The public building usually employs the lowest level of architectural talent, those rejected from private offices.
>
> [...]
>
> Public buildings, which are only second to residential buildings, are subjected, with no exception, to competitions. In that way we achieved worthy public buildings. Nevertheless, the residential buildings were never subjected to competitions. They are the exclusive domain of the bureaucracy. (Teveth 1957)

Planning professionals were not as pungent as Gelblum and Teveth, probably since the state was still the main supplier of work for private practitioners, but their criticism, which attacked quite similar issues, was not ultimately silenced. Thus in January 1958, the editorial of the influential *Journal of the Association of Engineers and Architects in Israel* (JAEAI) used Teveth's article and the ensuing response from housing officials (Mittelman 1957) to suggest that excess centralization of the design process is leading to stagnation and flaws in the design of housing, while expressing a wish for a dialogue which will dissolve the barriers between private professionals and the governmental bodies:

> During the recent months, criticism of the image of our national housing has increased. One smart journalist counted its many faults and blamed the architects. Another journalist bitterly targeted the Development Towns, and a third journalist engaged in the deficient new quarters in the outskirts of the main cities, and so on. Even professionals, when gathered in meetings, claim that they are dissatisfied by the image of our housing projects. Officials from the Housing Division, who were rightfully offended by the attack of the journalist, felt obliged to apologetically respond and provided the names of planners and architects which cooperated with them, to one extent or another, across the country.
>
> One can doubt whether the problem was limited to that certain criticism and its response. Could it be that the ones responsible for a housing project do not wish it to be nice and pleasing for its dwellers and visitors? Do architects and planners, who are responsible for all kinds of building types and who put together the buildings of the housing project, as well as planners of new quarters and towns, not aspire them to have a well-defined and convincing image? Are they less devoted to the cause than their critics? Can someone imagine that the entire body of knowledge kept by all the professionals involved in housing is lesser than that of their critics? Nevertheless, it is a fact that our housing projects are less than satisfactory, and often we are imbued with a sense of incompetence when examining them.

> […]
>
> We would also like to mention one phenomenon which has its share in the shaping of the housing projects and which affects the different solutions, which is the tendency to create concentrations of large planning bodies, a tendency enhanced by the polarity of the sectorial organization of every aspect of our lives. This phenomenon fosters ideological collectivism, blurs deviations or unconventional experimentations, and endangers the fruitfulness of creativity. Dissolving such central bodies into local teams and placing trust in professionals who do not belong to these bodies could contribute to the diversification of solutions and the attachment to the spirit of place, while enhancing the individual style within a centralized organizational setting. Without it, the danger of cutting experimentations by the creators is eminent, and conformity as well as common habit will prevail. (Handasa VeAdrikhalut 1958a)

While these reserved objections, like Gelblum's and Teveth's fierce attacks, should be read from within the wider perspective of an ongoing clash between Israel's socialist regime of that time, led by a single dominant party (*Mapai*), and private initiative, it must be acknowledged that the centralization of planning and design did contribute also to the banality and uniformity of solutions. What was generally accepted as an undeniable necessity during the first years of mass immigrations (Zolotov 2013), was now, when immigration rates started to decline, much less appreciated.

Although the editorial in the JAEAI was not signed, it is highly plausible that its author was the chief editor of the Journal, engineer Yaakov Ben-Sira (1899-1994); almost similar views were expressed in an article published by Ben-Sira about a year and half later (Ben-Sira 1959). Ben-Sira was one of the most influential town planners in Israel of that time, a respected professional who was the main figure behind the shaping of modern Tel Aviv while serving as the city's municipal engineer between 1929 and 1950. It is therefore not surprising that his restrained criticism did not fall on deaf ears; on 18 January 1958, shortly after the editorial was published, Tanne announced that "the Housing Division is preparing to hold competitions among architects and engineers for the sake of diversification, improvement, and perfection of the types and methods of housing", a statement the editors of the journal were happy to publish on its next issue (Handasa VeAdrikhalut 1958b).

5.1.3 The Model Housing Estate in Be'er Sheva

The model housing in Ramat Aviv was built in Israel's main metropolis. As means of improving the reputation of the Housing Division, the selection of the location was far from ideal, since it apparently neglected the weaker and provincial Development Towns. As architect Avraham Yasky later described in a roundtable discussion in 1972, which appeared in the first issue of the Hebrew professional journal *Adrikhalut*,

> The intention was to make in Tel Aviv – and in Tel Aviv only! – an interval [sic., probably wrong transcription of the word "Interbau"], which means to take an area under the minimal control of a builder and to enable several architects to create different buildings. This was done. What do we think of it today, 12-13 years later? This can be opened up for discussion. I personally think that the achievement was minimal.
>
> [...]
>
> A short time afterwards it was decided that because of political reasons (and one should remember how things happened then) it is impossible to build a model housing estate in Tel Aviv without doing the same in a Development Town. This is why it was decided to repeat this experiment in Be'er Sheva. The guidelines for this housing project in Be'er Sheva were exactly the same: six-seven architects will make the same houses in Be'er Sheva, for new immigrants. (Adrikhalut 1973, 6)

The available historical and archival material does not reveal why it was Yasky who was chosen to be the head of the team of the Be'er Sheva model housing project. Yet one can assume that Yasky's selection had a direct connection to his previous work for the Housing Division as the head of a small research team on low cost houses which was active for two years since November 1956 (see below, section 5.2.1). Yasky, who was only 31 at that time, was regarded as a rising star in the small world of Israeli architecture of the 1950's. He was born in Kishinev in 1927, immigrated with his parents to Palestine when he was eight, and studied architecture at the Technion in Haifa between 1946 and 1951. He then worked in the office of Arieh Sharon and Benjamin Idelson. In 1954 he established his own partnership with Shimon Povsner, a fellow (senior) worker in Sharon and Idelson's office, with whom he won several architectural competitions in the early 1950's. In 1956 this partnership dissolved and Yasky teamed with a younger colleague, architect Amnon Alexandroni (Rotbard 2007, 45-46).

Yasky's team of architects for the Be'er Sheva model project mainly consisted of young architects who graduated during the 1950's: his partner Alexandroni (b. 1929), Daniel Havkin (1925-1993), Ram Karmi (1931-2013), and Nahum Zolotov (1926-2014). Other participants were the architecture cooperative *Tichnun*, headed by Theodor Kisselov (1914-1979) and Aharon Bareli, and two architects from the Housing Division, Meir Tchechik and Bitush Komforti. The architects' relatively young age was not the only distinction between the Be'er Sheva and the Ramat Aviv teams. The whole conceptual framework was different, as Yasky later recollected:

> The first conclusion of the first discussion was that we do not want exemplary models. We want to create an environment in which no one could tell who did what, as long as the whole complex becomes significant. This was the fundamental difference between these two experiments [...]
> I think that the Be'er Sheva experiment was much more successful in the sense that a complete environment emerged from it and not a collection of models for buildings,

> in spite of the fact that it does consist of different buildings.
> (Adrikhalut 1973, 6)

Contrary to the Ramat Aviv project, the Be'er Sheva team cooperated as a single body in developing a master plan for the neighbourhood (Rotbard 2007, 561-564). This produced an unprecedented spatial layout in Israel, of which "it is hard to determine where the architectural project ends and where the urban project begins [...] any of the singular architectural elements of the housing project is in itself an architecture of a quasi-city-scale" (Rotbard 2007, 567-568). The area of the neighbourhood was divided into three spatial sub-units of three scales (200 x 200 m, 300 x 300 m, and 400 x 400 m), with the borders of each sub-unit defined by multi-storey super-blocks; the remaining space was filled with a dense array of small row-houses which were nicknamed "carpet". Each sub-unit consisted also of a single high-rise building (Figure 5.7). As a whole, the plan can be regarded as a direct response to the criticism of the uniformity and dullness of local public housing.

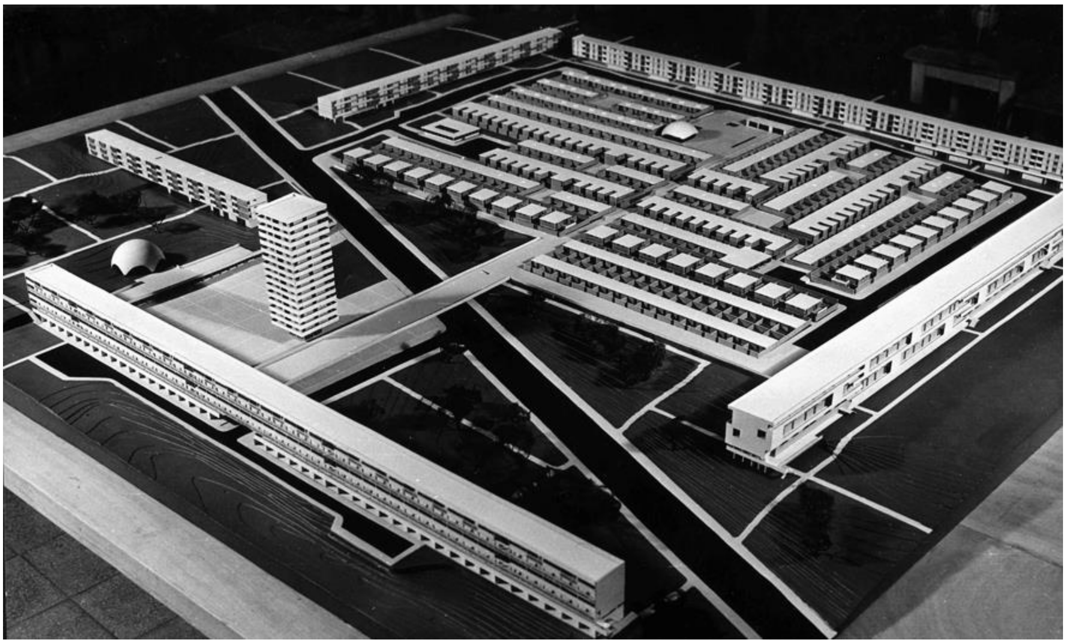


Figure 5.7: A model of the central (middle-sized) spatial unit of the Model Housing Estate in Be'er Sheva showing the border super-blocks, the "carpet" houses, and a tower (Efrat 2004, 328)

The project was first introduced to the public in July 1959, in a JAEAI issue dedicated to Housing in Israel (Handasa VeAdrikhalut 1959a). As it turned out, and apart from the carpet housing which was designed by

Zolotov and Havkin, only three out of the five buildings that appeared in the article were eventually realized: Yasky and Alexandroni's Quarter Kilometre Block (which was, and still is, the longest building in Israel), and the two blocks designed by *Tikhnun* cooperative. From the original three sub-units of the entire neighbourhood, only the two smaller ones were built. Additional super-blocks defining the smaller sub-unit, which did not appear in the JAEAI coverage, were designed by Yasky and Alexandroni (Figure 5.8 and Figure 5.9).

In spite of the higher profile of the super-blocks and the additional media attention given to the unprecedented dimensions of the Quarter Kilometre Block of Yasky and Alexandroni (Givon 1961, Artzieli 1962), the main architectural and urban innovation of the Model Housing Estate was the carpet housing scheme. Zolotov, who worked in Tel Aviv, and Havkin, who worked in Haifa, decided to split the work in a way that each would separately design parts of the carpet (Figure 5.10), after coordinating the general dimensions of each plot and alley (Zolotov 2013). This resulted in six different house types (three single-storey houses, and three two-storey houses, Figure 5.12 and Figure 5.13), each arranged in rows. All the houses had walled back yards and front yards (intended as a service area), except type D which had no front yard. In several cases the upper floor of a two-storey house extended over an adjacent alley (Figure 5.11), thus covering and shading parts of it. The single-storey and two-storey houses were arranged in alternating rows, in a way that each row of two-storey houses faced a row of single-storey houses on the other side of the alley.

Figure 5.8: The Model Housing Estate (in the centre) as realized, ca. 1965, showing Be'er Sheva's old city to the right and the new neighbourhoods, built after 1948, to the left. Aerial photograph by architect Nahum Zolotov, who also served here as the pilot (Nahum Zolotov Collection, Information Centre for Israeli Art, The Israel Museum)

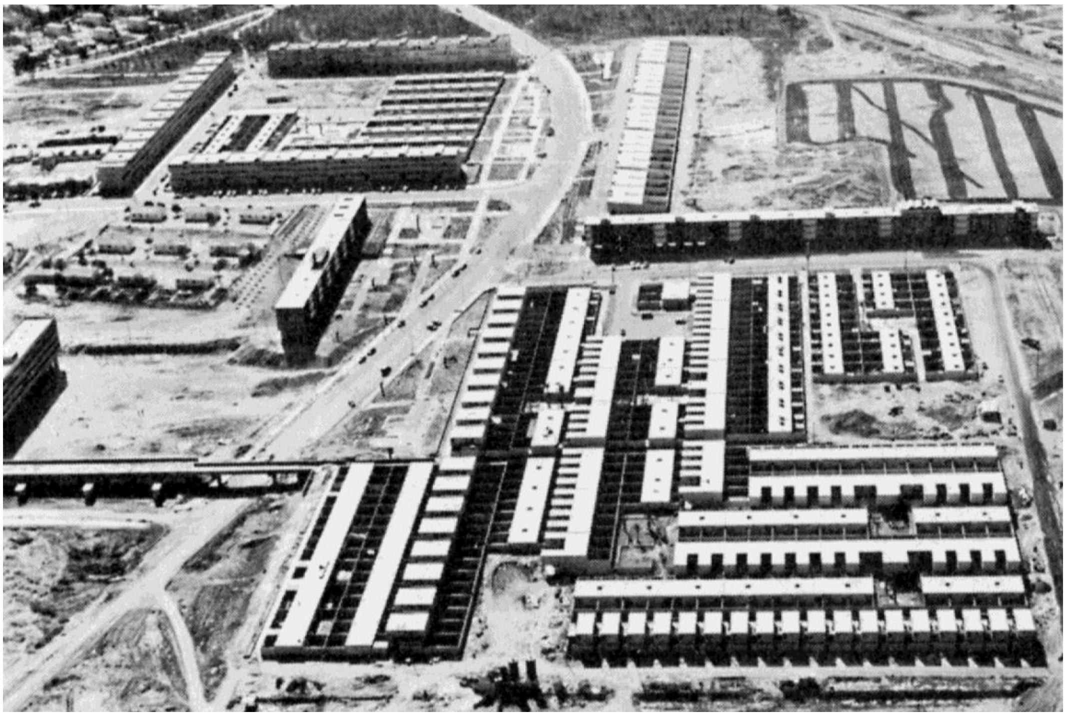


Figure 5.9: The Model Housing Estate as realized, ca. 1965 (Efrat 2004, 347)

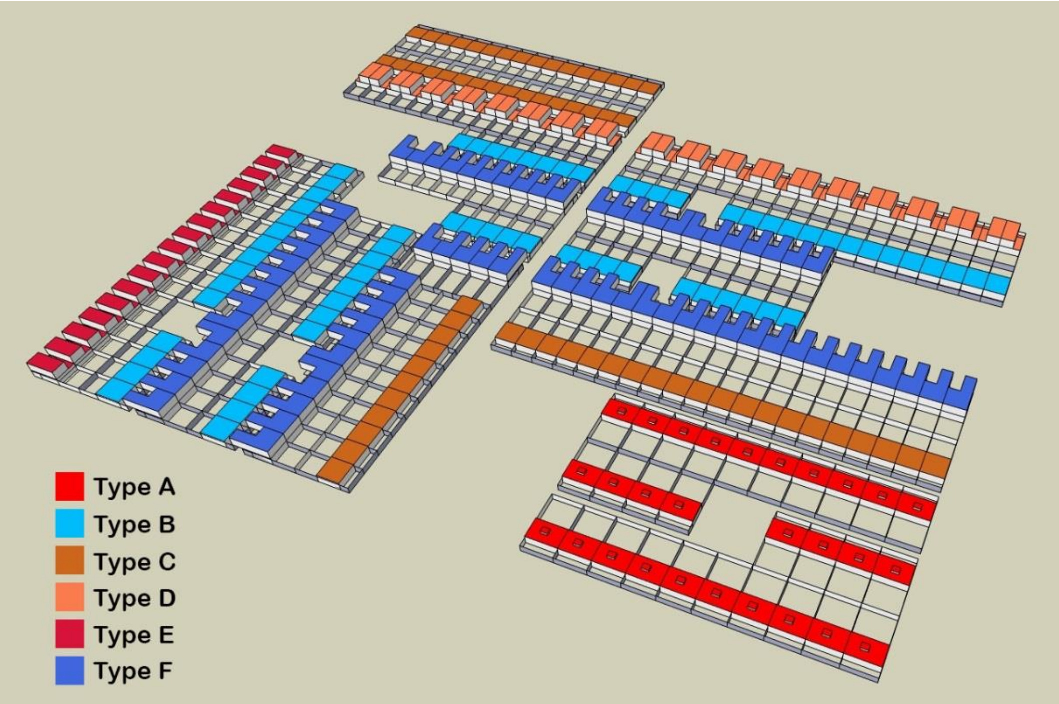


Figure 5.10: Computer model of the carpet housing in the central sub-unit of the Model Housing Estate showing the spatial distribution of the different housing types. Types A, C, D, and E were designed by Zolotov, types B and F – by Havkin. In the smaller sub-unit of the neighbourhood all the houses were of type A

Figure 5.11: A roofed alley in the carpet housing, the late 1960's, photograph by Ran Erde (Israel Architecture Archive)

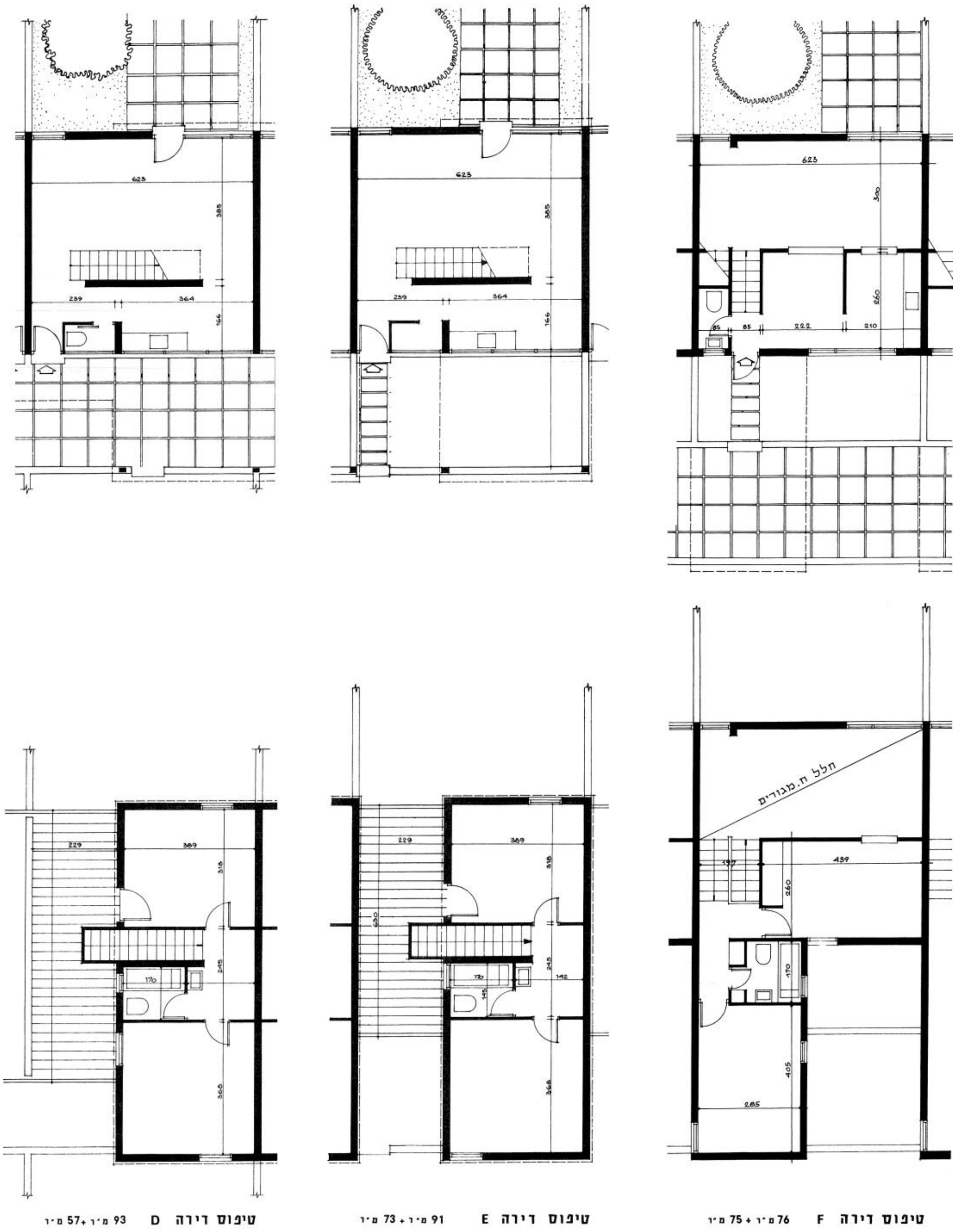


Figure 5.12: Carpet housing, plans of two-storey house types: D (left), E (centre), F (right) (Hirsch and Szereszewski 1968)

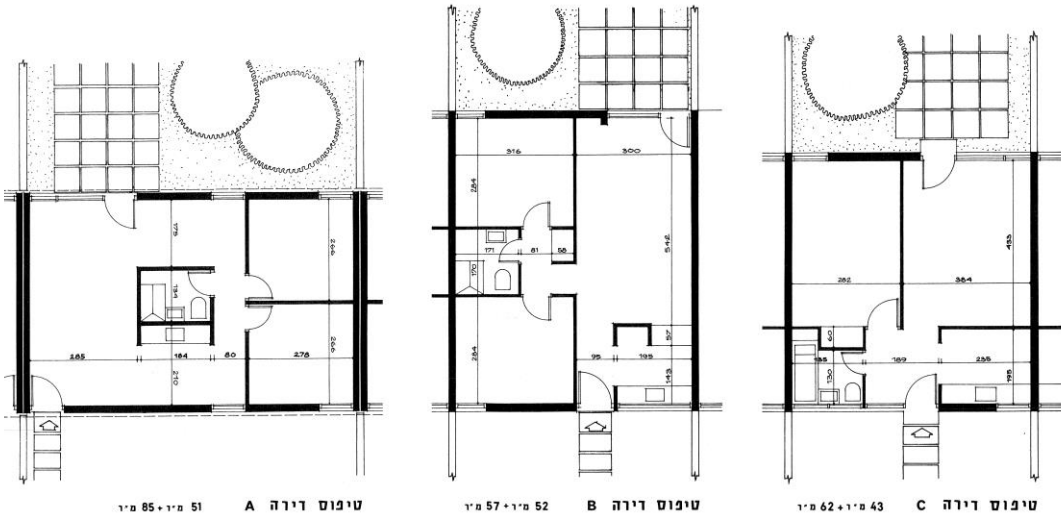


Figure 5.13: Carpet housing, plans of single-storey house types: A (left), B (centre), C (right) (Hirsch and Szereszewski 1968)

5.2 Climatic design in the Model Housing Estate

5.2.1 The Batsheva de Rothschild Foundation for Research and Planning of Low Cost Housing

Two years before the idea of the model housing projects was beginning to take shape, a philanthropic initiative planted the seed for what would later become the carpet housing in Be'er Sheva's Model Housing Estate. It was triggered by a visit to Israel in the winter of 1956 of Baroness Batsheva (Bethsabée) de Rothschild (1914-1999), a biologist and philanthropist who became an enthusiastic supporter of arts and science in Israel. This was Rothschild's second visit to Israel; the first was a family visit with her mother, Germaine, in 1951. In 1956 she was accompanying the Martha Graham Dance Company, of which she was a constant supporter since the 1940's.

On 9 March 1956, A few days after Graham's company took off from Israel, Haim Raday, deputy director general of Israel's Ministry of Labour, wrote to Meir de-Shalit, deputy director general of Israel's Prime Minister's office. Raday told de-Shalit that

> The Baroness, during her visit to the country, was negatively impressed by the appearance of the buildings of the popular housing. She expressed her wish that something will be done for the sake of improvement. In a meeting with officials from the Housing Division and the Public Works Department it was agreed that she will establish a foundation of about 20,000 Israeli pounds; this sum will fund the work of 2 architects and 2 draftsmen for a year. They will work in close cooperation with the Housing Division, which will guide them according to its needs and available means of construction. The basic intention is as follows: to formulate such proposals that, under the allocated cost for a certain housing unit, will produce work that will suit the local landscape, be more pleasing to the eye, etc. (Raday 1956)

Raday's letter came six days after architect Artur Glikson (1911-1966), the chief architect of the Housing Division, sent a long letter to Rothschild, following a meeting on the same morning. Writing about the housing projects built since the establishment of the State of Israel, Glikson admitted that "we share your opinion that the results of this work, which can be observed in our new towns as well as in new quarters of existing towns, are esthetically (sic.) unsatisfactory", and added that only "research and study" could produce better outcome. Therefore, Glikson suggested the establishment of a research team that will produce within one year "3-4 standard types of immigrant's Housing and a similar number of types of popular Housing for the low income group". The team's work would focus on several issues, among them the suitability of the housing types to "at least two climatically and topographically different regions of the country, as e.g. Beer-Sheva and Kiryath Shmoneh". Glikson estimated that the cost of such enterprise would be 20,000 Israeli Pounds for a single year of work, which will result in the production of "standard working drawings" for the different building types (Glikson 1956).

It took several months of legal arrangements, but by the end of July 1956 the allotted sum of 20,000 Israeli Pounds, which equalled 13,333.33 US dollars (Goldman 1956a), was transferred from Rothschild to the Ministry of Labour (Goldman 1956b). A board of trustees was composed, and included Minister of Labour Mordechai Namir, Glikson, Raday, architect Al Mansfeld, architect Uriel Schiller, and engineer Uriel Shalon, the president of the Association of Engineers and Architects in Israel. Alexander Keynan, director of the Israel Institute for Biological Research, was appointed as Rothschild's representative in the board, but later was substituted by his wife, Malka. The board gathered for the first time on 30 September 1956 in Tel Aviv (Batsheva de Rothschild Foundation 1956), and decided to appoint Avraham Yasky to be the head of a research team that will be dedicated to housing for new immigrants. A press release on the team's work was sent to the local newspapers and published in the end of October (Hatzofeh 1956).

THE FIRST INTERIM REPORT

Yasky accepted the nomination and began his work officially on 1 December 1956 (Raday and Glikson 1956). He recruited two members to his team: architect Meir Levi and civil engineer Amos Atlas. The research team submitted its first interim report on 21 March 1957, during the first work meeting of the Foundation's board of directors. Apart from the report, Yasky told the board members about the team's work, mentioning that they were "in touch with the Building Research Station at the Technion", while adding that the Climatology Department (of the Building Research Station) will provide an expert opinion on the suggested designs. Regarding the "climatological problems", Yasky said that they were trying to collect all the studies that were carried out locally (Batsheva de Rothschild Foundation 1957a).

Although Yasky's presentation made it clear that the preliminary research, especially in the field of building climatology, was not complete, the interim report (Yasky 1957) already included two architectural plans of the suggested design of what was referred to as "patio houses" or "courtyard houses", as well as a perspective drawing of a typical alley lined with such houses (Figure 5.14). Here it was clear that Yasky was trying to develop a newer version of a building type that was recently developed by Glikson and the Housing Division. Nicknamed "the growing patio house", it was a small and narrow house with an L-shaped floor plan which could be expanded by the residents on a later stage according to a predefined plan. At its final stage, the house was built around a patio, which served, apart from a source of ventilation and light, also as a separator between the living room and the rear bedrooms (Figure 5.15). As with Yasky's proposal, Glikson's patio houses were built on an elongated rectangular plot, arranged in rows (Shadar 2014, 43-51). A neighbourhood of patio houses of this type was built in Be'er Sheva in 1957 (Dvar Hashavua 1957)(Figure 5.16).

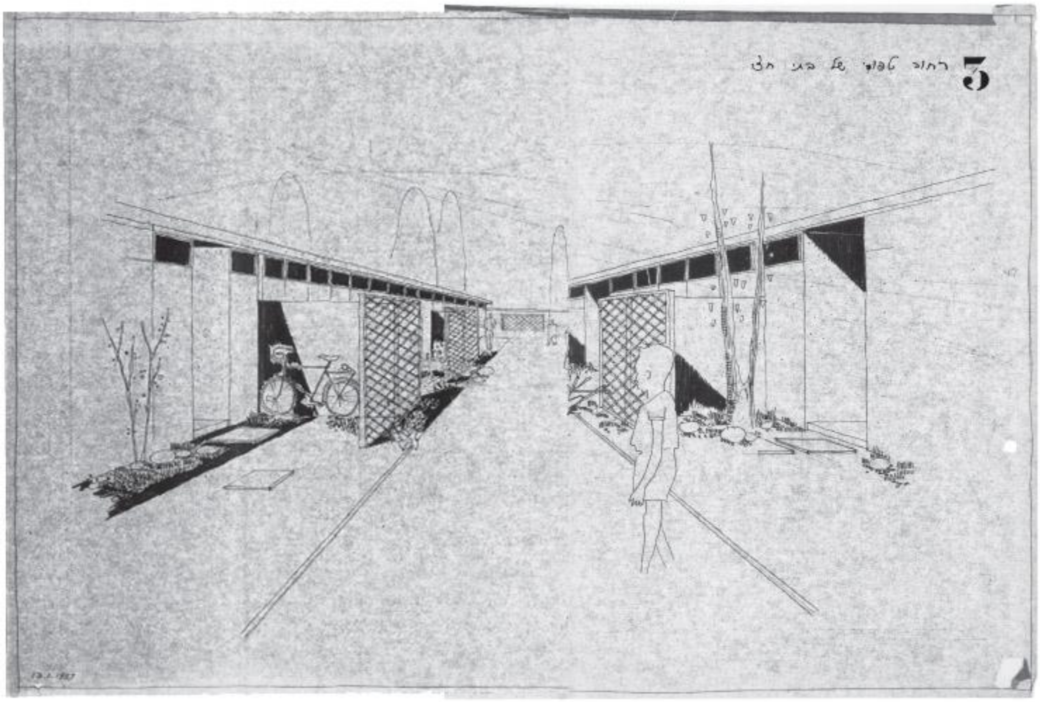


Figure 5.14: Rendition of a "typical street of patio houses", dated from 13.1.1957, as appeared in the final interim report of the Batsheva de Rothschild Foundation research team (Avraham Yasky Collection). The same drawing (though without the header shown here) was attached also to the first interim report of the research team

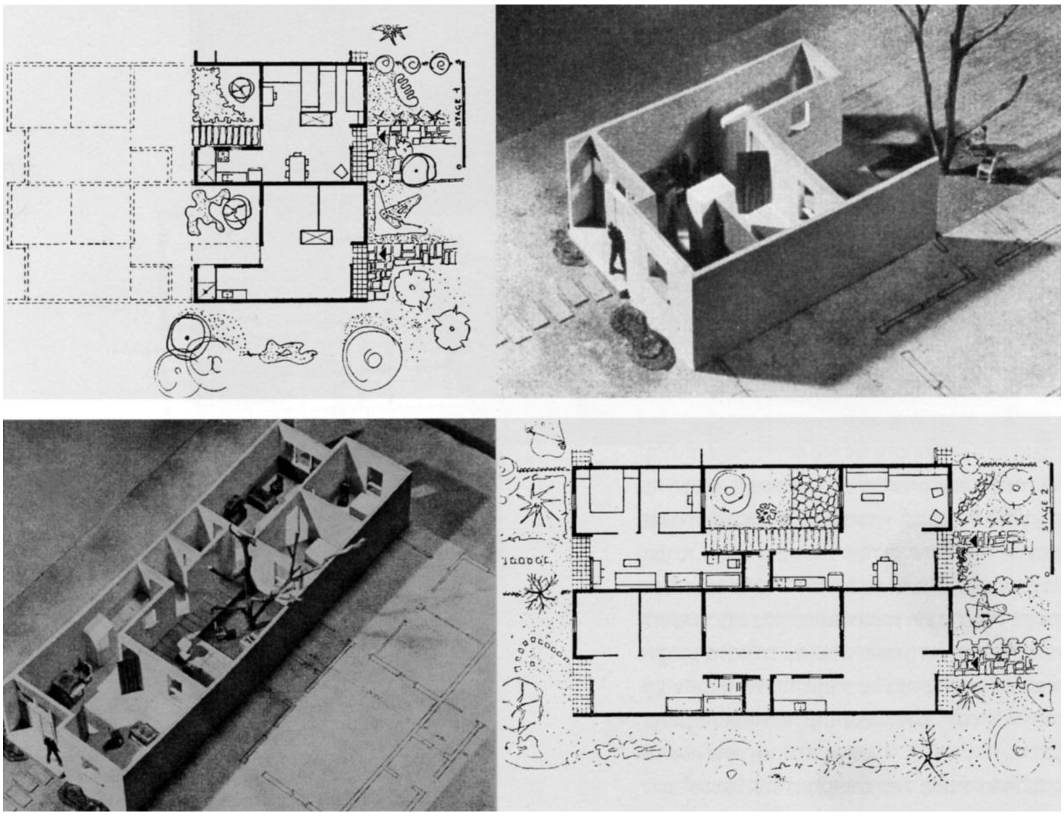


Figure 5.15: Artur Glikson, proposal for a growing patio house, 1956 (Shadar 2014, 43)

Figure 5.16: A neighbourhood of growing patio houses in Be'er Sheva (Neighbourhood D), the late 1950's (Shadar 2014, 44)

During the board meeting it became clear that the definition of the term "research", which was an integral part of the Foundation's name, was understood in different ways by some of its members. Glikson explained that "the team's work is not an academic research which focuses on the measuring of certain variables, but an architectural research [...] which means a research that aims at practical conclusions". To this Yasky replied that he doubts "whether we could accomplish with our limited resources the inspection and design of several types as well as conducting a research [...] I cannot take upon myself the execution of a precise research in issues the rest of the world is actually still struggling to resolve". Glikson commented that he thinks that Yasky should not "concentrate only on the plans that he prepares, since it will not promote our aim, it will not create the basis for the housing of new immigrants". Shalon supported Yasky and said that he is afraid that "such research could not be thorough enough", and Keynan, representing Rothschild, argued that "Ms. Batsheva Rothschild was particularly interested in the design of housing and not in fundamental questions". Here Glikson found it necessary to reiterate his views:

> The design of new immigrants' housing is deficient, since it is not grounded enough from the perspective of dwelling programs. To me, it was clear that the work of this

> Foundation should aim at achieving the best in all those fields by using architecture. If one does not try to be broad-minded as much as possible, one cannot succeed, and I think that because of the capabilities and the time we have, we should, in spite of everything, use this time for this purpose [...] The aim is that the design and the research will be interrelated and that the one will develop from within the other. (Batsheva de Rothschild Foundation 1957a)

Yasky's reservations were also expressed in his interim report. In its first part, he described the activities of the research team in a way that revealed some disagreements between him and Glikson. According to Yasky,

> These guidelines [which were formulated in Glikson's letter to Rothschild from 3 March 1956], delivered to me by architect Glikson and approved in a meeting of the Foundation's board of trustees, clarify that the team's work will concentrate mainly on design [here Yasky added the English word "design" to the Hebrew text] of typical house types in new immigrants' housing projects. Based on this, I invited to the team an architect and a structural engineer, people whose education is suitable for a distinctively design task.
>
> [...]
>
> In the end of January, after about two months of work, I met architect Glikson in order to summarize the first phase of our work and to outline its future. During our conversation, Glikson commented that our advancement in the practical design is too rapid, and that it is advisable that we dedicate more time to survey and research on the problems related to housing of new immigrants, in order to develop a well-formed program for future design.
>
> Following our conversation we prepared a framework for a program for "research on the house". This program was

> thoroughly discussed during the architects' meeting on 8 February, and following it we prepared a final program for the research that was approved during the architects' meeting on 22 February. In order to execute the research we have consulted people from the Institute for Applied Sociological Research and the Technion, and their guidance in choosing the suitable methods enabled us to begin executing the task, in which we are being occupied for the last couple of weeks. (Yasky 1957)

What is clear from Yasky's description is that the design work which produced the concept of an expandable "courtyard" house emerged even before proper research, and more specifically a research into climatic problems, was even initiated – a fact which, according to Yasky, was not welcomed by Glikson.

THE SECOND INTERIM REPORT

It seems that the open discussion at the board meeting steered the team's work towards a broader research than originally intended by Yasky. About two months later, on 29 May 1957, the team submitted a second interim report (Yasky et al. 1957), which summarized research findings in three areas: "climatology", "building constructions and materials", and "prices and budgets". The chapter on climatology, which consisted of three pages, was mainly based on an American guide book, *Application of climatic data to house design*, which was written by brothers Victor and Aladár Olgyay (see above, section 1.4.5) in cooperation with Thomas Malone, and was published by the Division of Housing Research at the American Housing and Home Finance Agency (Olgyay et al. 1954). In addition, a short reference was made to an unidentified work by George Parmelee, presumably his report *Problems of Indoor Climate in Israel* (Parmelee 1954), to a theoretical research on wall insolation conducted at the Station for Technical Climatology at the Technion (Peleg 1956), and to an earlier study of the Station for Technical Climatology in which the thermal performance of certain concrete structures for housing was monitored (Neumann et al. 1952a).

The short climatic chapter of the second interim report opened with a definition of the concept of human thermal comfort and included bioclimatic charts on which a thermal comfort zone was drawn, following the charts which appeared in *Application of Climatic Data to House Design* (Figure 5.17). The charts in the interim report showed monthly values of outdoor air temperatures to relative humidity for Tel Aviv, Be'er Sheva, Jerusalem, and Eilat (Figure 5.18). The authors then turned to analyse the effect of the sun on indoor climate during summer, citing the Technion research on insolation which affirmed that "brick house whose longer walls face west and east will absorb about 72% more [insolation] than a house whose longer walls face south and north". Following this, the authors attached a sun-path diagram, probably for Israel, and a diagram of shading calculations of fixed horizontal and vertical overhangs, applying the graphical method developed by the Olgyay brothers (Olgyay et al. 1954, 40-89).

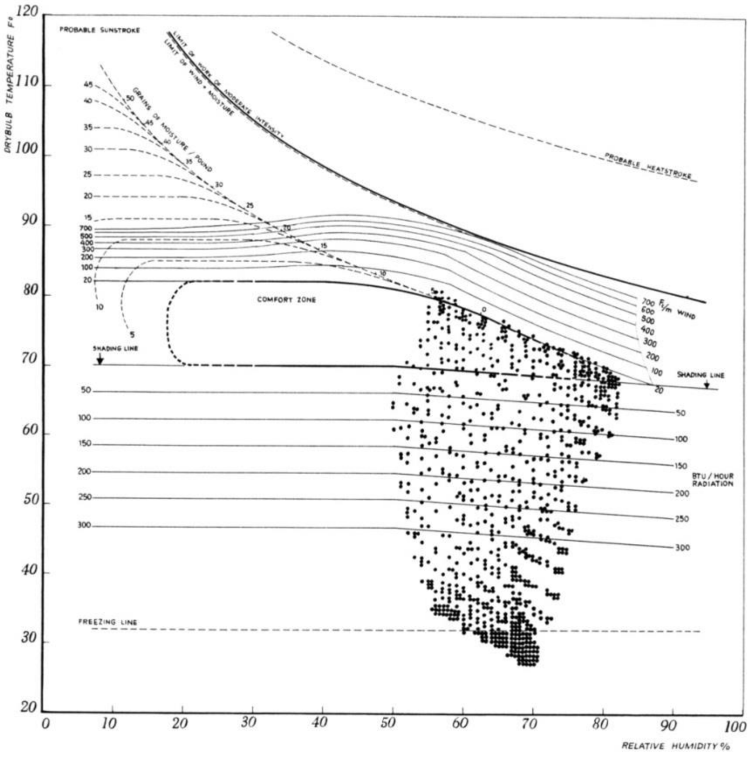


Figure 5.17: Olgyay's bioclimatic chart, with hourly average data in ten days intervals for the New York-New Jersey area (Olgyay et al. 1954, 32)

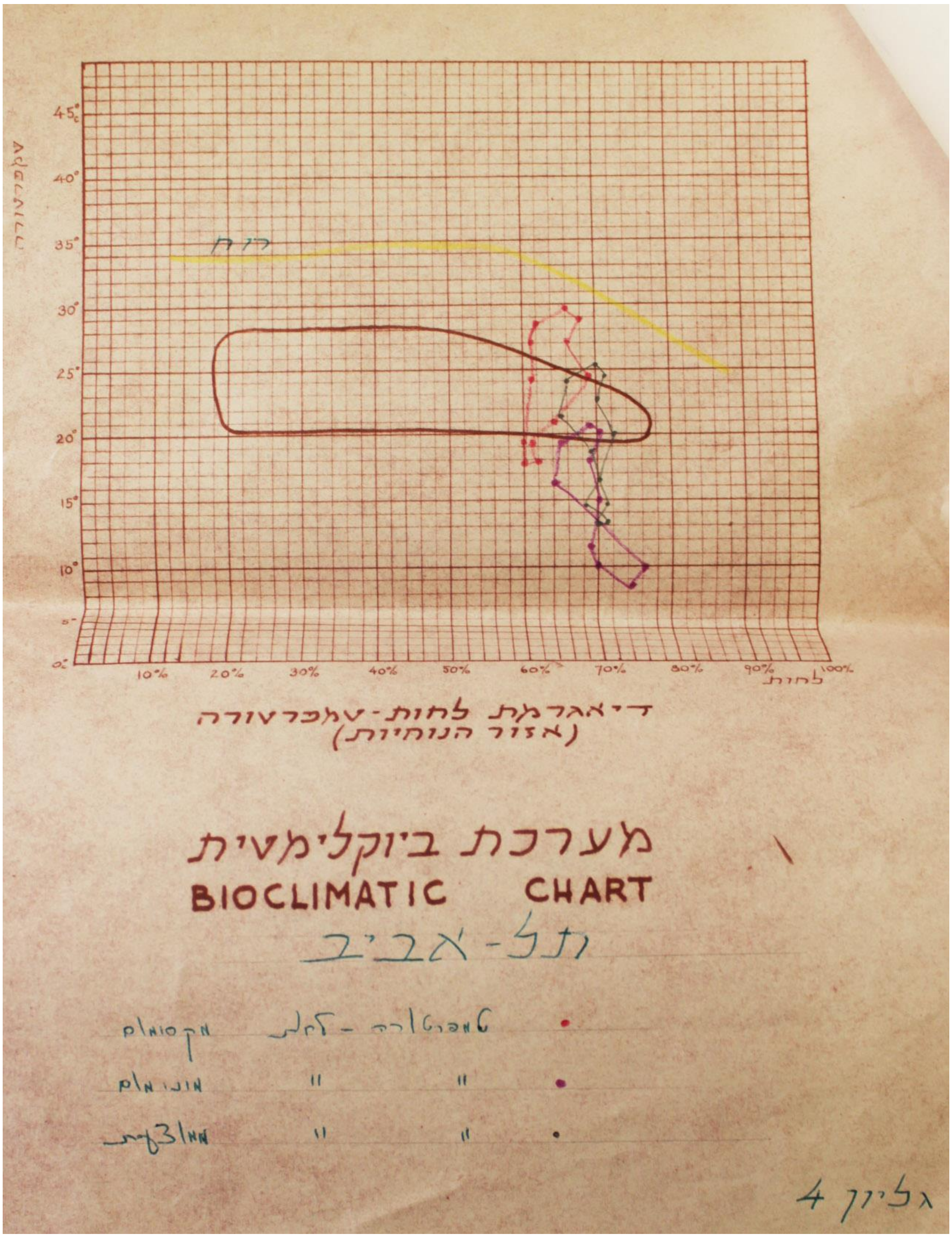


Figure 5.18: Bioclimatic chart for Tel Aviv, showing mean monthly maximal, minimal, and average values of outdoor air temperature to relative humidity, as appeared in the second interim report of the Rothschild Foundation research team (Yasky et al. 1957). The yellow line represents extended upper limits of the comfort zone under effective natural ventilation

The next climatic factor mentioned by the authors was ventilation, though this was done in a generalized manner, claiming only that since openings directed to a desirable wind may in times become source of excess penetration of solar radiation, the exact location of openings and their possible shading should be solved for each case separately. Another major issue which, like ventilation, was referred to only superficially was that of building materials. The authors copied from the thermal performance research of the Station for Technical Climatology, as well as from the American guidebook, typical representative daily temperature amplitudes of different construction types (Figure 5.19). A reference to the possible use of evaporative cooler in certain locations concluded the short summary.

