STRUCTURAL ENGINEERS, SUSTAINABILITY AND LEED®

" The World will not evolve past its current state of crisis by using the same thinking that created the situation."

~ Albert Einstein

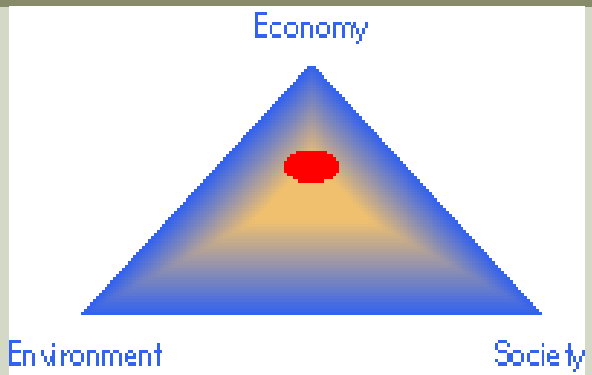
Diana Klein, LEED AP, P.Eng

Eco-Integration
sustainable design consulting

DEFINE SUSTAINABILITY FOR STRUCTURAL ENGINEERS?

"Meeting the needs of the present generation without compromising the ability of the future generations to meet their needs."

- Oxford 1987, The world commission of environment and development



- Safe
- Efficient
- Economic
- Durable
- **Adaptable - *Life measured in centuries***
- **Livable**
- **Low eco-footprint**
- **Multi-functional**
- **Reduction of energy demand**

BIOMIMICRY

JANINE BENYUS

EXAMPLES:
how nature has influenced industry

http://www.biomimicry.net/intro.html

OAK TREE

- Low sprawling structure
- Furled leaves
- Spiral trunk
- Structure to match forces
- Companion root systems
- Multi-functional parts – structure / skin / life

BIOMIMICRY

EXAMPLES: how nature has influenced industry

Barbs on weed seeds

Velcro-perhaps the most well-known biomimetic invention.

Orb-weaver spider silk

***New fiber manufacturing technique*-A way to manufacture fiber without using high heat, high pressure, or toxic chemicals. The fiber is stronger and more resilient that anything we now have; could be used in parachute wires, suspension bridge cables, sutures, protective clothing, etc.**

Abalone mussel nacre (mother of pearl coating)

***Hard coatings*-for windshields and bodies of solar cars, airplanes, anything that needs to be lightweight but fracture-resistant. A crystalline coating self-assembles in perfect precision atop protein templates. In the abalone, it's a 3-D masterpiece, tougher than anything we can manufacture!**

http://www.biomimicry.net/intro.html

Integrated Design

Team Play versus relay race:
Creation of goals for the team

A voice to influence design

A chance to integrate disciplines / integrate systems

Economic solutions / minimizing materials

ADAPTABILITY

How buildings learn

Stewart brand

Think about the things that are a hassle when you renovate

Design structures as a shell that can last 100 to 200 years, assume changes in use, mechanical systems and cladding.
Consider structural systems, floor loadings, floor to floor heights, ease of future renovations, i.e. removing and replacing the cladding, durable materials, construction quality.

Consider structural adaptability for future use and adequacy of alternative uses
Keep good as-built records

US GREEN BUILDING COUNCIL

USGBC

WHY WAS LEED CREATED?

A national nonprofit organization
A diverse membership of organizations / Consensus-driven
Committee-based product development

Developer and administrator of the LEED® Green Building Rating System

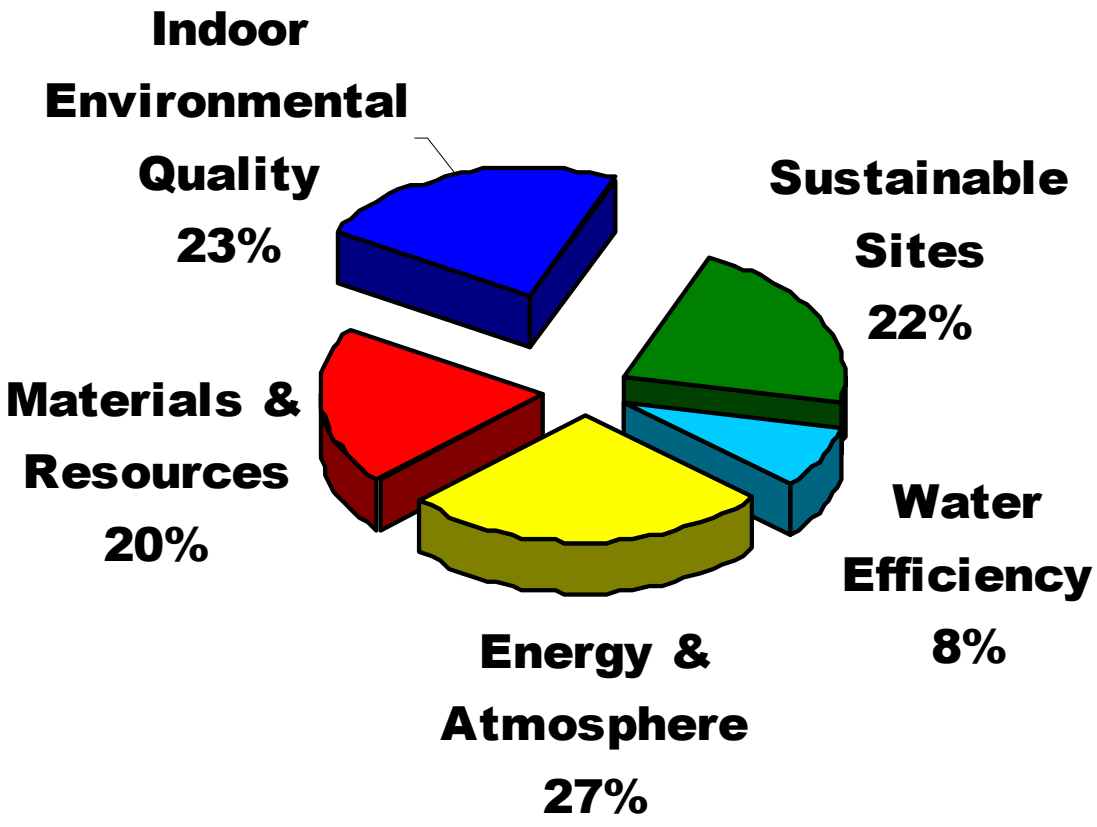
- Design guideline
- Consumer awareness
- Measurement - Prevent “greenwashing”