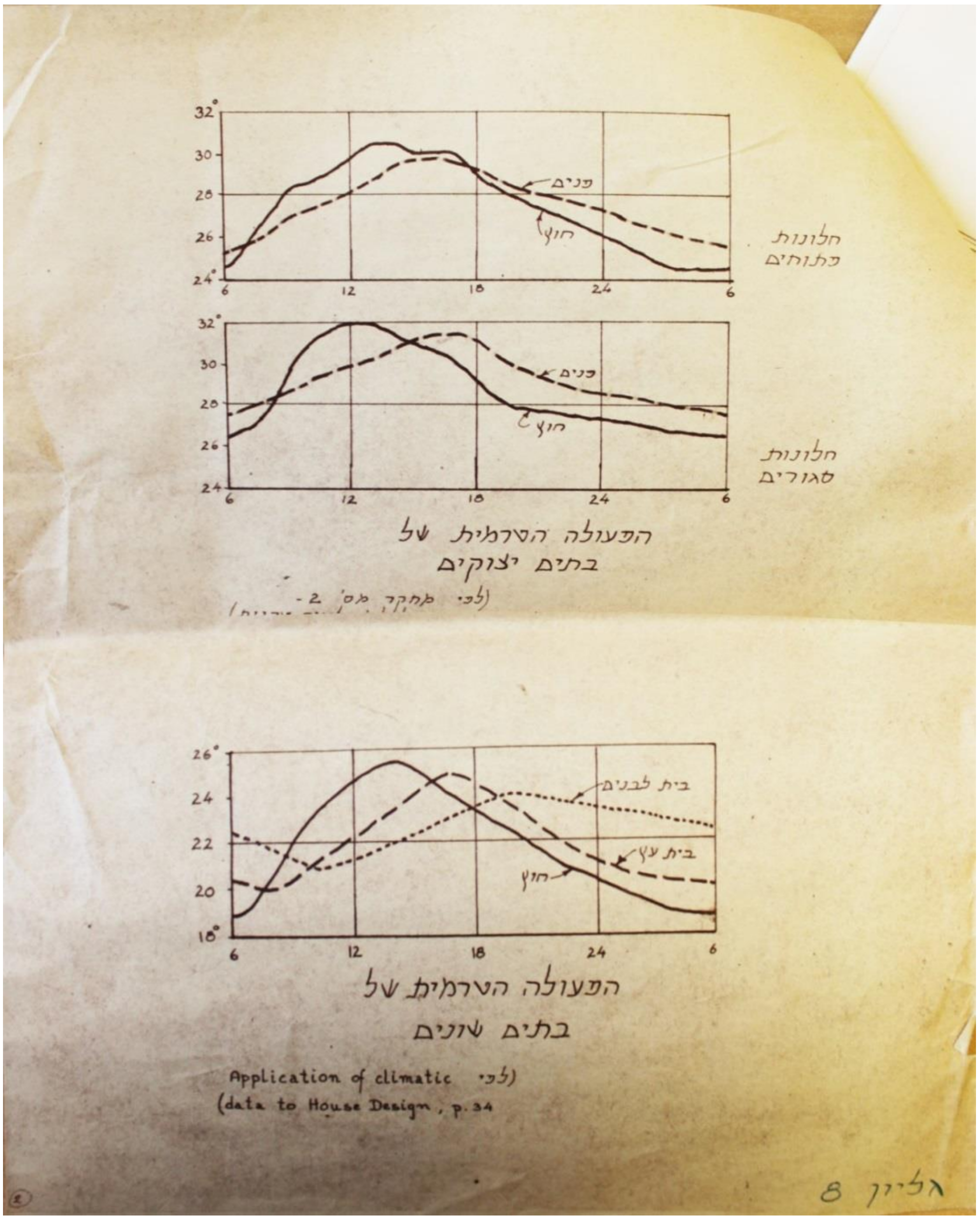


Figure 5.19: Typical thermal performance of reinforced concrete structures with opened and closed windows (two upper diagrams) and a comparison between the thermal performance of a brick house and a wooden house (lower diagram) as appeared in the second interim report of the Rothschild Foundation research team (Yasky et al. 1957)

Following this concise survey of knowledge, the authors concluded that there are some "fundamental problems" that should be climatically addressed, as follows:

> a. Defining the borders of the comfort zones according to seasons, living conditions, and clothing habits of the country's different communities.
> b. Defining the properties of the different building materials, different walls (double), as well as whole structures (thermal performance), according to insulation, heat capacity, time delay, etc.
> c. Defining the course of cross ventilation of apartments as an effect of different elements: general design, for example row houses with enclosed courtyards; chimneys of different forms for the ventilation of internal rooms; overhangs, awnings, shutters, double roofs, etc.
> d. Defining the amount of direct and diffuse [solar] radiation during the different seasons and daily hours. (Yasky et al. 1957)

This framework of a future research could not, of course, be realized based on the limited resources of the Foundation's research team. Nevertheless, the authors felt confident enough to use the existing climatic knowledge in order to put together a list of climatic design recommendations for Be'er Sheva and Tel Aviv. On Be'er Sheva, the authors wrote:

> The warm months are May-October. This is when the average temperature is above shade line. During the months of April and November there are days in which the average temperature is also above shade line. During the majority of days of May-October there is a need for protection against the sun.
>
> a. Building materials: massive construction by which we could achieve balancing of temperatures that will not exceed the outdoor mean temperature – is a possibility;

yet this temperature will be close to the upper limit of the comfort zone during 2-3 months of the year.

b. In order to delay the rise of temperature during daytime there is a need for shading as much as possible, mainly of windows.

c. Vegetation and grass, when possible, will prevent a great share of the reflected [solar] radiation, and the additional humidity induced by the vegetation will not create substantial disturbance because of the extreme dryness of the surroundings.

d. Evaporative devices may be used in certain times. We recommend examining the issue economically.

e. A maximal opening to wind directions after sunset should be secured. The wind flow is important mainly for the cooling of the structure. The wind might be cooler than needed for humans during their sleep, and thus the wind flow should not be directed to the beds.

f. The longer facades of the buildings will be oriented to approximately north and south. The exact orientation will be defined according to the shading arrangements and wind flow direction.

g. We recommend examining the effectiveness of self-ventilating double walls, especially those oriented to the hot wind. (Yasky et al. 1957)

FINALIZING THE RESEARCH WORK

On 5 December 1957, a year after Yasky started his work as the head of its research team, the Foundation's board of directors held another meeting. Since the original schedule prescribed the conclusion of the team's work within a single year, this was a time for summing up. Yet, because of some personal issues, Yasky asked for extra time in order to prepare the final report as well as work plans for a model house, a further development of the "courtyard house" presented by Yasky in March. When Raday commented that the current tendency is the construction of multi-storey buildings for new immigrants, Glikson tried to defend the choice of the courtyard house. He agreed that "the problem of housing new immigrants could not be resolved by applying a single type [of houses]", but added that "today there is a certain state of mind which favours the execution of only multi-storey houses, but this state of mind will pass for economic as well as social reasons" (Batsheva de Rothschild Foundation 1957b).

More than four months late, on 25 March 1958, another board meeting, this time with Baroness Rothschild present, was held in Tel Aviv. Glikson opened by telling the participants that the construction of model houses will soon begin. He explained that the first proposal was to build them in Be'er Sheva, since Be'er Sheva is the "largest construction site today" and the structures "are typical also from the climatic aspect to Be'er Sheva", but eventually it was decided to choose a closer location to Tel Aviv (Jesse Cohen neighbourhood in Holon) in order to facilitate continuous inspection of the structures. Yasky told the board that a draft of the final research report is due to be submitted in two weeks (Batsheva de Rothschild Foundation 1958a).

Nevertheless, only on the next board meeting on 25 September 1958 was a final report submitted. The meeting, which took place in Ramat Aviv, was attended by Rothschild, as well as high rank officials from the Housing Division: David Tanne, the head of the Division; Yehuda Tamir, the head of the Division's New Immigrants Housing Department; and engineer Asher Allweil, the head of the Division's Engineering Department. Yasky clarified that the report which was submitted to some of the attendants was only a draft and waited for their remarks. This draft was not filed among the Rothschild Foundation documents in Israel State Archives. Nevertheless, a copy of the final report's draft, probably the only surviving copy of the document, is privately kept by Yasky's son, Yuval Yasky, as part of the Avraham Yasky Collection. The folder in which the report is filed contains also a set of architectural plans of the model courtyard houses, as well as two letters sent to Yasky. The first was sent by Raday on 23 November 1961, in which he asks Yasky what is the current state of the Foundation's report and urges him to complete the task according to their past agreement (Raday 1961). The second, dated from 2 February 1964 (!), was written by Shmuel Shaked, director of the Physical Planning Division in the Ministry of Housing (which was established two and a half years before). Shaked, writing on the "publication of the report of the Rothschild Foundation", told Yasky that "we are waiting to hear from you on the work's progress" (Shaked 1964). In spite of that, it turned out that the report was never officially published nor widely distributed.

THE FINAL REPORT

The final report of the Batsheva de Rothschild Foundation research holds 59 pages. It opened with a list of recommendations that "were used for preparing a program for the final design", and then elaborated on several subjects: the design guidelines presented to the team (6 pages); a short history of new immigrant's housing in Israel (10 pages); climate (20 pages); and sociological aspects of immigrants housing (15 pages). It is an instructive document in many senses, and the fact it remained unpublished and unknown to the public can only be regretted.

The broad climatic chapter of the final report was inherently different from the climatic section of the second interim report (see above). This time, the team based its findings on monitoring studies which were executed by researchers from the Technion, with specific reference to design issues which involve the immediate surroundings of houses, house plan, roof and wall composition, room height, openings, and courtyards. The main climatic concern was summer conditions; the authors argued that "in Israel the problem of coldness is not an issue, since in most parts of the country warm clothing or heating by a primitive oven provide the necessary protection" (Yasky et al. 1958, 17).

Since the research team did not have the means or the expertise to perform primary study, their climatic chapter had to entirely rely on existing literature: four studies conducted in the Technion during the 1950's. Two studies addressed the issue of thermal properties of different wall and roof constructions, and were based on results obtained by monitoring scale models in Haifa and the Jordan Valley (Neumann et al. 1952b, Neumann et al. 1953); another study, which was also conducted on scale models in Haifa, examined several options of roof protection and insulation (Neumann et al. 1955b). The fourth study, which the report did not mentioned by its name, examined the effect of ceiling height on indoor climate, and was conducted by monitoring unoccupied residential buildings in a small town near Haifa (Shalon et al. 1957).[11] While the studies were well-constructed and could generate some general conclusions, their scope and techniques were limited, especially for a research on the general subject of housing. This inherent deficiency was not hidden from the authors, who chose to begin their climatic chapter with a clear reservation:

> The climatic research around the world, in spite of being developed, did not produced yet a tested systematic method according to which it is possible to calculate and design a building in response to the climate.
>
> It is necessary to study and measure the special conditions in every region and location, as well as to test and examine different methods in order to produce conclusions which affect the design.
>
> In Israel, measurements, studies, and experiments were conducted by several authorities, though these were very limited in their extents and time span, and usually addressed special problems, singular materials, and specific locations. Therefore, it is impossible to recommend on tested methods, but only to make some discrete comments. (Yasky et al. 1958, 17-18)

Surprisingly, and in spite of the reserved tone of the introduction, the authors did not refrain from offering decisive design recommendations in the concluding part of the report's climatic chapter. Among these recommendations was the importance of shading (by trees, vegetation, awnings, overhangs, "sun breakers", etc.), the reduction of reflected solar

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[11] A detailed analysis of the studies is given above, sections 3.5 and 3.7.

radiation (by vegetation or dark-coloured pavement), minimal exposure of the building envelope to direct solar radiation, and the application of bright colours to the building envelope. To this the authors added a somewhat controversial emphasis on ventilation as an important mean of lowering indoor temperature, irrespective of solar orientation, while rejecting the use of massive wall and roof constructions:

> Recommendations
>
> [...]
>
> 4. Maximal ventilation of the structure indoors, and its cooling by the wind outdoors. The wind – if not extremely hot as it is in Eilat or the Jordan Valley – provides great advantages in lowering the indoor temperature of the house, by releasing the warm air emitted indoors. Moreover, the wind flow removes the layer of warm air around the human body, and provides extra evaporation of sweat.
>
>   The external cooling of the structure by wind is also significant. The wind cools the external layer of the roof and walls and creates movement of the heat stored in them to the outdoors, instead of moving inside.
>
>   The problem of ventilation thus requires us to re-examine the common view on the orientation of buildings to north-south, a view that became almost a sacred rule in Israeli building. The research that was conducted in the Jordan Valley, whose conclusions were cited above, proves that with thin walls (10.5 cm) the maximal temperature on the east and west is only slightly higher than on the south, while with thick walls (22.5 and 33 cm) the maximal temperature on the south is higher than the temperature on the east and west. On the other hand, in the hot-humid coastal regions humidity is more disturbing than temperature, so wind flow must be necessary for securing relief. Since the wind comes

mainly from the west, the west-east orientation might be superior to that of north-south.

5. High heat capacity of the roof and walls (or, in other words, thick walls and roof) does not have such great importance as we usually think. It is true that a house with thick walls and roof is cool during the daytime, but during the evening and night, when they begin to emit the heat stored in them into the house, the temperature and the sultry feeling rise in a most disturbing manner. This is even more severe since the wind all across the country stops flowing from the early hours of the evening until about midnight. Those who recommend the use of massive and thick roofs and walls often rely on the typical way of building in many Oriental countries. Yet in order to make things right it should be reminded that in those places the habit of spending the evening hours and the night sleep on the roofs or at least in the courtyards is common. Therefore, in the dry regions of the country, when it is possible to have an outdoor night sleep, the method of thick walls and roofs is acceptable. Yet in the humid regions – and in many places around the country – the humidity at night reaches dew point and outdoor sleep is not an option.

From the above analysis, it can be concluded that: In the coastal region the construction of thin walls and roofs is desirable (shaded as much as possible), with large openings protected from the direct penetration of the sun. In hot and dry regions – like Be'er Sheva, for example – the mid-thickness walls (22 cm) are good, since they keep the coolness of the house until the early hours of the afternoon, while around two o'clock it is better to open up all the

> openings to their full extents in order to take advantage of the wind which releases the heat stored in the structure.
>
> Therefore, the orientation to the wind is desirable also in the dry regions. (Yasky et al. 1958, 34-35)

What is striking about these recommendations, apart from their authoritative tone, is the fact that besides a single study on the thermal behaviour of walls, no actual study conducted in Israel by that time could have supported them. None of the monitoring studies of the 1940's and 1950's dealt with the actual effect of wind on the cooling down of structures, especially not of cooling by naturally ventilating indoor spaces. The authors based their revolutionary assertion that "the west-east orientation might be superior to that of north-south" on a single study that was published in 1953 (Neumann et al. 1953). The study summarized the findings of two monitoring campaign: the first was executed as early as the summer of 1941 in Haifa, the second during the summer of 1952 in Kibbutz Maoz Haim (the Jordan Valley). In both campaigns no buildings were monitored but free standing mock-ups of different wall constructions of an area of 0.8 m^2.

One of the conclusions following the monitoring in Haifa was that "orientation of the walls to north-south resulted in a lower temperature at the centre of the wall in comparison to similar walls that faced west-east", a phrase copied word-by-word into the Rothschild Foundation report. Only in respect to the Maoz Haim campaign did the Technion study concluded that "the orientation of the wall has probably a minor effect on the temperature level on the internal side [...] the common belief that the western wall is the warm wall was not proven as right in the Jordan Valley. The origin of this belief is probably the fact that the western wall normally contains more openings (for the sake of ventilation) than other walls, thus enabling the direct solar radiation to penetrate the house from the west during the afternoon hours" (Neumann et al. 1953, 19-20).

The Maoz Haim study was conducted in an area of the most extreme hot and dry conditions in Israel. Moreover, it did not involve monitoring of buildings, and therefore could not examine the combined effect on indoor temperatures of natural ventilation, opening size and orientation, wall composition, and room orientation. Nevertheless, the authors of the Rothschild Foundation report seemed confident enough to generalize from its results an assertion that the most important element in cooling buildings in Israel is proper ventilation, irrespective of their solar orientation or other factors. They were also aware of the fact that their recommendation was in conflict with common design habits and beliefs. In the end, this recommendation coincided with other common habits and beliefs, those practiced by local architects during the 1930's (Ginzburg 1936, Karmi 1936, Posner 1937, Sharon 1937), which in retrospect were considered highly unsuccessful (see above, section 2.2).

More puzzling is the concluding paragraph of the climatic chapter of the report. Here, under the title "concluding remark", the authors seemed to take a step back from the decisive tone of their own recommendations, making the whole climatic chapter a tapestry of contradictions:

> We must add to the conclusion of this chapter that the treatment of the problems of climate in buildings cannot be done by "advices" or amateurish inventions. In our country we have enough experience with the grave results of a superficial treatment of climatic problems, which often leads to fruitless waste, and on the other hand causes great suffering to the population. Although a comprehensive and tested method for treating climatic problems of buildings is still missing, there are nonetheless knowledge and a plentiful of tools that could be used. There are tables and charts of the "comfort zones", according to which the temperature level can be treated in relation to the humidity. There are tables and instruments (like the heliodon) that when used can help in determining the shape of a shading element, etc. These issues must be treated by people of suitable training who will assist the architect. It could normally be beneficial if a team consisting of a physician, a

> climatologist, and an architect (or a structural engineer) cooperate on solving the problems of climate in buildings.
>
> And as a first step, it would be wise to send an architect (or a structural engineer) to training in the problem of making buildings fit for the requirements of climate. (Yasky et al. 1958, 36)

THE CARPET HOUSING CONCEPT

The Rothschild Foundation report was supplemented by a set of drawings of a proposed model houses. In spite of the later extensive research, the basic concept of rows of patio houses, which was presented to the board of trustees on its first meeting, remained intact. The authors proposed two types of patio houses: one for low and flat regions, the other for hilly landscapes. The concept was further developed into what was now nicknamed "carpet building", which was defined as "linked building, wall-to-wall on the sides and at the back, where each housing unit receives a courtyard, enclosed and private, within the first building stage" (Yasky et al. 1958, 46). In the executive summary of the report, the authors elaborated on the advantages of the concept:

> The area for each housing unit is about 120 sqm net, of which 35-40 sqm are of the house itself, located on the front, and on the back an enclosed courtyard of about 80 sqm. During the first stage the courtyard enables many uses, as: cooking, laundry washing and drying, a playground for toddlers, storage, and even time spending and sleep during summer. When the resident has enough means for the enlargement of the house, he can enlarge it to any size he wishes, inside the courtyard, without depending on the consent or the help of his neighbours and without any negative effect on the shape of the street. The enlargement, even if it reaches additional 40 sqm, would still leave a courtyard of more than 40 sqm.
>
> […]

> Building the house along the facade to the street and its enlargement on the second stage in parallel to the house of the first stage leaves two open sides (one to the street and the other to the courtyard) which provide cross ventilation.
>
> Carpet building also holds many advantages for the neighbourhood and the city. It enables a pretty high density while sticking to single-storey structures. It leaves a minimal amount of uncontrolled and undefined areas, as much as it provides a maximal amount of shaded alleys in the street. Altogether, this ensures a nice form of neighbourhood and city, similar to the long tradition of this type of building around the Mediterranean Basin. (Yasky et al. 1958, viii)

Although the carpet scheme was hailed as helping to cross ventilate the houses, one drawing that was attached to the report, titled "typical construction of houses with courtyards" (Figure 5.20) might raise some doubts. The drawing, and a matching model (Figure 5.21) which appeared in the article on the work of the research team (Handasa VeAdrikhalut 1959b), show five rows of single-storey houses. One row is perpendicular to the other four; two other rows face opposite directions while a shared wall divides the backyards of each row; in two rows the front facade of the houses is practically blocked by a wall enclosing a front yard. It can be argued that the general layout, as well as the use of walled courtyards, could not have resulted in an effective exploitation of cross ventilation, since the design was non-uniform in the orientation of the houses to the prevailing winds, but also because the external walls of the yards might have served as "wind breakers".

The dominance of the courtyards in the proposed layout had some resonance in the climatic chapter of the report. Here, the authors dedicated a section to the climatic role of courtyards, which probably relied only on general claims that were never scientifically tested, at least not in Israel:

> One of the most common elements around the Mediterranean Basin, which has been reapplied during the last years in many countries around the world, is the courtyard. The properties of such yard were not thoroughly tested yet in our country, but according to the available data one can generally determine the following characteristics:
>
> 1. The cold air that flows over the courtyard tends to fall down, and therefore afterwards the temperature inside it is lower than the outdoor [temperature].
> 2. By the suction of winds and the movement of hot air up, the courtyards is transformed into a chimney; thus the ventilation of the house facing the courtyard is enhanced, while the coolness inside the courtyard itself rises.
> 3. The courtyard is usable during the early evening and night hours when the house is still hot, and under dry weather conditions the courtyard is also usable for sleeping during the night.
>
> The above advantages could be attained under the following conditions:
>
> 1. Correct dimensions of the courtyard; if it is too small the temperature will be higher than inside the house because of the heat emitted by the walls. If it is too big it will have only small patches of shade, the chimney effect will not evolve, and the cold air will not "fall" into it.
> 2. The wall surfaces enclosing the courtyard and the courtyard's floor should be protected from radiation and reflection.
> 3. Shade is welcomed – mainly shading by trees or by light movable ceilings, in order to prevent the heating of the courtyard during daytime. (Yasky et al. 1958, 31-32)

While it is clear that the authors of the report were using some kind of external source or sources for this analysis, they did not surrendered their identity. Such analysis is not present in any of the studies that were explicitly mentioned in the final report or the second interim report, as well as in any other published study in Israel until that time. The whole subject of the thermal effects of courtyards was not addressed even later in studies conducted in Israel during the 1960's, probably because courtyards were not a typical feature in typical modern Israeli housing. Keeping in mind that the analysis is far from being clear or instructive for design purposes, its inclusion in the report can be interpreted mainly as a post-factum attempt to superficially justify the proposed model scheme long after the adoption of the "patio house" as its main element.

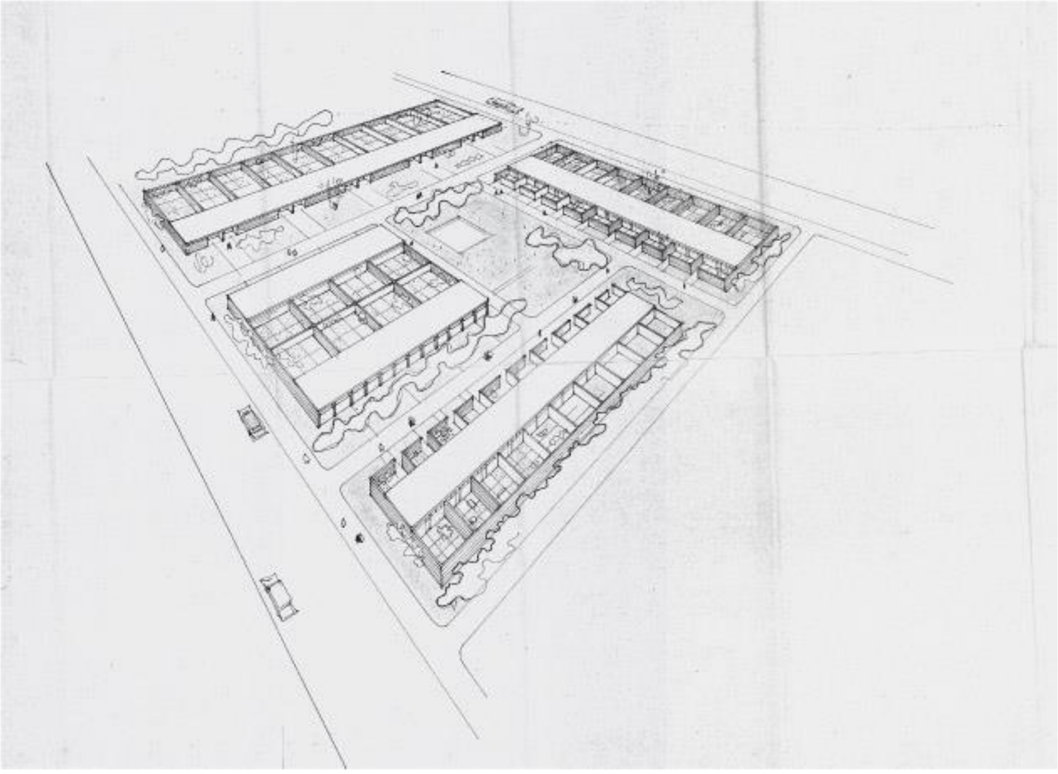


Figure 5.20: Rothschild Foundation research team, typical construction of houses with courtyards (Avraham Yasky Collection). This drawing was far from being an imaginary illustration of a potential execution of the carpet scheme: the historical evidence suggests that the drawing depicts an unrealized project intended to be constructed in Jesse Cohen neighbourhood in Holon

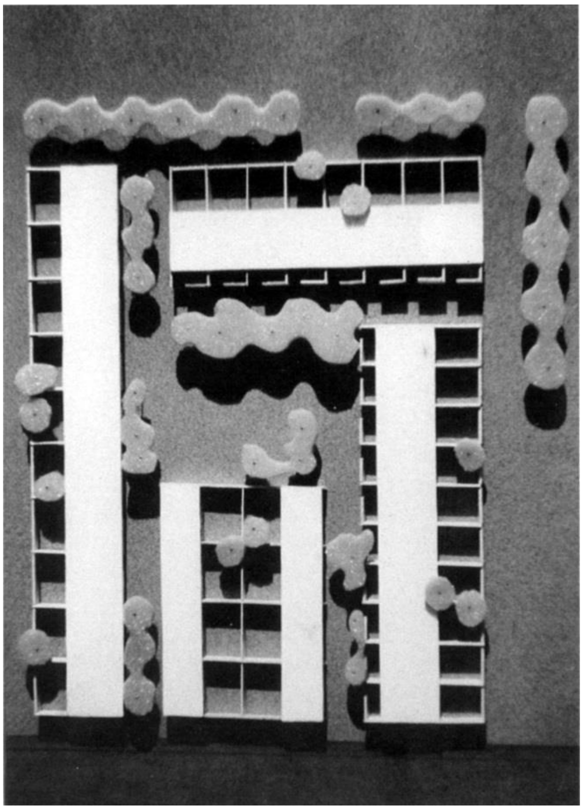


Figure 5.21: Rothschild Foundation research team, a model of the proposed carpet housing scheme (Avraham Yasky Collection)

Here it worth mentioning that the carpet housing scheme was not a totally original invention of the Rothschild Foundation research team. As mentioned above, a system of repetitive arrays of patio houses was already introduced and executed by Arthur Glikson, who closely supervised the work of the Rothschild Foundation research team. Although Glikson's system was far less sophisticated in term of the resultant urban fabric, his idea of an expandable patio house had certainly a direct impact on the patio houses of the Model Housing Estate. At the same time, it seems that both Glikson's ideas and the carpet scheme of the Rothschild Foundation report owe more than a little to an urban development scheme introduced by Michel Écochard (1905-1985), a French architect and urban planner, for the city of Casablanca . Devised during late 1940's, it was realized and internationally publicized during the early 1950's while expanding into other cities in Morocco and Algeria. The similarities with the carpet scheme of the Rothschild Foundation report suggest that his projects were the "Mediterranean Basin" inspiration the authors implicitly relied on.

Écochard came to Morocco in 1946, after being appointed the director of the local *Service de l'Urbanisme*, Morocco's highest planning authority. He was granted broad planning powers and generous budgets. His major concern was the relatively new phenomenon of *bidonvilles*, shantytowns absorbing mass immigration waves from Morocco's rural sites to its urban centres. Based on a comprehensive survey and research (Avermaete and Casciato 2014, 88-96), Écochard presented a grid system that was based on an 8 x 8 m module (Figure 5.22), which was duplicated in different ways in order to create several small neighbourhood units that constitute a single neighbourhood of 9,000 inhabitants. Each house was surrounded by a 2.8 m high wall, along which two or three rooms were to be built, while the rest of the parcel was left unbuilt as an open patio of at least 25 m^2 (Figure 5.24). The 64 m^2 grid unit was seen as the minimal living area for a single family. The complete grid consisted also of public spaces and public buildings in several scales, all conforming to the basic 8 x 8 m module (Avermaete 2010).

Écochard's grid system was extensively realized in the Carrières Centrales quarter of Casablanca (Figure 5.25), next to an existing *bidonville*, but was implemented also in other parts of the city (the Sidi Othman quarter), as well as in other Moroccan cities (Rabat, Agadir, Port Lyautey). These projects received an international acclaim through publications in professional journals. *L'Architecture d'Aujourd'hui*, one of the leading architectural journals of that time, recurrently covered Écochard's urban projects (Figure 5.26), and many photographs of several of the realized quarters appeared in four issues of the journal between 1951 and 1955 (May 1951, February-March 1953, December 1954, June 1955). A report submitted by Écochard to CIAM in 1952 (titled "Housing for the Greater Number"), and his presentation of the projects during the CIAM IX congress in Aix-en-Provence (1953) made them widely known among the professional circles of these years. It is unlikely that Glikson or Yasky were unfamiliar with Écochard's grid system of patio houses, and it can be confidently assumed that his urban projects, derived from urgent need for housing for the poor in hot climate, had direct impact on the schemes introduced by them during the second half of the 1950's.

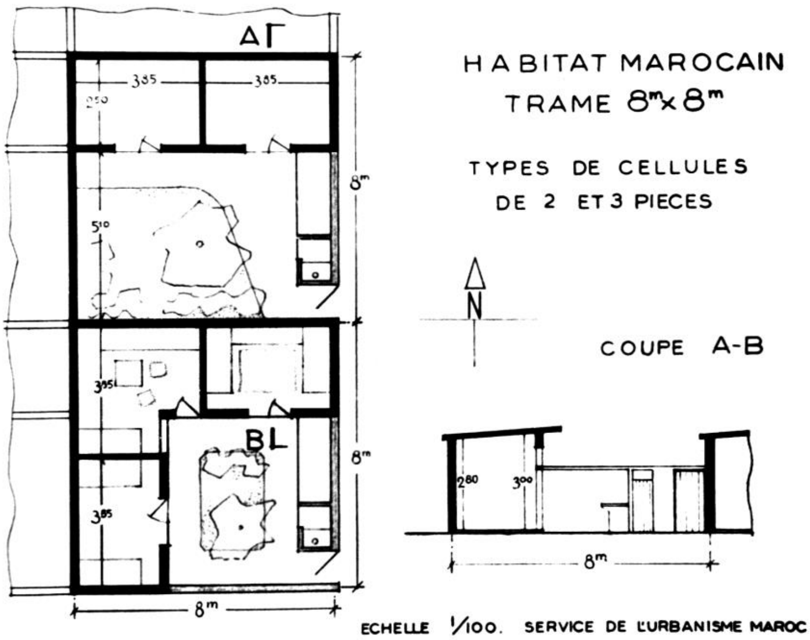


Figure 5.22: Service de l'urbanisme, a basic configuration of the 8 x 8 m module for a larger neighbouring unit (Michel Écochard Collection, Aga Khan Trust for Culture)

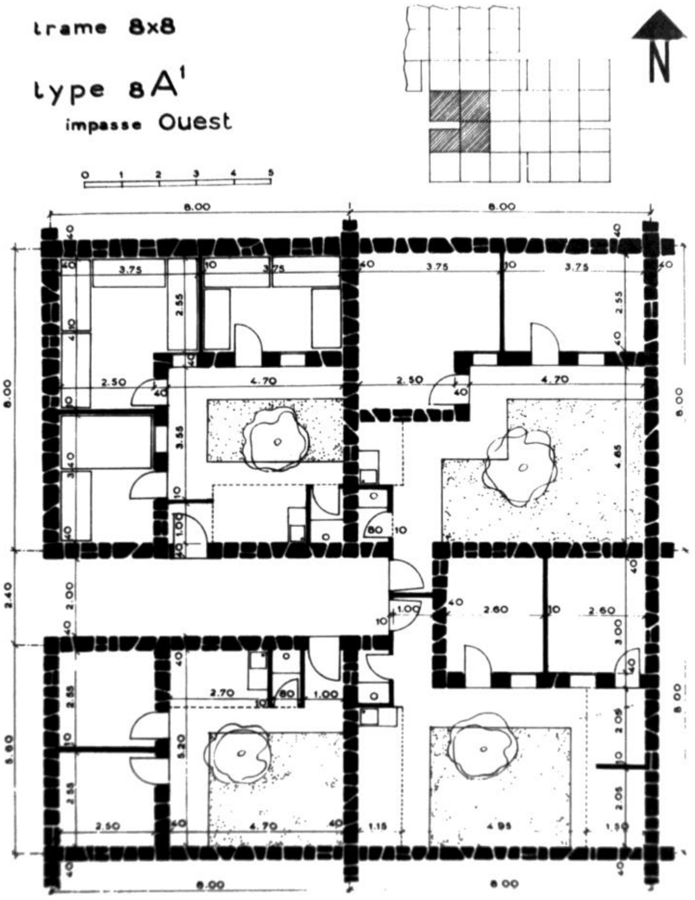
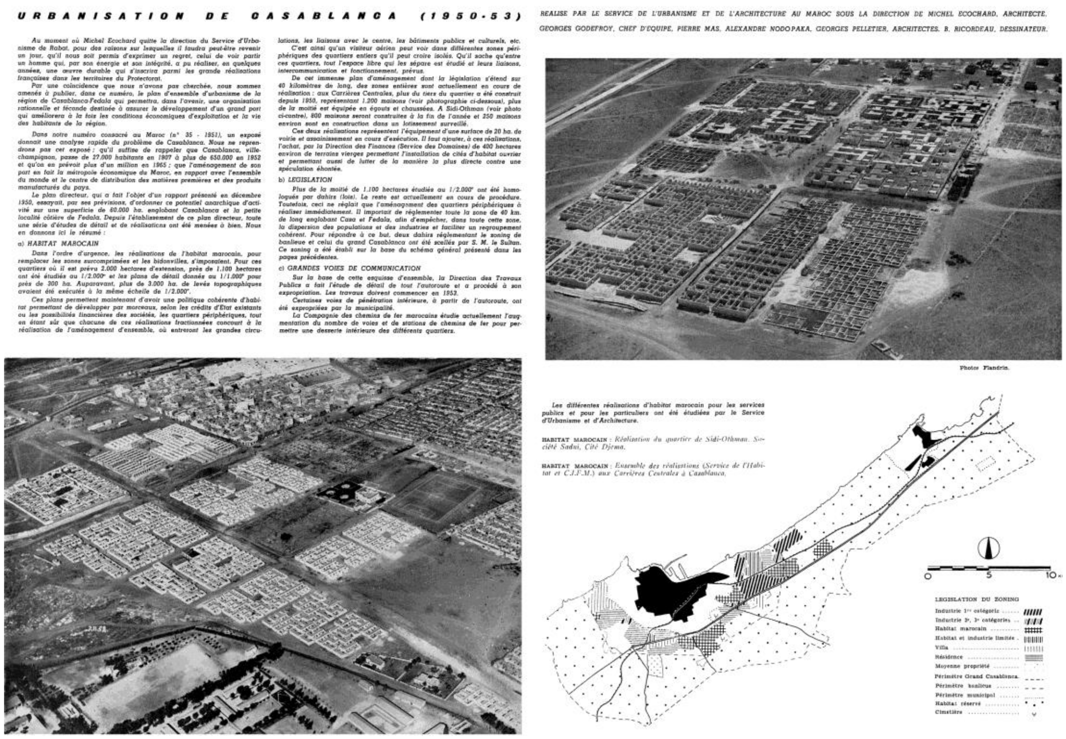


Figure 5.23: Service de l'urbanisme, plan for the realization of a cluster of four houses according to the 8 x 8 m grid (Avermaete and Casciato 2014, 274)

Figure 5.24: A group of realized housing units built according to the Écochard grid system in Yacoub El-Mansour quarter in Rabat, 1954 (Michel Écochard Collection, Aga Khan Trust for Culture)

Figure 5.25: Part of Carrières Centrales quarter in Casablanca, the new neighbourhoods built according to the Écochard grid system, the early 1950's (Michel Écochard Collection, Aga Khan Trust for Culture)



URBANISATION DE CASABLANCA (1950-53)

Au moment où Michel Ecochard quitte la direction du Service d'Urbanisme de Rabat, pour des raisons sur lesquelles il faudra peut-être revenir un jour, qu'il nous soit permis d'exprimer un regret, celui de voir partir un homme qui, par son énergie et son intégrité, a pu réaliser, en quelques années, une œuvre durable qui s'inscrira parmi les grande réalisations françaises dans les territoires du Protectorat.

Par une coïncidence que nous n'avons pas cherchée, nous sommes amenés à publier, dans ce numéro, le plan d'ensemble d'urbanisme de la région de Casablanca-Fedala qui permettra, dans l'avenir, une organisation rationnelle et féconde destinée à assurer le développement d'un grand port qui améliorera à la fois les conditions économiques d'exploitation et la vie des habitants de la région.

Dans notre numéro consacré au Maroc (n° 35 - 1951), un exposé donnait une analyse rapide du problème de Casablanca. Nous ne reprendrons pas cet exposé : qu'il suffise de rappeler que Casablanca, ville-champignon, passe de 27.000 habitants en 1907 à plus de 650.000 en 1952 et qu'on en prévoit plus d'un million en 1965 ; que l'aménagement de son port en fait la métropole économique du Maroc, en rapport avec l'ensemble du monde et le centre de distribution des matières premières et des produits manufacturés du pays.

Le plan directeur, qui a fait l'objet d'un rapport présenté en décembre 1950, essayait, par ses prévisions, d'ordonner ce potentiel anarchique d'activité sur une superficie de 60.000 ha. englobant Casablanca et la petite localité côtière de Fedala. Depuis l'établissement de ce plan directeur, toute une série d'études de détail et de réalisations ont été menées à bien. Nous en donnons ici le résumé :

a) HABITAT MAROCAIN

Dans l'ordre d'urgence, les réalisations de l'habitat marocain, pour remplacer les zones surcomprimées et les bidonvilles, s'imposaient. Pour ces quartiers où il est prévu 2.000 hectares d'extension, près de 1.100 hectares ont été étudiés au 1/2.000e et les plans de détail donnés au 1/1.000e pour près de 300 ha. Auparavant, plus de 3.000 ha. de levés topographiques avaient été exécutés à la même échelle de 1/2.000e.

Ces plans permettent maintenant d'avoir une politique cohérente d'habitat permettant de développer par morceaux, selon les crédits d'Etat existants ou les possibilités financières des sociétés, les quartiers périphériques, tout en étant sûr que chacune de ces réalisations fractionnées concourt à la réalisation de l'aménagement d'ensemble, où entreront les grandes circulations, les liaisons avec le centre, les bâtiments publics et culturels, etc.

C'est ainsi qu'un visiteur aérien peut voir dans différentes zones périphériques des quartiers entiers qu'il peut croire isolés. Qu'il sache qu'entre ces quartiers, tout l'espace libre qui les sépare est étudié et leurs liaisons, intercommunication et fonctionnement, prévus.

De cet immense plan d'aménagement dont la législation s'étend sur 40 kilomètres de long, des zones entières sont actuellement en cours de réalisation : aux Carrières Centrales, plus du tiers du quartier a été construit depuis 1950, représentant 1.200 maisons (voir photographie ci-dessous), plus de la moitié est équipée en égouts et chaussées. A Sidi-Othman (voir photo ci-contre), 800 maisons seront construites à la fin de l'année et 250 maisons environ sont en construction dans un lotissement surveillé.

Ces deux réalisations représentent l'équipement d'une surface de 20 ha. de voirie et assainissement en cours d'exécution. Il faut ajouter, à ces réalisations, l'achat, par la Direction des Finances (Service des Domaines) de 400 hectares environ de terrains vierges permettant l'installation de cités d'habitat ouvrier et permettant aussi de lutter de la manière la plus directe contre une spéculation éhontée.

b) LEGISLATION

Plus de la moitié de 1.100 hectares étudiés au 1/2.000e ont été homologués par dahirs (lois). Le reste est actuellement en cours de procédure. Toutefois, ceci ne réglait que l'aménagement des quartiers périphériques à réaliser immédiatement. Il importait de réglementer toute la zone de 40 km. de long englobant Casa et Fedala, afin d'empêcher, dans toute cette zone, la dispersion des populations et des industries et faciliter un regroupement cohérent. Pour répondre à ce but, deux dahirs réglementant le zoning de banlieue et celui du grand Casablanca ont été scellés par S. M. le Sultan. Ce zoning a été établi sur la base du schéma général présenté dans les pages précédentes.

c) GRANDES VOIES DE COMMUNICATION

Sur la base de cette esquisse d'ensemble, la Direction des Travaux Publics a fait l'étude de détail de tout l'autoroute et a procédé à son expropriation. Les travaux doivent commencer en 1952.

Certaines voies de pénétration intérieure, à partir de l'autoroute, ont été expropriées par la municipalité.

La Compagnie des chemins de fer marocains étudie actuellement l'augmentation du nombre de voies et de stations de chemins de fer pour permettre une desserte intérieure des différents quartiers.

REALISE PAR LE SERVICE DE L'URBANISME ET DE L'ARCHITECTURE AU MAROC SOUS LA DIRECTION DE MICHEL ECOCHARD, ARCHITECTE.
GEORGES GODEFROY, CHEF D'EQUIPE, PIERRE MAS, ALEXANDRE NODOPAKA, GEORGES PELLETIER, ARCHITECTES. B. RICORDEAU, DESSINATEUR.

Photo Flandrin.

Les différentes réalisations d'habitat marocain pour les services publics et pour les particuliers ont été étudiées par le Service d'Urbanisme et d'Architecture.

HABITAT MAROCAIN : *Réalisation du quartier de Sidi-Othman. Société Sadui, Cité Djema.*

HABITAT MAROCAIN : *Ensemble des réalisations (Service de l'Habitat et C.I.F.M.) aux Carrières Centrales à Casablanca.*

LEGISLATION DU ZONING

Industrie 1re catégorie	▨
Industrie 2e, 3e catégories	▨
Habitat marocain	▦
Habitat et industrie limitée	▥
Villa	▥
Résidence	▤
Moyenne propriété	·
Périmètre Grand Casablanca	– – –
Périmètre banlieue	– – –
Périmètre municipal	······
Habitat réservé	• •
Cimetière	⌄

Figure 5.26: A double-page spread from the February-March issue of *L'Architecture d'Aujourd'hui* on the Casablanca projects which were realized according to Écochard's grid system: Carrières Centrales (left) and Sidi Othman (right)

It is interesting to note that the climatic issue did not receive much explicit attention by Écochard, and that climatic justifications were not given for his 8 x 8 m grid system. On the other hand, since Écochard did try to learn from the traditional local living habits in order to create a modern, regulated, and semi-urban form which will be suitable for Morocco, it can be argued that some inherent climatic aspects of the traditional urban form, typical to many places around the Islamic world, were implemented in his grid system of narrow alleys and patio houses even unconsciously. These were later transferred, including some of their climatic advantages, to the "carpet" scheme presented by Yasky.

5.2.2 From the Batsheva de Rothschild Foundation to Be'er Sheva's Model Housing Estate

During the last board meeting of the Batsheva de Rothschild Foundation on 25 September 1958, David Tanne, the head of Israel's Housing Division in the Ministry of Labour, solemnly announced:

> The most important role played by the BS de Rothschild Foundation was that of being the first evidence for the fact that we have entered a period of thinking in housing construction in Israel. I am convinced that the result of this study is very important to us. We accomplished great changes in the Housing Division. Mr. Glikson concentrates now only on planning research – what should be the needs of building housing projects in Israel. Moreover, we are building now two model housing estates, one in Ramat Aviv and one in Be'er Sheva. Each housing estate will be built by 6-8 architects under similar conditions. (Batsheva de Rothschild Foundation 1958b)

Tanne then added, based on the material he received from Yasky, that the Housing Division will build tens of model apartments in "northern Tel Aviv, Bat Yam, or Be'er Sheva". Baroness Rothschild, who attended the special meeting, asked why it was not possible to build a whole neighbourhood of the proposed house types, and Tanne replied that a neighbourhood should always consist of several and different house types. About two weeks later, Yasky attended a special meeting, which was defined as a meeting of the "technical committee" of the Rothschild Foundation. The other participants were Allweil, Arieh Doudai, Glikson, and Tamir from the Housing Division, as well as Mansfeld. The discussion focused on the construction of 37 housing units in Jesse Cohen neighbourhood in Holon, in what seems to be a direct implementation of the decision taken by the Foundation's board on 25 March 1958 (see above, section 5.2.1). Yasky added that all the plans for "the 3 types" are ready (Batsheva de Rothschild Foundation 1958c). It is highly probable that the perspective rendition of the "typical construction of houses with courtyards", which was attached to the research team's final report (Figure 5.20), was actually an illustration of the intended project in Holon, since the drawing showed three different house designs arranged in rows, amounting to a total sum of exactly 37 units.

The October 1958 meeting of the technical committee ended with a decision to convene again within one month, after Yasky submitted some missing details to Allweil and Doudai. Nevertheless, any trace of such meeting could not be found by the author among the Housing Division files in Israel State Archives. Instead, the files contain a later letter from Tanne to Yasky (dated 5 January 1959), which approves Yasky's appointment as the head supervisor of the "houses that will be executed according to the aforementioned research work in Holon, Jesse Cohen". Yasky was also responsible for the preparation of a set of plans to be submitted to the local authorities (Tanne 1959b). This is the last document on the subject in the Rothschild Foundation files; no housing project which can be directly attributed to the Foundation's work was ever built, in Jesse Cohen neighbourhood or anywhere else.

The proclaimed goals of the Rothschild Foundation research team were thus left unattained: the team's final report was never published and remained unknown to the public, and the model houses were never built. This may raise some questions, since all the parties involved in the Foundation's work were allegedly highly interested in publicizing its activity. Arguably, the explanation for this silent demise lies in Tanne's announcement on the Model Housing Estates project whose extents and possibilities were much broader than the limited experimental project in Holon. What seemed to be an innovative way to enhance public housing in 1956, seemed much less exciting by the beginning of 1959. Yasky's involvement in the Model Housing Estate in Be'er Sheva as the head of the design team enabled him to implement his own ideas on a much larger scale than what was suggested as the grand finale for the Foundation's work. The carpet housing concept which emerged out of his research team was to be realized in Be'er Sheva, not in Holon.

Although not a single explicit statement links the carpet housing of the Rothschild Foundation to the carpet housing of the Model Housing Estate, a thick implicit line does connect the two. Apart from the personal role played by Yasky in both cases and the formal resemblance of the design, it is probably not a coincidence that the only professional publication on the

Foundation's work, a single-page article in the July-August 1959 issue of the JAEAI which was dedicated to housing, appeared as an introduction to a wider coverage on the planning of the Be'er Sheva Model Housing Estate (Handasa VeAdrikhalut 1959b, Handasa VeAdrikhalut 1959c). Moreover, the way the authors of the Rothschild Foundation report described their "ideal" image of a residential neighbourhood, which extended far beyond the concept of the carpet housing, can be easily read as an early prescription for the Be'er Sheva neighbourhood, where the carpet housing is weaved into a richer yet systematic urban environment of other building types and sizes:

> The deficient image of the housing projects and the new towns in Israel is probably the biggest weakness of the entire enterprise of construction. While in the design of apartments and houses we have developed solutions that are not worse and in many times even better than accepted solutions in many countries around the world, in town planning – especially in its visual aspect – the weakness is still great and calls for a broad and deep discussion. This cannot be done within the current framework, and therefore we will confine ourselves only to several points which relate to the image of the city.
>
> At first, we shall mention the problem of "uniformity and variance". During the early stages of the building of new immigrants' housing, uniform types were often used. We all know the neighbourhoods consisting only of two-storey houses for four families or neighbourhoods entirely built from semi-detached houses. On the one hand, this extra uniformity creates what is perceived as monotonous dullness; on the other hand, the self is lost within this absolute uniformity. There is no identification between a person and his apartment, he is not proud of it and does not like it, and he feels burned out inside this big, monotonous whole.

There is, however, the option of variance, which is, when excessively exploited, is not less dangerous than uniformity. We know neighbourhoods in Israel – mainly those built during the last three years – where variance of building types do exist. There are houses of one, two, or three storeys. There are semi-detached houses and row houses, houses built from red brick or exposed blocks, or plastered houses painted in assorted colours. Exaggerated variety is not better than uniformity, it creates restless views in the eye of the beholder, and blurs the domains of "belonging" to the neighbourhood unit. Instead of sensing the belonging of his house to the general housing unit of the neighbourhood, the individual feels as if he lives in an endless unorganized conglomerate.

The problem of uniformity and variance is a severe problem and the search for satisfactory solutions is shared by many planners around the world. Nevertheless, one can now indicate several solutions developed in different places.

<u>The first way</u> is an "organized" allocation of the buildings, by which we mean organizing buildings along perpendicular axes. This way of placing buildings on a simple grid secures the uniform and organized relation between the buildings and the organized views towards them.

<u>The second way</u> is the creation of a pattern or a recurring theme. The pattern unit is created by a group of different buildings, while the recurrent use of the unit creates the general pattern or the uniformity of the housing project. It is clear that such a way is not a simple one, the subject of the pattern and its recurring use is difficult and delicate, yet the principle itself holds an answer to the problem of uniformity and variance.

> The third way of creating a proper image and a correct content within the neighbourhood unit is the creation of a reference unit. Such unit can be in the size of a whole neighbourhood unit or occupy only part of it. It depends on the topography of the building site, the building density, and the building height. In any case, the aim is the creation of a built unit that the eye can perceive from any spot within it. This creates a sense of belonging to the entire unit, of which a house is its basic cell. Such sense can be created when building in a basin of a valley by placing the low buildings at the centre, while the high buildings on its periphery draw its limits. On a hill the solution might be the opposite: a high building or buildings will be built at the centre, becoming a focal point for the low buildings of the periphery. In planar areas, on the other hand, a belonging unit can be created by using high buildings which set the limits of the unit. (Yasky et al. 1958, 41-42)

It is hard not to see the similarities between this description of a hypothetical ideal neighbourhood in which the sense of belonging enhanced by its typology and the way Yasky described a decade later the design of the Be'er Sheva Model Housing Estate. In his later recollection, Yasky argued that the first aim of the design was "to give a valuable definition to the term neighbourhood", which meant to design it as "an urban element of clear character, which should be noticeable from within the urban fabric". Thus, long "wall" buildings were used to define the Estate's limits, while high-rise buildings (which were never realized) served as local reference or focal points; the whole scheme was meant to create "a well-formed system, easily and clearly perceived by the human eye". In order to preserve the "uniform architectural character" of the neighbourhood, it was decided to use identical building materials in all buildings (Yasky 1968, 2-4).

Similar description was given by Yasky in the roundtable discussion of 1972 (see above, section 5.1.3), which stressed the use of buildings as creators of spatial unity and identity of an urban area. As with the analysis which appeared in the Rothschild Foundation report, Yasky claimed to use the tools of urban design in order to create a sociological effect through the clear definition of space. His words reveal also that the main design concern was a psycho-formal one, which had very little to do with the local climate:

> We started to ask ourselves several questions. The first one was: what is the meaning of building in Be'er Sheva? Does it have a different meaning than building in Tel Aviv? Here we ended up with a certain concept: first of all, this attempt to create big and long horizontal lines, which attach themselves in a very earnest manner to the long lines of the horizon, as well as the carpet which settles on the topography and seems to spill the whole building area over the topography. As much as we felt the need to organize some vertical elements in order to create landmarks, the intention was to create three towers. This is the outcome of a certain analysis of the problem.
>
> Another element that we searched for in such landscape and such environment – is the division line, as I would call it, between the external, almost hostile, environment of the desert and the place where the city begins. This was an extension of the initial thought, and it was an attempt to close the area by what can be described as a wall, and to create a division line between outside and inside.
>
> […] If we talk about a neighbourhood or a city quarter – this must be a thing which will have a meaning as a neighbourhood or a quarter and not as something which exists in-between boxes or cans of building. One should take a certain area and define it. (Adrikhalut 1973, 7)

5.2.3 Climatic aspects of the Be'er Sheva Model Housing Estate

Although climate could not have been overlooked by the Model Housing Estate planning team because of the mere fact that the neighbourhood was located in the Israeli desert, it seems as if the team members paid little attention to climatic questions, especially when compared to issues of urban form. While the formal aspects of the design of the Model Housing Estate show affinity to the analysis which appeared in the Rothschild Foundation report, traces of the report's extensive climatic chapter are much less noticeable in the design. This may also indicate the minor weight that was eventually given to climatic concerns in the design of the Model Housing Estate.

Yet some superficial approach to climate does arise from the way Yasky and others described the design considerations behind the carpet housing scheme. Although it is clear that the use of the carpet scheme supported the uniformity of the spatial character of the neighbourhood heralded in the Rothschild Foundation report, this was not explicitly stated by Yasky, who preferred to use a quasi-climatic justification for the application of the carpet scheme in Be'er Sheva while claiming that "the broad use of the 'carpet' scheme was intended to create comfortable housing conditions in the Negev" (Yasky 1968, 3). The same line of thought emerged also from Yasky's description of the second design goal of the whole project, which was defined as "a proper solution for a neighbourhood in a desert area":

> […] avoiding larger than necessary open spaces – which are hard to use as gardens and to maintain (especially under the arid conditions of the Negev); leaving out marginal areas which are not owned privately; finding shading solutions – by using the buildings – for pedestrians, for children games, for public gathering places; and determining optimal density for the residential areas in order to create comfortable conditions for maintenance in popular housing. (Yasky 1968, 2)

This description of the "climatic" aspects of the design of the carpet scheme is clearly less than comprehensive. The alleged advantages of cross-ventilation and the climatic role of the courtyards, which were lengthily discussed in respect to the carpet houses in the Rothschild Foundation report, were not present in the description given by Yasky to the Be'er Sheva project. While cross ventilation was one of the main justifications for the introduction of the carpet scheme, the design of the Be'er Sheva neighbourhood consciously aimed at blocking the winds before reaching the carpet houses, allegedly protecting them from the desert sand carried by the winds.

Another surprising finding is the fact that the architects who finally designed the houses of the carpet scheme were unaware of the work done by the Rothschild Foundation research team. In an interview with the author several months before his death, Nahum Zolotov, one of the two architects who designed the carpet houses, said decisively that "there was no study", and that "Yasky was the head of the team, we worked together, he coordinated the work, but this was not based on a study". When confronted with the story of the Rothschild Foundation, Zolotov admitted he "was not aware" of its existence (Zolotov 2013), and described the work process of the design team in the following way:

> I did not know that such study existed. I know that there was very harsh criticism, in the newspapers, in the professional journals, on the Ministry of Housing, that they build all around the country according to standardized plans [...] You say that the criticism came from Baroness de Rothschild, I say it was also in the newspapers, that it is inconceivable that they build [the same buildings] in every location. The Ministry of Housing decided to make two experiments: a Model Housing Estate in Tel Aviv [...] and they invited us, the young, we were really young, to design in Be'er Sheva, they gave us the area. We said, the plan for Be'er Sheva is not suitable for Be'er Sheva, this is not a garden city, we will do something else. Maybe Yasky came up with the idea, maybe

> it was based on this study of his. We said, let's make a frame of multi-storey buildings that will protect against the afternoon wind which carries loess sand from the desert, and inside we will build something low with pedestrians. This is how the plan evolved. (Zolotov 2013)

In an earlier televised interview with director Amos Gitai, Zolotov argued that the carpet houses were seen as the "most inferior" of all the buildings of the Model Housing Estate (Zolotov 2012). He and Havkin were assigned with their design after an alleged draw, though Zolotov himself admitted that he was not present at the actual event (Zolotov 2013). Thus, the specific design of the patio houses that Yasky prepared for the Rothschild Foundation and later for the unrealized Jesse Cohen project were not used for the design of the carpet housing in Be'er Sheva, though the concept clearly survived.

When asked on the climatic elements of the design of the carpet houses and especially on the different orientation of houses of similar types, Zolotov told the author the following:

> When an architect starts designing and receives the plot, the topography, he has to consider not only east and west, but also from where the house is entered, how the house functions, and so on. This is only one of the components, as the sun is one of the components. Against the sun there are several types of protection – an awning to the south usually helps during the summer, if the sun penetrates during winter it is rather good, you can get some protection. As for the access to the house, the topography, you have to find a solution, you cannot protect yourself. I mean, I would not say that we neglected this subject [of climatic design], but this was not the main component. (Zolotov 2013)

As for the construction details, Zolotov told the author that what was common at that time as solar protection of windows and [glass] doors, i.e. wooden wing shutters of fixed slats, was provided for the occupants. This is compatible with historic photographs of the houses, though some photos show that many of the original shutters were replaced by roller shutters of PVC slates shortly after the houses were occupied (Figure 5.27). The houses were built out of exposed hollow concrete blocks 20 cm thick with no external plaster or paint, since, as Zolotov put it, "there was no money for plaster, plaster is luxury".

One key issue, which had direct thermal consequences, was the composition of the roofs. According to Zolotov, "I remember that the structural engineer that worked with me, who designed the ceilings there, was forced to make ceilings of a thickness of 10 centimetres, which is not a ceiling, it is a membrane. There was no other choice". When the author asked Zolotov whether this thin layer of roof construction was left exposed, Zolotov immediately replied, "no, on top of these 10 centimetres there were six centimetres of sand, because the cast concrete is very much inaccurate, so there is a layer of sand, and on top of it there was flooring of 20 by 20 tiles, they called it 'Mosaica', it is called 'Terrazzo' [both terms are used in Hebrew to describe Terrazzo floor tiles]" (Zolotov 2013). To director Amos Gitai, Zolotov told that "the Ministry of Housing limited us to 10 centimetre thick ceilings, they did not even let us build a ceiling of 20 centimetres, which means blocks and a screed of concrete above it [ribbed slab]" (Zolotov 2012). While Zolotov's description is definitely reliable and consistent with photographic evidence (Figure 5.28), historic photographs show that the upper layer of flooring was nevertheless covered with a thin asphalt layer (Figure 5.27) which was then whitewashed (Figure 5.29).

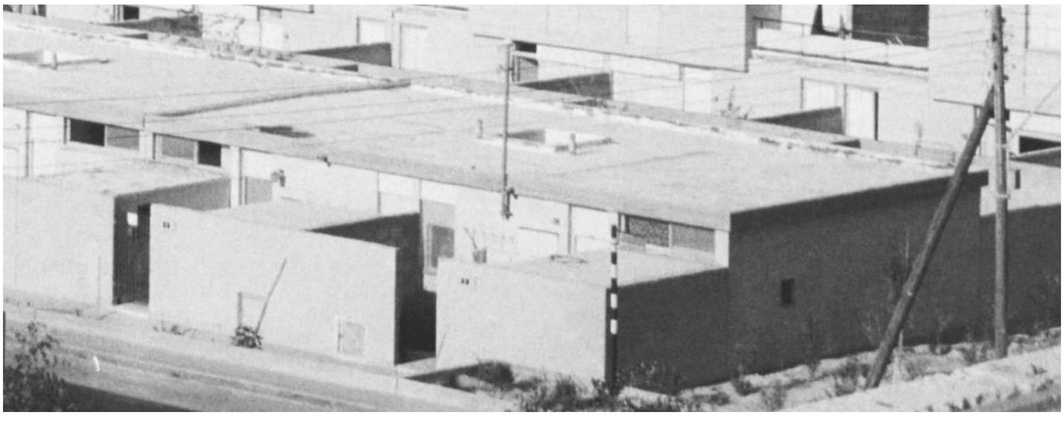


Figure 5.27: Carpet housing (house types B and D), a photograph from the mid-1960's showing the traces of asphalt on the inner side of the roof parapet (Rotbard 2007, 596)

Figure 5.28: Carpet housing (type A), casting of the roof slab (Nahum Zolotov Collection, Information Centre for Israeli Art, The Israel Museum). The photograph suggests that a high concrete parapet was cast before the casting of the roof slab

Figure 5.29: A rare colour slide of the carpet housing showing houses of types A and C, photograph by architect Daniel Havkin (Havkin Collection, Israel Architecture Archive). The whitewash of the roofs is clearly noticeable, as well as the non-whitewashed walls

Another way of reducing costs was to limit the internal height of the rooms to 2.50 m. This was not a special feature of the carpet houses but a general policy adopted at that time by the Housing Division. It was based on a study on the "climatological, architectural and economic aspects" of ceiling heights in residential buildings (see above, section 3.7), financed by the Housing Division and the United States Operations Mission to Israel and executed by the Building Research Station at the Technion. The study concluded that rooms with a ceiling height of 2.50 m did not show worse indoor climate conditions than rooms with a ceiling height of 2.68 m and 2.86 m. Moreover, it was calculated that each lowering of a ceiling by 10 cm cuts about 1% of construction costs (Shalon et al. 1957). Although the study based its findings on monitoring of buildings in a town near Haifa, a similar research, which was conducted in Be'er Sheva in 1957 (Givoni and Shalon 1962), led to similar conclusions and to the adoption of room height of 2.50 m as a new standard for housing projects in Israel.

A key design issue with major climatic consequences which was not explicitly addressed by Yasky or Zolotov was the general orientation of the Model Housing Estate. While all the buildings were located on a perfectly orthogonal grid, this grid was not aligned to the north but to the north-west. This had probably no climatic reasoning. During the 1972 symposium mentioned above, architect Yaakov Rechter criticised the Be'er Sheva neighbourhood, claiming that it "totally ignores the urban fabric". To this Yasky answered in the following way:

> Have you ever saw Be'er Sheva from the air? Have you noticed that the neighbourhood is built as an extension of the old city, in spite of the fact that it was not built on a north-south orientation? This was done in purpose [...] This is exactly the grid of the old city. By the way, there is also a small portion that we did near the Hostel [for Academics], which has the same form. We hoped that someday it will merge. (Adrikhalut 1973, 9)

This explanation surprisingly ignores the climatic logic behind the old city's design. The "old" Be'er Sheva was actually a new town founded by the Ottoman rulers of Palestine around 1900. The town was planned in a grid pattern of 60 squares blocks of 360 m^2 each, and its orientation was perfectly aligned with the prevailing north-western summer breezes (Cohen 2006, 47). Although clear evidence to the climatic considerations behind the general orientation of the Ottoman city is lacking, it is highly probable that climate was indeed the primary variable that was considered, since the major roads that extended from the city were not aligned with the grid's orientation (Figure 5.30). Yasky, it seems, did not give too much importance to the prevailing wind direction, and based the design of the Model Housing Estate on blocking the same winds from reaching the carpet housing by enclosing it within the long multi-storey blocks.

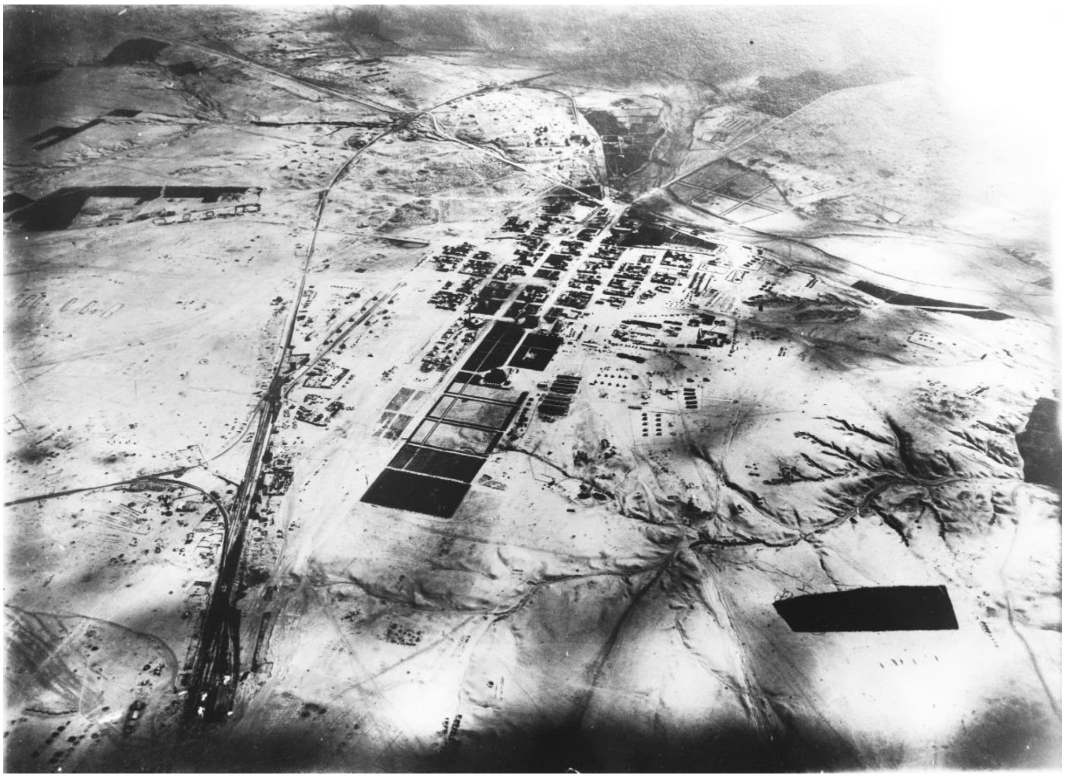


Figure 5.30: Old Be'er Sheva (Beersheba) in a German aerial photograph looking south-east, 1918 (Bayerisches Hauptstaatsarchiv, Munich, via the Digital Media Centre, Younes and Soraya Nazarian Library, University of Haifa). On the left is the railway line that was laid during the First World War by the Ottoman army. On the upper part of the photograph the intersection of the roads to Hebron and Asluj can be spotted

5.2.4 The post occupancy survey

During January and February of 1965 the Ministry of Housing conducted a post-occupancy survey among the residents of the Model Housing Estate.

This was not a normal routine, and was probably a result of the exemplary status the neighbourhood received since its very inception. An official publication of the survey's results was printed in 1968.

The survey was sociological in nature and was based on a sampling of 318 apartments which covered all the building types in the neighbourhood, including the six different house types of the carpet housing. Of the 318 selected apartments, answers were received from 276 families, which constituted about 50% of all the neighbourhood's residents. The study was based on personal interviews with "the housemaid" of each family ("because it was assumed that she is more acquainted with the problems of the apartment and the neighbourhood"); each had to answer 80 standard questions, or 100 questions in the carpet housing (Hirsch and Szereszewski 1968, 12-14).

The residents were questioned on several subjects, including their impression of several climatic aspects of the design. The findings on what was referred to as the "climatic aspect" of the design were summarized in the following way:

> Provision of suitable solutions for the special problems of the desert climate was one of the main goals of the design. The design elements that were believed to resolve this problem were:
>
> - Maximal shading by built elements (roofed alleys, etc.).
> - Protection against winds carrying dust by erecting walls around the low-rise houses, setting long multi-storey buildings around the low-rise houses, etc.
> - Creation of a clear border (the long multi-storey buildings) between the external desert and the internally built, developed area.
> - Concentration of public spaces which require greenery on a single spot, and maximal paving of intermediate areas.

The solutions relating to the problems of shading and heat are mainly relevant to summertime. Therefore, some reservation about the findings is needed, since these were produced during the winter. While the interviewees were questioned about their summertime experiences, the fact that the interview took place during winter might have produced a different emphasis on the problem.

The roofed alleys as a shading solution and protection against the heat were found to be effective in the carpet housing. Nevertheless, it should be stressed that this structure did not resolved other climatic problems, and even created problems in other domains.

The residents of the single-story houses in the roofed alleys complained on inadequate ventilation inside the apartment, compromised privacy, and noise coming from the alley.

Solutions for protection against heat, storms, and dust-inducing winds were found to be better in this neighbourhood than in any other neighbourhood in Be'er Sheva. Tenants who used to live in other neighbourhoods commented that this neighbourhood constitutes an improvement.

Besides the design solutions of the enclosing, the structure of courtyards, and the continuity of areas, which were found to be effective, the factor of complete landscaping of the area, including pavements, roads, and gardening, should be mentioned, since it has the utmost importance in resolving the problem of sandstorms and dust.

Other climatic problems that were examined are problems of ventilation, moisture, and heat in the apartment, problems which are also related to the design of the apartment and quality of construction. It should be stressed that in order to

> obtain a fuller image of the climatic conditions of this form of construction, more than reliance on the residents' reactions to the climatic conditions inside the apartment is required, and precise climatic tests should be conducted.
>
> Ventilation
>
> - It was not found that ventilation inside the apartments of the single-storey houses in the carpet housing is affected by the surrounding multi-storey buildings. As already stated, this finding should not be accepted at face value and further investigation should be conducted (see the factors mentioned in chapter IV on climate).
> - In the roofed alleys there is a severe problem of ventilation in the single-storey apartments: it should be stressed that complaints on the lack of ventilation, and the stifling sensation inside those apartments, is more acute than any other complaints which were raised by [residents of] similar apartments in the normal (not roofed) alleys.
> - In the multi-storey buildings ventilation was mentioned as one of the advantages of living in those buildings.
> - Ventilation problems related to the design of the apartment were found in several types. The common complaint was on the lack of ventilation in bedrooms where cross-ventilation is not possible (see chapter X on apartment types). (Hirsch and Szereszewski 1968, 20-21)

The detailed climatic chapter of the study tried to weigh the overall "climatic performance" of the different house types by applying a combined index in which each climatic factor (ventilation, solar heat, sand penetration, moisture, winter heating difficulties) was given a weighted score on the scale of 1 to 10. The score represented the residents' satisfaction from each factor, thus the higher the score the higher the satisfaction. The results were then summarized in a table (Table 5.1).

Table 5.1: Climatic index for all the house types of the Model Housing Estate, as appeared in the post-occupancy study (Hirsch and Szereszewski 1968, 83)

Apartment and building type	Score, number of points					**The general climatic index (max. 50 points)**
	10 ventilation	**10 solar heat**	**10 sand penetration**	**10 moisture**	**10 heating difficulties**	
A **Small carpet**	6.2	7.0	7.9	2.8	5.1	29.0
A **Big carpet**	5.4	6.5	5.8	1.3	4.5	23.5
B	4.4	5.0	9.2	3.1	1.6	27.8
C	7.2	5.7	6.8	2.7	8.6	31.0
E	4.8	6.3	8.5	1.1	2.2	22.9
D	4.2	4.5	7.5	0	1.1	17.3
F	4.8	5.0	7.6	2.4	2.8	22.6
Sum for the low-rise buildings	5.9	5.9	7.7	2.3	5.1	26.9
M_1	8.3	8.3	8.8	3.7	5.8	34.9
M_2	7.9	9.4	8.7	3.6	6.5	36.1
K	9.4	9.4	4.7	3.8	7.9	35.2
L_1	7.3	7.3	7.5	4.1	4.3	30.5
L_2	6.1	6.9	5.0	4.2	7.7	29.9
Sum for the multi-storey buildings	8.2	8.5	6.9	3.9	6.6	34.1
Sum total	6.8	7.0	7.1	2.9	5.7	29.5

Although the application of a "general score" for climatic performance may be misleading, the weighing of the results in each category enables to draw some conclusions in respect to the thermal performance of the carpet housing when compared to the surrounding multi-storey buildings. Maybe the most profound difference was found in respect to indoor overheating during summer. Here, 41% of the residents of the low-rise houses reported that they suffer from the overheating of the apartments (answering the question "are you particularly suffer from the heat inside the apartment during summer?"), while only 16% of the residents of the multi-storey buildings expressed a similar complaint. The highest rates of dissatisfaction (54%) from the indoor summer conditions were found in the houses in the roofed alleys (Hirsch and Szereszewski 1968, 77). To the question "are you experiencing any difficulties in heating the apartment during winter?" a positive answer was received from 50% of the carpet housing residents and 36% of the residents of the multi-story buildings (Hirsch and Szereszewski 1968, 82).

5.3 Simulating the thermal performance of the Model Housing Estate

While the post-occupancy survey may give some general indications to certain flaws in the design of the carpet housing, a dynamic thermal simulation of the different building types can produce a much more accurate portrayal of the effects of the design on indoor climate, and to examine several key elements of the design: building orientation, wall finishes (with or without whitewash), and roof composition. The simulation focused on the carpet housing, since it occupied most of the neighbourhood's area and is still regarded as its main achievement.

The thermal performance of the houses was evaluated using version 8.1 of the EnergyPlus simulation engine (U.S. Department of Energy 2013). Since the carpet housing was constructed from long rows of identical houses of the same type, a typical instance of each house type, i.e. a house flanked on both sides by similar houses, was selected for simulation. Shared walls with adjacent house were simulated as adiabatic. For reasons of simplification, each house, including the two-storey houses, was simulated as a single thermal zone. Shading from adjacent houses and walls around the plots was also simulated. Floor area and external yard area of each house type appear in Table 5.2. Renderings of the simulated models appear in Figure 5.31.

Table 5.2: Floor area and outdoor yard area of each house type

House Type	Floor Area [m^2]	Yard Area [m^2]
A (Zolotov)	51	85
B (Havkin)	52	57
C (Zolotov)	43	62
D (Zolotov)	93	57
E (Zolotov)	91	73
F (Havkin)	76	75

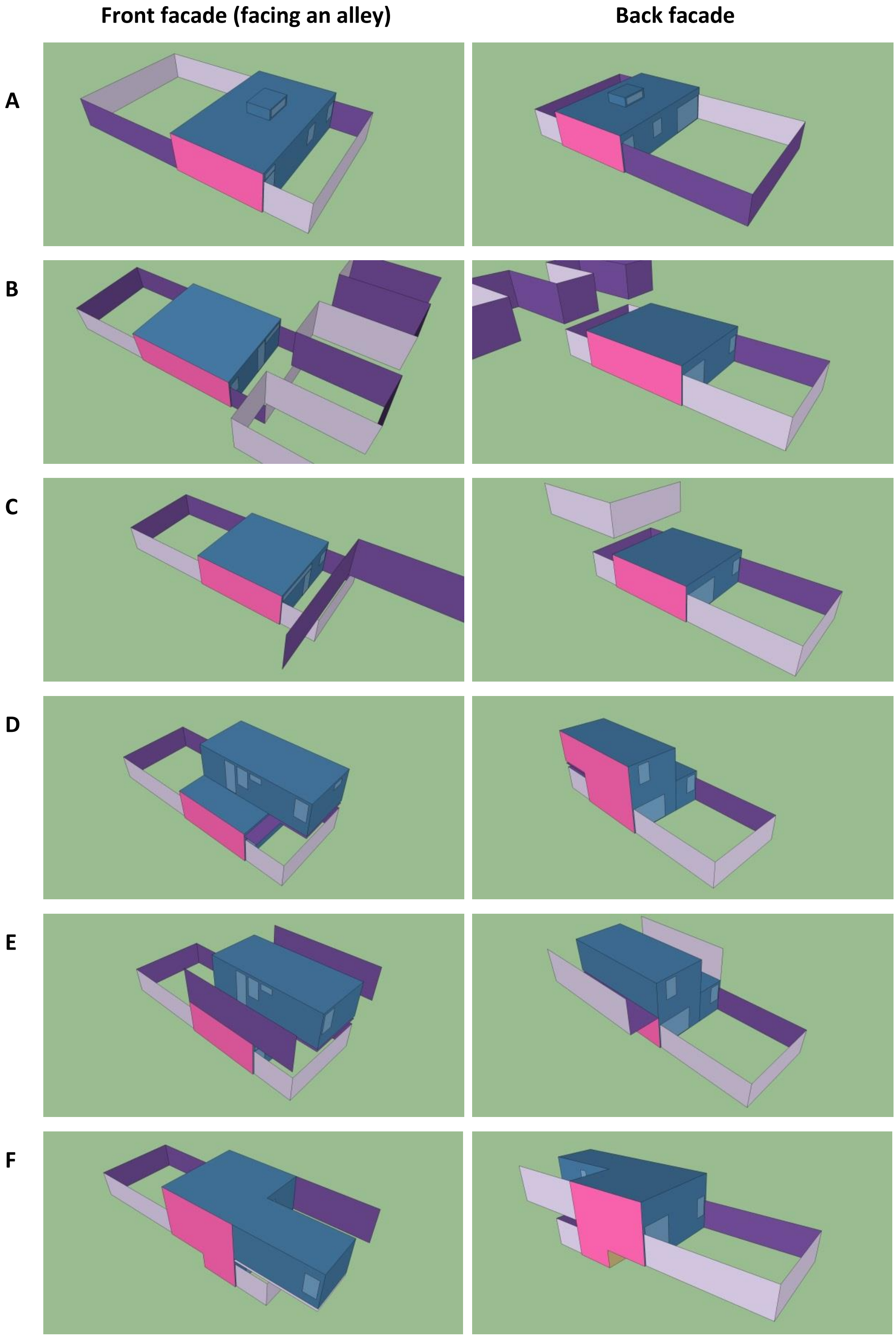


Figure 5.31: Renderings of front and rear views of the modelled houses, as were used for simulation. The pink colour represents an adiabatic wall, and the purple colour a shading element (walls, adjacent buildings) with no thermal properties

Historic or contemporary documentation of the building materials in the Model Housing Estate does not exist. However, it was possible, based on the architectural plans published in the post-occupancy survey (see above, Figure 5.12 and Figure 5.13), historic photographs, and on-site survey, to reconstruct a full material list of the main building components (Table 5.4). Physical properties (thermal conductivity, density, specific heat, and solar absorptance) of the building materials were extracted from existing literature (Table 5.4 and Table 5.5). Physical properties of windows (U-value, solar heat gain, visible transmittance) were calculated using version 7.2 of the WINDOW software (Lawrence Berkeley National Laboratory 2014b). Weather file of a sample year was created using Version 7.0 of the Meteonorm software (Meteotest 2012), based on monitored historic weather (from the years 1961-1990) and radiation (1981-1990) data.

Since all houses were originally built with external shutters, a typical scenario for shutters application, in which during summer window shutters were kept fully closed during daytime, was simulated in all simulation scenarios (Table 5.6). Similarly, in all scenarios a typical natural ventilation profile was used (Table 5.7), based on the values given in the CIBSE guide to environmental design (CIBSE 2006, 5-8): 3.0 ACH for open windows, 1.0 ACH for closed windows. The ventilation profile simulates a situation in which during summer windows are left open during the night (nocturnal cooling), while kept closed during the day. All windows were simulated as closed during winter. Internal loads (Table 5.8) were simulated based on typical occupancy schedules for weekdays and weekends (Figure 5.32 and Figure 5.33).

Table 5.3: Main building elements of the Model Housing Estate

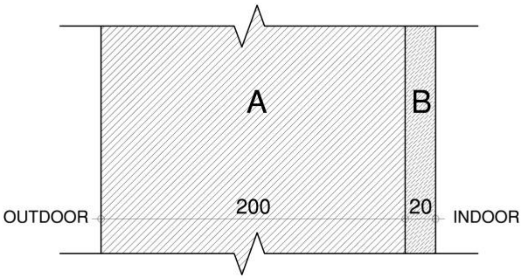
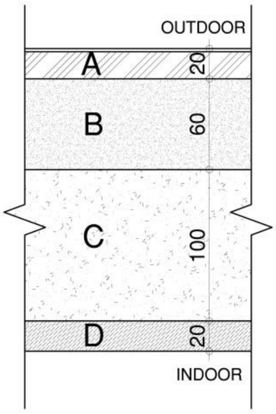
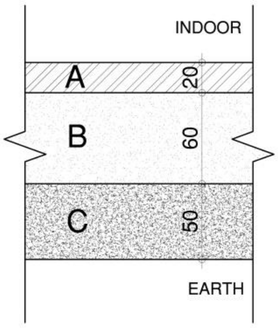
Building Element	**Typical section (dimensions in mm)**	**Materials and resultant U-value**
External wall		A: Hollow concrete block B: Indoor plaster **U value: 2.11 W/m^{2}K**
Roof		A: Concrete floor tile, whitewashed over sealant asphalt layer B: Sand C: Reinforced concrete D: Indoor plaster **U value: 3.00 W/m^{2}K**
Floor		A: Cement floor tiles B: Sand C: Concrete screed **U value: 3.09 W/m^{2}K**
Windows	-	Painted wooden frame, 4 mm single plain glass sheet
External doors	-	Wooden door, painted

Table 5.4: Thermal and physical properties of simulated materials

Material	Thermal Conductivity (W/mK)	Density (kg/m^3)	Specific Heat (J/kgK)	Source
Cement floor tiles	1.1	2100	840	(CIBSE 2006, 3-37)
Foam concrete	0.07	320	920	(CIBSE 2006, 3-37)
Hollow concrete block	0.86	930	840	(CIBSE 2006, 3-37)
Indoor plaster	0.22	800	840	(CIBSE 2006, 3-36)
Reinforced concrete	1.9	2300	840	(CIBSE 2006, 3-37)
Sand	1.74	2240	840	(CIBSE 2006, 3-35)

Table 5.5: Solar absorptance properties of simulated exterior materials

Material	Solar Absorptance	Emissivity	Source
Hollow concrete block	0.56	0.94	(CIBSE 2006, 3-43)
Whitewash	0.35	0.9	(Givoni 1998, 75)

Table 5.6: Simulated window shutter operation (open/closed)

Daily Hours	Summer	Winter
	1.5-31.10	**1.11-30.4**
07:00-19:00 (day)	Closed	Open
19:00-07:00 (night)	Open	Open

Table 5.7: Simulated ventilation rates (in ACH)

Daily Hours	Summer	Winter
	1.5-31.10	**1.11-30.4**
07:00-19:00 (day)	1	1
19:00-07:00 (night)	3	1

Table 5.8: Internal loads used for the simulation

Type	Value for Maximal Occupancy
People	0.1 person/m^2, 115 W/person (64 met)
Electric equipment	1 W/m^2
Lights	1 W/m^2

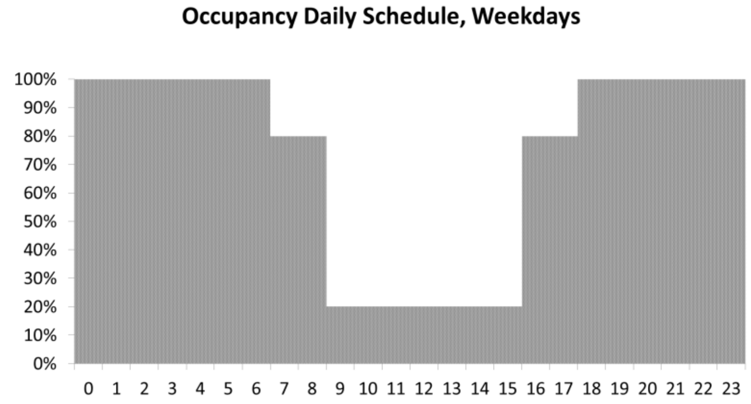


Figure 5.32: Occupancy schedule for weekdays

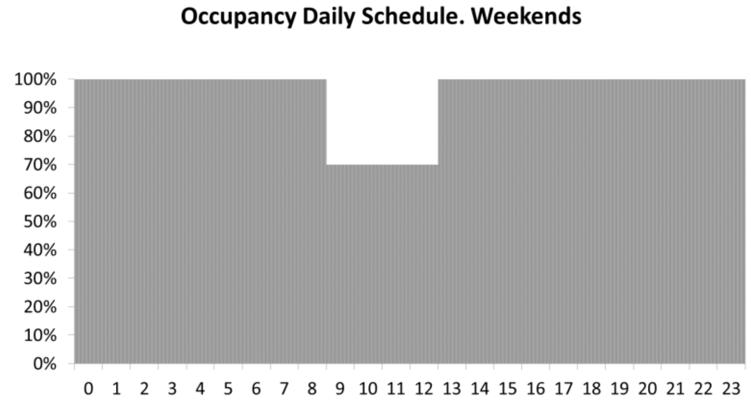


Figure 5.33: Occupancy schedule for weekends

5.3.1 Effect of building orientation

As was elaborated above (see chapter 1), building orientation was a recurrent theme in the architectural discourse in Israel of the 1950's. In his Rothschild Foundation report, Yasky claimed that the common habit of orienting the main building facades to the north and south is not justified, and advocated the orientation of buildings to the prevalent wind direction. This might have been one reason behind the orientation of the Model Housing Estate to the northwest, though this was not explicitly acknowledged by the designers.

In order to explore the implications of orientation on thermal performance, eight design scenarios for each of the carpet housing house types were simulated: four in which the front facade faces full north, south, east, and west, and four in which the front facade is oriented almost perfectly to northwest, northeast, southwest, and southeast. The latter four options represent the four orientations existing in the carpet housing, though not for each house type (Table 5.9). Simulating each house type in eight different orientations enabled to conclude what was the optimal orientation and whether the realized orientations produced a substantially better or worse indoor summer conditions. Assessment was done by calculating "overheating rates" (defined as the percentage of hours with indoor temperatures above 27°C) for each house type and orientation. The results appear in Figure 5.34 and Figure 5.35.

Table 5.9: Number of realized units of each house type and orientation. Orientation refers to that of the front facades

House Type	NE	SE	NW	SW	Total
A	21	27	27	21	96
B	-	27	-	41	68
C	16	36	-	11	63
D	36	-	-	-	36
E	-	-	17	-	17
F	47	-	25	-	72

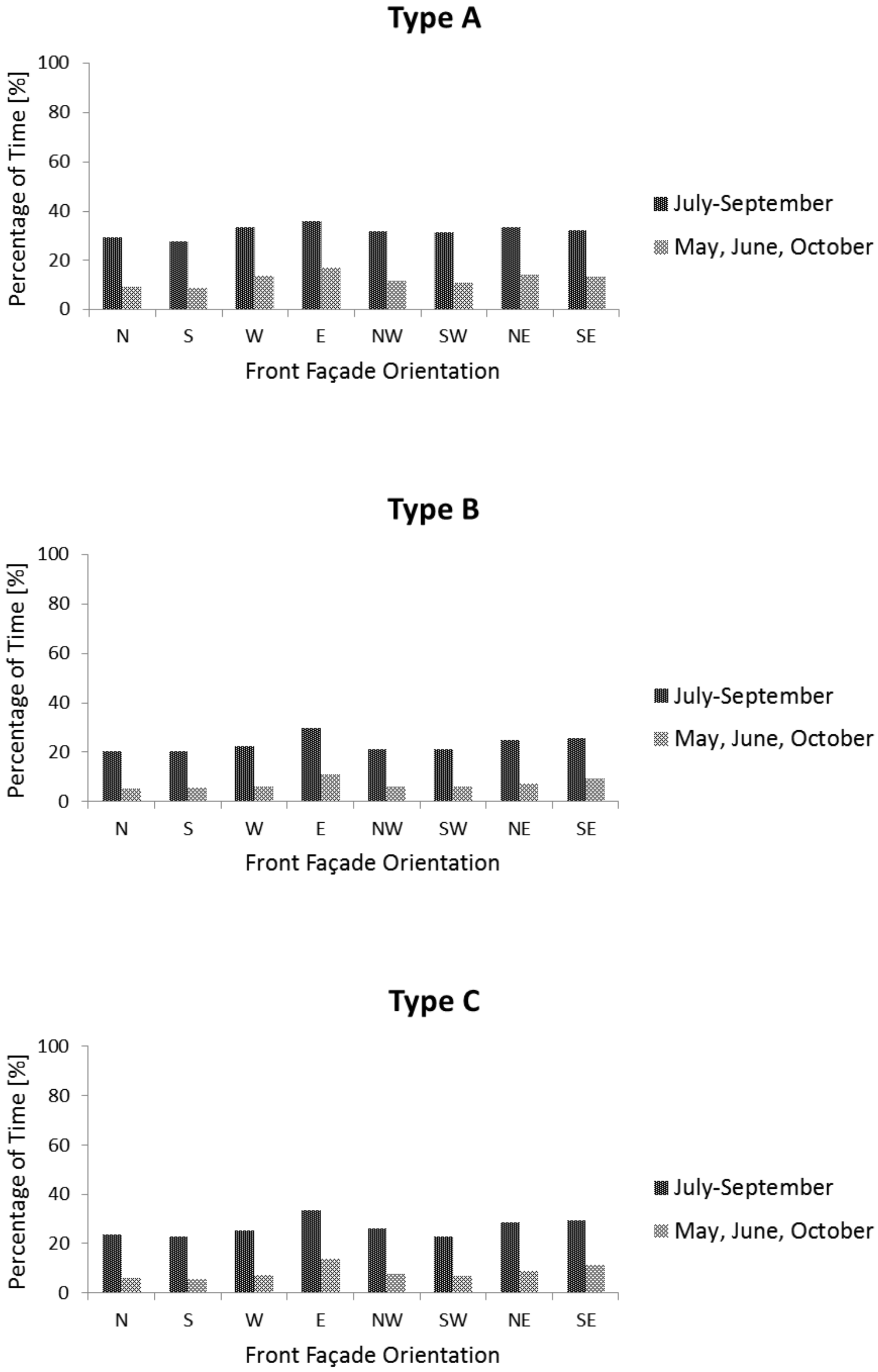
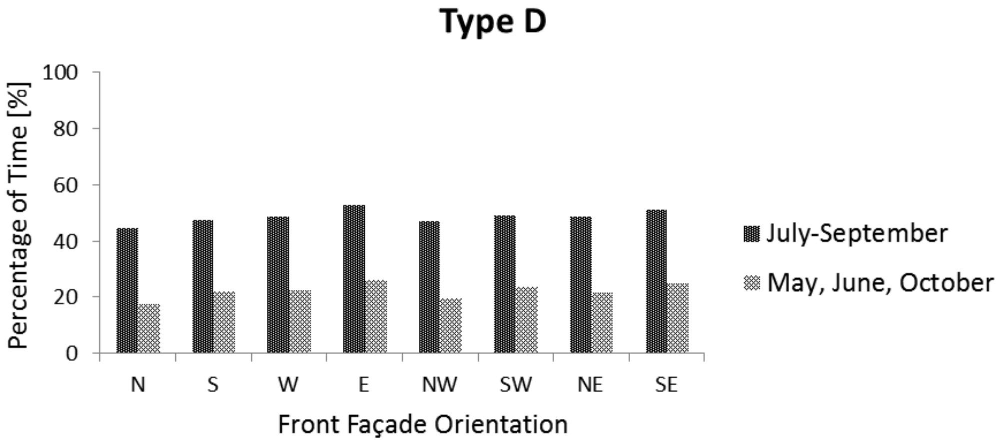
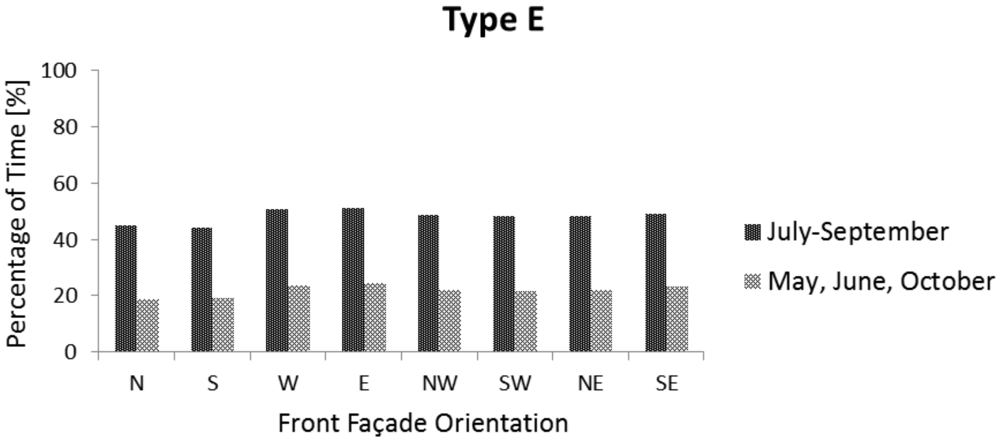


Figure 5.34: Overheating rates for different orientations for the single-storey house types of the carpet housing





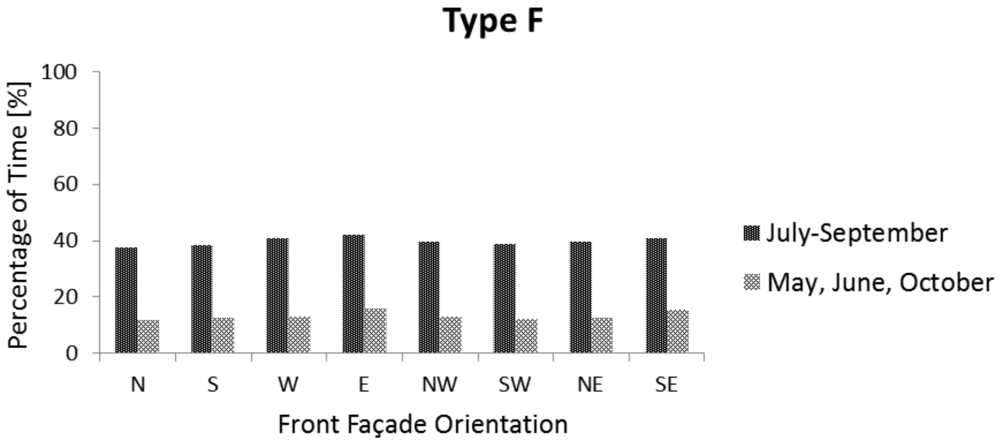


Figure 5.35: Overheating rates for different orientations for the two-storey house types of the carpet housing

As can be seen in the above comparison, orientation has a minor effect on the overheating rates during the hot season. Analysis of the temperature amplitude for a typical summer day (calculated as the mean dry-bulb temperature of each hour separately between 1 July and 30 September) produces similar results. A comparison between the best realized orientation (i.e., the orientation in which the maximal daily temperature is the lower) of each house type with the best unrealized orientation (north or south) reveals a higher differences between realized and unrealized orientations in types A, D, and E (0.6-0.7K difference in maximal daily indoor temperature, Figure 5.36 and Figure 5.37). The difference in thermal performance between the different house types, irrespective of building orientation, is also clear (Figure 5.38). Here, it is evident that the single-storey houses produced lower indoor temperatures during daytime.

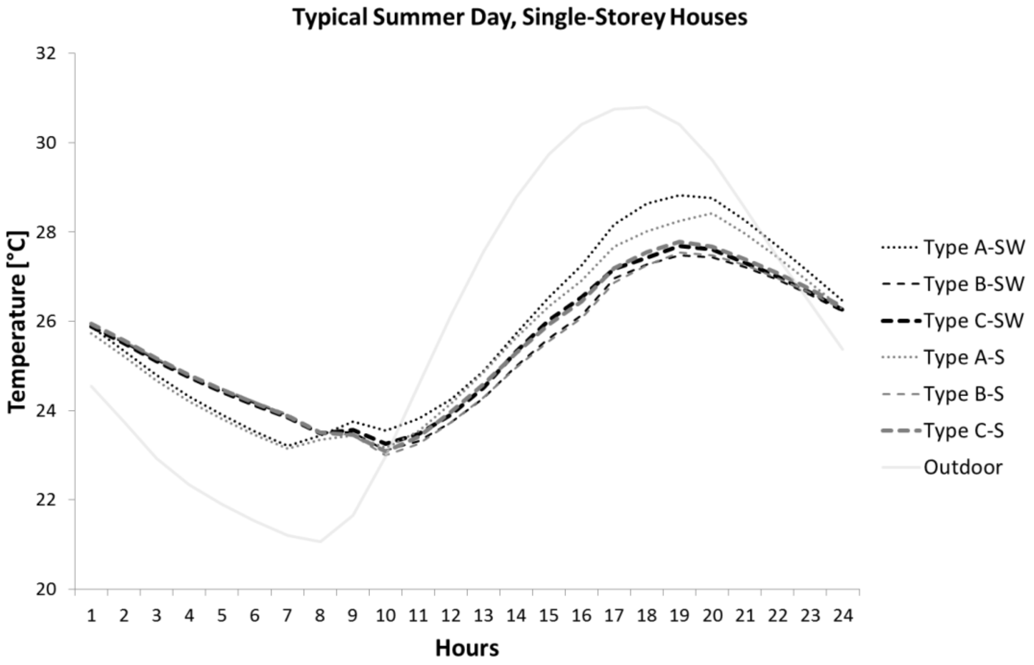


Figure 5.36: Daily temperature amplitudes for a typical summer day, single-storey house types

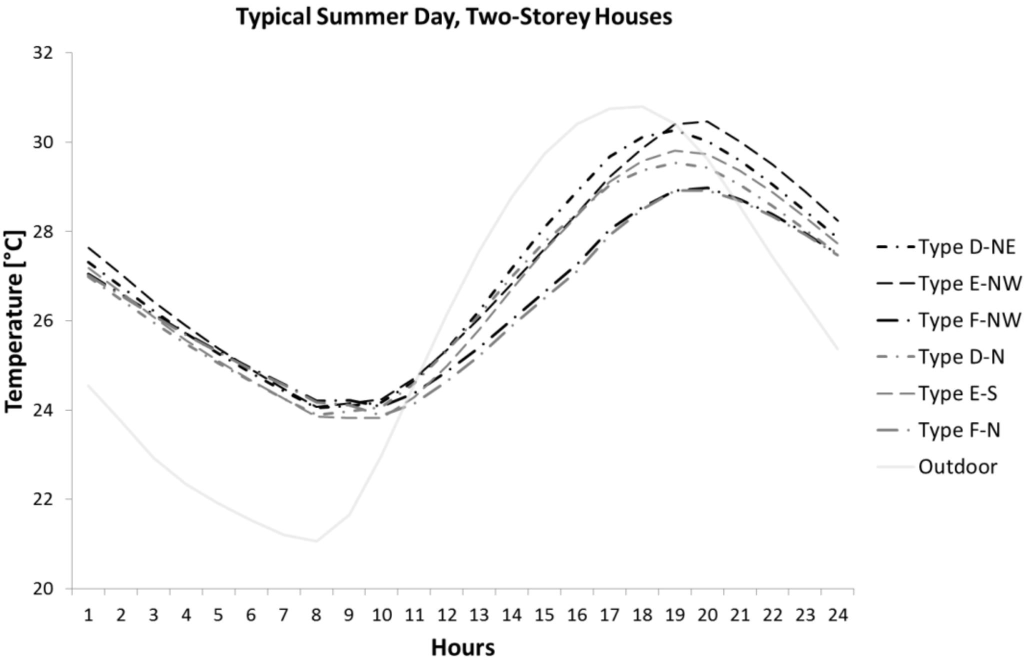


Figure 5.37: Daily temperature amplitudes for a typical summer day, two-storey house types

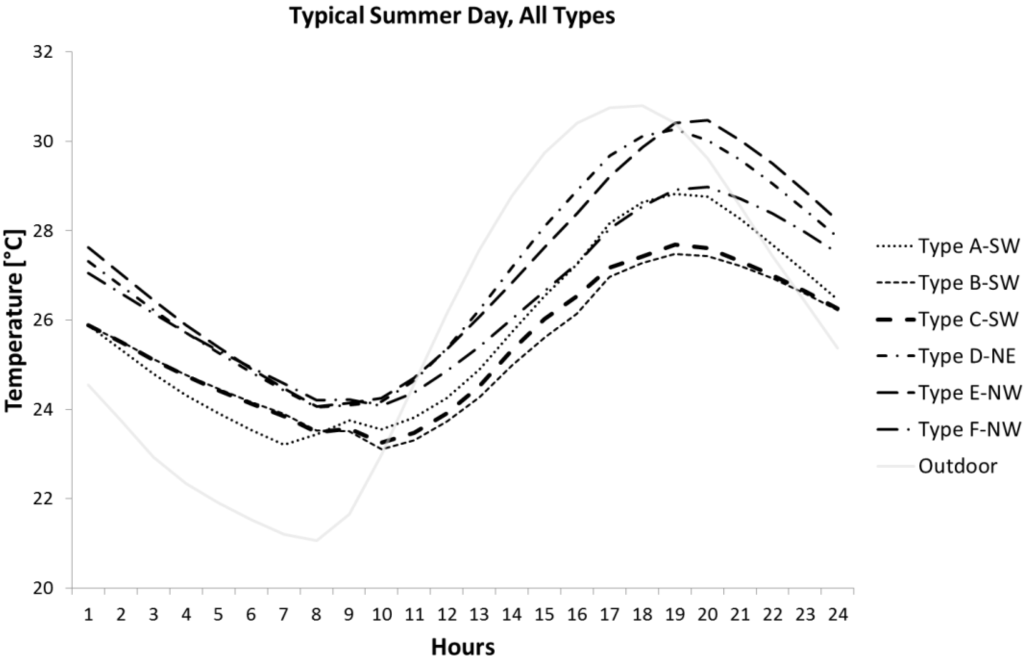


Figure 5.38: Daily temperature amplitudes for a typical summer day, best orientation of each house type

5.3.2 Effect of wall finish

One simple way of reducing the absorption of solar heat in a building's envelope is by applying bright colours (mainly whitewash) on the external surfaces of the envelope, thus reflecting higher amount of the incident solar radiation. This method was quite common in Israel long before the construction of the Model Housing Estate, and was usually applied as a default option for both roof and wall surfaces. Yet, in the carpet housing whitewash was applied only to the concrete roofs, while the walls, which were constructed of hollow concrete blocks, were left without any treatment on their external face (plaster and paint were applied only on the internal face of the blocks). According to architect Nahum Zolotov, this was done in order to reduce construction costs.

Although there is no doubt that costs were reduced by avoiding the painting of the walls, it can still be argued that the decision not to paint the walls might have been influenced also by a certain taste for exposing the "material truth" of the construction, a popular tendency in Israel of that time. In many contemporaneous buildings with lesser budgetary constraints the concrete blocks of the walls were left exposed as well. At the same time, the additional costs that the mere painting of the walls might have induced do not seem high enough to fully justify the decision not to paint them.

In order to examine the effect of whitewashing the external face of the concrete block walls, two simulation scenarios were compared for each house type: a baseline case of the house as built (when a house type was realized in more than a single orientation, the orientation which produced the lowest indoor summer temperatures was selected); and a hypothetical case in which the solar absorptance of the walls of the same house was set to 0.2 (representing whitewash of walls) instead of 0.56, based on values measured by Givoni (1998, 75).

As can be seen in Figure 5.39 and Figure 5.40, whitewashing of the walls could have resulted in slightly lower indoor summer temperatures during the hot hours. While the overheating rates could only be lowered in a minor proportion, the maximal summer indoor temperature could be lowered by 0.6.-0.7K (Figure 5.40), except in types B and C (with a difference of less than 0.3K).

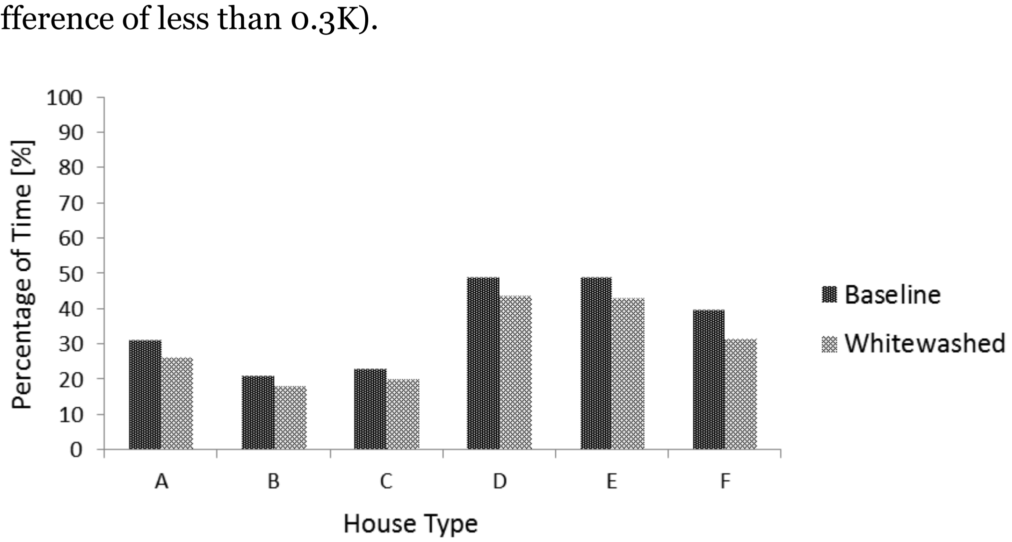


Figure 5.39: Overheating rates for all house types, comparing the original design (baseline case) with an alternative design in which all external walls are simulated as whitewashed

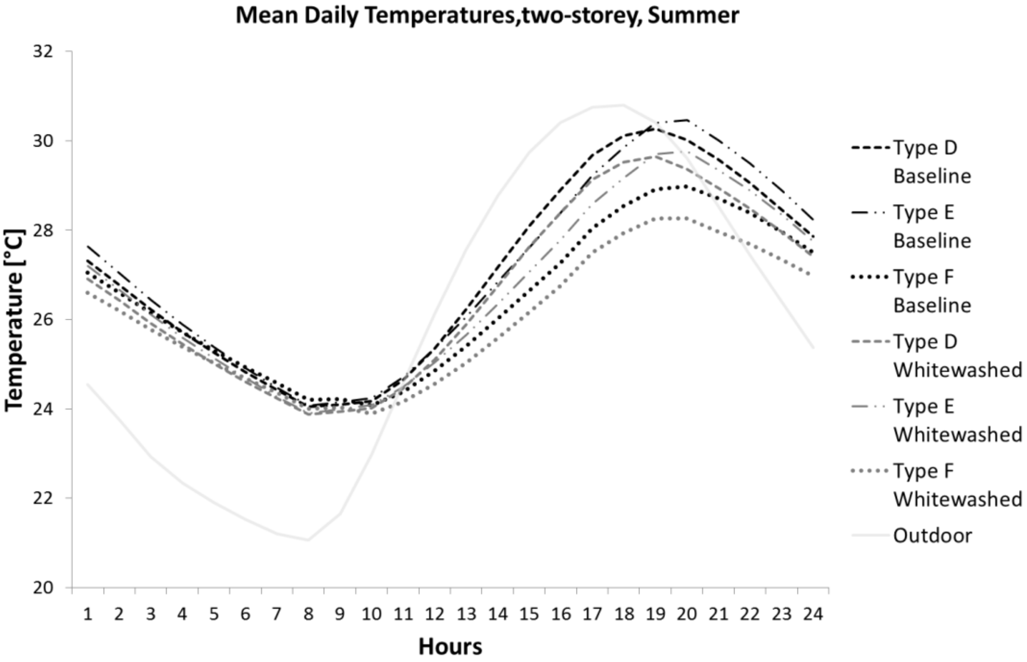


Figure 5.40: Daily temperature amplitudes for a typical summer day, two-storey house types, with or without (baseline) external whitewash of the walls

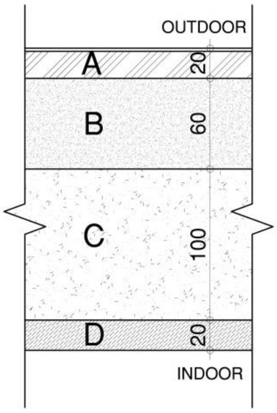
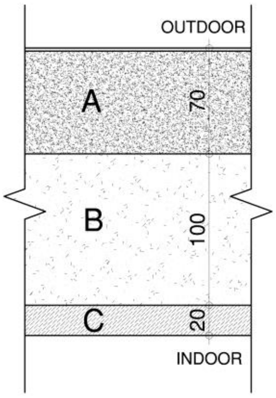
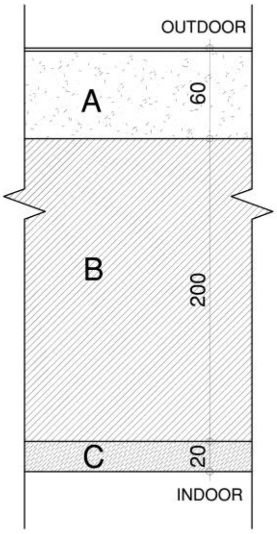
5.3.3 Effect of roof composition

Another simple method of lowering indoor summer temperatures is by applying some sort of thermal insulation to the roof construction. As mentioned above (section 5.2.3), the composition of the roofs in the carpet housing was somewhat controversial due to its minimalism: a thin reinforced concrete slab of 10 cm was covered with a layer of sand and concrete floor tiles, which were then sealed by applying asphalt on top of the tiles. Whitewash was applied on top of the asphalt.

Two relatively simple alternatives to this roof composition were common in Israel of the 1960's: the simplest of all in term of application was the addition of a layer of foam concrete, serving as thermal insulation, on top of the concrete slab; the other, mentioned also by Zolotov, was the construction of the ribbed slab construction in which hollow concrete blocks were used as an inlay material between the reinforced concrete ribs (Table 5.10). These two alternatives were simulated for each house type and then compared to a baseline case of the houses as built (when a house type was realized in more than a single orientation, the orientation which produced the lowest indoor summer temperatures was used for simulation).

Results show that in all house types major improvement in indoor summer conditions could have been achieved with both alternative roof constructions. Foam concrete application could have lowered maximal indoor summer temperature by 1.5-1.6K in the single-storey houses (Figure 5.41) and by 0.7-0.9K in the two-storey houses (Figure 5.42). Ribbed slab construction was less effective, but still could have lowered maximal indoor summer temperature by 0.5-0.6K in the single-storey houses (Figure 5.43). In terms of overheating rates, foam concrete insulation might have produced a dramatic improvement in the single-storey houses (Figure 5.44).

Table 5.10: The three simulated roof compositions

Roof Composition	**Typical section (dimensions in mm)**	**Materials and resultant U-value**
As built		A: Concrete floor tile, whitewashed over sealant asphalt layer B: Sand C: Reinforced concrete D: Indoor plaster **U value: 3.00 W/m^{2}K**
Alternative A: Thermal insulation with foam concrete		A: Foam concrete, whitewashed B: Reinforced concrete C: Indoor plaster **U value: 0.78 W/m^{2}K**
Alternative B: Ribbed slab construction		A: Reinforced concrete, whitewashed B: Hollow concrete block C: Indoor plaster **U value: 2.03 W/m^{2}K**

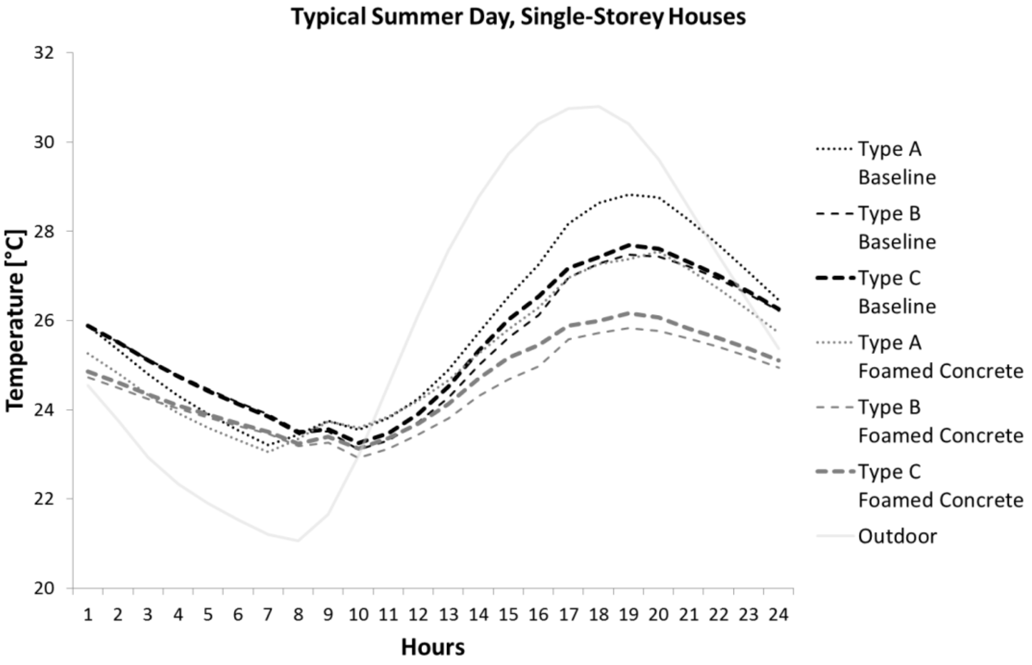


Figure 5.41: Daily temperature amplitudes for a typical summer day, single-storey house types, a comparison between the built roof composition and an alternative composition with an external foam concrete insulating layer

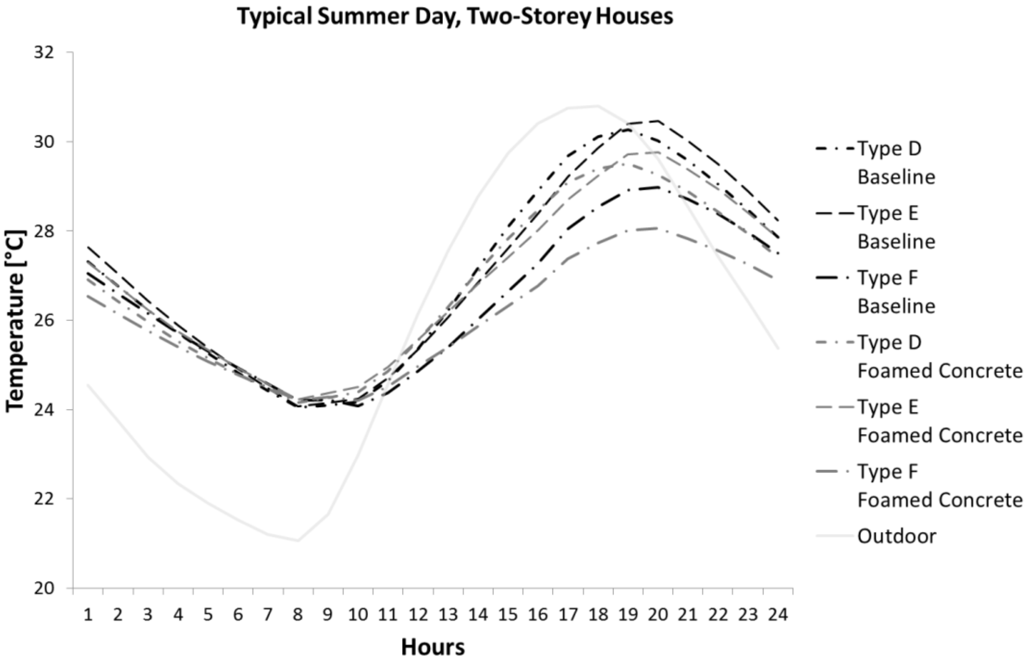


Figure 5.42: Daily temperature amplitudes for a typical summer day, two-storey house types, a comparison between the built roof composition and an alternative composition with an external foam concrete insulating layer

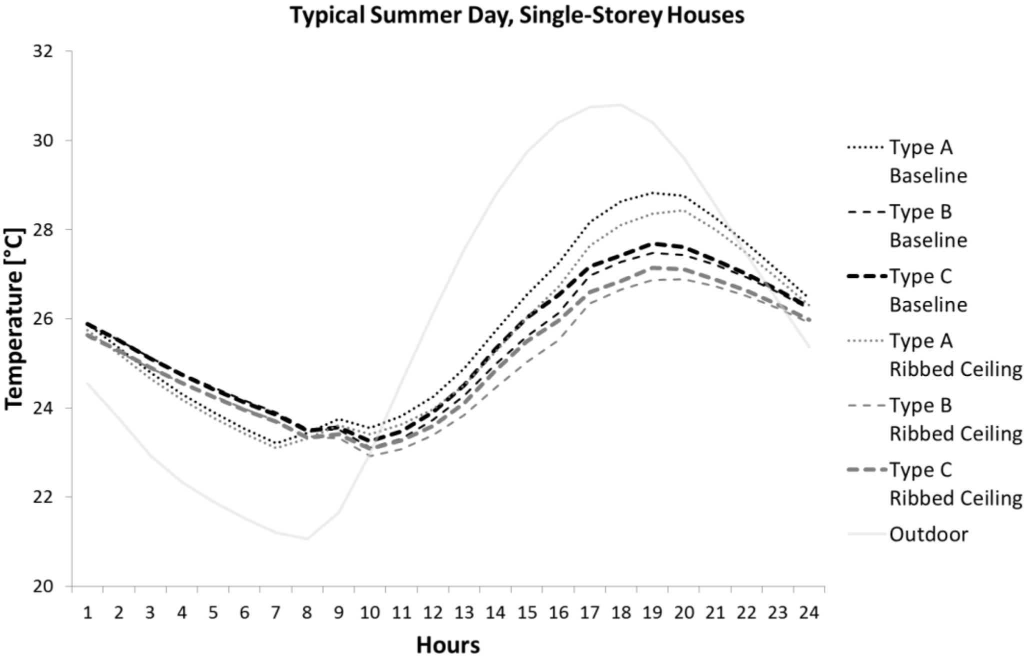


Figure 5.43: Daily temperature amplitudes for a typical summer day, single-storey house types, a comparison between the built roof composition and an alternative composition of ribbed slab with hollow concrete blocks inlay

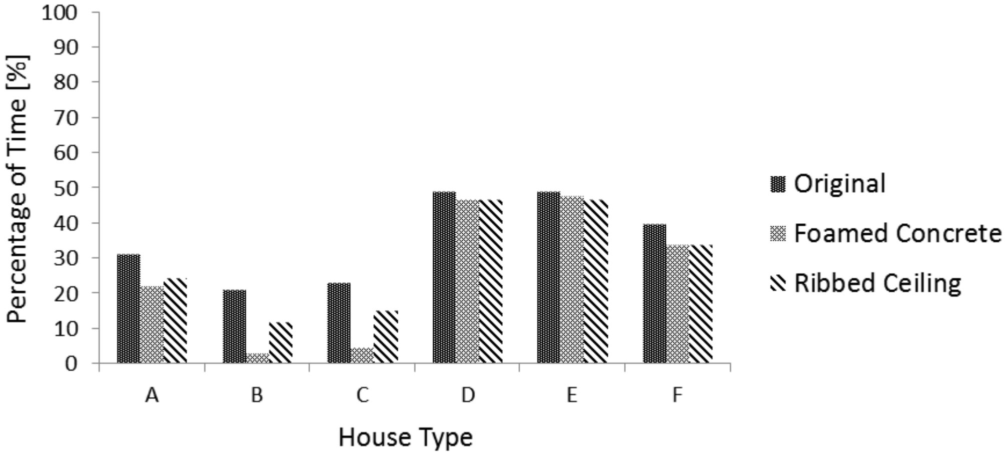


Figure 5.44: Overheating rates for all house types, comparing the original design (baseline case) with the two alternative roof compositions

5.3.4 Cumulative effect of orientation, wall finish, and roof composition

In order to assess the cumulative effect of the best alternatives presented above, two simulation scenarios were compared: a baseline scenario for each house type (when a house type was realized in more than a single orientation, the orientation which produced the lowest indoor summer temperatures was selected), and an alternative scenario in which wall finish was simulated as whitewash and roof composition was simulated as in Alternative A in Table 5.10 (foam concrete insulation). In house types A, B, And E, where orientation did have an effect on indoor summer temperatures, the alternative scenario was simulated using the best unrealized orientation of the facade facing the street (south in type A, north in types D and E).

The results show a substantial possible improvement of indoor summer conditions in all house types. The alternative design produced much lower overheating rates in all house types (a reduction of 15-25%). The difference in daily maximal indoor temperature during summer ranged between 1.6K and 2.6K. The biggest improvement was simulated in house type A, the most common of all house types in the Model Housing Estate.

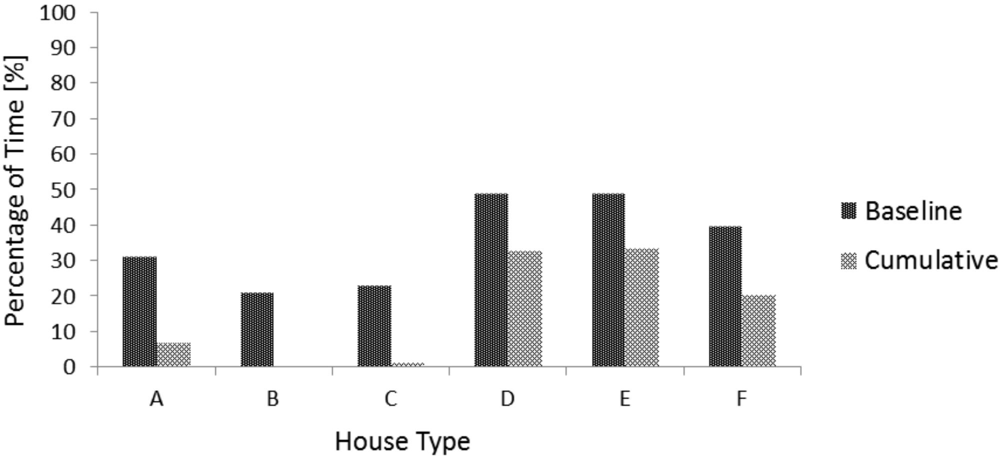


Figure 5.45: Overheating rates for all house types, comparing the original design (baseline case) with the cumulative scenario

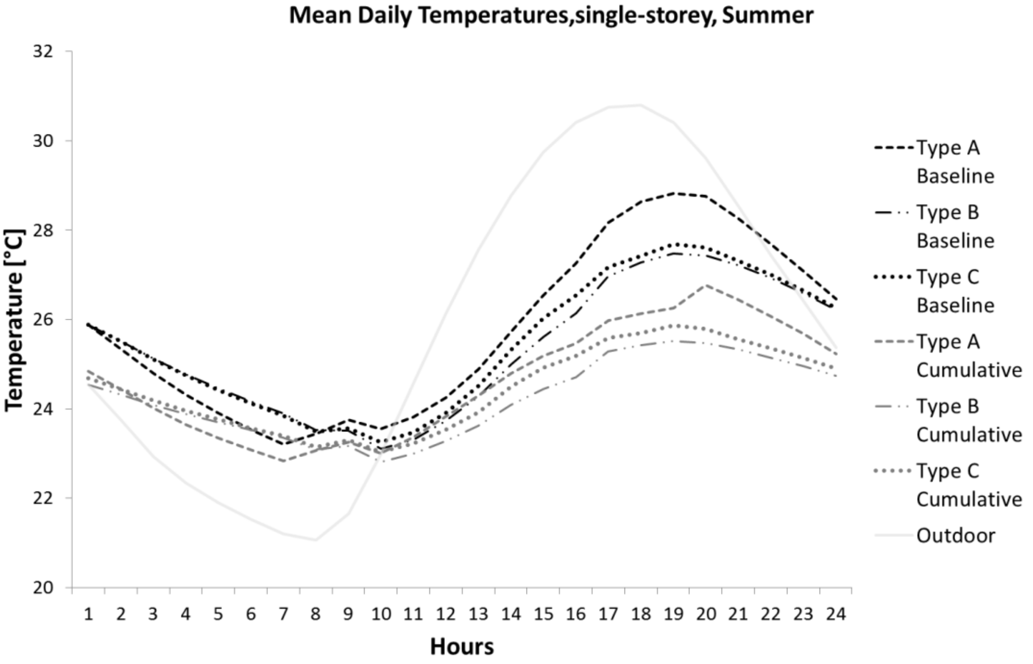


Figure 5.46: Daily temperature amplitudes for a typical summer day, single-storey house types, a comparison between the original design (baseline case) with the cumulative scenario

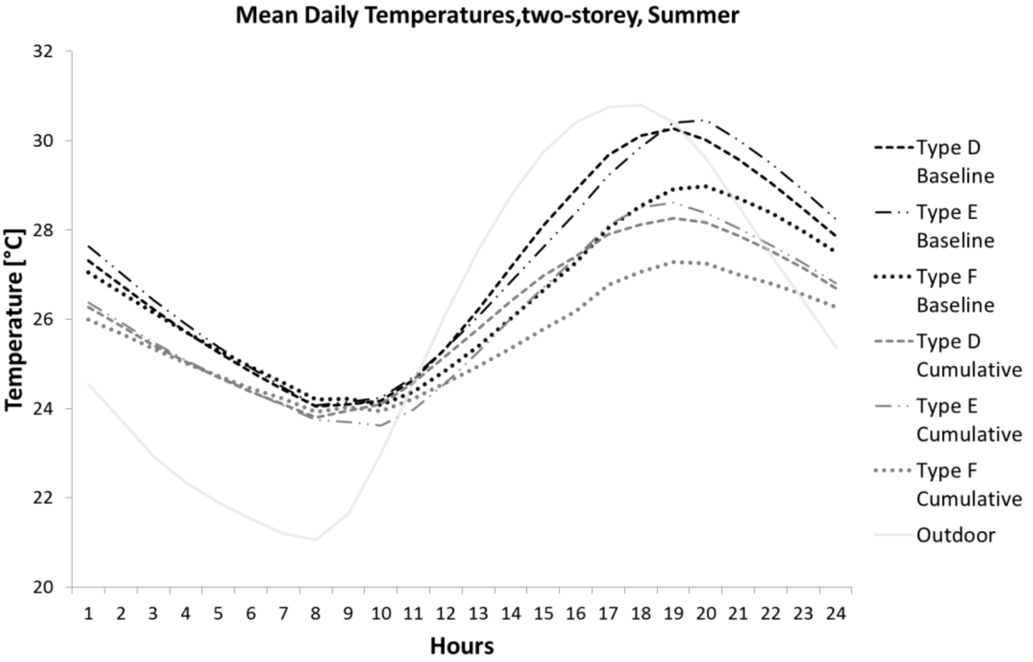


Figure 5.47: Daily temperature amplitudes for a typical summer day, two-storey house types, a comparison between the original design (baseline case) with the cumulative scenario

5.3.5 Discussion

Although solar orientation of buildings became a key issue in climatic design of buildings in Israel of the 1940's, 1950's, and 1960's, the design of the carpet housing in the Model Housing Estate in Be'er Sheva minimized the effect of orientation on indoor conditions. This was the result of three major design elements: the system of row houses, which reduced the amount of building envelope exposed to outdoor conditions; the relatively small size of the houses; and the surrounding walls and adjacent buildings which enhanced shading from direct solar radiation. For these reasons, house types with less adiabatic wall area (types A, D, and E) presented the greatest difference between the best realized and best unrealized orientations.

The total area of exposed walls also played a major role in the simulated effect of whitewashed walls. Here, the two-storey houses, as well as house type A, showed an almost similar effect of lowering the maximal summer indoor temperatures. At the same time, because of the existence of adiabatic walls in all house types, even the highest reduction in indoor temperatures was relatively moderate.

The greatest reduction of indoor summer temperatures was recorded with an alternative roof construction which consisted of basic thermal insulation. It affected more the single-storey houses, though improvement was simulated also in the two-storey houses. Thermally speaking, roofs in the carpet housing were the single most important building component; and although this property is typical to low-rise houses in general, it is important to note that the relatively poor thermal performance of the roof design resulted from a decision of the original designers and developers to consciously apply a minimal and thermally-poor (U-value of 3.00 W/m^2K) construction while much better and relatively conventional alternatives could have been employed.

The two suggested alternatives for roof design were not esoteric in any sense to the original designers, and were even examined in three local studies during the first half of the 1950's (Neumann et al. 1952b, Neumann et al. 1955b, Wittkower et al. 1953). While application of hollow concrete blocks as the main roof material could have had a relatively moderate effect on indoor temperatures, foam concrete could have had a clear positive effect on lowering indoor summer temperatures in all house types. When a cumulative effect of the three suggested modifications (orientation, wall finish, roof insulation) was calculated, the results showed that much more could have been done to better the indoor summer conditions of all houses, even under the alleged budgetary constraints. The main reason for the discrepancy between the realized and the enhanced construction was entirely dependent on decisions taken by the designers, which could have been avoided even without changing the spatial arrangement and composition of each house type and of the neighbourhood as a whole.

Nevertheless, it should also be acknowledged that the unique spatial scheme of the "carpet" resulted – even with the original design features – agreeable indoor summer conditions in the single-storey houses, as well as in house type F. Here, maximal daily summer temperature was 1.5-3.0K lower than the maximal outdoor temperature. This can mainly be attributed to the neighbourhood's dense fabric, the use of row housing as a general rule, and the shading provided by adjacent built elements (walls, houses). Yet, when compared to the outdoor-indoor maximal temperature difference in the cumulative simulation scenario (4.2-4.9K in the single-storey houses, 1.8-3.1K in the two-storey houses), it can be argued that much more could have been done to face the local climatic challenge.

5.4 Conclusion

The architectural historian Hadas Shadar, who extensively researched the history of the carpet housing in Be'er Sheva's Model Housing Estate, emphasized the role of climate as the main definer of the neighbourhood. This, argued Shadar, made it "successful since it has a thoughtful integration between local climate principles and Western housing culture and technology" (Shadar 2004, 37-41, 45). Yet Shadar's statement and evaluation of the climatic elements of the project were based merely on the conclusions of the 1965 post-occupancy survey, which did not include any scientifically sound monitoring of the thermal properties of the houses and their surroundings and actually implied that indoor climate in the carpet housing was far from being satisfactory, at least in the eyes of its inhabitants.

While it is clear that the narrow, shaded alleys between the houses were a positive and climatically-aware element of the design, less attention was given in historical writing to indoor conditions in the carpet housing, in spite of the clear indications to some climatic deficiencies of the design, and mainly to the overheating of indoor spaces. In a meeting of the design team of Neighbourhood E in Be'er Sheva dedicated to the post-occupancy survey of the Model Housing Estate, which took place in Be'er Sheva on 23 February 1965, engineer Weintraub from the office of the District Planner argued that there were "three major defects" in the carpet housing: "A. The drainage and releasing of water was left untreated. B. The effects of climate on the apartment were not considered. C. The building details were not properly thought of". Weintraub then added that

> It was not taken into account that the temperature differences of the desert climate (day and night summer and winter) create a special problem, that of the need of insulation. In the roofs the penetrating heat lowered the value of the apartment and one should have kept the common method of a screed gradient and cast asphalt. All the tested claddings have failed. Of course, the lack of waterspout was noticeable. On the other hand, the

> detachment of the roof from the walls proved to be effective.
>
> (Planning Team of Neighbourhood E in Be'er Sheva 1965)

Weintraub's account revealed that while climate was present as a recurrent background theme during the design process of the neighbourhood and even afterwards, no real attention was given to relatively simple building details which had a direct and sometimes significant effect on the indoor climate of the houses. In that sense, his account pointed to a discrepancy between the "climate-speak" behind the project and the actual design, which seemed to neglect major climatic aspects of the environment. The close examination of the design process of the Model Housing Estate, and especially that of the evolvement of the carpet housing scheme, shows a recurrent tendency to use climatic phraseology as a thin cover to other, much different, design motivations and goals. What is more striking is the way new advances in building climatology were (mis)cited and then ignored or, even worse, taken out of context to support design decisions which were based on totally different considerations.

As was shown above, the carpet housing of the Model Housing Estate, which was allegedly devised as an urban scheme suitable for the desert climate of Be'er Sheva, was actually developed as a generic solution, independent of specific climatic concerns, by the Bat Sheva de Rothschild Foundation research team. The scheme came into being in a very early stage during the research work, some months before a preliminary and very superficial climatic study was completed. The immediacy of its conception and the fact it was not altered in any way even after a more extensive climatic study was eventually conducted, indicates that the design was very much detached from the contemporary achievements of local building climatology research, humble as they were.

In the case of Yasky's carpet housing scheme and especially in its implementation in the Model Housing Estate in Be'er Sheva, climate did play a rhetoric role in the justification of form. As we have shown, the climatic explanations for the carpet scheme were not grounded in the contemporary scientific knowledge in building climatology. The "desert conditions" of Be'er Sheva were explicitly addressed only in relation to the spatial scheme of the neighbourhood, the internal shading of the public areas, and the protection of the neighbourhood's core from sandstorms. Other climatic issues, like the question of building materials and finishes, seemed to escape any systematic thinking and decision making. From the above analysis it seems that these questions had a considerable impact on the indoor climate of the houses.

The negligence of the climatic aspect of the building details is even more surprising after reading the climatic chapter of the Rothschild Foundation report. Yasky and his research team included specific climatic recommendations in the area of building construction which were entirely forgotten by Yasky and his Be'er Sheva design team. Most telling is the report's two concluding climatic recommendations:

> 6. Bright colour or shiny areas are a very useful measure (see the roof temperature table) while being simple and inexpensive way of reflecting the radiation and preventing the overheating of the house in spite of the unpleasant glare it sometimes creates.
>
> 7. Minimal and inexpensive insulation, mainly in flat roofs, is a possible effective method also for popular constructions. Such insulation can even become economical, since it can reduce the number of expansion joints in a building. Insulation can be employed by using simple materials like: Ytong, lightweight concrete of all kinds, a thick layer of Celotex, mineral wool, etc. At the same time, insulation should be used in a correct manner. It should be applied on the lower part of the roof (that which faces the rooms) and not on its external side. During the evening hours, the upper insulation inhibits – after the roof has been heated – the release of heat outdoors, and thus the conduction will be into the house. In contrast, an internal insulation inhibits the conduction indoors and most of the accumulated heat is released

> outdoors. We do not know of any precise measurements of the effectiveness of such insulation, since we could not trace experiments which examine this method, yet the method seems good enough for recommendation, taking in mind that it should be the subject of further precise testing. (Yasky et al. 1958, 36)

These two practical measures – painting the houses in bright colours and applying an insulation layer to the roofs – were consciously ignored in the construction of the Model Housing Estate, the first because of purely aesthetic prejudice, the second probably because of uncalculated motivation to minimize the building costs. Simulating alternative scenarios enabled to argue that these two design decisions resulted in a noticeable deficiency in the buildings' thermal performance. In other words, unnecessary discomfort for the carpet housing residents could have been avoided if the original architects would have insisted on two relatively simple design features.

At the same time, one can also argue that even without a better roof composition and whitewashing of the walls, the carpet scheme could have been regarded as a more than agreeable solution for the challenge of desert dwelling, mainly due to the dense urban fabric and the minimal exposure of the building envelopes to the sun. In 1968, a decade after the carpet concept was first introduced in the Rothschild Foundation report, Baruch Givoni, then the head of the Department of Building Climatology at the Technion's Building Research Station, published a report which consisted of general recommendation for climatic design in Israel. Writing on town planning in desert areas, he favoured the construction of "long and tall buildings", but then added

> An alternative might be a very dense system of single or two-storey houses which receive light and air mainly through small courtyards, and which are protected from the side of the wind by a strip of tall buildings. In the case of two-storey buildings, it is possible to use parts of the ground floor as passages and playgrounds for children, roofed and

> shaded under the second floor, which are open to the sky only as far as lighting and ventilation purposes are satisfied. In this way it is in fact possible to construct a quarter which consists of a continuous system of apartments, with thick dividing walls between them which will be used for the buildings' heat capacity and as acoustic insulators, and with flat, thick, and whitewashed roofs. Ventilation and lighting of the apartments can be obtained through relatively small courtyards. Such design enables to some extents to insulate the built quarter from the hot and dusty desert air, and to maintain lower temperatures not only inside the buildings but also in the passages between them. (Givoni 1968a, 24)

Although Givoni added that these conclusions were not based on actual experiments on an urban scale, his observations did rely on a decade of scientific work, including extensive building monitoring in Be'er Sheva. The similarities between his recommendations and the Be'er Sheva carpet housing are clear and telling. The main difference lies only in the way in which this design solution evolved: what has been recommended by Givoni after a decade of systematic research work was realized in Be'er Sheva based on what can only be described as healthy climatic instincts.

In the end, and in spite of its achievements, the carpet housing of the Model Housing Estate could have gained much more from contemporary scientific knowledge. The adoption of a Kasbah-like solution for the Be'er Sheva neighbourhood partly mimicked traditional climatic know-how and therefore produced satisfactory climatic results, though, as with its Moroccan predecessor, it was not based on analytical examination of the climatic situation, and even ignored available data that could have enhanced the buildings' thermal performance. The fact that this rejection of knowledge relates also to what was recommended by Yasky himself in his Rothschild Foundation report is a source of puzzlement, which may lead to the conclusion that the report's climatic chapter was nothing more than a task that was accomplished for the record, not for implementation in future design; This might also explain its contradictory nature.

6 THE ESHKOL TOWER, UNIVERSITY OF HAIFA

6.1 Historical background

The Eshkol Tower at the University of Haifa (32.7628 N, 35.0175 E, 478 m above sea level, Figure 6.1) is a high-rise building that is used as the main administrative building of the university. The tower was a key element in a master plan for the university campus, conceived in 1964 by the Brazilian architect Oscar Niemeyer (1907-2012). Niemeyer was also the original designer of the tower, though his design went through a series of modifications that in parts were done without Niemeyer's direct involvement. Construction of the tower took place between 1974 and 1977 following a detailed design by the Israeli architect Shlomo Gilead (1922-2005). At the time of construction, the building, consisting of 28 floors above ground, each of about 540 m^2, was the second tallest building in Israel, with a total height of 90 m (Figure 6.2).

Figure 6.1: The Eshkol Tower (on the middle left side) in a contemporary aerial photograph (gis.haifa.muni.il)

Figure 6.2: The Eshkol Tower, the south-eastern facade, the late 1970's (University of Haifa Archive)

6.1.1 Oscar Niemeyer and the University of Haifa Campus

The Eshkol Tower is probably one of the most conspicuous buildings in Israel. Its location, on top of one of the northern summits of the Carmel mountain ridge, and its exceptional height, render it visible from a great distance. This unusual combination is the product of unusual circumstances, in which a world leading architect, no longer welcome in his home country, finds a fertile ground for his monumental style in a relatively small city with a powerful and visionary mayor.

In the early 1960's Niemeyer was one of the most renowned architects worldwide. He rose to fame during the 1940's, following the increasing exposure that the modern Brazilian architecture was receiving in international professional circles (see above, section 4.1.2). In 1956 Niemeyer was invited by President Juscelino Kubitschek to design the buildings of Brazil's new capital, Brasília, a task which enabled him to exercise his phenomenal artistic talent almost without limitations and in an enormous and unprecedented scale.

Niemeyer was a proclaimed communist, and his affiliation with the leftist Kubitschek was turned against him after the Brazilian anti-socialist coup d'état of 31 March-1 April 1964. Brazil faced political instability since the beginning of the 1960's, following the unwitting resignation of President Jânio Quadros in August 1961, but it was the military coup of 1964 and its consequences that made Niemeyer an unwelcome person in his own country; as a result, Niemeyer spent much of the time until the early 1980's outside Brazil.

Although Niemeyer's arrival in Israel partially coincided with the events of the military coup, it was arranged some time before the events and had no direct connection to the sudden change in Niemeyer's political status in Brazil. According to Niemeyer's own recollection, which appeared in his memoir *Quase memórias: viagens - tempos de entusiasmo e revolta 1961-1966*,[12] in the beginning of 1964 he was planning to travel to Ghana, following an invitation from the University of Accra, and from there to continue to Israel, accepting an invitation from Yekutiel Federmann, a local businessman. A victim of persistent flying phobia, Niemeyer left Brazil by sea, but was forced, because of "travel difficulties", to change his plan and continue to Europe instead of getting off at Las Palmas. He stayed in Paris for about a month and then travelled to Lisbon, hoping to catch a plane to Africa. In Lisbon he first heard about the military coup in Brazil. He then decided to cancel his African journey and to travel directly to Israel (Elhyani 2002, 148-149).

Notwithstanding Niemeyer's recollection of the events, on 11 March 1964, three weeks before the coup in Brazil, a small report in the Israeli daily *Maariv* informed that Niemeyer "will come to Israel on 15 March in order to work on construction plans for areas owned by 'the Federmann Company'"; The brief account was based on a statement made by Yekutiel

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[12] Niemeyer's memoir, published in 1968, was written in Portuguese. The account given here is based on a Hebrew translation, done by Tanya Meltzer, of pages 30-48 of the original memoir, which cover the Israeli chapter of Niemeyer's recollections. The Hebrew translation first appeared in Elhyani (2002, 148-154), and later reappeared in Efrat (2004, 282-288). The cover of Niemeyer's memoir shows a model of his master plan for the University of Haifa campus.

Federmann upon returning to Israel by air (Maariv 1964a). A similar news item appeared on the same day in another Israeli daily, *Haaretz* (Elhyani 2002, 47). It is not clear whether Federmann was misquoted or had some misunderstanding with Niemeyer, but, as Niemeyer himself recollected, he arrived in Israel only after the 1 April coup in Brazil. A later article in *Maariv* from June 1964 mentioned that Niemeyer arrived in Haifa (the central port town of Israel at that time) "exactly on [the Israeli] Independence Day" (Oz 1964), which was celebrated in 1964 on 16 April; this is consistent with the fact that probably the first news item on the actual arrival of Niemeyer to Israel appeared only on 21 April 1964 (Maariv 1964b).

While Niemeyer, as well as the short newspaper reports on his arrival, claimed that his visit to Israel was meant to promote large construction projects for a private entrepreneur (Federmann), his relationship with Federmann was probably a little more complex. Niemeyer, it can be argued, was actually a servant of two masters: one was Federmann, owner of a local hotel chain trying to promote high-rise projects in Haifa and Tel Aviv, the other was Abba Hushi (1898-1969), the powerful socialist mayor of Haifa, "the workers city" as it was then known in Israel. One of Hushi's flagship projects was the foundation of a university in Haifa, as an effort to enhance equal opportunities for the population of northern Israel. The university was officially established in 1963 as a subsidiary institute of the Hebrew University in Jerusalem. Its first administrative director, who later became the university's first president, was Eliezer Rafaeli (b. 1926). Rafaeli was recruited while studying at Columbia University in New York and joined the university in February 1963 (Rinot 1967). One of his first tasks was to promote the planning of a campus for the "university institute", as it was then called (Eshel 2002, 276-281).

In an interview with the author, Rafaeli shed light on the connection between Hushi and Federmann, which led to the invitation of Niemeyer to Israel. According to Rafaeli,

> I reached an agreement with the guy who built the Dan hotels, Yekutiel Federmann – he had built here in Haifa

> several hotels, Dan Carmel hotel, and in other places, and I knew he was looking for an architect to build big things in the country – that I will travel to locate Niemeyer, and will propose him, speaking in the name of both of us, to design for Federmann the things that he is interested in, and for us to design a university. Federmann agreed, yet I received an even more interesting proposal: Federmann paid also for us. So Niemeyer did not insist too much and accepted the proposal and relocated from Europe to the top floor of the Dan Carmel hotel, which was the first hotel of Federmann here in Haifa. On the top floor he received six rooms, there he was hiding, and there he designed the things that Federmann asked for, as well as what we asked for. (Rafaeli 2013)

Although it is hard to determine who came first with the idea of inviting Niemeyer to Israel, it is probable that Niemeyer's long visit was strongly connected also to the University of Haifa project. In a newspaper interview in 1988, Federmann told reporter Esther Zandberg:

> Abba Hushi told me: you know people, bring me a renowned architect who will build Haifa. I knew the president of Brazil, Kubitschek, very well, and that's how I got to Niemeyer. We took him for the university in Haifa. We financed him. He also helped us to build Izraeliya, and he also contributed something in Neve Shaanan [both are neighbourhoods in Haifa]. (Zandberg 1988)

Thus, shared interests of financial and political powers were behind Niemeyer's arrival to Israel: Federmann was trying to use the name and esteem of the great architect in order to fend off opponents to the high-rise structures he was proposing in Haifa and Tel Aviv, while Haifa's mayor, who also confronted national and local criticism of his "megalomaniac" idea of the university (Eshel 2002, 276), relied on Niemeyer's reputation as a master of grand enterprises for realizing his own vision (Elhyani 2002, 90).

The area selected for the future campus consisted of about 90 hectares, two kilometres south of the adjacent Technion campus (Figure 6.3). The site consisted of a relatively limited planar area of about 6 hectares at the top of the mountain ridge (Figure 6.4). While the spatial layout of the Technion, which was located on a much less hilly setting, followed the conventional scheme of an agglomerate of single-purpose buildings, Rafaeli, after long consultations, was keen on proposing another concept, that of "a university under a single roof". This had two major reasons: first, the evolvement of academic life and organization into a multi-disciplinary domain which required constant interactions of experts of different backgrounds; and second, the physical location of the future campus, with its challenging topography, rendered construction on most of its parts non-economical. In addition, the long and narrow rectangular shape of the more probable construction site at the ridge summit and its windy environment called for a compact layout in which internal movement would be minimal, while being protected from external weather conditions (Rafaeli 2013).

The concept of "a university under a single roof", which was introduced by Rafaeli, was fully embraced by Niemeyer. In his building for the Central Institute of Sciences at the University of Brasília (1963-1971, Figure 6.5), Niemeyer implemented a very similar concept, designing a 700 m long building which contained most of the university's departments and faculties. For the Haifa campus, Niemeyer's solution was based on a long rectangular slab which contained all the lecture halls, classes, and labs, as well as a central library, cafeterias, and an auditorium. On top of this massive slab Niemeyer designed additional geometric volumes, the most conspicuous of all was a box-like tower which originally intended to host researchers from all of the university's departments (Figure 6.6). The resemblance of the whole configuration to Niemeyer's design of the National Congress of Brazil in Brasília (1957-1964, Figure 6.7) is evident, in spite of the great differences in function.

Figure 6.3: An aerial photograph showing the silhouette of the University of Haifa campus (top end, centre) and the Technion campus, stretching over a much larger area, the 1980's (University of Haifa Archive)

Figure 6.4: A current map showing the whole area allocated for the University of Haifa campus (confined to the north and east by the blue line) and the concentration of its buildings only on the summit of the mountain ridge (gis.haifa.muni.il)

Figure 6.5: Oscar Niemeyer, Central Institute of Sciences at the University of Brasília, the mid-1960's (www.museuvirtualbrasil.com.br)

Figure 6.6: Oscar Niemeyer, proposal for the University of Haifa campus, a model, 1964 (Anonymous 1966)

Figure 6.7: Oscar Niemeyer, the National Congress of Brazil, Brasília, 2009 (photograph by Rob Sinclair, www.flickr.com)

Apart from its monumental impact, typical of many of his designs (Elhyani 2002, 94), Niemeyer's plan was allegedly meant to facilitate counter interaction between researchers of different fields by concentrating them in a single, vertical building (Rafaeli 2013). As with the Central Institute of Sciences in Brasília, the complex was meant to be gradually occupied. The construction of the main building was supposed to be highly sophisticated, using large structural precast concrete elements (Elhyani 2002, 94). As for the tower, on the first stage it was unclear how it would be constructed, and what would be the details of its facades.

Niemeyer produced his design of the University of Haifa campus in less than two months. According to a newspaper report from the beginning of June 1964, Niemeyer met Hushi for the first time in mid-May. The two visited the future site of the university and were supposed to meet again on the first week of June and revisit the site before actual design begins (Shchory 1964). In the beginning of August an official announcement on the completion of the campus master plan, as well as the design of its main building, appeared in local newspapers (Davar 1964a). Several days later, the plan for the Haifa campus was publicly put on display alongside other projects designed by Niemeyer during his stay in Israel in an exhibition, titled *90 Days in Israel*, which opened at the lobby of Federmann's Dan Hotel in Tel Aviv (Elhyani 2002, 134-135, Davar supplement for housing and building 1964).

Niemeyer left Israel on 22 September 1964, leaving behind two of his closest assistants, the (Jewish) structural engineer Samuel Rawet and the German architect Hans Müller, as well as Haim Tibon (born Herbert Strohweiss in Berlin, 1927), a local architect who had been later appointed by Niemeyer to be his official representative in Israel. The team moved from Federmann's Dan Carmel Hotel to the offices of the Engineering Department of the Haifa Municipality, which coordinated the project. Niemeyer's plan, including a 83 m high tower, received an official approval by the local planning committee of Haifa on 20 December 1964 (Haifa local committee for building and planning 1964). Nevertheless, the relations between Niemeyer's team and the municipal establishment were tensed: Tibon told Zvi Elhyani, who wrote his master thesis on Niemeyer's projects in Israel, that the municipality wished to replace Niemeyer with an Israeli architect, Shlomo Gilead, who was much more familiar with the local planning establishment and administration. This led to Rawet's unexpected leaving of Haifa on 4 March 1965 and the ensuing dissolving of Niemeyer's team (Elhyani 2002, 104-105).

While Gilead claimed he received the commission based on an explicit condition that the future design will follow Niemeyer's concept (Elhyani 2002, 105), his appointment opened a new chapter in the design of the university campus. A first deviation from Niemeyer's plan occurred already in the beginning of 1966, when the university asked Gilead to design a smaller "multi-purpose" building in order to resolve the space shortage in the facilities that were then used by the university in several locations around the city (Committee of the University Institute of Haifa 1966). This building, in contrast to Niemeyer's mega-structure, suited the budgetary constraints imposed on the young university. It was constructed during 1967 as a fully detached building, in a distance from the site of Niemeyer's building, whose construction was still delayed (Figure 6.8). The inauguration of the multi-purpose building in late October 1967 marked the transfer of the university's activities to its new campus, but at the same time undermined the spatial unity of Niemeyer's original plan (Elhyani 2002, 105-106). Although Niemeyer's name continued to appear on official documents relating to the construction of the campus (including the construction plans of the tower in 1974), he was no longer directly involved in the detailed realization of his original, and now distorted, concept.

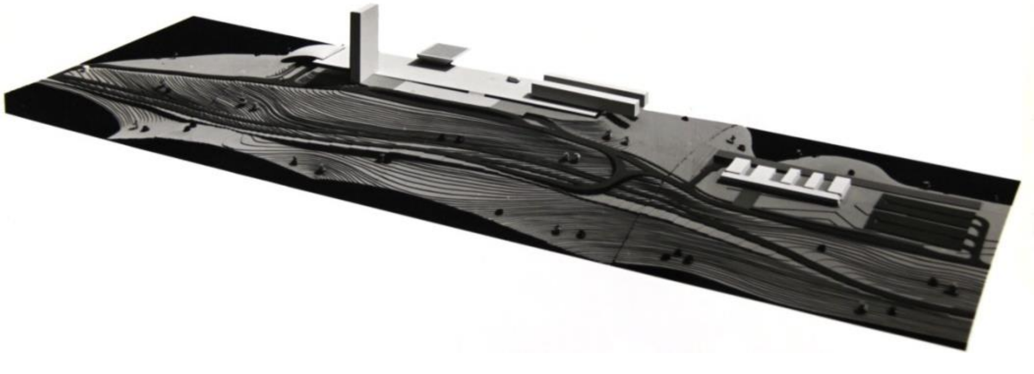

Figure 6.8: A model of the University of Haifa campus showing on right the additional multi-purpose building designed exclusively by Gilead (Anonymous 1966)

6.1.2 Construction of the Eshkol Tower

Infrastructure works on the site of the university's main building began on 9 October 1967 (Anonymous 1967), and a cornerstone was laid less than two weeks later (Davar 1967). At this stage, the university planned to build only the main double-level "platform" designed originally by Niemeyer, without its additional volumes, including the researchers' tower.[13] Nevertheless, preliminary design of the tower was taking place during 1968, since the tower's basement floors were an integral part of the main building. The construction of the main building was much slower than expected, and was completed only during 1971, including all the tower's basement floors (University of Haifa Executive Committee 1971).

The slow construction of the main building delayed the detailed design of the tower. In the beginning of September 1971, Joseph Koen, Haifa's City Engineer, sent a letter to Gilead with a recent meeting summary in which the architect and all the consultant engineers were asked to complete the design of the tower in the "shortest possible time" (Koen 1971). This had its effect, and in late December 1971 Ze'ev Sivan (?-2001), the University Engineer, reported to Rafaeli that the tender for the Eshkol Tower was ready for distribution (Sivan 1971). In a unfortunate coincidence, four days later Pinchas Sapir, Israel's Minister of Finance, sent a letter to the University informing its officials that the government, the main financer of the construction works in the campus, decided to halt its support for construction of new public buildings, including the Eshkol Tower (Rafaeli 1972). This was done in an attempt to cut public expenditure that was believed to raise inflation rates. Although the university tried to change the government's decision, all appeals were denied, putting the construction of the tower on hold.

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[13] The tower was named after Israel's third Prime Minister, Levi Eshkol, shortly after his death in February 1969. Until then it was referred to only as "the tower" or as a part of "Niemeyer's building".

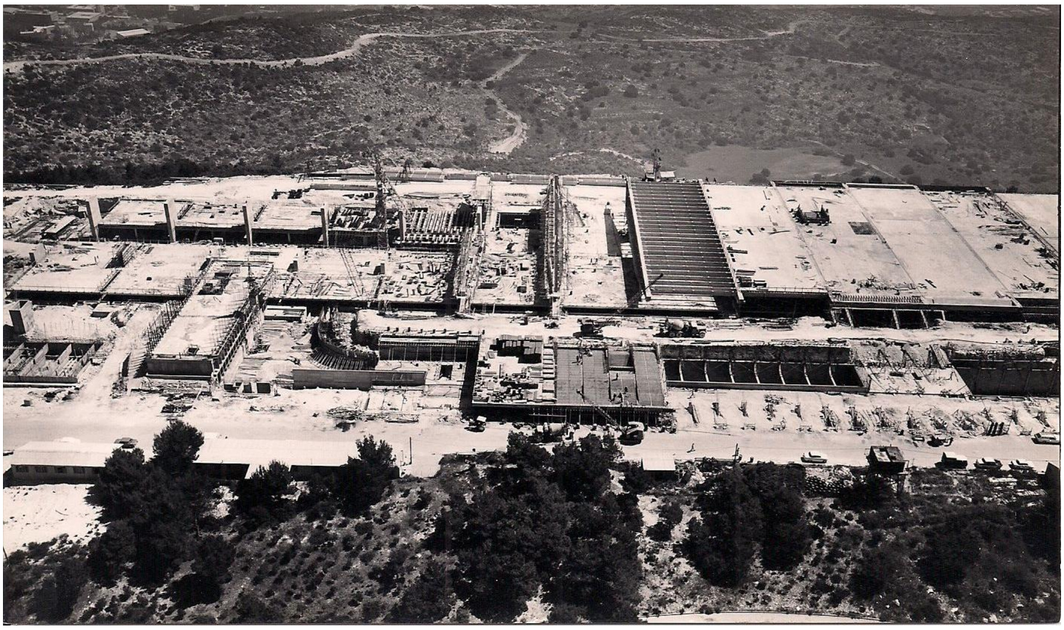

Figure 6.9: Construction of the main building of the University of Haifa, looking north-east, ca. 1970 (University of Haifa Archive). The structural frame of the basement floors of the Eshkol Tower, protruding from the rectangular shape of the main building, can be seen on the left

During the second half of 1972, Ramir, the local construction company that was still constructing the main building, approached the university with a proposal (Sivan 1972a, Udassin 1973). Ramir was interested in receiving a contract for the construction of the tower while still having its men on site, and therefore was trying to find alternative routes that could change the government's decision. Their idea was to substitute reinforced concrete with steel as the main structural material and to construct the tower from prefabricated elements that will be produced and later assembled by an Italian company named IRON, a subsidiary of a big aluminium manufacturer from Milan, FEAL (*Fonderia Elletrica Allumino e Leghe*).[14] FEAL was suggested as the manufacturer of the tower's curtain walls, as well as of its modular indoor partitions, doors, and recessed ceilings. It was believed that construction of the tower using prefabricated and imported elements will convince the government to remove the

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[14] The Italian company was founded in 1943 by Giovanni Varlonga, a Milanese mechanical engineer. Since the mid-1950's the company was offering a comprehensive prefabrication solution for buildings which included steel frames and glass-aluminium curtain walls. In 1969 FEAL was employing 1,100 workers in its two facilities in Milan and Rome (Trench and Mills 1969, 2).

construction ban over the project (Rafaeli 1975a), especially since the Italian company offered the university an attractive financing scheme.

The proposal to redesign the tower using steel construction was welcomed by the university's Executive Committee, and after a visit by Rafaeli and Sivan to Rome and Milan in January 1973 the university decided to look into the steel alternative in greater detail. On 26 February 1973, after extensive coordination with Sivan, Gilead, and Moshe Shnabel (the project's structural engineer), as well as with all other consultant engineers, Ramir signed an agreement with IRON, securing the status of the later as a possible sub-contractor in the Eshkol Tower project. About two weeks later, the government approved the execution of the project (Udassin 1973).

A new obstacle emerged during March 1973: a close examination of the new Israeli standard for earthquake resistance of structures (still under preparation at that time) revealed that in order to build the tower in its original height the typical floor plan must be redesigned. Sivan wrote to Rafaeli that an adaptation of the original structural design of the tower using reinforced concrete might take another year, while switching to steel should enable the university to start the tower's construction as soon as in October 1973 (Sivan 1973). While final decision on the structural system of the tower was not taken, redesign of the building to conform to the Italian systems was under way. In the beginning of May 1973 Sivan, Gilead, Shnabel, as well as the owner of Ramir, Joseph Udassin (1918-2004), visited Milan and met FEAL representatives in order to discuss construction details, including a thorough rethinking of the facades' design (Shnabel 1973b).

It took a few more months for FEAL to edit a detailed proposal for the construction of the tower, based on their negotiations with Gilead, Shnabel, and others. On 16 December 1973 the university's Executive Committee decided to approve the construction of the tower using FEAL steel and aluminium systems and to select Ramir as the project's main contractor (University of Haifa Executive Committee 1973). Following the decision, a final tender, containing a full set of architectural and engineering drawings, was issued on March 1974. Niemeyer's name still appeared on the tender's cover page and on all of its architectural drawings as the main architect of the building, with Gilead's name following (Figure 6.11), though the new design introduced major changes in the tower's layout and facades, including the transformation of the original 1.66 m facade module into a 1.20 m module (Figure 6.10). The new design was more efficient in term of usable floor space in each of the typical floors, rising from 49% to 55% of the gross floor area (Rafaeli 1975b).

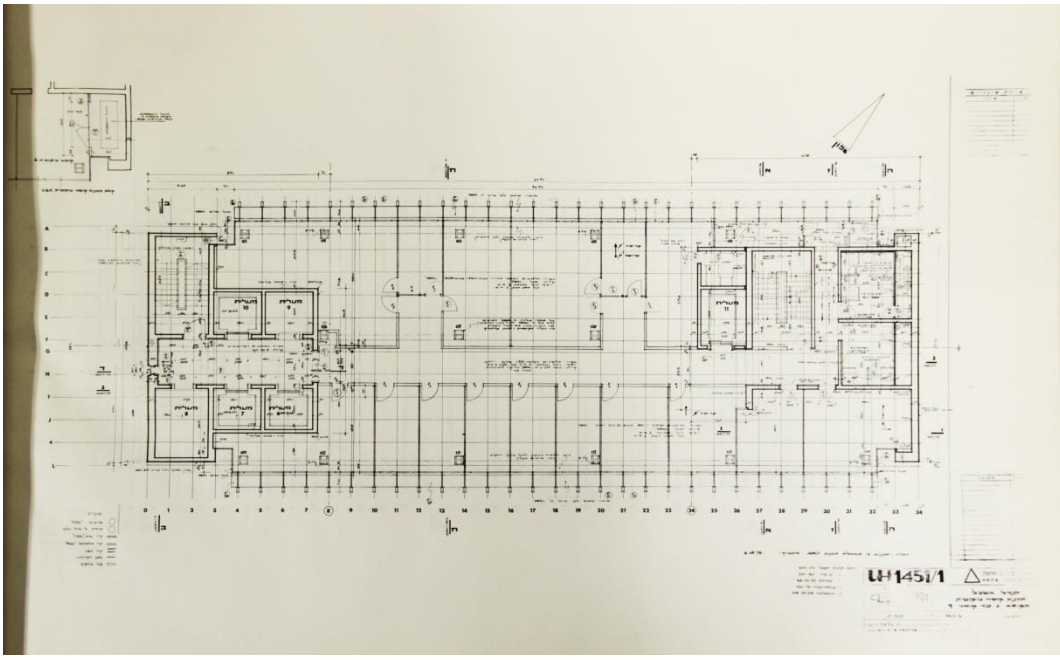

Figure 6.10: Typical floor plan of the Eshkol Tower by architect Shlomo Gilead as appeared in the March 1974 tender (University of Haifa Archive). The tower consisted of two service cores made out of reinforced concrete

אוניברסיטת חיפה
מחלקת פתוח ותחזוקה

מגדל אשכול לסגל ומחקר

אדריכלות - פרופ' א. נימאיר ברזיל, פרופ' ש. גלעד חיפה
קונסטרוקציה - א.טרוים, א. מילר, מ. שנבל מהנדסים יועצים
אינסטלציה חשמלית - "יאני" בע"מ
אינסטלציה סניטרית - י. אלישע בע"מ
מזוג אויר - איסקוביץ שפירא מהנדסים בע"מ
אקוסטיקה - הנדסה אקוסטית - מהנדסים יועצים
בטיחות - אינג' מ. בלייבוג ושות' בע"מ
תאום ופקוח - א.מילר, מ. שנבל ושות' - מהנדסים יועצים

Figure 6.11: Cover page of the tender for the construction of the Eshkol Tower, March 1974 (University of Haifa Archive). Oscar Niemeyer's name appears as the building architect, followed by Gilead's name

While the main structural frame of the building was designed in steel, the two service cores (one in each side of the building slab) were to be constructed out of reinforced concrete, based on a demand by Gilead (Sivan 1973). This enabled Ramir to start the tower's construction early in 1974 (Ron 1975), several months before the imported building parts were supplied (Figure 6.12). Assembly of the steel elements, as well as the curtain walls, started in July 1975 (Sivan 1975) and lasted for about a year. By December 1976, four floors were ready for occupation (University of Haifa Building Committee 1976). More floors were gradually occupied from the second half of 1977 until the end of 1978. 14 years after Niemeyer proposed his concept for the university campus, his vision came into being, though with much alterations and modifications.

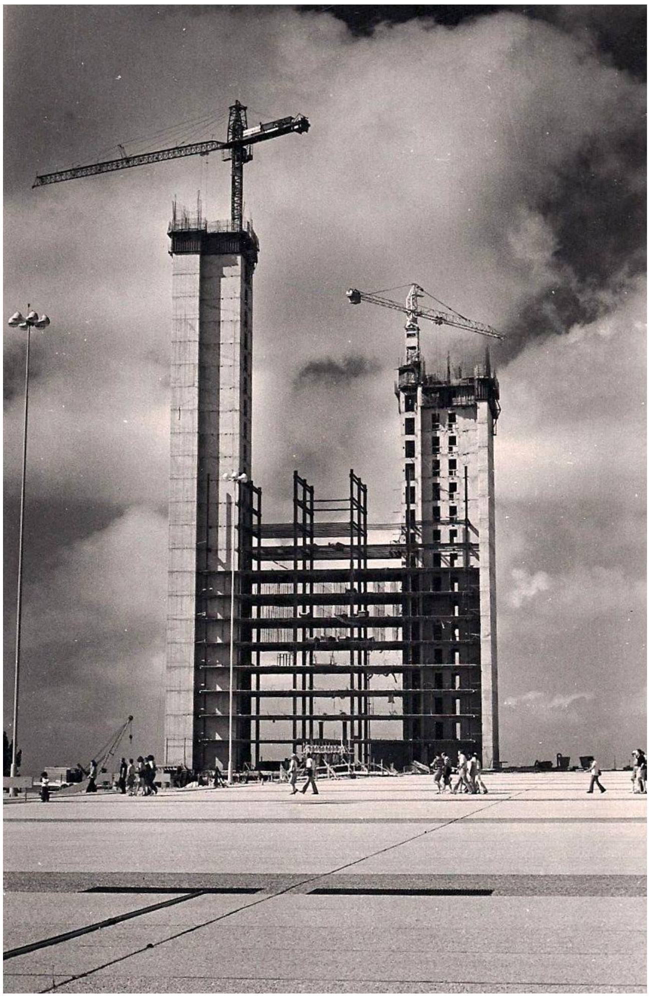

Figure 6.12: Eshkol Tower during construction, ca. 1975, a photograph showing the construction of the steel structural frame between the two service cores made out of reinforced concrete (University of Haifa Archive)

6.2 Climatic design in the Eshkol Tower

On 4 April 1968, an unusual article appeared in the Israeli daily *Maariv*, the most widely-read newspaper in Israel at that time (Figure 6.13). Matters of building climatology usually do not make it to the headlines, not even to the back pages. But this time, a five-column piece by a young reporter, Dan Mirkin, was dedicated exclusively to questions of building orientation and facade shading. Its subject was the tower designed by Oscar Niemeyer for the University of Haifa. The report's significance for the current study calls for its full quoting:

> One of the trademarks of the university that is being built in Haifa will be a high tower that will rise to the height of 25 floors above the main building. The main building itself, consisting of two floors, will stretch over 360 metre, where once was – before being "decapitated" – one of the most beautiful hills of the Carmel mountains.
>
> The casting of the foundations for the first phase of the main building began recently. This phase will include a major part of the building itself, part of the library, and the tower's base. It is possible that the construction of 10 floors of the tower will be done during this first phase, which should reach its end by the year 1970.
>
> After the entire plan was approved, not without debate, the Haifa Municipality recently approached the head of the Department of Building Climatology at the Technion [Baruch Givoni], asking for his expert opinion on the need to install an air conditioning system in the tower.
>
> Taking in mind the cost of the university's construction (tens of millions of Israeli Pounds), it is true that the installation of an air conditioning system, even a very expensive one, could not affect the general expenses. Nevertheless, if it will turn out that its installation could be spared by improvements of the design, and if the high maintenance costs of such a

system can be spared too, it is advisable to closely look into the matter.

According to the Haifa-based architect, S. Gilead, who is employed by the university's designer, the Brazilian architect Niemeyer, as the architect in charge of its construction, the whole building was oriented "as the mountain demanded, along the south-north axis, with a slight deviation". The rectangular-shaped tower is perpendicular to the long side of the building. Its two narrow facades face east and west, while its two longer facades face north and south. Yet this orientation is not precise. The southern facade slightly faces south-east, and the northern facade slightly faces north-west.[15]

"Leaves" of Concrete

In contrast to most buildings, the tower is not supported on internal structural columns but on external columns attached to the longer facades, stretching to its full height, from the ground upwards. These columns will resemble "leaves" of concrete.

In the northern facade of the tower, these concrete-leaves will be attached to the tower's facade in diverse angles, in a way that will prevent them from casting shadows on the southern facade of the tower. Here, sunbeams will hit during the hottest hours of the day, while in the northern half of the building, the workers and teachers will be forced to turn on the electric light throughout the day, since the concrete-leaves will be attached to the facade diagonally, and will protect it from the sun.

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[15] This description is not totally accurate, since the main facades of the tower are oriented almost precisely to the north-west and south-east.

To the question of the Haifa city engineer, Professor Givoni replied that "the current plan calls for the installation of air conditioning in the tower". Following my request, he indicates three significant points, quote:

- "On the Carmel it is possible to build without air conditioning, but this requires a solution for the problem of the sun and ventilation".
- "The vertical light-breakers (as Professor Givoni calls the "concrete leaves") are fundamentally inefficient. Even if things will be turned all the way around, and the light breakers of the northern facade will be perpendicular and those of the southern facade will be diagonally attached to the facade, the problem will not be solved, though this **might help**" (emphasis added – D.M.).
- "The solution is to redesign the shading system. Under the current conditions, based on my examination, there will be a very strong penetration of sun from one side – and no light from the other side".

Professor Givoni explains, that the excessive heat in the tower will result not only from the penetration of sun beams and heat from the southern side, but also because of the dimness in the northern side, which will force the workers to use electric lighting all day long, thus increasing even more the heat and the need for air conditioning.

Givoni says that another problem will rise: an uneven distribution of heat on both sides of the tower that will create difficulties in the installation of the air conditioning system.

Thus Spoke Niemeyer

Let us return to architect Gilead. I asked why the redesign of the concrete leaves, which in the current plan are bad in terms of shadow, lighting, and temperature adjustment, is not considered.

Gilead replies: "First, because Niemeyer did so, as something to be obeyed to the letter. Secondly, it can be assumed that in any case the tower will consist of an air conditioning system, since in such a high building it is hard to maintain efficient air regulation without air conditioning".

I asked whether a mistake occurred, and architect Niemeyer might have forgotten that he builds in Israel, in which the sun passes through the south and not through the north. Mr. Gilead replied that he does not know, but does not think so.

Gilead explained that the planned entrance to the tower is from its southern side, and therefore in this side the leaves must be perpendicular to the wall, in order to enable a wide and easy passage. I asked him whether he will let himself, in light of the problems that arose, to call Niemeyer and ask him whether he has an alternative proposal. Mr. Gilead first replied: "It is hard for me to answer". After reconsidering his words he asked to correct himself and said: "I consider such an option".

I asked the Haifa Municipality engineer whether the municipality considers the re-examination of the tower's design.

I was answered that from the beginning the tower was meant to be air conditioned, yet now there was a wish to examine the possibility of savings. The municipality refused to add more details.

> Architect Gilead thinks that there are considerations and dictates which are more significant than savings and functionality in the tower's layout, like dictates of the landscape and aesthetic considerations. Yet it is said that the problem of shade can be resolved without compromising the form of the tower; for example, horizontal light-breakers that will be concealed behind those vertical "concrete leaves".
>
> It seems that sacrificing such amounts of money for aesthetics, which is, though controversial, very exquisite, will not be a wise step. As long as the building of the tower is pending and only its foundations were cast, it is not too late to check whether its design can be fundamentally altered, or at least to "switch chairs" between the southern and northern facades. (Mirkin 1968)

Mirkin's article addressed a fundamental issue in building design, that of the omnipresent tension between functionality and aesthetics. His portrayal of the story puts the architects on one, allegedly purely aesthetic, side, while keeping a representative of building climatology on the opposite side of "functionality" (not to say common sense). The reality, though, was probably more complex, as can be concluded from the fact that Niemeyer's allegedly non-functional shading design was eventually significantly altered by Gilead, in spite of Gilead's clear words to the reporter. At the same time, one cannot deny that the original design should have raised much concern even before Givoni was asked for his opinion.

As far as the author has managed to discover, Mirkin's article was one of its kind. Givoni's critique on Niemeyer's design did not appear in any other contemporary newspapers or in other reports on the construction of the tower. Moreover, except Givoni's original report, the author was not able to trace any reference to the affair in documents kept in the archives of the Haifa Municipality and the University of Haifa, though copies of Mirkin's article were filed by several university officials. On the other hand, Givoni's analysis was not left totally unaddressed, and had eventually a clear impact on the final design of the tower.

As for Givoni, it seems that the expected faulty performance of the tower was not a common sight even for him, who was critical of the climatic aspects of the design of many local buildings. His open critique on the design of the tower, as was quoted by Mirkin, was not common either, especially since it addressed specific design and designers, not some general and anonymous design trends. Moreover, in Givoni's eyes, the case was conspicuous enough to be mentioned by him in an interview with the author conducted in December 2012, when he was 93. After being asked a general question on the attitude of architects to scientific knowledge, Givoni referred to Niemeyer's design of the university tower, saying:

> I was then a head of a department at the Technion, they sent me these plans. I said, in Haifa, to build a building which is totally dependent on air conditioning, I don't like it. So they told me, who are you to criticise him [Niemeyer], and they built it. And later there were troubles [...] When the [air conditioning] system does not work people suffocate, you cannot open up the windows, because it interferes with the air conditioning. The air conditioning engineer does not allow it, it negatively affects the efficiency of his system. (Givoni 2012)

Givoni's expert opinion was issued on 9 January 1968 and was addressed to Joseph Koen, the Haifa City Engineer. In comparison to his newspaper interview, it is a short and almost laconic document, spanning over a little more than a page, which was issued under the name of the Technion's Building Research Station. Givoni was short in words but sharp in his verdict:

> Following your letter from 30.11.1967, we were trying to configure whether air conditioning is required in the aforementioned building, and concluded as follows:

a. Penetration of Sun into the Building

In rooms oriented to the south-east there will be a considerable penetration of sun during all morning hours, and therefore indoor temperatures will rise considerably above the level of outdoor air temperatures. The external shading devices, given in the form of structural columns perpendicular to the building's wall, are ineffective in terms of the prevention of direct sun penetration.

In rooms oriented to the north-west there will be no penetration of sun at all.

b. Expected Lighting Conditions

In rooms oriented to the south-east excessive light intensity and glare are expected, and therefore we have to recommend on the application of internal venetian blinds for lighting adjustment. In rooms oriented to the north-west light will be insufficient for work purposes and additional artificial lighting during daytime will be required. This will certainly induce additional indoor heat.

c. Ventilation

Under the proposed design conditions it seems that deficient natural ventilation conditions are expected, as well as difficulties in the adjustment of ventilation using normal windows.

d. Conclusion

The results of our investigation seemingly indicate that uncomfortable indoor conditions, which cannot be avoided without considerable modifications of the building design, are expected. Therefore I conclude that it is advisable to install air conditioning in the structure. (Givoni 1968b)

The historical documentation of the different phases of the design, though fragmentary at times, can help in determining whether Givoni's criticism was justified and whether the final design of the building's facades prevented the climatic malfunctioning he predicted. It can also help in estimating whether the modification of the facades' design was indeed a response to Givoni's criticism, and to quantitatively evaluate whether the final design improved dramatically the tower's performance in terms of thermal and visual comfort.

המגדל הגבוה של אוניברסיטת חיפה

תיכנונו של הבניין, בהשראת האדריכל הנודע נימאייר, מתעלם מבעיות הצל ונראה שבחדריו עתיד להיות חום רב

— מאת דן מירקין —

אחד מסימני ההיכר של האוניברסיטה ההולכת ומוקמת בחיפה יהיה מגדל גבוה שיזדקר מהבנין הראשי לגובה של 25 קומות. הבנין הראשי עצמו, על שתי קומותיו, ישתרע על 360 מטרים, במקום שבו היתה — לפני ש„גולדה" — אחת הגבעות היפות שבהרי הכרמל.

באחרונה ניגשו לצקת את היסודות לשלב א' של הקמת הבנין הראשי. השלב יכלול הקמת חלק גדול של הבנין עצמו, חלק מהספריה ומסד המגדל. יתכן גם שבשלב הראשון, העתיד להסתיים בשנת 1970, יוקמו כבר 10 קומות של המגדל.

לאחר שכבר אושרה התכנית כולה, לא בלי ויכוח, פנתה באחרונה עירית חיפה אל ראש המחלקה לקלימטולוגית הבניה בטכניון בבקשה לקבל חוות דעת אם נחוצה מערכת מיזוג אויר במגדל.

אמנם בהשואה לתקציב בנין האוניברסיטה (עשרות מיליוני ל"י) אין הקמתה של מערכת מיזוג אויר, ולו גם יקרה מאוד יכולה להשפיע על סכום ההוצאות הכללי. אולם אם אמנם גם יסתבר שאפשר לחסוך את הקמתה על ידי שיפורים בתכנון ואם אמנם אפשר יהיה לחסוך את דמי האחזקה הגבוהים של מערכת כזאת, כדאי יהיה לבדוק זאת.

לדברי הארכיטקט החיפני, ש. גלעד, המועסק על ידי מתכנן האוניברסיטה, הארכיטקט הברזילאי נימאייר, כאדריכל משנה לעניני הקמתה, הועמד המבנה כולו „כפי שהכתיב זאת ההר, לאורך הציר דרום־צפון, עם סטיה מסויימת". המגדל דמוי המלבן ניצב לרוחב הבנין. שתי החזיתות הצרות שלו פונות למזרח ולמערב ושתי החזיתות הרחבות לצפון ולדרום. אולם הכיוונים אינם טהורים. החזית הדרומית פונה מעט דרומית־מזרחית, והחזית הצפונית פונה מעט צפונית־מערבית.

„דפים" של בטון

בניגוד למרבית המבנים אין המגדל נישא על ידי עמודי תמיכה פנימיים, אלא על ידי עמודים חיצוניים, הדבוקים לחזיתות הרחבות לאורך כל גובהו של המגדל, מלמטה למעלה. אותם עמודים יהיו מעין „דפים" של בטון.

בחזיתו הצפונית של המגדל יוצמדו אותם דפי־בטון אל חזית המגדל בזויות שונות, כך שלא יטילו למעשה שום צל על החזית הדרומית של המגדל. כאן תכינה קרני השמש בשעות החמות ביותר של היום. ואילו בחציו הצפוני של הבנין יצטרכו הפקידים והמורים להדליק אור חשמל בכל שעות היום, כי דפי הבטון יוצמדו לחזית בזוית ויסוככו עליה מפני השמש.

לשאלת מהנדס עירית חיפה השיב הפרופסור גבעוני כי „על פי התכנית הנוכחית יהיה צורך להתקין מיזוג אויר במגדל", לבקשתי הוא מציין שלוש נקודות חשובות ואביא אותן כלשונן:

- „על הכרמל אפשר לבנות בלי מיזוג אויר, אבל זה מחייב לפתור את בעית השמש והאוורור".
- „שוברי האור הוורטיקליים (כפי שמכנה פרופסור גבעוני את „דפי הבטון") הם ביסודם בלתי יעילים. גם אם יחליפו את היוצרות ושוברי האור בחזית הצפונית יהיו ניצבים ובחזית הדרומית יחוברו בזוית לחזית, הבעיה לא תיפתר, אבל זה יכול לעזור" (ההדגשה שלי — ד.מ.).
- „הפתרון הוא לתכנן מחדש את מערכת הצל. בתנאים הנוכחיים, על פי הבדיקה שערכתי, תהיה חדירת שמש חזקה מאוד מצד אחד — ובלי אור מהצד השני".

פרופסור גבעוני מסביר, שהחום הגבוה במגדל ייגרם לא רק מחדירת קרני השמש והחום מהכיוון הדרומי, אלא בגלל האפלוליות שתשרה בצד הצפוני והיא תאלץ את העובדים להשתמש בתאורה חשמלית במשך כל שעות היום, דבר שיגביר עוד יותר את החום והצורך בהתקנת מיזוג אויר.

לדבריו תתעורר בעיה נוספת: חלוקה לא־שוה של חום בשני צידי המגדל, דבר שיקשה מאוד על התקנת מערכת מיזוג האויר.

כה אמר נימאייר

נחזור שוב לארכיטקט גלעד. שאלתי מדוע אין חושבים לתכנן מחדש את דפי הבטון, שבתכנית הנוכחית הם גרועים מבחינת הצל, התאורה וויסות הטמפרטורה.

הוא משיב: „ראשית, משום שכך עשה נימאייר, בחינת כזה ראה וקדש. שנית, אפשר להניח שבין כה וכה תהיה במגדל מערכת מיזוג אויר, משום שבבנין כה גבוה קשה להביא לויסות אויר יעיל ללא מיזוג אויר".

שאלתי אם יתכן שקרתה טעות ומהארכיטקט נימאייר אולי נשתכח שהוא בונה בישראל, בה השמש עוברת בדרום ולא בצפון. מר גלעד השיב שאינו יודע, אולם אינו סבור כך.

הוא הסביר לי שהכניסה המתוכננת למגדל היא מצידו הדרומי, ולכן דוקא מכיוון זה צריכים המדפים להיות ניצבים לקיר, כדי לאפשר מעבר נוח ורחב. שאלתיו אם לאור ה־ להתקשר לנימאייר ולשאול בעיות שהתעוררו ירשה לעצמו אותו אם יש בידו הצעה אלטרנטיבית. מר גלעד השיב תחילה: „קשה לי לענות". לאחר ששקל את דבריו בפעם נוספת ביקש לתקן את עצמו ואמר: „אני שוקל אפשרות כזאת".

שאלתי את מהנדס עירית חיפה אם חושבת העיריה לבדוק מחדש את התכנון המגדל.

בתשובה נאמר לי שהמגדל נועד מתחילתו להיות ממוזג אויר, אולם עתה רצו לבדוק אפשרות לחסכון. אנשי העיריה סירבו להרחיב את הדיבור.

הארכיטקט גלעד סבור שעדיפים שיקולים ותכתיבים גדולים יותר מן החסכון והפונקציונאליות בהעמדת המגדל, כגון תכתיבי נוף ושיקולים אסתטיים. אולם אומרים שאפשר לפתור את בעית הצל מבלי לקפח את צורתו של המגדל. למשל, אם יצניעו שוברי־אור אופקיים מאחורי אותם „דפי בטון" אנכיים.

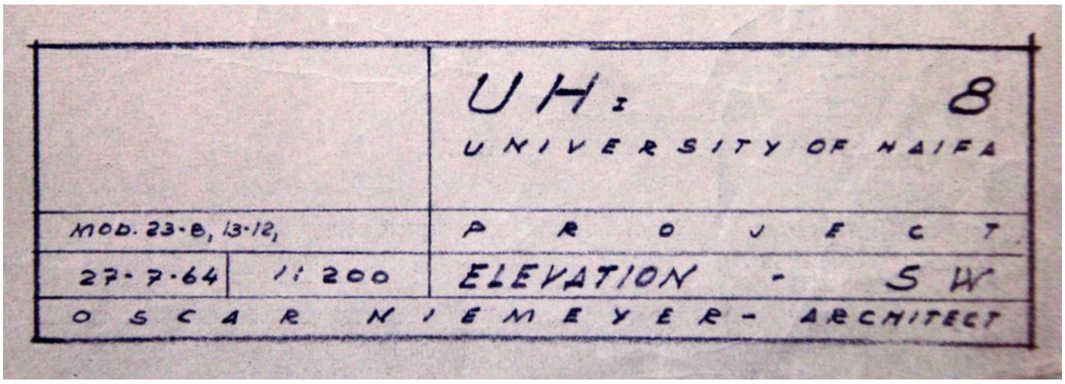
נראה שהוצאת סכומים אלה על מזבח האסתטיקה, שאף היא שנויה במחלוקת חריפה מאוד, לא תהיה צעד נבון. כל עוד לא החלו לבנות את המגדל אלא רק יצקו את יסודותיו עוד אין זה מאוחר לבדוק אם אפשר לשנות את תכנונו באופן יסודי, או לפחות „להחליף את היוצרות" בין החזית הדרומית והצפונית.

כך תיראה אוניברסיטת חיפה עם השלמתה. ממקום בנייתה נשקף נוף המפרץ כולו:

Figure 6.13: The original newspaper article which dealt with the critique of Baruch Givoni on the shading systems of Niemeyer's design of the tower (Mirkin 1968)

6.2.1 Oscar Niemeyer's original sun breakers design

The oldest surviving evidence for Niemeyer's design of the Eshkol Tower is a set of architectural drawings kept in the Shlomo Gilead Collection at Israel Architecture Archive. Signed exclusively by Niemeyer (Figure 6.14) and dated from 27 July 1964 (with two additional and unspecified modifications during the same year), this 1:200 scale set contains plans and sections of the entire university campus project, including a 26-storey tower. These drawings were later photocopied, minimized to a 1:800 scale, and included in a booklet kept in the Abba Hushi Archive at the University of Haifa. Undated, this booklet contains two photographs of the untouched site before construction, two general plans of the layout of the university buildings, six photographs of a cardboard model of the site and buildings, a landscaping plan, and architectural plans and sections of the main building. Since the multi-purpose building already appeared in the photographed models, it can be assumed that the booklet was assembled in 1966, perhaps in an effort to attract donors for the buildings; for unknown reasons, some of the headings are in French. A free-hand sketch by Niemeyer, showing the project silhouette, appeared on the booklet's cover (Figure 6.15).



UH: 8
UNIVERSITY OF HAIFA
MOD. 23-8, 13-12,
PROJECT
27-7-64
1:200
ELEVATION - SW
OSCAR NIEMEYER - ARCHITECT

Figure 6.14: Oscar Niemeyer's name as appearing on an elevation drawing of the University of Haifa project, 27.7.1964, scale 1:200 (Shlomo Gilead Collection, Israel Architecture Archive)

אוניברסיטה של חיפה

L'UNIVERSITÈ DE HAIFA

LG
341
.H28
U45
1960

Figure 6.15: The front page of the booklet containing a reduced-size set of Niemeyer's original plans of the university's main building, including its tower (Anonymous 1966)

The tower which appeared in the 1964 plans had no apparent shading system. Although a detailed design of the facades is clearly missing, the existing plan, elevation, and section show a similar design, in which the windows on both of the tower's main facades are located in the external surface of the building, with no additional "sun breakers" or other shading devices. At the same time, the building envelope is not made out of a curtain wall, but consists of an array of identical narrow windows (Figure 6.16 and Figure 6.17). The photographed cardboard model (see above, Figure 6.6 and Figure 6.8) showed no articulation of the tower's facades.

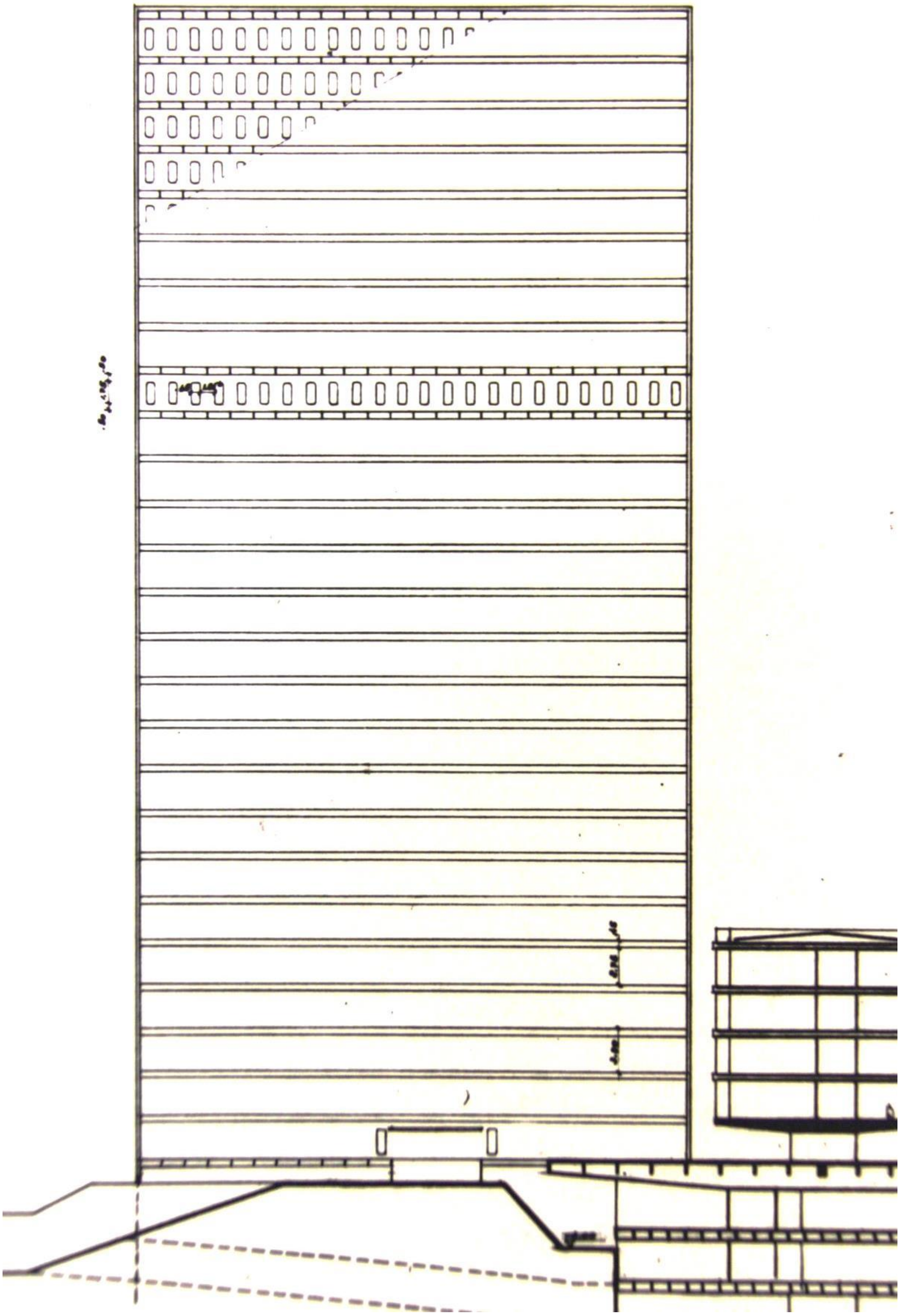


Figure 6.16: The 1966 booklet, a detail view of the elevation of the tower's south-eastern facade (Anonymous 1966)

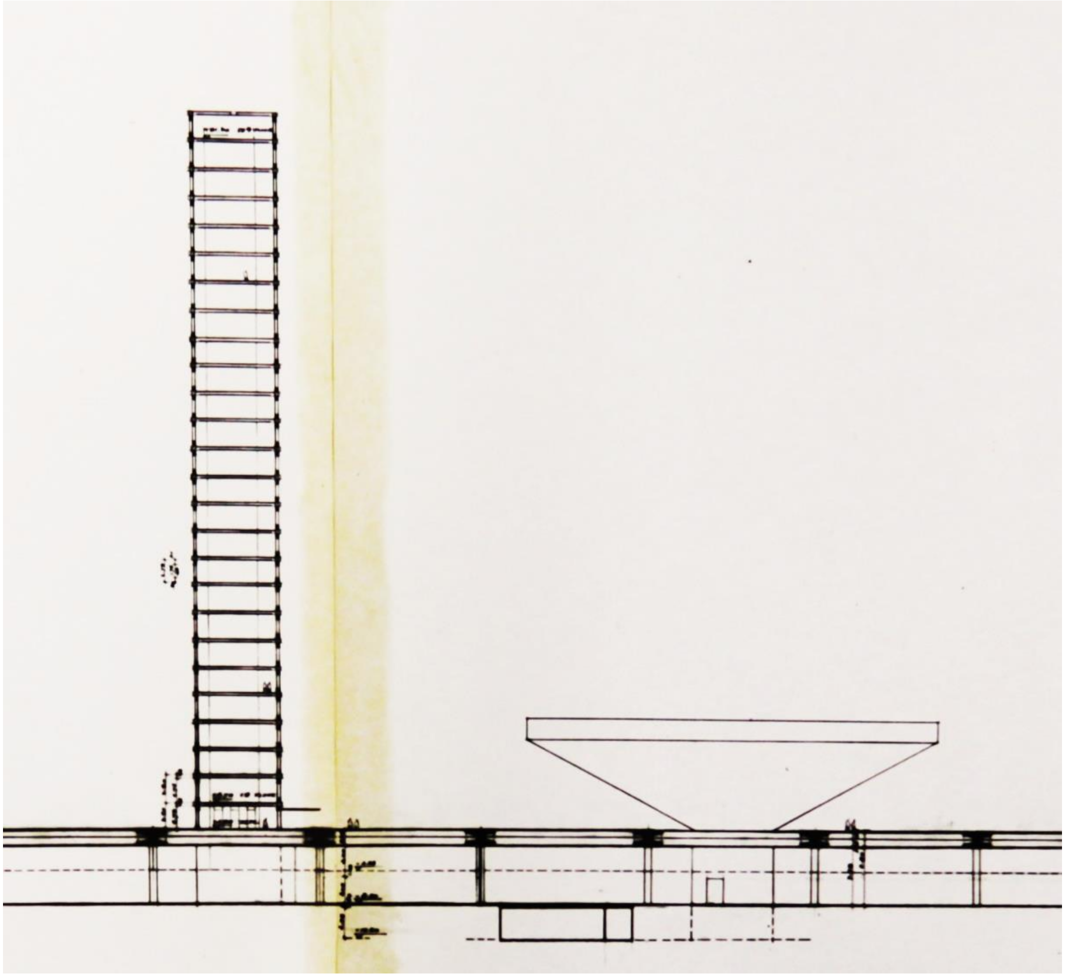


Figure 6.17: The 1966 booklet, a detail view of a general section of the main university building showing a cross section through the tower (Anonymous 1966)

The 1964 design by Niemeyer was clearly premature. Although it is not clear when the design of the vertical sun breakers came into being, it is probable that by Niemeyer's second visit to Israel in August 1965 (Elhyani 2002, 138) the updated design was already complete, following the work done by Niemeyer's team in Israel. Since no architectural plans survived from this era, it is hard to determine the true nature of the design at that stage. Nevertheless, a single typical floor plan dated from February 1968 that was found by the author in the University of Haifa Archive (Figure 6.18)[16] shows precisely what was described by Mirkin in his article:

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[16] Although the plan is not clearly signed, probably because of copying fault that cut the credits line out of the drawing sheet, another drawing which is kept at the same location, dated from 15 September 1968, does contain a full credit box. This later drawing shows window details of the main building, and seems to belong to the same drawing set as the February 1968 drawing of the typical floor plan. The credit line of the later drawing indicates Niemeyer, Müller, and Gilead (in

a south-eastern facade divided by perpendicular vertical "fins", and a north-western facade screened by diagonal vertical elements of different angles. The vertical "fins" of the south-eastern facade are 100 cm deep, extending (with a minor gap of about 10 cm) from the external surface of the windows outwards. They appear in 1.66 m intervals along the facade, reflecting the module that was later changed because of the constraints of the FEAL system modulation. In addition to the vertical "fins", limited horizontal shading could have been provided by the floor slabs, which protrude about 45 cm from the external window surface.

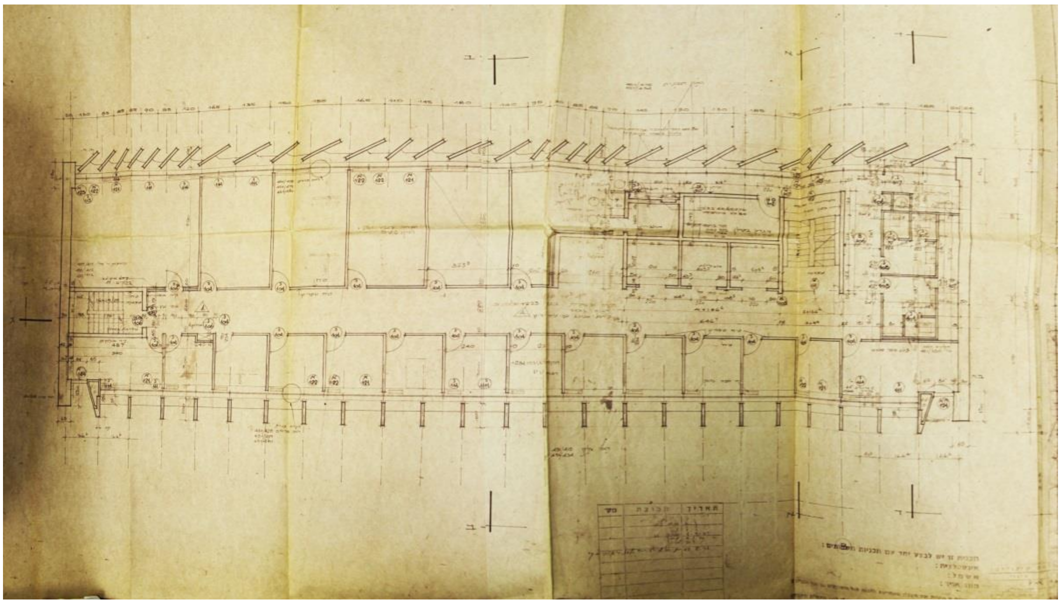


Figure 6.18: Early typical floor plan of the Eshkol Tower, unsigned, dated from 6.2.1968 (University of Haifa Archive, container 0735). On the south-eastern facade a 1.66 m module was applied for the sun breakers. While the same module was applied for the windows of the north-western facade, the vertical diagonal sun breakers were arranged in what seems to be a random modulation

Based on Gilead's answers to Mirkin, it must be assumed that the 1968 drawing shows a sun breakers design which was conceived solely by Niemeyer. By chance, this design was not wholly left on paper: since the sun breakers were supposed to be part of the structural system of the tower, they were realized in their original shape when the tower's

---

that order) as the designers, and is identical to the credit box which also appeared on the architectural drawings of the March 1974 tender. The copy kept in the archive holds a distribution list in which the last registered date is 17 August 1971, possibly indicating that the design was kept unchanged long after Givoni's critique was publicized.

basement floors were cast as part of the construction of the main university building. Plan of the realized upper basement floor, as built, was included in the 1974 tender documents (Figure 6.19); it shows a sun breakers arrangement identical to the 1968 plan. Photographs taken during the construction of the main building show basement floors realized with the original sun breakers design (Figure 6.20 and Figure 6.21).

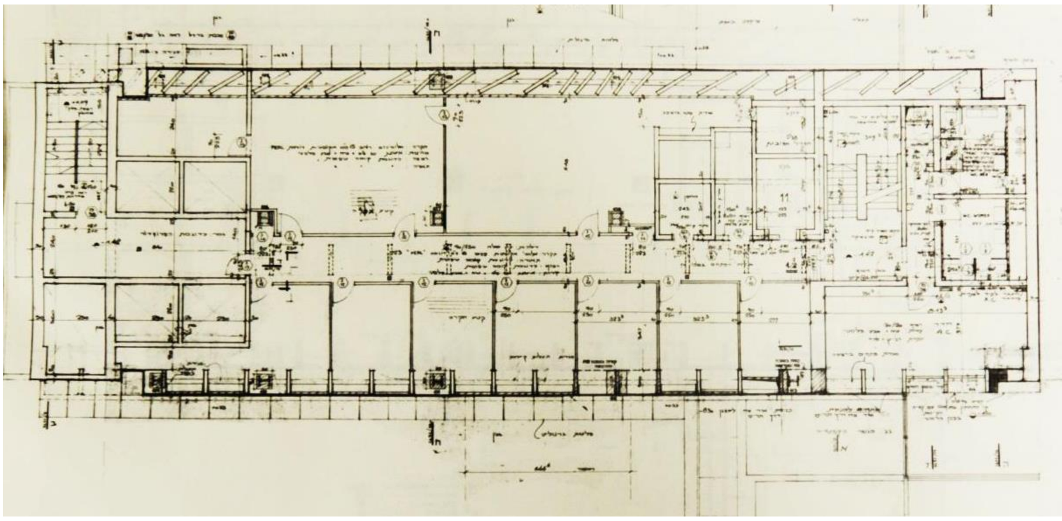


Figure 6.19: Architectural plan of level -1.42 of the Eshkol Tower, as appears among the March 1974 tender plans (University of Haifa Archive). The plan shows the original sun breakers design of Niemeyer as was already realized in the tower's basement floors

Figure 6.20: A detail from an aerial photograph taken during the construction of the main building of the university, showing the realized south-eastern facade of the basement floors of the Eshkol Tower (University of Haifa Archive)

Figure 6.21: A detail from an aerial photograph taken during the construction of the main building of the university, showing the realized north-western facade of the basement floors of the Eshkol Tower, including the diagonal vertical sun breakers (University of Haifa Archive)

Reconstruction of Niemeyer's original design can also be assisted by his later project for the University of Mentouri in Constantine, Algeria, designed and fully realized by Niemeyer between 1971 and 1977. The campus consists of several structures, one of them is a tower of 21 storeys (above ground) which resembles in many senses the tower designed by Niemeyer in Haifa (Figure 6.22). The tower's main facades, which face north and south, are identical in their design: the facade is divided into 16 equal fields by vertical concrete "fins" which extend from the basement to the tower's full height. In contrast to the Eshkol Tower, these "fins" narrow as they climb up the facades, creating an uneven shading effect along them. It is hard to describe them as "sun breakers", since their shading effect seems minimal (Figure 6.23); yet they create a visual effect which could have been intended by Niemeyer also for the Eshkol Tower. This visual effect was significant enough also for Gilead, who insisted on keeping the vertical sun breakers even when all other aspects of the facade design have already been changed.

Figure 6.22: Oscar Niemeyer, the administration tower at the University of Mentouri, Constantine, southern facade (photograph by Mostafa MT, Panoramio)

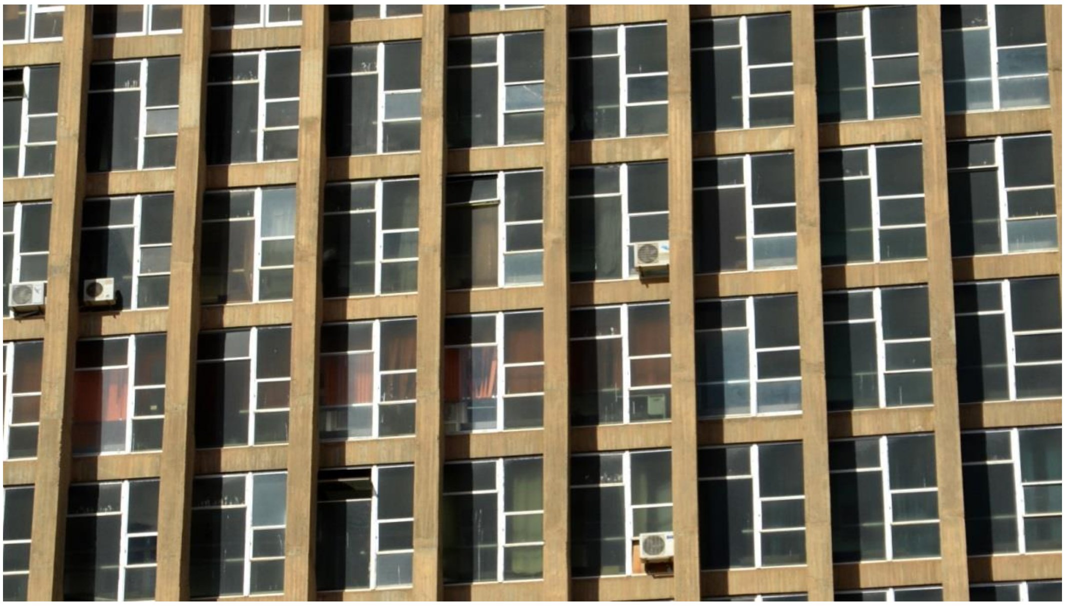


Figure 6.23: Oscar Niemeyer, the administration tower at the University of Mentouri, Constantine, detail of the southern facade (photograph by alxalmeida, Panoramio)

The University of Haifa tower was not the first project in which Niemeyer designed diagonal sun breakers. Similar concept appeared in two of his projects from the same years: the Ministry of Justice Building (today: Palace of Justice Raymundo Faoro) in Brasília (designed in 1962 and completed in 1972), and the Edmond de Rothschild House in Caesarea (designed in 1965 and never realized). In the Ministry of Justice (Figure 6.24) the diagonal sun breakers were applied in the north-western facade (Figure 6.25); from the sketches for the Rothschild House (Figure 6.26) the orientation of the sun-protected facade is not clear. In the Ministry of Justice, the sun breakers are located in a fair distance from the building's curtain wall, while in the Caesarea house it is not clear if the wall right behind them is opaque or transparent. Their tilt in the Ministry of Justice is opposite to that of the sun breakers of the Eshkol Tower, indicating that, contrary to Mirkin's suggestion, Niemeyer did adjust his design to the sun positions in the northern hemisphere.

Figure 6.24: Oscar Niemeyer, the Ministry of Justice Building in Brasília, 2014 (https://goo.gl/HxTzN5). The diagonal sun breakers of the north-western facade are seen to the left

Figure 6.25: Oscar Niemeyer, the Ministry of Justice Building in Brasília, redrawn site plan by Ferreira and Máximo (2013) showing the diagonal sun breakers to the left

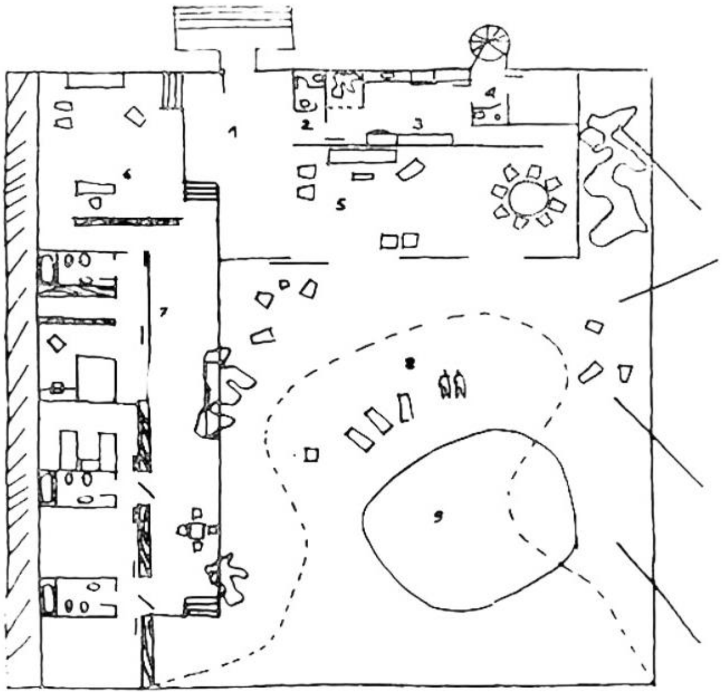


Figure 6.26: Oscar Niemeyer, sketch for the Edmond de Rothschild House, Caesarea, 1965, showing diagonal sun breakers to the left (Philippou 2008, 206)

Givoni's expert opinion was not left unnoticed by Niemeyer and Gilead, and though it is hard to find documents in which any of them directly refer to Givoni's critique on the design of the sun breakers, Givoni's claim that the solar protection of the south-eastern facade is "ineffective" was probably behind its redesign. On 11 October 1968 Hans Müller, Niemeyer's partner, wrote to Gilead from Rio, replying to letters by Gilead and Koen, as well as to a recent cable from Gilead (all probably lost). Müller was referring to the south-eastern sun breakers, probably in response to a proposal of Gilead to add to them horizontal sun breakers, just as Mirkin was suggesting in his article:

> We apologize for the delay, but it was rather difficult to find a good solution. Everything seemed havy [sic.] and bad. Maybe it is the best, to abandon further horizontal sunbreakers. Maybe with our new suggestion we don't need them any more. We thought also, if necessary, of curtains made out of plastic or wood in the interior. (Müller 1968)

To the letter Müller attached a new typical floor plan of the tower, drawn probably by him and dated from 1 October 1968, in which the south-eastern facade received "exactly the same" sun breakers as the diagonal sun breakers already designed for the north-western facade. The plan, like Müller's letter, is kept in the Shlomo Gilead Collection at Israel Architecture Archive. Some remarks were written by Müller on the plan, including one which explained the technical logic behind the new design: "if elements are distributed like this, they can give maximum protection of sun beams considering 9^{00} o'clock; later, the sun will rise and will not enter anymore so deep in the building" (Figure 6.28). In a sense, Müller was actually following part of Givoni's suggestion, as quoted by Mirkin, to flip between the sun breakers designs of the two facades, but without changing the design of the north-western facade, in spite of Givoni's prediction that its sun breakers would result in undesirably low indoor illuminance levels.

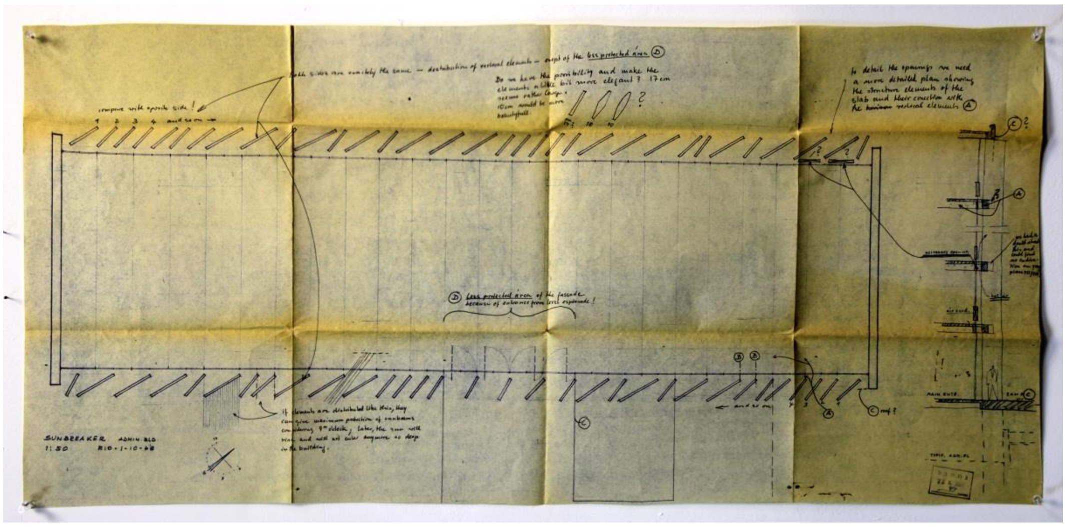


Figure 6.27: Hans Müller, an updated design of the sun breakers of the south-eastern facade, drawn in Rio and signed on 1.10.1968 (Shlomo Gilead Collection, Israel Architecture Archive)

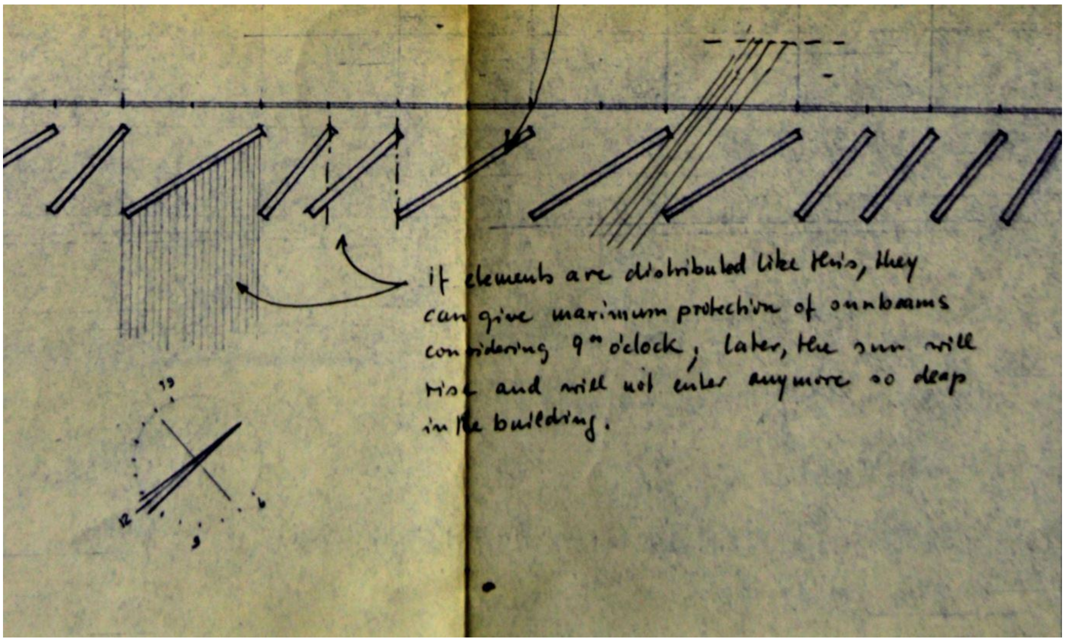

if elements are distributed like this, they can give maximum protection of sunbeams considering 9 o'clock; later, the sun will rise and will not enter anymore so deap in the building.

Figure 6.28: Hans Müller, a remark explaining the technical function of the new sun breakers design, a detail of the 1.10.1968 plan (Shlomo Gilead Collection, Israel Architecture Archive)

The new design was not accepted. On 10 December 1968, in a planning coordination meeting at the University of Haifa, some examples for synthetic curtains, coated on their external side with reflected aluminium strings, were presented to Gilead, who noted that this is only a partial solution since "a portion of the heat will remain indoors". Rafaeli then suggested "to return to the first solution, which is placing elements on the building's exterior". Eventually it was agreed that Gilead would come up with a design of a "delicate external sun breaker" (Planning Coordination Committee of the University of Haifa 1968). A month and a half later, On 25 January 1969, Gilead sent another letter to Niemeyer's office, explaining the problem he is facing with the sun breakers design and the reasons for the rejection of Müller's proposal from 1 October 1968:

> Dear Prof. Niemeyer,
>
> After a short delay, I send you three proposals for the solution of administration building sun breakers (S-E elevation). The delay was caused because I tried hard to solve the problem without fixed sun breakers. I reverted to the fixed form only after all my proposals for venetian blinds, etc. were rejected.
>
> In our drawing nr 1 you can see a precast concrete sun breaker, in drawing nr 2 and 3 an asbestos cement form.
>
> Its size is a function of the sun height (in December). The foundations are already finished, so it is not possible to change the order of the vertical structural sun breakers in this S-E side (your letter from October 11th 1968).
>
> [...]
>
> The matter of the sun breakers of the tall building is very urgent and I implore you to answer as quickly as possible, either by pointing at one of the alternatives, or suggesting your solution. We are already lagging behind the present state of execution. (Gilead 1969)

The main problem with the redesign of the sun breakers (in both facades) was probably their structural role. Since the foundations of the building were already cast according to the 1968 plans, any change in their location meant that the structural scheme of the tower would have to be revised. Niemeyer's final proposal, presented by Gilead during a planning coordination meeting on 4 May 1969, was to use "straight asbestos boards whose angle can be changed". This suggestion, however, was not welcomed, because of "concern to the form of the facade", and the design of a diagonal L-shaped concrete precast was suggested as an alternative (Planning Coordination Committee of the University of Haifa 1969). This was probably the last time the design of the sun breakers was discussed between Gilead and the University authorities. Delays in the execution of the main building made the facade design of the tower less urgent than was believed in late 1968. Nevertheless, in spite of the rejection of Niemeyer's proposals, a new model of the tower was built, this time with what seems to be perfectly diagonal sun breakers for the south-eastern facade (Figure 6.29 and Figure 6.30).

Figure 6.29: A model of the Eshkol Tower reflecting the original sun breakers design by Niemeyer for the south-eastern facade, ca. 1968 (Shlomo Gilead Collection, Israel Architecture Archive)

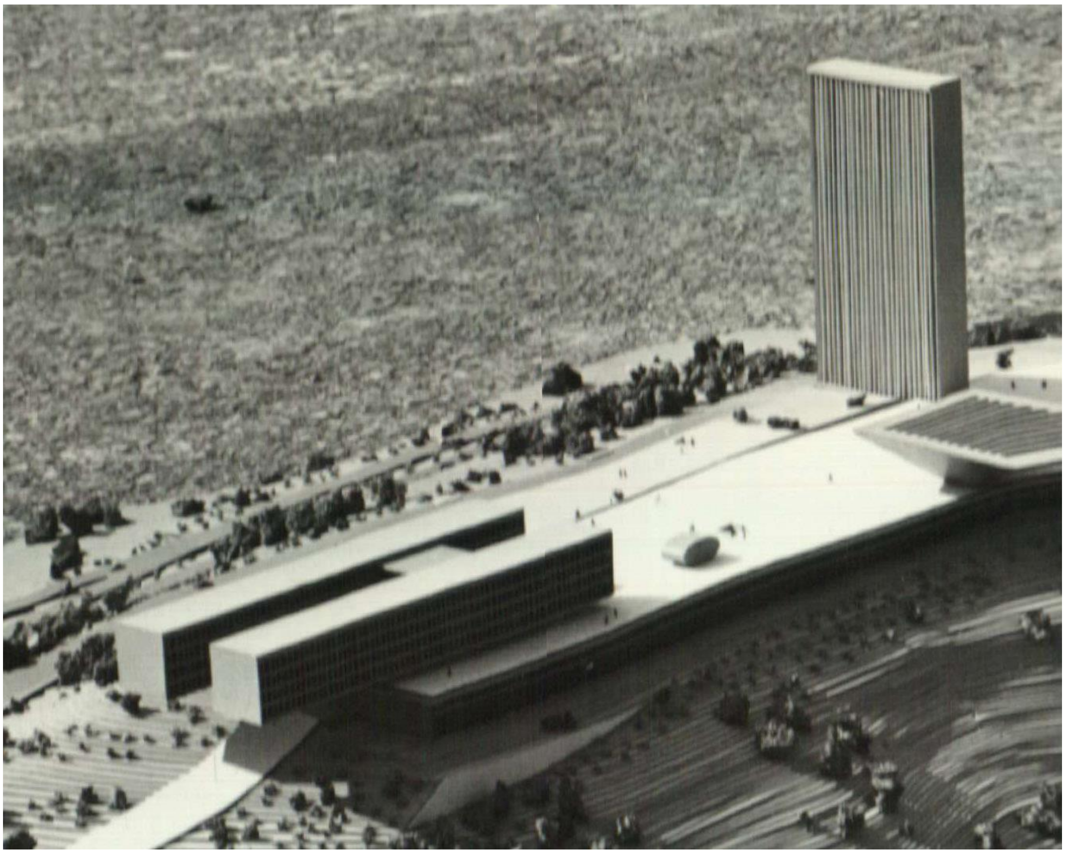


Figure 6.30: An updated model of the Eshkol Tower, reflecting a new design of the sun breakers of the south-eastern facade, ca. 1969 (Shlomo Gilead Collection, Israel Architecture Archive)

6.2.2 Shlomo Gilead's redesign of the sun breakers

While Niemeyer's original design of the facades still appeared in plans distributed during 1971, this was no longer the case with the plans prepared by Gilead for the March 1974 tender. Although the redesign of the facades owes more than a little to the decision to redesign the tower as a steel structure, two major changes in the original design were made before the decision was taken. The author was unable to trace plans from the tender of December 1971, which was put on hold because of the government's construction ban, but a copy of a typical floor plan, dated from 15 April 1973, was found among other documents relating to the tower kept at the Haifa Municipality Archive. The drawing is signed only by Gilead; it reflects the construction of a concrete structure, as indicated also by its title.

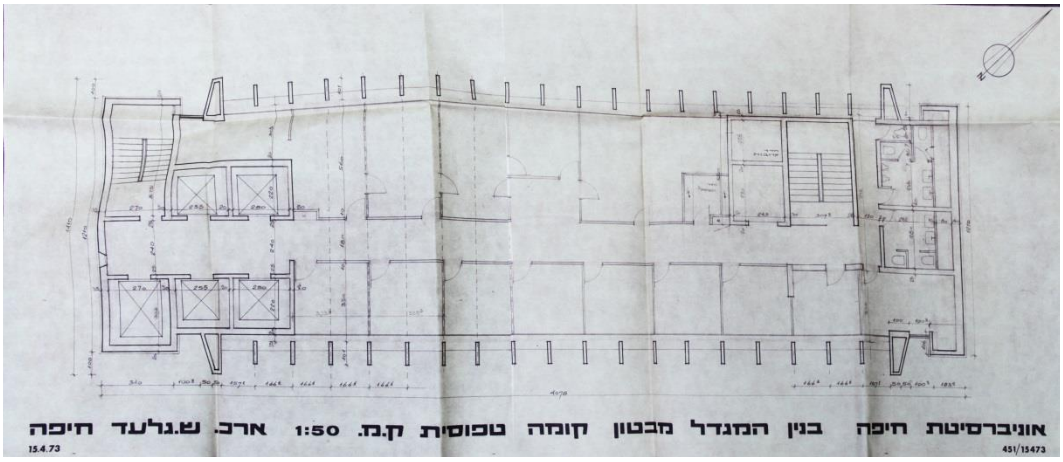


Figure 6.31: Typical floor plan of the Eshkol Tower, to be realized in concrete, signed by architect Shlomo Gilead and dated from 15.4.1973 (folder 2486/3, Haifa Municipality Archive)

The April 1973 plan consists of two major differences when compared to the February 1968 plan: the first is the addition of a second service core for five elevators on the south-western side of the towers (in the 1968 plan the building's four elevators were all located in a north-eastern service core); and the second is a new design of the vertical sun breakers of the north-western facade. Here, the diagonal sun breakers were replaced by perpendicular sun breakers, identical to those attached to the south-eastern facade. As in the 1968 plan, all vertical "fins" were 100 cm deep and arranged in 1.66 m intervals. The modification of the north-western facade may reflect a sober acknowledgement of the validity of Givoni's criticism, or at least of his assertion that the diagonal sun breakers will result in dark interiors in the north-western part of the tower.

The issue of the sun breakers design was reopened for discussion when FEAL's curtain wall system began to be considered. On 30 November 1972, the design team of the Eshkol Tower, including Gilead, Sivan, and Shnabel, held a meeting with Udassin and engineer Pareen, a representative of FEAL. Udassin presented two options for a steel structure: the first, by FEAL, was based on a new 1.20 m modulation, while the second, which was designed by a Dutch-Swedish engineering firm, kept the 1.66 m modulation of the original plan. According to the meeting minutes,

> Gilead said that he favours the second proposal which copies the original design. As for FEAL's proposal, he does not

> object to the new module of 1.20 m, as long as the sun breakers will be consistent with the original proposal of Prof. Niemeyer, with dominant vertical elements. (Eshkol Tower Design Team 1972)

About three months later, Gilead, Sivan, and Shnabel visited Italy for the first time in order to discuss all the constructions details with FEAL's engineers (Sivan 1972b). FEAL proposed vertical sun breakers that were consistent with the standard FEAL 1.20 m module, projecting from the facade by "11+32 cm", while "the rest requires the covering by venetian blinds or suitable glass" (Shnabel 1973a). Yet in a meeting between Gilead, Shnabel, and FEAL's representatives, Russo and Pareen, in Haifa on 8 April 1973, the "solution of horizontal sun breakers instead of the vertical" was discussed (Eshkol Tower Design Team 1973a). This was the first indication that horizontal sun breakers, which did not exist in Niemeyer's original design, were being considered for the tower.

During the first week of May 1973, Gilead, Sivan, Shnabel, Nissenbaum (system engineer), and Udassin visited Italy again to meet with FEAL's engineers. One of the main issues that were being discussed was the design of the horizontal sun breakers. After much consideration, Gilead chose a solution in which metal-sheet elements will be installed "from the window sill to the required level under the window in order to obtain the desired shading" (Shnabel 1973b). Yet on 25 May 1973, in a meeting of the design team, Gilead told the participants that he is working on two optional facade designs, both with vertical shading elements. He added that he "arrived at the conclusion that the horizontal sun breakers do not provide an architecturally satisfactory result, and therefore a solution with the vertical sun breakers was worked out" (Eshkol Tower Design Team 1973b).

Gilead suggested two optional sun breakers modulation, of 60 and 80 cm, and probably intended to combine horizontal and vertical elements. The new design must have had its effect on the cost of the tower's shading system, since about a month later, in another meeting of the design team, Gilead found it necessary to stress that he is "giving the utmost importance to the shading of the rooms since without it he thinks that the building is unusable" (Eshkol Tower Design Team 1973c). In August 1973, the sun breakers' cost was estimated at 500,000 USD, while the total cost of the steel structure, curtain walls, and indoor partitions was 2,000,000 USD (Rafaeli 1973).

In the end, the combined solution which was worked out by Gilead was the realized one. In the final design, the vertical elements were complemented by three horizontal bent aluminium sheet elements that did not appear in Niemeyer's design. The March 1974 tender included typical sections of the shading system (Figure 6.32), as well as a literal description of the final design (Figure 6.33 and Figure 6.34):

> Sun breakers are constituted of a vertical bearing structure, placed at a distance of 750 mm. from the facade, supported by transoms joined to facade mullions in correspondence of every floor of the Building. The vertical bearing structure consists of a mullion made out of an aluminium sheet 2 mm. thick, anodized in light bronze, having a 250 x 120 mm. section rigidized [sic.] at intervals by aluminium extruded profiles, having the necessary design strength. The horizontal elements consist of alu. sheets, of an adequate thickness according to dimensions and loads which they are subject to anodized in medium bronze. These elements, besides the real function of sun breakers, contribute to the horizontal stiffening of the bearing structure, joining among them all the mullions which constitute the structure. (University of Haifa 1974, 6)

The final design of the horizontal elements provided protection against a relatively wide range of sun angles. The vertical elements, which were now only 25 cm deep, were repositioned in a distance of 75 cm from the windows surface and in 1.20 m intervals; this made them much less effective as shading elements and practically minimized their role to the provision of structural support to the horizontal shading elements. In addition to the articulated sun breakers system, internal venetian blinds were also installed in all spaces (Figure 6.35).

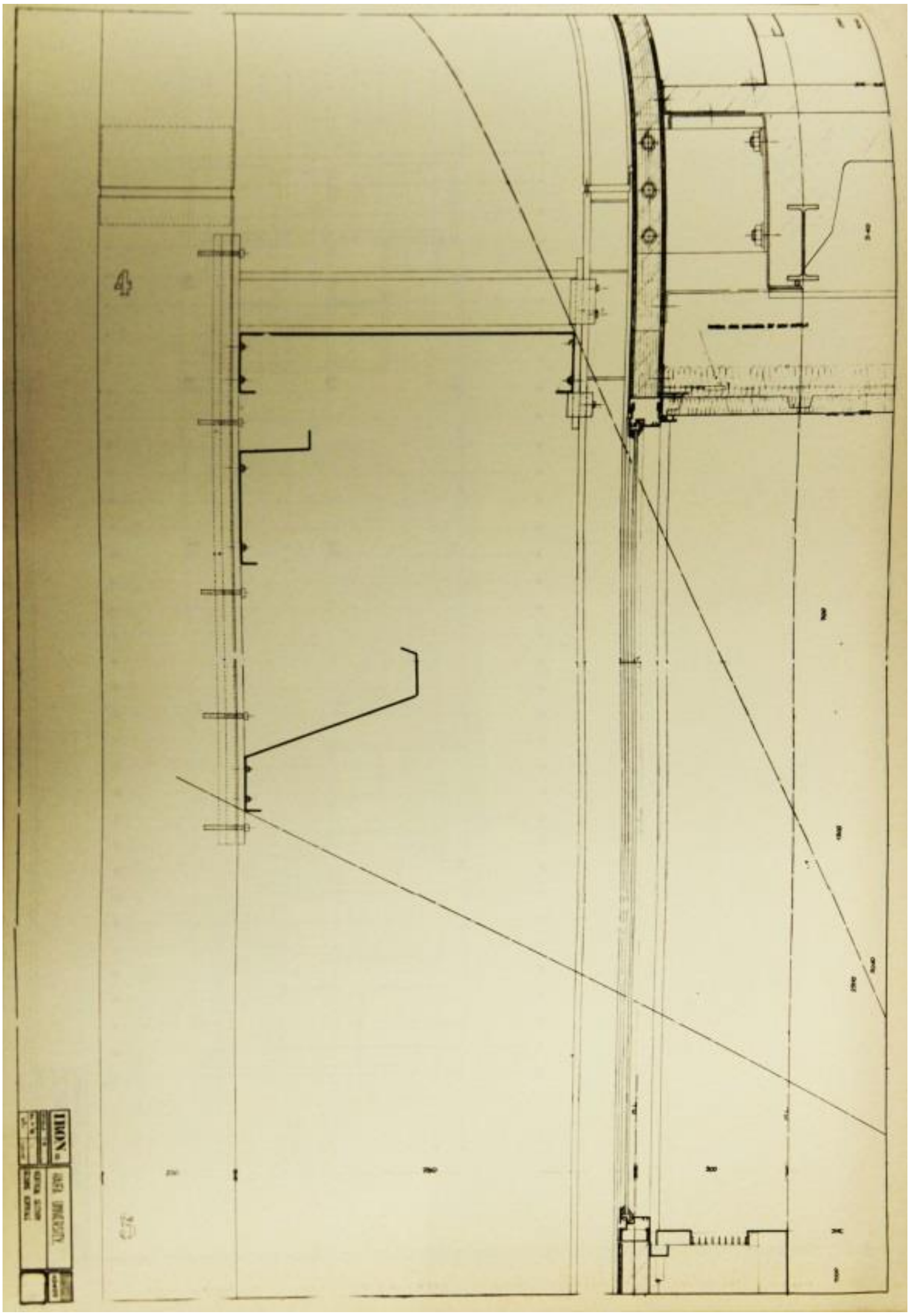


Figure 6.32: IRON, a vertical cross section of a typical window showing the realized sun breakers system of the Eshkol Tower, as appeared in the March 1974 tender (University of Haifa Archive)

Figure 6.33: Eshkol Tower, the sun breakers system as realized, the south-eastern facade, 2013 (photograph by the author)

Figure 6.34: Eshkol Tower, the north-western facade, 2013, showing the realized sun breakers system in its full extent (photograph by the author). Identical sun breakers were installed also on the south-eastern facade

Figure 6.35: Eshkol Tower, the south-eastern facade, December 2013, showing the extensive use of venetian blinds in the rooms (photograph by the author).

6.2.3 The curtain wall of the Eshkol Tower

The Eshkol Tower was the first high-rise building in Israel to use a light-weight curtain wall. As realized, the curtain wall consisted of 1.50 m high window strip (fixed and openable) and a 1.54 m high opaque spandrel in each of the typical floors. According to the March 1974 tender documents, the windows were made of anodized aluminium frames 60 mm thick, with normal, non-toughened translucent 6 mm glass. The spandrel was of the same thickness (60 mm), consisting of an external face of anodized aluminium sheet, asbestos cement plates filled with 40 mm urethane foam, and an internal painted steel sheet (University of Haifa 1974, 4).

Lack of adequate documentation makes it hard to determine whether a similar curtain wall composition was also prescribed by Niemeyer. Nevertheless, it is more than likely that Niemeyer intended to use much larger glazing surfaces for the Haifa tower, as in many other projects he designed since the late 1930's. In his design of the curtain wall of the administration tower at the University of Mentouri a few years later (see above, Figure 6.23), the entire wall surface between the external concrete columns and the floor slabs was fully glazed.

Although the curtain wall composition was expected to have a major effect on the tower's indoor climate, it is surprising to note that even during the long negotiations between Gilead and FEAL (the curtain wall manufacturer) the issue of its climatic performance was not given any attention, at least not in a way which was documented. During his two visits to Italy in February and May 1973, Gilead's main concern regarding the windows was their operability (Shnabel 1973a, Shnabel 1973b), not their thermal properties (eventually, it was agreed that in each floor half of the windows could be opened, while the other half should remain fixed). As far as the original protocols of the meetings in Italy reveal, the thermal properties of the windows and opaque spandrels were not discussed.

Another issue that was not discussed during the negotiations with FEAL, and probably even not in any internal discussion between Gilead and the university officials, was the glazing ratio of the facades. The modified design resulted in a glazing ratio slightly lower than 50% of the external wall area; this reflected a glazing to floor area ratio of 27% in the north-western facade and 34% in the south-eastern facade. In comparison to other contemporary towers in Israel of that period, the Eshkol Tower was the first to employ massive use of facade glazing; this alone should have called for a much closer examination of the thermal effects of the design.

Glazed curtain walls were not totally new to Israel of the 1950's and 1960's. Since the mid-1950's, several public, commercial, and office buildings (all of them low-rise) were designed with a relatively primitive glass wall construction; many of them were not based on industrialized system of any sort. One of the pioneers of this type of glass application was architect Dov Karmi, whose designs from that time combined relatively large glazing surfaces with elaborate sun protection devices. Maybe the most known of these attempts was Karmi's ZIM House in Tel Aviv, which was built in 1956-1957. An office building of four storeys, three of its facades were sealed by a curtain wall consisting of wooden-frame windows and opaque asbestos cement panels 10 mm thick (Givoni and Niv 1964a, 6). The building was destroyed in a fire that broke on the morning of

4 February 1966 (Figure 6.36); the fire's devastating results (one person dead; the full consumption of the building) were the outcome of the use of light and flammable materials for the building's inner partitions, as well as for the insulation of the air conditioning ducts (at that time, no fire safety regulations existed in Israel).

Figure 6.36: The fire at the ZIM house in Tel Aviv, 4 February 1966, the southern facade (courtesy of Lior Taharany, Tel Aviv Firefighters Archive, Israel Fire and Rescue Authority)

The notorious fate of Karmi's pioneering glass facade (though not a direct outcome of its design) might have had some influence on the avoidance of fully-glazed curtain wall constructions in Israel for more than another decade. As taller buildings were starting to emerge, a local idiom came into being; it rejected the curtain wall concept and replaced its slick appearance with the bulky expression of horizontal strips of dominant exposed (and mainly prefabricated) concrete in which the deep windows were almost hidden from sight (Figure 6.37). The idiom, which was clearly influenced by the contemporary Brutalist fashion, was also perceived as climatically adapted to the Israeli conditions, mainly because of the shading provided by the deep window strips, the lower glazing ratio of the facades, and the thermal mass of the concrete elements of the facades.

Figure 6.37: Moshe and Mordechai Ben Horin, Metzudat Ze'ev office building in Tel Aviv (1963-1965), 2011 (photograph by Yoav Lerman)

Just as this transition in taste was starting to take place, the Building Research Station at the Technion initiated a broad study, financed by Israel's National Council for Research and Development, on curtain walls. Baruch Givoni, who directed the research, was assisted in parts by architect Amnon Niv (1930-2011) and physicist Milo Hoffman. The study produced five reports, each dealing with different aspects of curtain walls: report on a tour in Europe (Givoni 1963), survey of buildings with curtain walls in Israel (Givoni and Niv 1964a), literature survey and analysis of problems (Givoni and Niv 1964b), survey of local factories which may contribute to the development of curtain walls (Givoni and Niv 1964c), and finally an experimental study of the thermal characteristics of curtain walls in warm climate (Givoni and Hoffman 1965b).

The curtain walls study was not dedicated only to questions of indoor climate; as a matter of fact, it provided an extensive overview of many technical aspects of curtain walls construction, including structural behaviour, available construction materials, construction details, and sealing options. The combination of literature survey, a tour to factories and construction sites in Switzerland, France, England, the Netherlands, Denmark, and Sweden, on-site survey of realized curtain walls in Israel, survey of local manufacturers of relevant building materials and elements, and physical measurements of experimental settings, produced an unprecedented body of knowledge that could have benefited local architects.

Givoni and Niv's description of local realizations of curtain walls, based on site inspections of ten projects, may explain why the curtain walls' appeal was already waning in Israel of the mid-1960's: the wooden or aluminium frames used for their construction were either badly maintained or inaccurately assembled; "thermal treatment" of the walls did not exist; noise insulation was poor; glazing surfaces were larger than needed, resulting in excessive glare and overheating; shading devices were inefficient, resulting in higher or lower than needed illuminance levels; and unexpected maintenance problems were common (Givoni and Niv 1964a, 2-5). Although the authors intentionally abstained from exposing the names or locations of the examined buildings, it is easy to identify the ZIM House as the first example which appeared in the report. Here, the occupants testified on glare, overheating, lack of adequate illuminance, ventilation problems, and excessive noise even when windows were closed (Givoni and Niv 1964a, 6-8).

The more theoretical analysis of possible problems pertaining to curtain walls constructions in Israel, which appeared in the third report of the study, dedicated a chapter to "problems of indoor climate". Givoni and Niv began their analysis by claiming that "it is still unknown how to design curtain walls without air conditioning in a way that will secure reasonable indoor climate conditions under heat". They traced the weak spot in the very low thermal capacity of the opaque elements of the curtain walls, as well as heat and light penetration through windows (Givoni and Niv 1964b, 49-51). The local experiment published by Givoni and Hoffman a year later, which examined only the thermal properties of opaque curtain wall elements under local conditions, reiterated this assertion, and added a more detailed analysis, as well as and design recommendations:

> In regions where outdoor air temperature does not rise above the comfort level, according to the local level of vapour pressure (Givoni 1963) and daytime ventilation is advisable, curtain wall structures could provide comfortable conditions, if internal heating by penetration of solar radiation is prevented (Givoni and Hoffman, 1964). In such regions the design of the building should ensure the possibility of cross-ventilation of the structure, especially in the evening. In Israel, this applies to the sea-shore region [where Haifa is located] and the mountains of the Galilae [sic.] and Jerusalem. The thermal resistance of the walls in these regions should be such that the maximum internal surface temperature in ventilated buildings should not rise more than about 2°C above the air maximum. The actual value of the thermal resistance which is required to meet this demand, depends mainly on the external colour. In any case, for residential buildings a minimum value of thermal resistance should be secured, to ensure winter comfort and prevention of condensation.
>
> A tentative value for the thermal resistance of the walls of about R=1.0 (in^2 x °C x hr / kcal) is recommended for the sea-shore region and of R=1.5 for the mountains and inland regions. Further research is required for the establishment of more accurate specifications. (Givoni and Hoffman 1965b, 3)

In respect to the use of glass, the curtain walls study was limited. In the literature survey included in the third report, a list of common glass types did appear (sheet glass, tempered glass, plate glass, porcelain enamel glass, double glazing, laminated glass, and heat absorbing glass), as well as elaborate descriptions of their manufacturing processes and typical properties (Givoni and Niv 1964b, 30-31). Yet the study did not try to recommend an "ideal" glass to facade ratio, in spite of its implicit criticism of the larger than needed glazing surfaces in the locally surveyed buildings.

The curtain walls study was not the only local scientific effort that could have assisted the design of the curtain wall of the Eshkol Tower. In 1964 Givoni and Hoffman published a report on the "effectiveness of shading devices", in which they analysed the effect of typical shading devices under the Israeli sun, based on theoretical calculations. The study was very clear in its conclusions: for eastern and western windows, the authors recommended a horizontal window with combined horizontal and vertical shadings (in their words, "frame shading"). They added that contrary to the common belief among architects, vertical window with "infinite" vertical shading is not the most suitable for east and west facades but actually the worst option. For southern windows, the authors recommended horizontal windows with "infinite" horizontal shading. For south-eastern and south-western windows, a horizontal window with "frame shading" was recommended as the most efficient shading type (Givoni and Hoffman 1964). These conclusions were based on the yearly performance of the shading devices and took into account the desired penetration of sun during winter.

Givoni's criticism of Niemeyer's design was thus backed by several studies in highly relevant issues. Yet even Givoni, who openly expressed his concern from the sun breakers design, did not say much about the initial decision to use a curtain wall, not to mention other matters of materials selection, assembly techniques, and future maintenance. Givoni's silence on these issues is even more surprising because of the unprecedented size of the tower's curtain wall (in Israeli terms) and the lack of local experience and expertise in curtain wall constructions.

6.3 Simulating the thermal performance of the Eshkol Tower

Baruch Givoni's criticism of the original design of the Eshkol Tower was decisive: Givoni thought that the combination of the building's orientation, the use of a light-weight curtain wall, and the sun breakers design would result in a building that would unnecessarily depend on air conditioning. His suggestion was to redesign the sun breakers system in order to overcome what he viewed as future climatic problems. Eventually, the sun breakers system went through a process of redesign, but this happened at a much later stage, and without any direct involvement of Givoni. Thermal simulation of the Eshkol Tower is capable of providing information for assessing Givoni's analysis, comparing the thermal performance of the original sun breakers design of Niemeyer with the modified designs of Gilead, and determining to what extent other design decisions (buildings orientation, curtain wall composition) negatively affected the indoor climate.

The thermal performance of the tower was evaluated using version 8.1 of the EnergyPlus simulation engine (U.S. Department of Energy 2013). In order to simplify the comparative analysis, indoor climate was simulated for the north-western and south-eastern parts of the tower's 13th floor, a level located about 40 m above ground. This was done after preliminary analysis showed negligible differences between the 13th floor and the top and bottom typical floors. A comprehensive detailing of the tower's building materials appeared in the March 1974 tender documents, which included architectural and structural plans, as well as written specifications. Assisted by historic photographs and on-site survey, it was possible to use it for accurately determine the composition of the main building components (Table 6.1). Physical properties (thermal conductivity, density, specific heat, and solar absorptance) of the building materials were extracted from existing literature (Table 6.2 and Table 6.3). Physical properties of windows (U-value, solar heat gain, visible transmittance) were calculated using version 7.2 of the WINDOW software (Lawrence Berkeley National Laboratory 2014b). Weather file of a sample year was created using Version 7.0 of the Meteonorm software (Meteotest 2012), based on monitored historic weather (from the years 1961-1990) and radiation (1981-1990) data. Illuminance simulations were conducted using the OpenStudio suite Version 1.5 (National Renewable Energy Laboratory 2014), which uses the Radiance 4.2 lighting simulation modules (Lawrence Berkeley National Laboratory 2014a).

Table 6.1: Main building elements of the Eshkol Tower

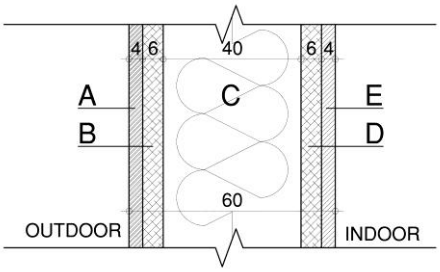
Building Element	Typical section (dimensions in mm)	Materials and resultant U-value
Curtain wall, opaque spandrel		A: Aluminium sheet, anodized, bronze hue B: Asbestos cement board C: Urethane foam D: Asbestos cement board E: Steel sheet, painted **U value: 0.626 W/m^{2}K**
Curtain wall windows	-	60x60 mm aluminium frame, anodized, bronze hue , 6 mm single transparent glass sheet, non-toughened
Roof	-	30 cm reinforced concrete slab, whitewashed
Ceiling between floors	-	5 cm thick concrete screed covered by a 4 mm foam bed and 3 mm vinyl asbestos tiles
External walls of service cores	-	Reinforced concrete of varying thicknesses (15-52 cm), exposed

Table 6.2: Thermal and physical properties of simulated materials

Material	**Thermal Conductivity (W/mK)**	**Density (kg/m^3)**	**Specific Heat (J/kgK)**	**Source**
Aluminium sheet, bronze hue	45	7680	420	(CIBSE 2006, 3-34)
Asbestos cement board	0.6	1920	840	(CIBSE 2006, 3-36)
Concrete screed	0.46	1200	1000	(CIBSE 2006, 3-47)
Reinforced concrete	1.9	2300	840	(CIBSE 2006, 3-37)
Steel sheet	45	7800	480	(CIBSE 2006, 3-34)
Urethane foam	0.028	30	1470	(CIBSE 2006, 3-34)

Table 6.3: Solar absorptance properties of simulated exterior materials

Material	**Solar Absorptance**	**Emissivity**	**Source**
Aluminium sheet, bronze hue	0.34	0.72	(CIBSE 2006, 3-42)
Reinforced concrete, exposed	0.73	0.93	(CIBSE 2006, 3-43)
Whitewash	0.35	0.9	(Givoni 1998, 75)

The Eshkol Tower was designed to be fully air conditioned. Since sufficient data on the actual air conditioning system which was installed in the building was not available for the author, and since the simulations aimed at evaluating the possible overheating of the indoor spaces under different shading elements and orientations, it was decided to simulate the building without air conditioning. A constant ventilation rate (1 ACH in all spaces) was used, based on the value given in the CIBSE guide to environmental design (CIBSE 2006, 5-8). This value is believed to reflect a constant closure of all windows in the building (no active natural ventilation). Internal loads (Table 6.4) were simulated based on typical occupancy schedules for weekdays and Saturdays (Figure 6.38 and Figure 6.39). On Sundays[17] it was assumed that no activity was taking place in the tower's typical office floors. These occupancy schedules reflect the tower's main use as an office building.

Table 6.4: Internal loads used for the simulation

Type	Value for Maximal Occupancy
People	0.1 person/m^2, 115 W/person (64 met)
Electric equipment	1 W/m^2
Lights	1 W/m^2

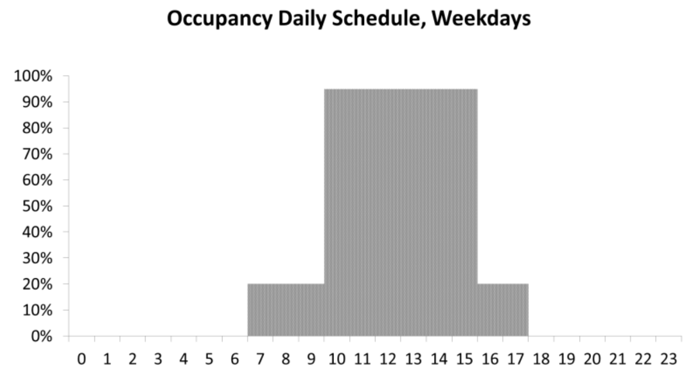


Figure 6.38: Occupancy schedule for weekdays

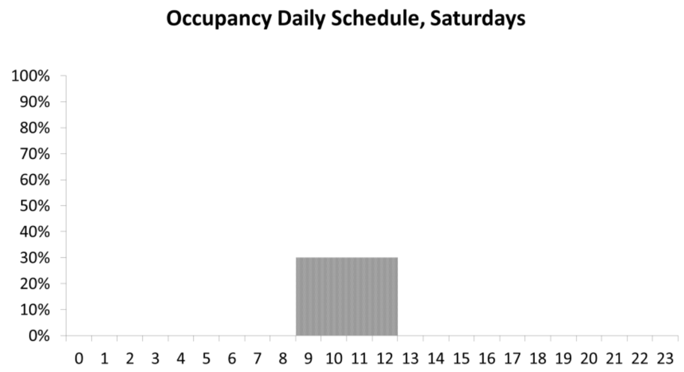


Figure 6.39: Occupancy schedule for Saturdays

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[17] The Israeli working week starts on Sunday and ends on Thursday. The university campus is open on Fridays until the early afternoon hours, which means some activities can take place in its buildings. Since EnergyPlus does not have an option of designating alternative days of a working week, the standard Monday to Friday scheme was used.

6.3.1 Effect of building orientation

In Mirkin's article about the tower, Gilead was quoted as saying that the building was oriented "as the mountain demanded, along the south-north axis, with a slight deviation". This was a false statement: the tower's main facades were oriented almost perfectly to the south-east and north-west. According to Gilead, the orientation was dictated by the natural characteristics of the given site, which allegedly left the designers no other choice in respect to the building's orientation. This claim, however, must not be taken at face value; what eventually determined the tower's orientation was the sculptural attitude of Niemeyer, who chose to place several geometric volumes on top of a vast monolithic "plateau" that he used for "levelling" the natural landscape of the mountain ridge.

In order to evaluate the thermal effect of the building orientation, four simulation scenarios were compared: a baseline scenario of the tower as realized, the building in a hypothetical orientation to the north and south, and two scenarios of the building with no sun breakers system: one oriented as the realized building, the other to the north and south (Table 6.5). Assessment was done by calculating "overheating rates" (defined as the percentage of hours with indoor temperatures above 27°C) for each scenario during daytime (07:00-19:00) only, since the building was not meant to be occupied during nighttime. Average results for the summer months (July-September), as well as for the cooler months of May, June, and October, are given in Figure 6.40.

Table 6.5: Simulation scenarios for evaluating the effect of building orientation

Scenario Name	Description
BS	The tower as built
NSOWS	The tower as built, main facades oriented to the north and south
NS	The tower as built, without sun breakers
NSO	The tower as built, main facades oriented to the north and south, without sun breakers system

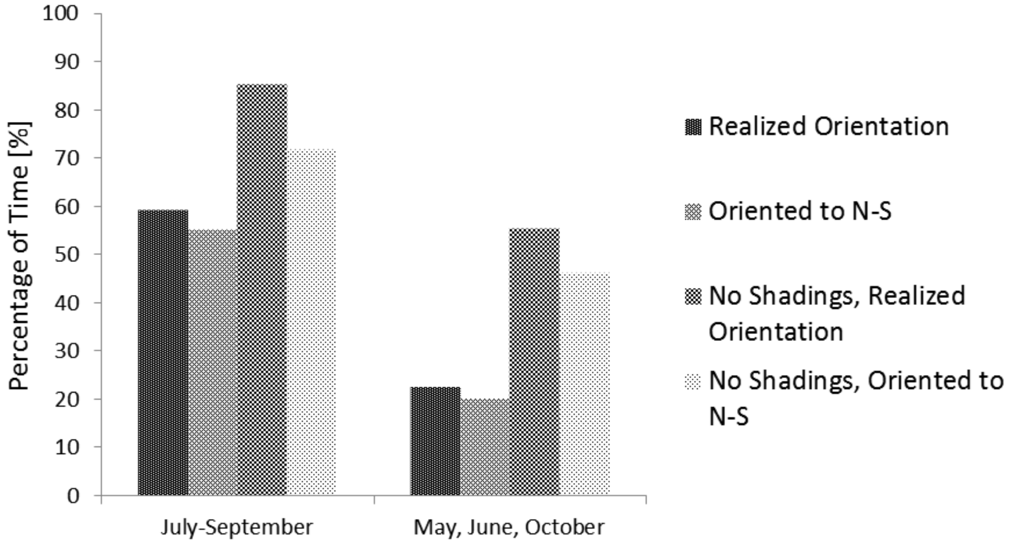


Figure 6.40: Daytime overheating rates for different orientations, with and without sun breakers, for the south-eastern side of the tower

The comparison shows that orientation had little effect on the overheating of indoor spaces during the hot season, mainly because of the application of sun breakers; similar results were obtained for the north-western and south-eastern rooms alike. With no sun breakers system, the north-south orientation reduced the daytime overheating rates during summer by 9.5% in the northern rooms and by 13.5% in the southern rooms. Analysis of the temperature amplitude for a typical summer day (calculated as the mean dry-bulb temperature of each hour separately between 1 July and 30 September) shows that a north-south orientation is indeed favourable, but has a very little advantage over the realized orientation because of the shading effect of the sun breakers (Figure 6.41 and Figure 6.42). Without shadings, a north-south orientation would have reduced indoor temperatures much more profoundly in the northern side of the tower.

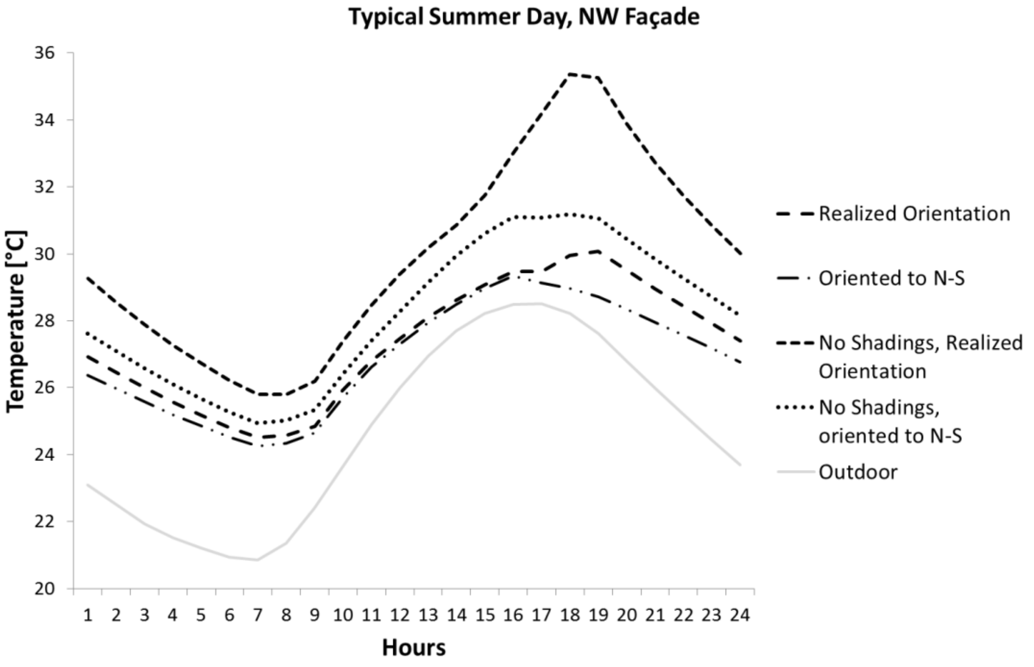


Figure 6.41: Daily temperature amplitudes for a typical summer day, the north-western side of the tower

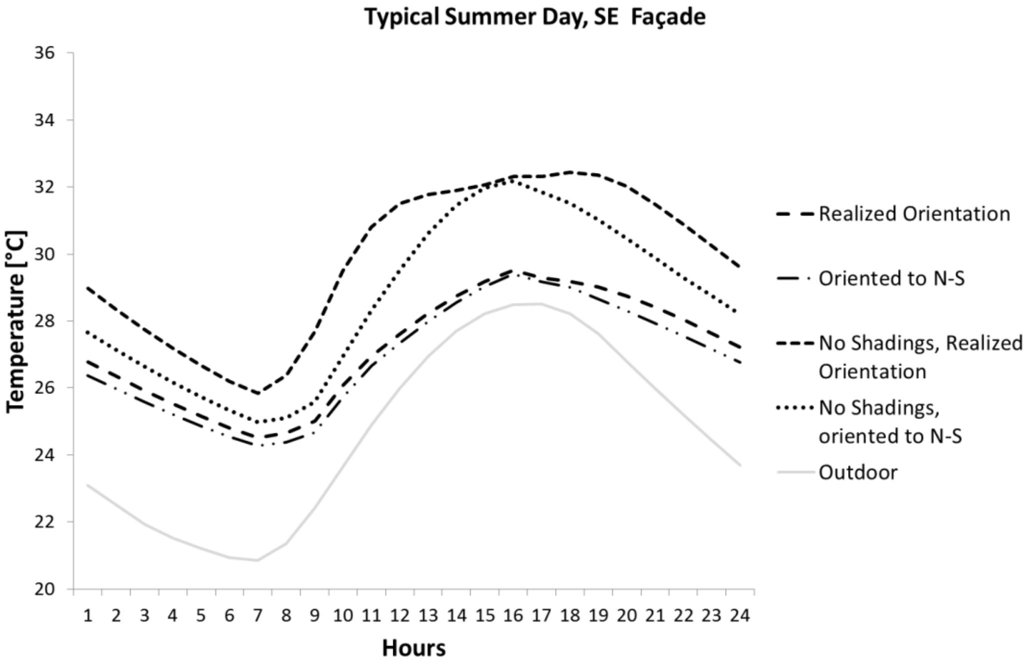


Figure 6.42: Daily temperature amplitudes for a typical summer day, the south-eastern side of the tower

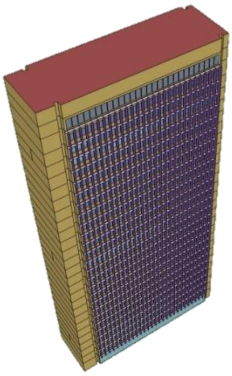
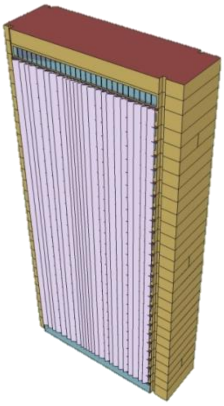
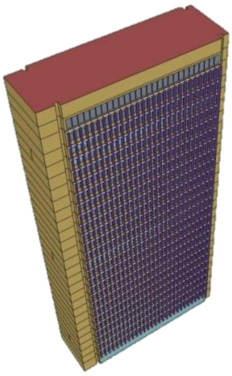
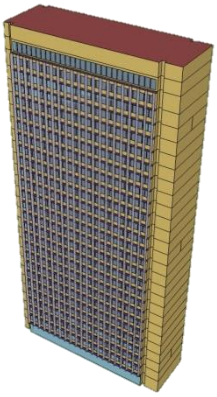
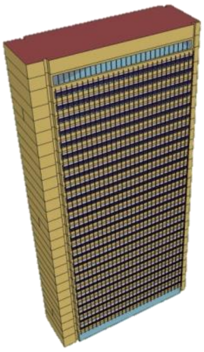
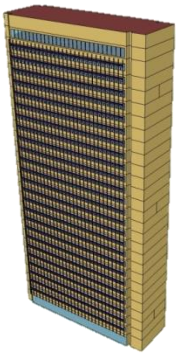
6.3.2 Effect of sun breakers design

Much attention was given by Gilead to the final design of the sun breakers system of the tower. When it was evident that the original concept by Niemeyer must be modified because of the transformation to streel frame, Gilead unsuccessfully tried to retain some visual resemblance to the original design while changing the sun breakers' material from concrete to aluminium. This resulted in a totally alternative shading system, in which elaborate horizontal elements were added, while the vertical elements were substantially narrowed.

Alongside Gilead's final design, two other versions of the sun breakers system were proposed during the design process (Figure 6.43): Niemeyer's original design, as appeared in the February 1968 plan, and Gilead's 1973 modification of Niemeyer's design, in which the north-western sun breakers were remodelled as a spitting image on the south-eastern ones. Niemeyer's original design was the one that received much criticism from Baruch Givoni, and this criticism probably motivated Gilead to modify Niemeyer's version in his two later proposals. It is therefore interesting to compare the thermal effects of the three alternative designs, as well as the discrete effect of each of the two components (horizontal vs. vertical) of the system which was eventually realized.

Since the redesign of the tower in each of the three stages (1968, 1973, 1974) involved also the changing of the total width of the window strip in each of the main facades (started with 36.65 m in 1968, narrowed to 31.47 m in 1973, and widened again to 33.60 m in 1974), it was decided, for the sake of comparison, to adhere to the final geometry and to simulate the earlier sun breakers designs on top of it. Therefore, the number of vertical elements in the simulated models of the 1968 and 1973 versions is different from their number in the original plans; at the same time, they are still arranged in 1.66 m intervals and are all 100 cm deep, as was originally designed. A full list of the scenarios which were used for this comparison is given in Table 6.6.

Table 6.6: Simulation scenarios for evaluating the effect of the sun breakers design

Scenario Name	Description	South-eastern facade	North-western facade
OS	The tower as built, sun breakers according to Niemeyer's design (1968)		
MSB	The tower as built, sun breakers according to Gilead's revised design from 1973		
BS	The tower as built, realized sun breakers design		
OHS	The tower as built, only horizontal sun breakers		
OVS	The tower as built, only vertical sun breakers		
NS	The tower as built, without sun breakers		

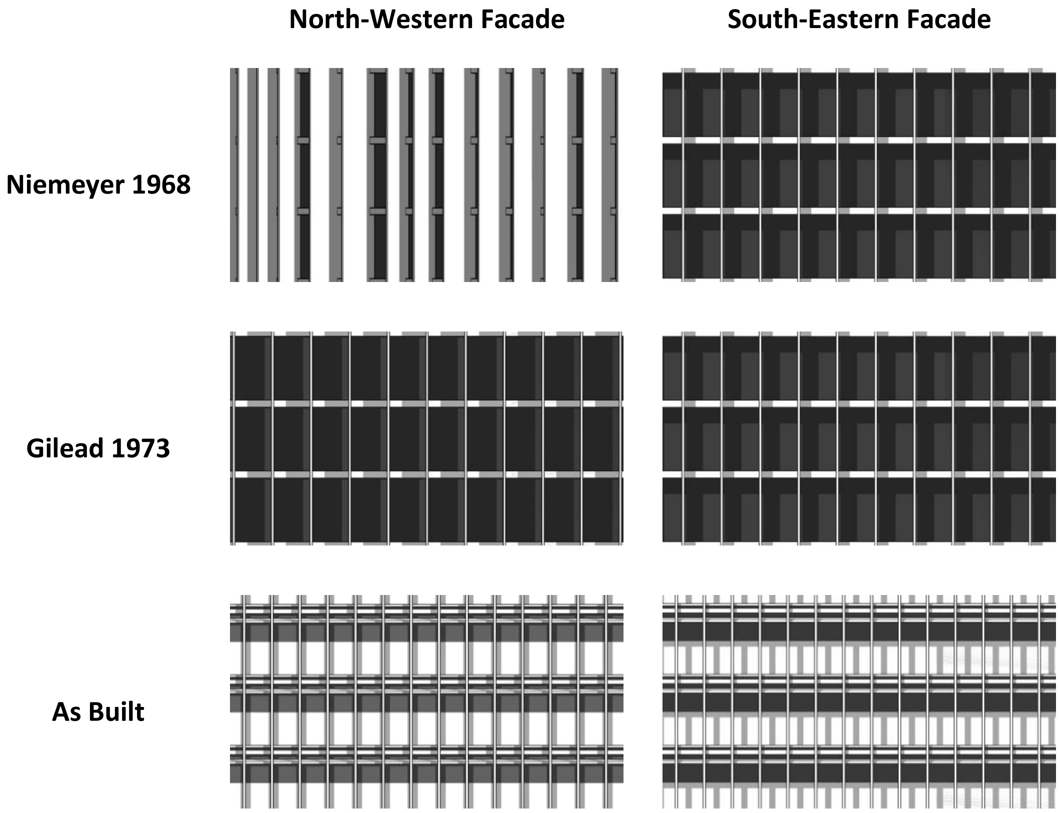


Figure 6.43: Eshkol Tower, shaded elevations of the main facades with the three sun breakers designs. Shading reflects daylight conditions for 21 September at 17:30 (north-western facade) and 11:30 (south-eastern facade)

Comparison of daytime overheating rates of the different sun breakers design clearly shows that the realized version produced lower indoor overheating rates (10-14% less than the earlier versions) for the south-eastern side of the tower, while having a minor effect on the north-western side (Figure 6.44 and Figure 6.45). At the same time, even with the new design, daytime overheating rates during summer were relatively high (59%). For the realized design, a much lower, though not negligible, overheating rate of 23% in both sides of the tower was calculated for the milder months on May, June, and October.

When examining a typical summer day (calculated as the mean dry-bulb temperature of each hour separately between 1 July and 30 September), it can be argued that all three designs proved to be effective in reducing indoor temperatures (Figure 6.46 and Figure 6.47). Naturally, this effect was more pronounced during daytime, which is of much higher importance for an office building. As for the maximal daily temperature of a typical day, the addition of sun breakers in the realized design lowered the indoor temperature by 5.2K in the north-western side and by 2.8K in the south-eastern side. Niemeyer's original design had a much better effect than the 1973 design by Gilead, since it provided a much better protection against the north-western sun.

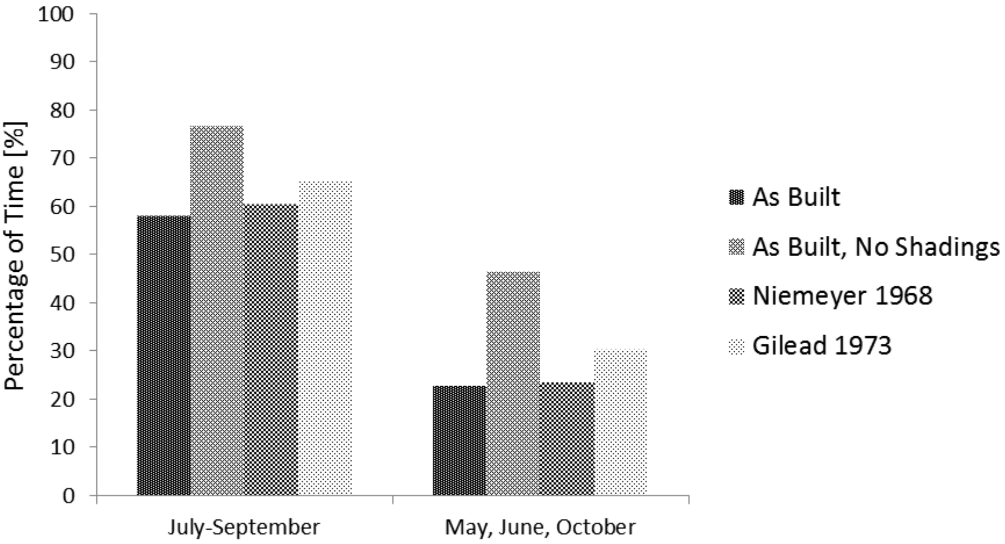


Figure 6.44: Daytime overheating rates for different sun breakers designs for the north-western side of the tower

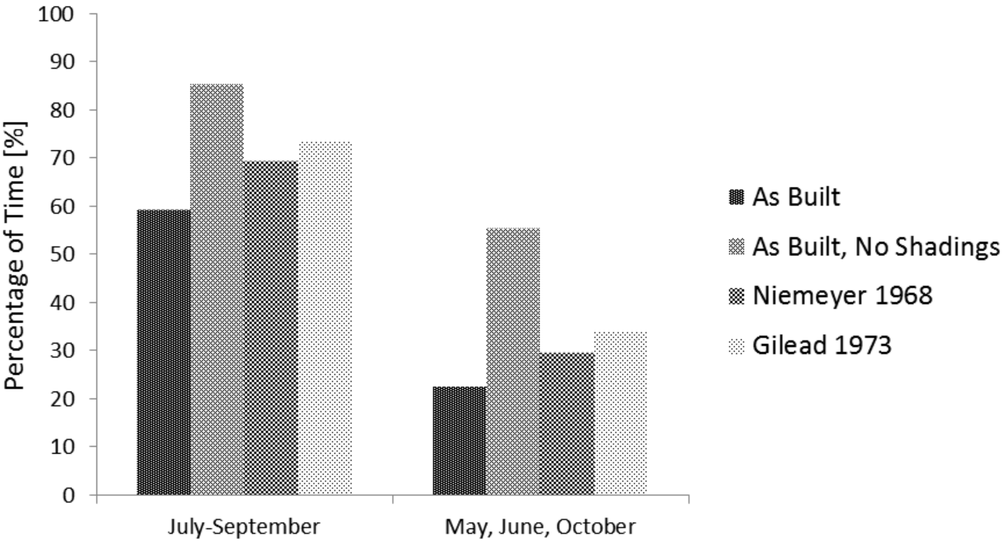


Figure 6.45: Daytime overheating rates for different sun breakers designs for the south-eastern side of the tower

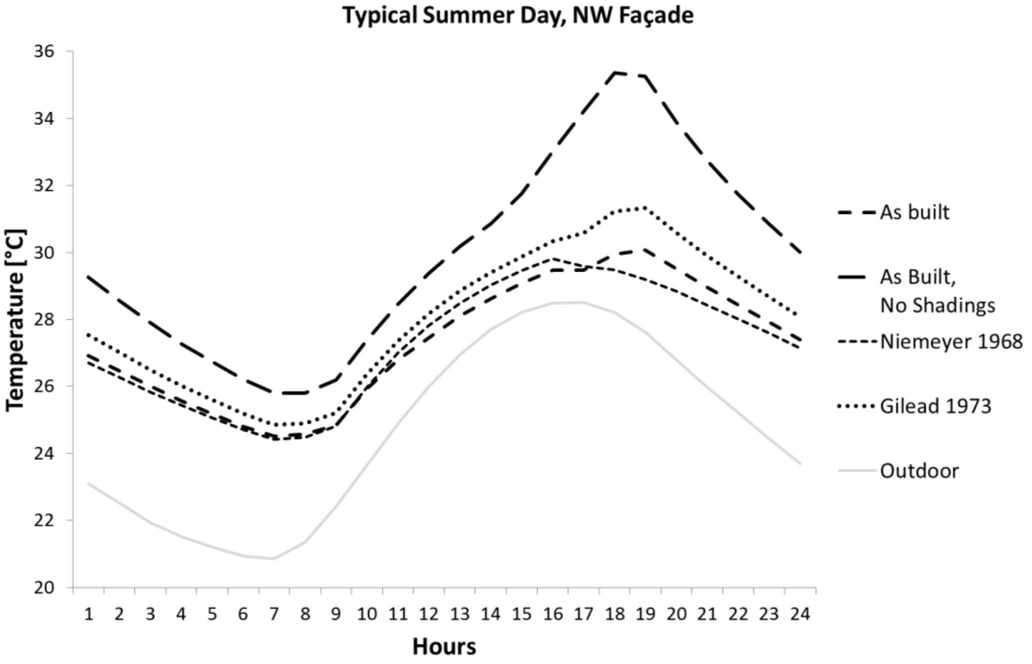


Figure 6.46: Daily temperature amplitudes for a typical summer day, the north-western side of the tower, comparison of the three sun breakers designs

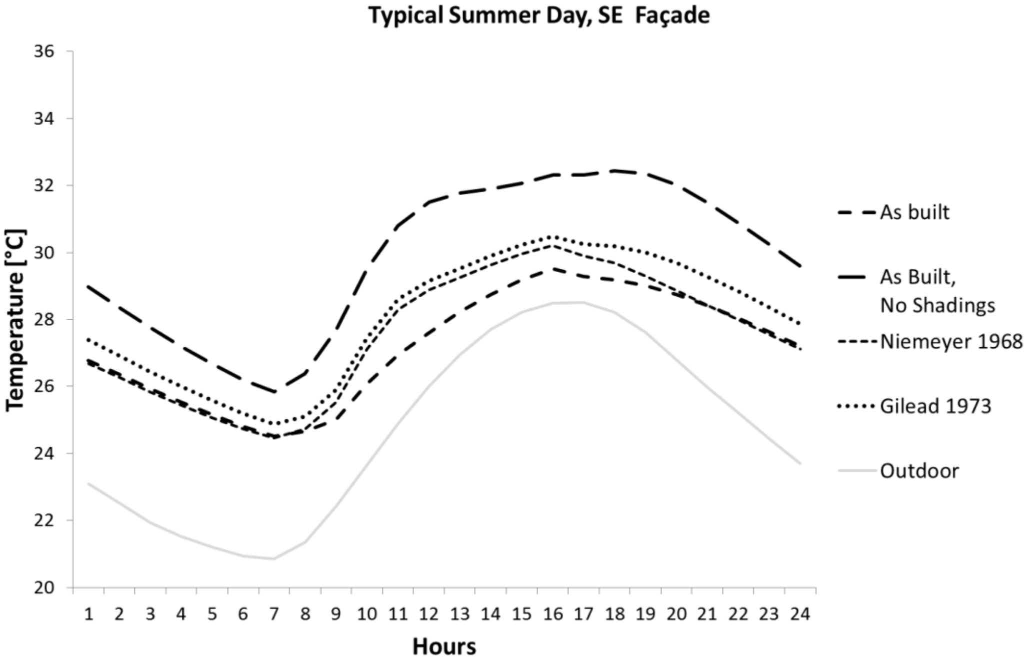


Figure 6.47: Daily temperature amplitudes for a typical summer day, the south-eastern side of the tower, comparison of the three sun breakers designs

In spite of the relatively good performance of the final version of the sun breakers design, analysis of the function of its components reveals that its positive effects should be almost entirely attributed to the horizontal elements of the design, as can be seen in Figure 6.48 and Figure 6.49.

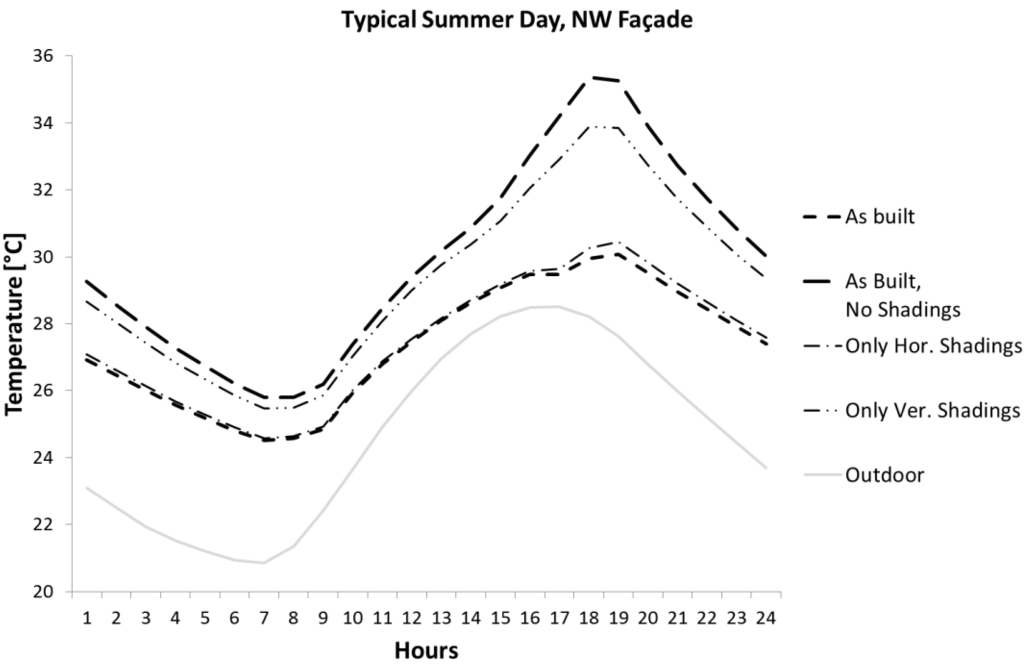


Figure 6.48: Daily temperature amplitudes for a typical summer day, the north-western side of the tower, comparison of components of the realized sun breakers system

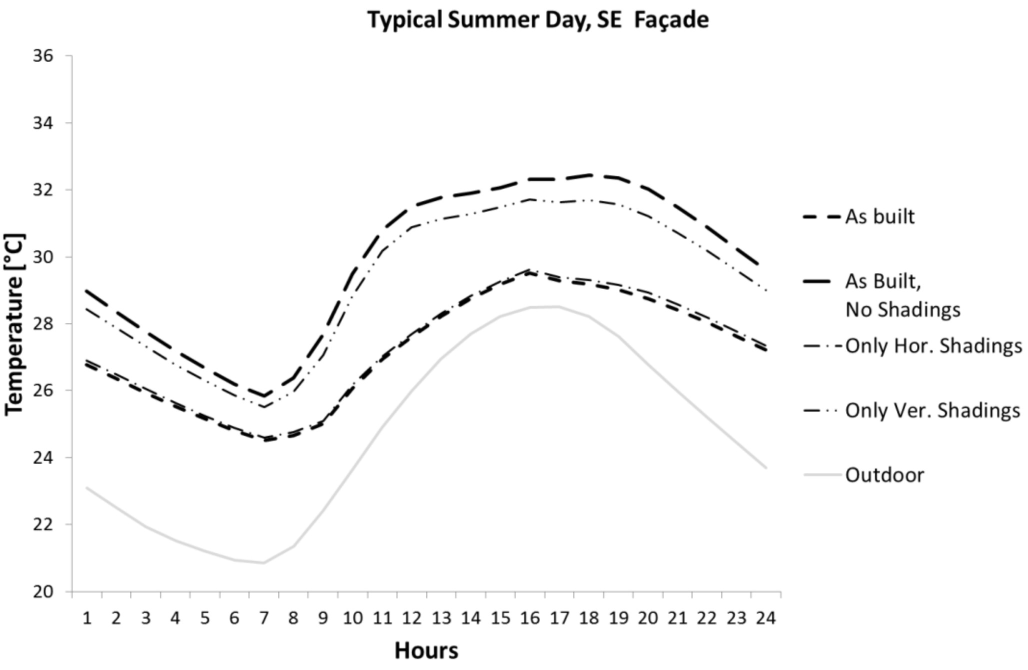


Figure 6.49: Daily temperature amplitudes for a typical summer day, the south-eastern side of the tower, comparison of components of the realized sun breakers system

Givoni's criticism of Niemeyer's design did not target only its thermal effects, but also its effect on indoor illumination. Givoni argued that the sun breakers system would create gloomy indoors in its northern side. Although this qualitative assumption is almost evident from a brief examination of Niemeyer's design, simulation of indoor daylight illuminance can reveal the precise quantitative effect of Niemeyer's version, as well as its relation to the other sun breakers designs. The simulation was conducted for a typical room in each of the tower's two main facades. Since the interior layout of a typical floor, as well as the glazing details, went through changes, the typical room in each design stage is a different one (Table 6.7), and reflects the intended combination of room size, window size, and shading. Although clear documentation of window details of the 1968 plan is missing, it was assumed that Niemeyer's original design, as well as its modified 1973 version by Gilead, consisted of a full floor to ceiling glazing of the facade, as is the case in Niemeyer's tower at the University of Mentouri (see above, Figure 6.23) and in many other contemporary projects by Niemeyer. In contrast, the realized design reduced the glazing ratio of the facades by half to a 1.50 m high strip of windows on every typical floor.

Table 6.7: Dimensions (in cm) of a typical room of the Eshkol Tower in each of the three design stages

	North-Western Facade		**South-Eastern Facade**	
	Width	Depth	Width	Depth
Niemeyer 1968	323	560	240	270
Gilead 1973	323	550	323	340
As Realized	470	660	230	452

Comparison of mean yearly illuminance maps, consisting of hourly values for each room, supports Givoni's criticism of Niemeyer's design of the north-western facade of the tower. The rooms on the north-western side were designed by Niemeyer to be relatively deep, and their orientation ensured that in most of the time illuminance levels without shading will be comfortable, though not very high. Niemeyer's design of the sun breakers resulted in unnecessary blocking of direct and indirect sun light, which produced very low mean hourly illuminance levels of less than 900 lux in the best case (Figure 6.50). This would have called for a constant use of artificial light, just as predicted by Givoni. By comparison, Gilead's 1973 design, which replaced the original sun breakers with a system similar to that of the south-eastern facade, produced much higher mean illuminance levels for a room of similar dimensions. His modified design of 1974, which utilized a totally different shading concept, produced also satisfactory results, while reducing the glare potential in the south-eastern rooms (see the comparison in Figure 6.51).

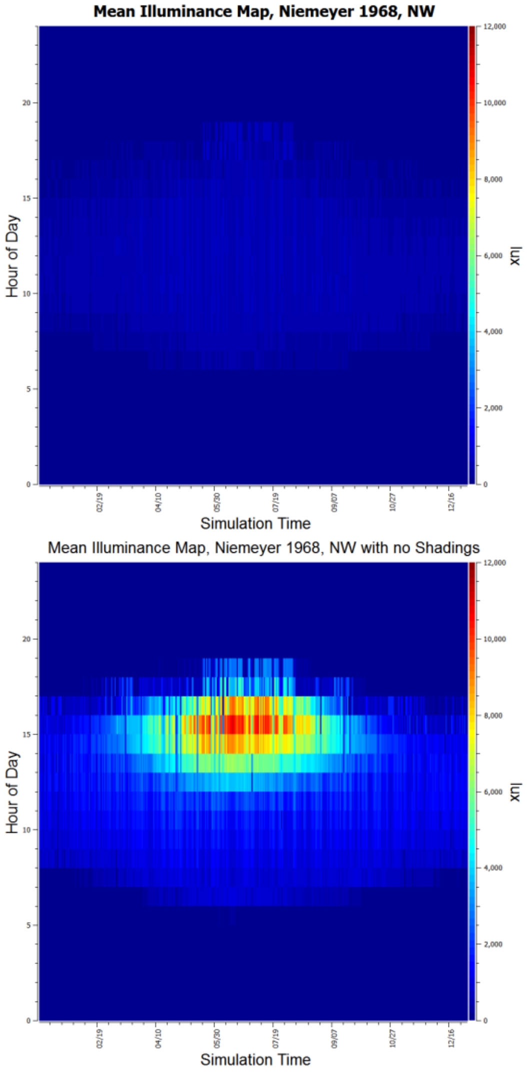
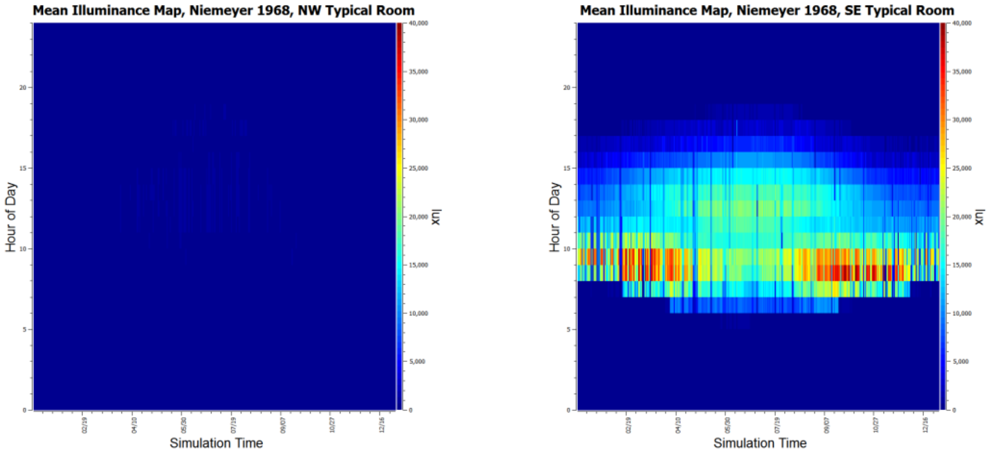


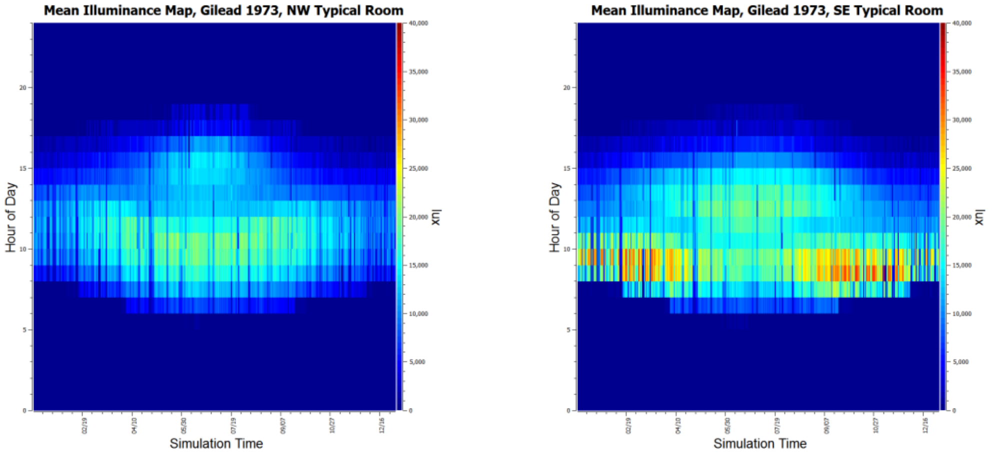
Figure 6.50: Mean illuminance maps (annual overview) on a 0-12,000 lux scale for a typical north-western room of Niemeyer's 1968 design, with (up) and without (bottom) the sun breakers system

North-Western Facade **South-Eastern Facade**

Niemeyer 1968



Gilead 1973



As Realized

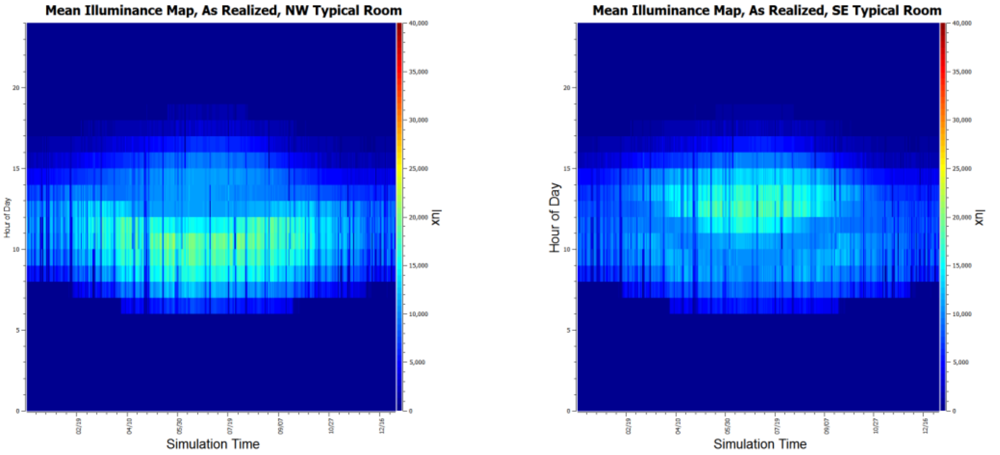


Figure 6.51: Mean illuminance maps (annual overview) for typical rooms on a 0-40,000 lux scale, the three design stages of the Eshkol Tower

6.3.3 Effect of facade glazing ratio

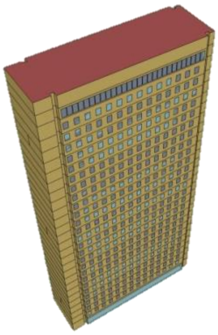
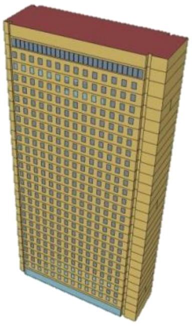
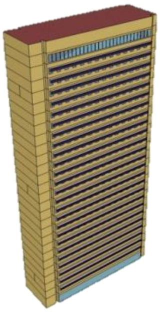
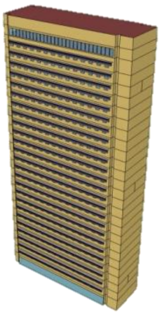
One blind spot accompanied all the discussions on the final design of the tower's facades: that of the application of relatively large glazing surfaces. Although the earliest, tentative facade design by Niemeyer (see above, Figure 6.16) showed what seems to be a mainly opaque facade dotted with small windows, his 1968 plan consisted of a glazed curtain wall in the main facades.

The glazed curtain wall persisted throughout all design modifications, and although slightly more than 50% of the facade area was opaque in the final version, the ratio of glazing to usable floor area remained high, ranging from 27% in the north-western facade to 34% in the south-eastern facade. While the opaque component of the curtain wall showed good thermal resistance (a calculated U-value of 0.626 W/m^{2}K), the windows were made out of plain 6 mm glass and had very poor insulative properties (a calculated U-value of 5.345 W/m^{2}K). This made the glazing a major weak spot in the thermal performance of the curtain wall.

In order to estimate the thermal effect of the extensive use of glass, two hypothetical simulation scenarios with a reduction of 50% of the glazing area in each of the main facades were applied: one without any shading system, the other with the application of horizontal shadings identical to the horizontal components of the final design (since the vertical components had a negligible shading effect, as was elaborated in section 6.3.2). Window composition was not changed. The additional opaque area of the facades was simulated as being identical to the opaque spandrel composition of the realized tower. Rendering of the two simulation models are given in Table 6.8.

Results show that a reduction of the facades' glazing area by 50% could have had some effect on lowering indoor summer temperatures, though this effect is not dramatic. In terms of daytime overheating rates, less glazing area with horizontal sun breakers resulted in a reduction of about 5% in both sides of the tower, compared to the realized design (Figure 6.52). Reduction of maximal indoor temperature for a typical summer day ranged between 1.1K in the north-western side and 0.9K in the south-eastern side (Figure 6.53 and Figure 6.54).

Table 6.8: Simulation scenarios for evaluating the effect of facade glazing

Scenario Name	Description	South-eastern facade	North-western facade
NSLW	50% less windows, no shadings		
OHSLW	50% less windows, Horizontal shadings as realized		

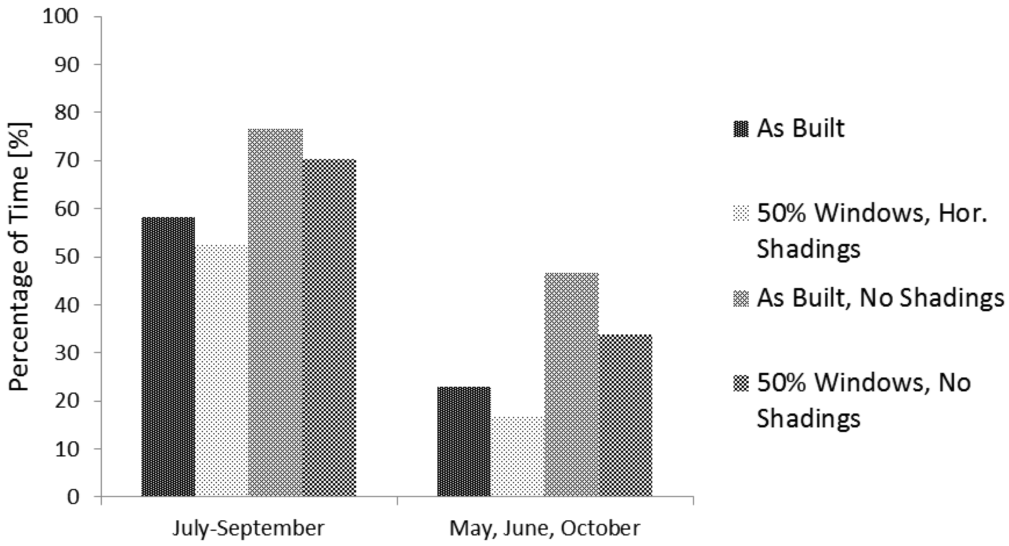


Figure 6.52: Daytime overheating rates for different glazing ratios for the north-western side of the tower

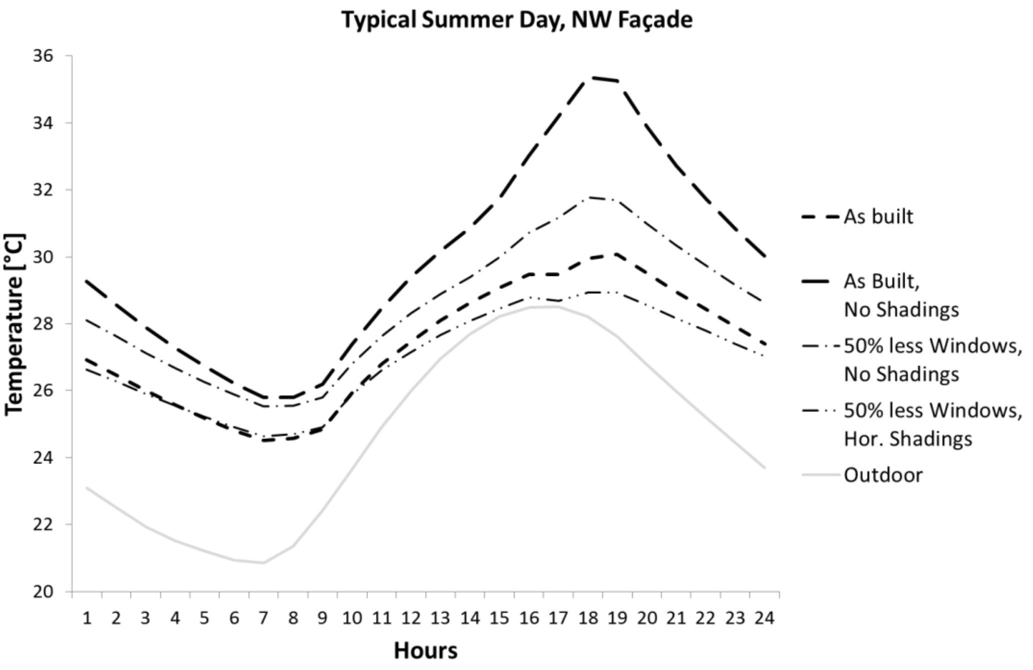


Figure 6.53: Daily temperature amplitudes for a typical summer day, the north-western side of the tower, comparison of different glazing ratios

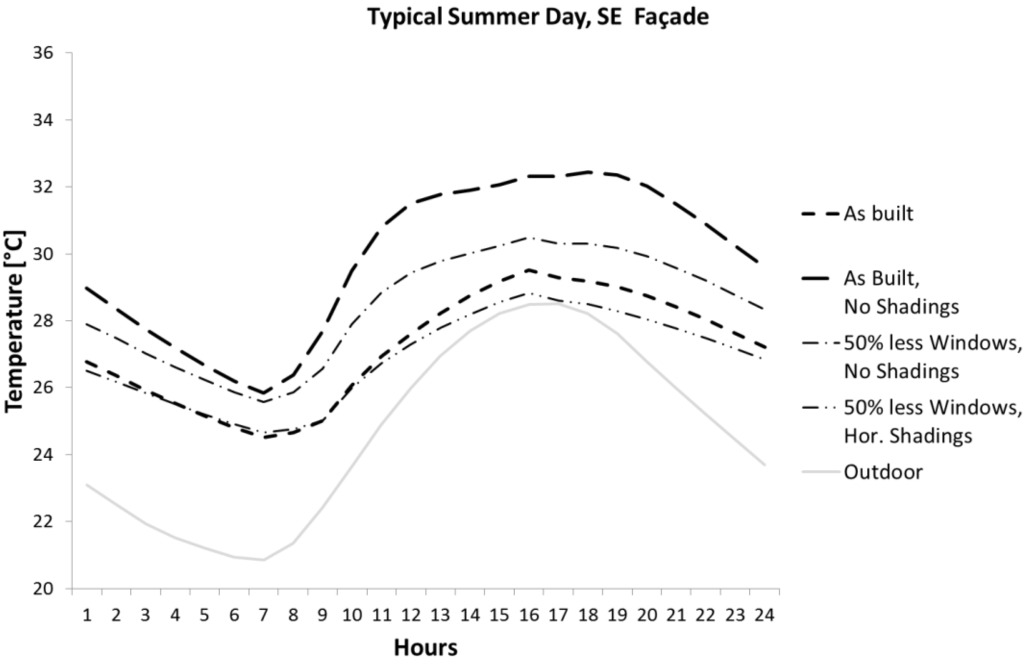


Figure 6.54: Daily temperature amplitudes for a typical summer day, the south-eastern side of the tower, comparison of different glazing ratios

6.3.4 Effect of natural ventilation

In his criticism of the design of the Eshkol Tower, Givoni claimed that "on the Carmel it is possible to build without air conditioning" and that "the current plan calls for the installation of air conditioning in the tower". It is therefore interesting to examine whether Niemeyer's original design, as well as the realized design of the tower, could have produced satisfactory summer indoor conditions relying only on natural ventilation. For each of the designs a natural ventilation scenario was applied, reflecting the opening of windows only during the night (19:00-07:00, nocturnal cooling). The air change rate figures (1.0 ACH during daytime, 3.0 ACH during nighttime) were based on the values given in the CIBSE guide to environmental design (CIBSE 2006, 5-8). Results show that Givoni was right in the sense that indoor temperatures still remained above outdoor temperatures during summer in both designs, calling for some sort of mechanical cooling (Figure 6.55). This is also exemplified in daytime overheating rates, which could be reduced by nocturnal ventilation only by 6-7% in both sides of the tower (Figure 6.56). A similar reduction could have been achieved also in the original design of Niemeyer, to which Givoni's criticism was directed.

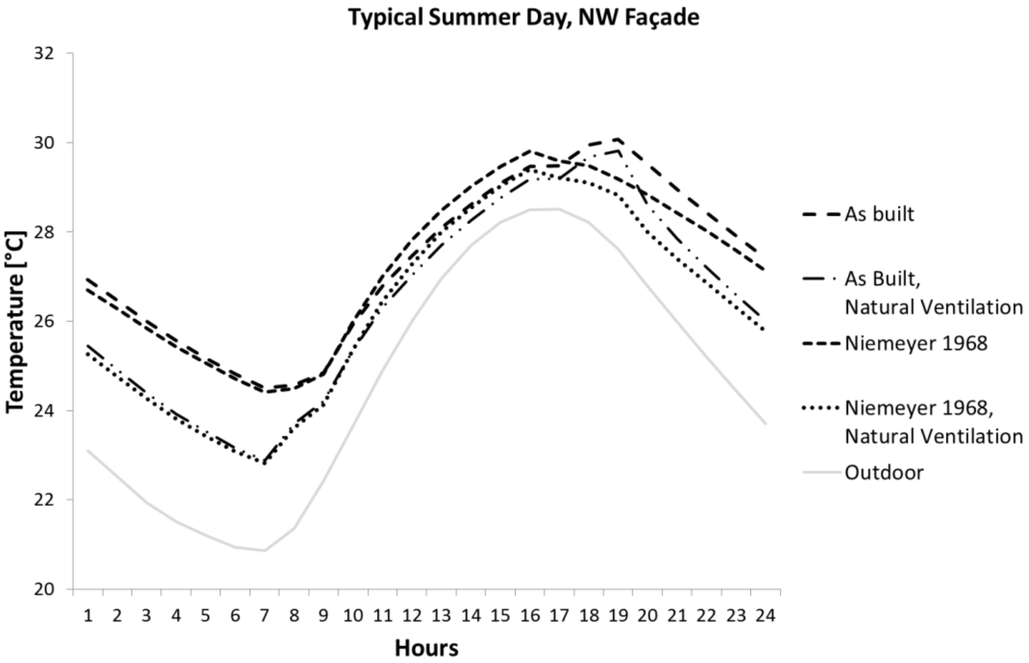


Figure 6.55: Daily temperature amplitudes for a typical summer day, the north-western side of the tower, comparison of application of nocturnal natural ventilation

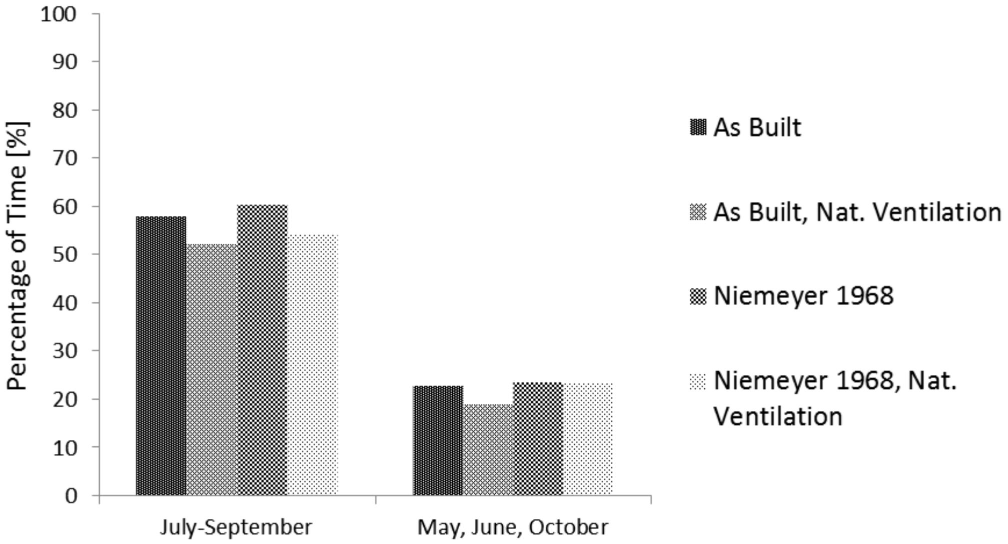


Figure 6.56: Daytime overheating rates with or without nocturnal ventilation for the north-western side of the tower

6.3.5 Cumulative effect of orientation, sun breakers, glazing ratio, and natural ventilation

Each of the above analyses showed that certain basic design decisions, as building orientation, sun breakers design, and facade glazing ratio had a noticeable effect on the summer thermal performance of the building. In his criticism of the tower's design, Givoni suggested that the design of the building created unnecessary climatic flaws. It is therefore interesting to examine to what extent simple modifications of the design could have had a positive effect on the tower's indoor climate. For this purpose, two additional simulation scenarios were analysed: a version of the realized building in which facade glazing ratio was cut by 50%, only horizontal sun breakers were applied, and the main facades of the building were oriented to the north and south; and a similar version in which nocturnal natural ventilation was additionally simulated.

In terms of daytime overheating rates, considerable improvement - a reduction of 16% in both sides of the tower - was calculated for the cumulative modification combined with natural ventilation. Nevertheless, this enhanced scenario still produced relatively high daytime overheating rates of 42-43% during summer. Maximal summer daily temperatures in this scenario were lower by 1.1K in the south-eastern facade and by 2.3K in the north-western facade, compared to the corresponding temperatures of the realized building (Figure 6.58). The cumulative-natural ventilation scenario was the only simulation scenario in which maximal summer daily temperature were lower than the respective outdoor temperatures.

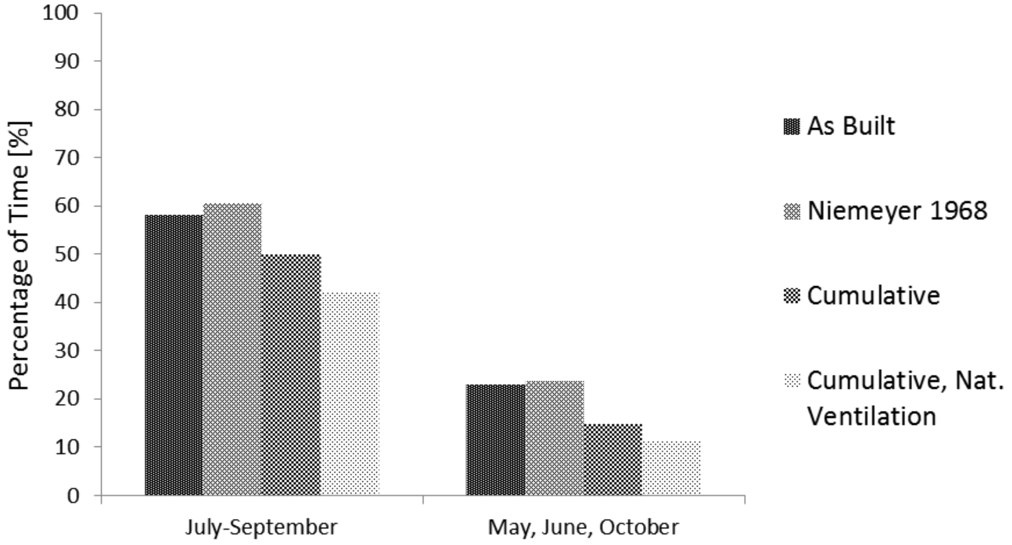


Figure 6.57: Daytime overheating rates for the two cumulative scenarios, compared with the original design by Niemeyer and the realized building, the north-western side of the tower

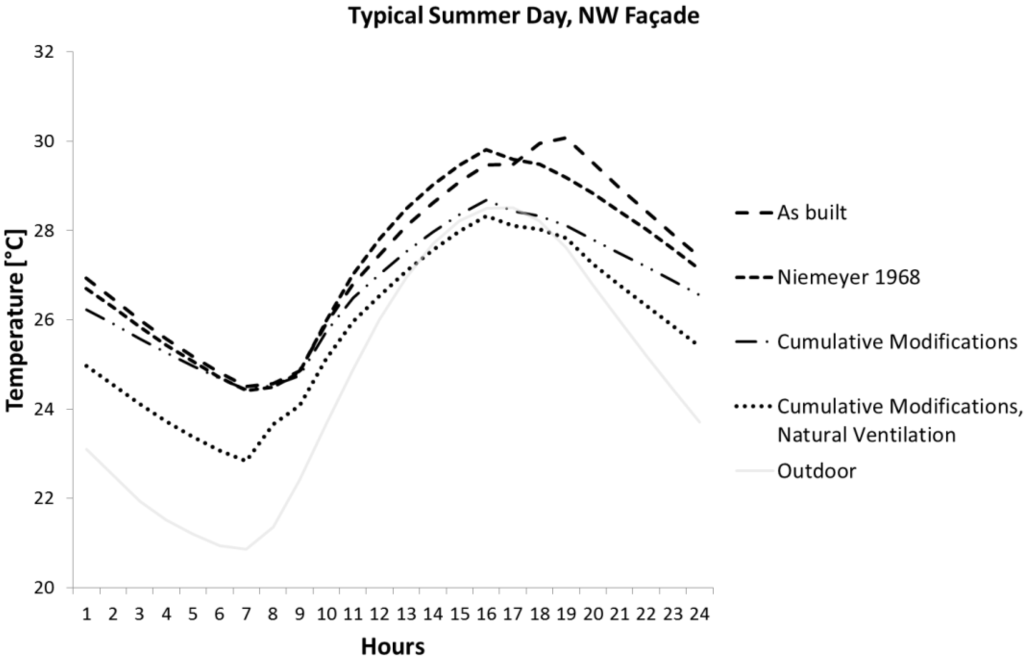


Figure 6.58: Daily temperature amplitudes for a typical summer day, the north-western side of the tower, comparison of the cumulative scenarios with Niemeyer's original design and the realized building

6.3.6 Discussion

Three major design decisions had the most significant effect on the indoor climate of the Eshkol Tower: the design of the sun breakers system, the composition of the curtain wall, and the orientation of the building. Of these, the design details of the sun breakers had the single most crucial effect on the thermal performance of the building, as well as on its indoor visual comfort.

The sun breakers of the Eshkol Tower had a dual function: to reduce the heat load generated by penetration of direct solar radiation into the building, and to minimize the indoor glare by blocking and diffusing the incident sunlight. In order to produce a successful design, a balance between the two functions had to be maintained. While Niemeyer's original design of the sun breakers of the north-western facade reduced the maximal daily summer temperature (for a typical day) by 6K (which was still 0.8K higher than the realized design), it proved to be unsuccessful because of its highly negative effect on indoor illuminance levels. The realized design, on the other hand, produced the best balance between thermal and visual comfort out of the three alternative designs. This was achieved mainly because the dominant vertical elements of the original design were eventually replaced with elaborate horizontal elements.

While all sun breakers designs received much attention, no genuine discussion followed the design decision on the application of curtain walls. The simulations showed that here probably lies the main thermal weakness of the structure: the very low thermal mass of the curtain wall as a whole, combined with the relatively large glazing surfaces and the use of plain glass, created a building that produced relatively high summer overheating rates. This could have been improved by a radical modification of the facades details, including the use of building materials with much higher heat capacity and glazing materials with much better insulating properties.

While much simpler enhancements, like the reduction of glazing ratio, combined with the reorienting of the building to the north and south and the application of nocturnal ventilation, could have improved the summer thermal performance of the building, the simulations also indicate that overheating, and thus the use of air conditioning, could not have been entirely avoided during summer. Analysis of the daily temperature amplitudes for a typical summer day showed that even in the best performing scenario, indoor temperatures were constantly higher than outdoor temperatures. Therefore, it can be concluded that the decision to use a light weight wall construction was the one that resulted in the main thermal challenge of the tower. Without substantial change in the material properties of the facades, this challenge could have only been met with the application of mechanical cooling.

6.4 Conclusion

Ever since the *Brazil Builds* exhibition in 1943 (see above, section 4.1.2), Brazilian architecture was famous worldwide for its creative application of external shading devices. Oscar Niemeyer, arguably the most renowned Brazilian architect of his time (who some even regard as "the father of modern Brazilian architecture"), produced several of the finest examples of the shading idiom developed and extensively used in Brazil. A telling indication to Niemeyer's reputation in this field is the fact that eight of his designs, more than any other architect, were chosen by the Olgyay brothers as case studies for their seminal work on shading devices (Olgyay and Olgyay 1957).

Niemeyer's reputation as a master of solar control should be questioned after a close examination of his design of the tower of the University of Haifa. As in some other buildings designed by Niemeyer in Brasília a few years prior to the Haifa project (Amorim and Szabo 2006, da Silva and Amorim 2006), the university tower, had it been realized according to Niemeyer's design, might have been regarded as an architectural masterpiece while proving very poor in terms of climatic performance. Especially alarming was Niemeyer's design of the north-western facade of the tower, which can be regarded as an awkward solution to a simple problem. As predicted also by Givoni in his expert opinion from 1968, illuminance analysis showed that Niemeyer's north-western sun breakers would have created gloomy interiors with only the slightest hint of daylight, a heavy price for overheating prevention that could have been avoided with a different design. Although this effect was eventually overturned in the realized building, several other features of Niemeyer's design, including the building's orientation and the use of light weight and highly glazed facades, still survived and negatively affected the overall climatic performance of the building.

At a certain moment, the design of the Eshkol Tower was characterized by a direct confrontation between building climatology imperatives and "starchitect" dogma. The newspaper article that told the story of the climatic criticism of architect Baruch Givoni, and the response to it by architect Shlomo Gilead, presents an almost perfect demonstration of the constant contradictions of aesthetics and functionality typical to architectural design. Gilead, representing Niemeyer, was more than clear about his own list of priorities: he favoured to stick to Niemeyer's design even after confronted with Givoni's climatic analysis, only "because Niemeyer did so, as something to be obeyed to the letter". For him it was obvious that "dictates of the landscape and aesthetic considerations" play a more important role than mere functionality. Yet when the project entered a new phase, Gilead became confident enough to give up Niemeyer's design of the north-western facade, and later even to redesign the main facades anew. In that sense, especially after Gilead's insistence on integrating horizontal sun breakers into the final design, building climatology overcame an allegedly rigid aesthetic determination in the final design of the tower's envelope.

It is hard to decisively determine whether Givoni's harsh criticism of Niemeyer's design was the main motivation behind the modifications of the tower's main facades. One should remember that the design would have probably remained the same, besides the modification of the north-western sun breakers design, unless the university, because of its own budgetary and administrative constraints, decided to redesign the tower using industrialized metal elements. At the same time, the circumstantial evidence should lead to the conclusion that Givoni's opinion did make a difference: the modifications took place only after Givoni's opinion was made public, and only after the first four (underground) floors of the tower were already executed according to Niemeyer's original design. Moreover, the modification of the facades was almost entirely limited to the main points raised by Givoni.

Notwithstanding this achievement, Givoni's main argument, that the tower could have been designed to be naturally ventilated, was never truly considered. The reliance on air conditioning, so it seems, made the thermal effects of the design less important in the eyes of the designers. The intensive occupation with the sun breakers design was only a by-product of the much more fundamental design decision to use light curtain wall with large glazing areas, a decision that was never questioned, not even by Givoni. The excessive glazing of the facades created two problems: the overheating of indoor spaces and the glare induced by direct sun light. The sun breakers were mainly meant to solve the second problem, while only partially ameliorating the indoor thermal conditions; they could not have done more as long as the curtain wall, as a concept, remained untouched.

The design of the Eshkol Tower created a climatic problem that could have been partially avoided through relatively minor changes to the design. It is true that in its realized version some of the potential deficiencies of the original design were addressed, and that the modifications helped in reducing the cooling loads of the building. Yet an even greater improvement could have been achieved by reducing the glazing ratio of the facades (which would not have negatively affected indoor illuminance conditions), orienting the building's main facades to the north and south, and naturally ventilating the building, at least during the night. All these modifications would not have induced extra costs but rather reduced them. The fact that even they (in contrast to the "heavier" concept of giving up the curtain wall, which would have called for radical changes to the design) were not put on the table during the whole design process, and the fact that no one questioned the thermal implications of the curtain wall application, may lead to the conclusion that in the end, the long shadow of Niemeyer could not have been entirely avoided. Aesthetics, so it seems, did have the last word in the tower's design.

7 CONCLUSION: SCIENTIFIC KNOWLEDGE AND ARCHITECTURAL REPERTOIRES

In 1983, while reflecting on research needs in the field of "problems of climate and energy in building" in Israel, Baruch Givoni, now a professor at the Institute of Desert Research in Sde Boker, wrote:

> In recent years, interest in issues of building adaptation to different climate conditions and reduction of energy consumption in building, while securing comfort conditions, has been increasing. Yet comprehensive studies in these issues, in Israel and abroad, have already been conducted for many years. As a result, much scientific knowledge, especially on the subject of building climatology, exists, though this is not reflected in the common practice in planning and construction.
>
> […]
>
> During the last 25 years intensive research has been conducted in our country, mainly at the Building Research Station, on the requirements of thermal comfort, the effect of different factors on architectural design, and the effect of the thermo-physical properties of structure on energy requirements of buildings, as well as on specific issues like the problem of condensation in buildings, penetration of rain, etc. Moreover, comprehensive studies on different subjects pertaining to problems of climate and energy in buildings under climatic conditions similar to ours have been conducted in many research institutions abroad.
>
> Experts in the aforementioned field are familiar with the results of these studies.
>
> As an outcome of these studies, much scientific knowledge, which is suited to the local climate conditions and common building techniques, has been accumulating. Nevertheless, a

> wide gap exists between the accumulated knowledge and its practical application. One reason for the absence of application is the lack of design tools that would "translate" the scientific knowledge into practical design instructions and would enable to adapt the design approach in advance to the different climate conditions, as well as to provide designers and design clients with the possibility to test the compliance of the design with the requirements of energy savings during the different design stages. (Givoni 1983, 43, 46)

Following this somewhat discouraging analysis, Givoni proposed a comprehensive set of concrete actions, extending over 14 densely written pages, for changing the reality he was describing, including additional research. Although some of the suggested actions have been implemented since, it is hard not to argue that Givoni's description from 1983 still holds much relevance to the current state of affairs: even today, building climatology in Israel can be justifiably described as the unwanted child of Israeli architecture. Although two of its most important protagonists were architects, the emerging discipline, which grew out of architectural needs and demands, was never able to find its place at the heart of local architectural practice. Thus, and in spite of its scientific achievements throughout the years, Israeli building climatology had very little effect on Israeli architecture, its design habits, and its built products.

Building climatology in Israel emerged because of concrete concerns over the thermal dysfunctionality of modern buildings that were erected in Palestine during the 1920's and 1930's. While climate was not an uncommon theme in the writings of architects from that time, scientific research on the effects of climate on building was only initiated during the 1940's, as an almost private project of a handful of determined professionals. Only one of them, Werner Joseph Wittkower, was an architect; his activities during that decade were exceptional in every sense, both in terms of his analytical abilities and organizational talents. Yet Wittkower was not a typical architect of his times, and the fact that he held no position in any public institution limited not only his ability to realize even the smaller part of his plans but also to disseminate the results among his local colleagues.

Wittkower's sporadic and individualistic approach had very little chance to remain relevant after the changes that took place in the Technion in the beginning of the 1950's. After the establishment of the Building Research Station (BRS) in 1952, and even more after the return of Givoni to Israel in 1960 to assume the position of the head of the Department of Indoor Climate of the BRS, the ground was prepared for the emergence of building climatology as a comprehensive body of knowledge that could be widely employed by architects. By the middle of the 1960's Givoni and his team were able to provide concrete answers on questions of thermal comfort, building orientation, building massing, window size and orientation, shading design, and to some extent wall and roof composition. Givoni's disappointment with the reluctance of architects to take advantage of his finding was evident, especially since many of the studies conducted by the BRS were initiated and financed by Israel's Ministry of Housing in order to be implemented in the many residential projects it initiated, designed, and executed.

As an auxiliary body of knowledge, building climatology in Israel serves as an excellent example for the emergence of a subsidiary professional repertoire (see above, sections 1.4.5 and 1.4.6). Its emergence resulted from the recurrent climatic failures of design solutions which were based on unestablished beliefs; this created a need for the application of scientific research methods for overcoming the climatic challenges of building design. During the first stages of its development, when research was focused mainly on the single question of building orientation, it seemed as if the results produced by building climatology were about to become a genuine part of the larger repertoire of the architectural profession. Yet as research expanded, when it became evident that the climatic challenges cannot be met only by answering a single design question, architecture's professional repertoire was gradually blocking itself from further absorption of scientifically-based climatic knowledge.

Architects still contended they were concerned about the climatic aspects of building, but their occupation with climatic issues was no longer taking advantage of the ever-growing products of scientific research. The new body of knowledge was thus consolidating as a new subsidiary repertoire, which was mainly delivered to architects, if at all, through the medium of external consultancy.

The three case studies analysed in the current study provide a full gamut of application (or rejection) of climatic repertoire within architectural design. The historical research into their design processes, combined with the simulation of their climatic performance, enables us to draw some conclusions on the application of climatic knowledge in the design of buildings and its possible effects on their climatic performance. In the Gilman Building in Tel Aviv, climatic knowledge was an integral part of all design stages (conceptual, preliminary, detailed) and was applied as an inherent part of the designer's professional toolkit. This was not surprising, since the building's main architect was Wittkower, who was preaching for climatically-aware design since the early 1940's. The result was an intelligent design which combined aesthetic appeal and spatial coherence with climatic function, fully exploiting the available scientific knowledge in order to produce almost optimal indoor conditions.

The story of the Model Housing Estate in Be'er Sheva revealed a troubling discrepancy between the use of climatic jargon and the application of climatic knowledge in design. The invention of the "carpet" housing scheme during the work of the Batsheva de Rothschild Foundation research team was not based on preliminary climatic analysis. At the same time, the team's research reports allegedly referred to scientific literature on climate and building, giving the (false) impression that climatic issues were actually considered before the consolidation of the final design proposal. Similar disregard for concrete climatic knowledge typified also the application of the "carpet" scheme in Be'er Sheva: no climatic analysis of the future site was conducted, the general orientation of its buildings was a reminiscent of the existing urban fabric of the old town and was not based on climatic recommendations, and the selection of building materials and finishes was also detached from established scientific findings (which resulted in the architects' compliance with the demand to use thin and thermally problematic concrete slabs for roofing). Fortunately enough, the "carpet" neighbourhood of Be'er Sheva proved to be a relative climatic success in spite of the almost total rejection of the subsidiary climatic repertoire. This was a result not of a conscious application of scientific knowledge, but of half-conscious mimicry of traditional practices and forms which proved to work well for vernacular builders. At the same time, the translation of the traditional forms into modern construction techniques was negatively affecting the indoor performance of the houses, precisely because of the negligence of an already available and relevant scientific knowledge.

The intuitive approach to climate and building, which resulted in tolerable conditions in Be'er Sheva, almost led to a climatic fiasco in the Eshkol Tower in Haifa. What eventually prevented it from happening was not a process of calculated analysis, but an unexpected twist in the very final stages of the plot. The original design by Oscar Niemeyer was more than problematic in its application of what was considered to be solar protections; after it was analysed in 1968 by Givoni, receiving clear and direct criticism, one could have expected it to be modified. Nevertheless, Niemeyer's reputation as a master of solar protections and his professional status seemed to have prevented Shlomo Gilead, the architect in charge, to openly admit that the design should go through major changes. When he tried to approach Niemeyer and asked for his approval for some modifications, he received an improbable redesign of one facade which might have resulted in even worse indoor illuminance conditions. Only on a later stage, when the tower's facades had to be redesigned because of the decision to use an alternative structural system, Gilead dared to entirely redesign the solar protections of the building without consulting Niemeyer and to effectively follow Givoni's advice. This, however, was far from being enough; the other climatic weak spots of the original design (orientation, facade glazing, curtain wall composition) could not have been modified in such later stages. Climatic knowledge in the Eshkol Tower was therefore integrated into the design process as a subsidiary repertoire, and its limited (though successful) effect was a direct result of its application during the very last design stage.

What the case studies affirm, in addition to the common practice of architects to regard climatic knowledge as belonging to a separate, subsidiary professional repertoire, is the utmost importance of the design stage in which climatic knowledge is integrated into design. Following our scheme of diminishing design flexibility (see above, section 1.4.6), it can be argued that the utilization of climatic data, because of its "external" status, becomes less effective if it is not considered throughout all the design stages. In the Gilman Building, this knowledge was applied from the stage of conceptual design up to detailed design, creating an almost optimal solution; in the Model Housing Estate, the knowledge (in the form of reliance on vernacular models) was applied during conceptual design, but was absent from later design stages, resulting in deplorable climatic failures of the buildings' envelopes; and in the Eshkol Tower, climatic knowledge was totally absent from conceptual and preliminary design, and had only a limited (though positive) effect on the building's thermal performance when it was eventually considered during the detailed redesign of the facades.

The case studies, however, represent instances in which climatic considerations could be traced throughout the design process. Given the superficial approach of the architectural profession to climatic data (which was evident, for example, during the design process of the Model Housing Estate), it is hard to believe that such considerations could be traced at all in many other architectural projects of that period. Some additional historical evidence, including first-hand testimonies, supports this view. In this respect, it seems that not much have changed, at least not for the better, since. What did change during the last decades is the growing volume of climatic and environmental discourse not only within the defined field of architecture but among the broader circles of the professions that are responsible for the creation of "fit environments for human activities". Obligatory and preferential standards for the enhanced environmental performance of buildings (especially in the field of energy efficiency) helped, mainly in Europe and North America, to regain consciousness for the technological and climatic aspects of building during their design process. Nevertheless, though in certain countries architects are officially responsible for energy calculations of their buildings, they usually hire external consultants who enter the process only in order to "resolute" the problems created by "architecture", thus having a similar position as other consultants in the field of air conditioning, electricity, plumbing, etc.

The change can be hardly seen as a direct result of developments in the interests of architects, and moreover in their design practices. It would have never seen light had environmental technology had much lesser energetic burden, if it were less "regenerative", to use Reyner Banham's terminology. The heavy price in terms of energy expenditure imposed by buildings, which results in a considerable environmental cost as long as the consumed energy is polluting and non-renewable, initially instigated a reactionary response which tried to turn the wheel back, renounce the new environmental technologies, and return to "vernacular" and "passive" environmental solutions which originated before the introduction of consumer electric energy. This trend reflected a considerable amount of deliberate blindness, since without the energy-hogging technologies it is hard to imagine the existence of a dense and industrialized urban society (which has some undeniable achievements); it is ever harder to imagine its peaceful and voluntary disappearance.

Thus, though it is possible to design some nice little structures which are totally detached from main energy networks (structures of so-called zero "ecological footprint"), it can be argued that after four decades of going back to pre-electrics, these solutions are esoteric and marginal; they can hardly present any practical alternative to the highly-urbanized world of the 21st century. The real solution for the challenge of non-renewable energies lies in finding alternative, renewable, and non-polluting energy resources, and not in the total renunciation of electric energy. Until such resources are found, and since it is improbable to ban the use of air conditioning and heating, it is more than reasonable to demand architects at least to minimize the heating or cooling loads of their buildings in order to minimize the use of air conditioning. This makes the subsidiary repertoire of building climatology not less relevant to current architectural practice than half a century ago, but much more.

Buildings are currently the most significant locations of energy consumption in the developed world (in the US, about 40% of the annual energy consumption originates in buildings, mainly because of lighting, heating, and air conditioning (US Department of Energy 2015)). Those who are responsible for the design of buildings, and especially architects (who are still regarded as the highest authority among the expanding array of design professions), are also directly responsible for the energy they consume. The shirking of responsibility for the environmental and technological aspects of design, and moreover the typical architectural discourse in issues of environment and technology from which quantifiable factors are absent, lead to the creation of wasteful, over-sized, and often unintelligent architecture.

The lasting failure of architecture as a profession in the absorptance of climatic knowledge can be traced also in the way the digital revolution has been transforming architecture during the last decades. Computers can be used today for the relatively easy prediction of the environmental performance of structures (or, in other words, for the calculation of their energetic price) even before their construction. At the same time, it seems as if architects tend to view the computer mainly as a form-generating tool, not as a calculating machine. Contemporary "digital architecture" mainly relies on one type of software whose sole purpose is to assist the architect in the formal aspects of design, almost entirely detached from its physical performance and energy consumption, even when the most sophisticated parametric tools are applied.

As also noticed by Banham, the scientific (and the ensuing technological) leap was the one which enabled the ever-growing formal freedom of architecture. This freedom raises a fundamental question in respect to the traditional description of architecture as integration of visual art and functional engineering. On the one hand, it is tempting to never mind "all that environmental rubbish" and to "get on with the architecture" (Banham 1984, 11), to leave engineering to the engineers and to focus on the visual attractiveness of buildings, their "spatial" qualities, and the sensual "experiences" they create. On the other hand, it is possible not to succumb to such an approach, which limits architecture's influence, and to neatly stitch together form and environmental performance in a way that would minimize the energy consumption of buildings.

In retrospect, it seems as if Banham's prophetic alarm on the unorganized hordes of air conditioning and plumbing consultants that would flood architecture and change it beyond recognition was a bit exaggerated. Science and technology did not lead to the emergence of an Other Architecture, not to mention Other Architects. Yet what is still valid is the "specialization" divide between those occupied with "architecture" and those responsible for the provision of "technical" solutions that makes it habitable. The sanctification of form over environmental performance has led to architecture's self-entrapment in the exaltation of visual image; in the architect's set of considerations, a blow to environmental performance in favour of building form is always preferable to a blow to building form in favour of its environmental performance. Even today, the vast majority of architects can tell you what their building "does" and maybe even how much it weighs, but not how much energy it consumes or how much gas it burns. This is not a result of lack of tools or knowledge, but rather of their rejection by architects. Without their integration into the professional repertoire of architects, or at least without the application of the subsidiary climatic repertoire of architecture throughout all design stages, their effect would remain limited and partial, in spite of any advancement in the science that lies behind them.

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9 OR ALEKSANDROWICZ: CURRICULUM VITAE

ACADEMIC DEGREES

2012-2015	Doctoral Studies in Engineering Sciences Architecture (ScD degree), supervisor: Prof. Ardeshir Mahdavi, Faculty of Architecture and Planning, Vienna University of Technology
2009-2012	MSc (magna cum laude) in Building Science and Technology, Faculty of Architecture and Planning, Vienna University of Technology
1996-2002	BArch (magna cum laude) in Architecture, Azrieli School of Architecture, Tel Aviv University

ACADEMIC APPOINTMENTS

2012-2014	Project assistant in EU project 3CE292P3 (Development and Application of Mitigation and Adaptation Strategies and Measures for Counteracting the Global Urban Heat Islands Phenomenon), Department of Building Physics and Building Ecology, Faculty of Architecture and Planning, Vienna University of Technology
2005-2006	Assistant lecturer at the Architecture Department, Bezalel Academy of Arts, Jerusalem

PROFESSIONAL EXPERIENCE

2006-	Chief editor of Architectures series at Babel Publishers, Tel Aviv (see below)
2008-2009	Senior architect at Dunsky Architects, Ramat Gan
2000-2007	Senior architect at JP Friedman & Associates, Tel Aviv

PUBLIC PROFESSIONAL ACTIVITIES

2014-	Member of the Committee for Architecture Terminology at the Academy of the Hebrew Language, Jerusalem

SIGNIFICANT PROFESSIONAL PROJECTS

Chief editor of Architectures series at Babel Publishers, Tel Aviv, a long-standing book series in Hebrew dedicated to books on architecture and urbanism.

BOOK EDITING

2007	Avraham Yasky, Concrete Architecture [in Hebrew] by Sharon Rotbard
2008	The Death and Life of Great American Cities [Hebrew edition] by Jane Jacobs, including annotations
2008	Learning from Las Vegas [Hebrew edition] by Robert Venturi, Denise Scott Brown and Steven Izenour, including translation and annotations
2009	City of Concept: Planning Tel Aviv [in Hebrew] by Nathan Marom
2010	Delirious New York [Hebrew edition] by Rem Koolhaas, including translation and annotations
2012	Cradle to Cradle [Hebrew edition] by Michael Braungart and William McDonough, including translation and annotations
2012	Land City: Local Essays [in Hebrew] by Esther Zandberg, including foreword
2013	A Time for Conservation [in Hebrew] by Amnon Bar Or, including complementary historical research
2014	The Architecture of the Well-Tempered Environment [Hebrew edition] by Reyner Banham, including translation, annotations and postscript

PUBLICATIONS

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Or Aleksandrowicz and Israel Architecture Archive, Daring the Shutter: The Tel Aviv Idiom of Solar Protections, Tel Aviv: Public School Editions, 2015.

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