Transform the marketplace!

LEED CATEGORIES

Four levels of LEED-NC certification

Certified Level	26-32 points
Silver Level	33-38 points
Gold Level	39-51 points
Platinum Level	52-70 points



CREDIT SET-UP

Each Credit is set up with

- Intent
- Requirements
- Submittals
- Potential Technologies & Strategies

Format for ID (Innovation in Design) credits same

DOUGLAS BORDER CROSSING
LEED REGISTERED

Read Jones Christoffersen
Consulting Engineers

Integrated Design is key to the success of Sustainable Design / LEED

THE ROLE OF THE STRUCTURAL ENGINEER IN THE SUSTAINABLE PROCESS

TEF III, UBC
LEED SILVER

LEED however does not (at this stage) address many of the issues around structure and sustainability eg

- Adaptability / longevity
- Actual embodied energy/CO_2 resulting from system choices
- Minimization/elimination of materials such as finishes / exposing the structural form

LEED is an evolving document/process – the next steps are looking at Life Cycle Analysis (LCA) in LEED

SUSTAINABLE SITES

STORMWATER MANAGEMENT

Intent:

Limit disruption and pollution of natural water flows by managing storm water runoff

How can structural engineers input to this?

Strategies include use of pervious materials for the site – suggestions of materials to be aware / have a basic knowledge of:

- Pervious concrete
- Grass pave / gravel pave

UBC Rose Garden Parkade

SUSTAINABLE SITES

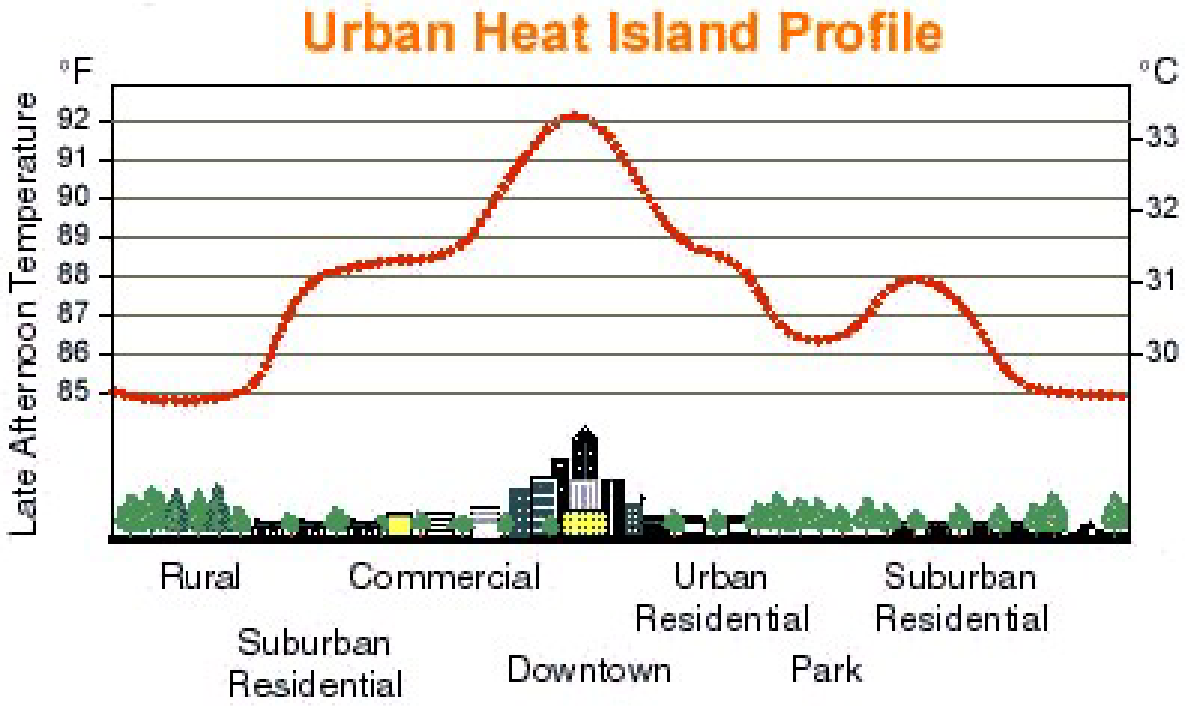
HEAT ISLAND EFFECT: ROOF

GREEN ROOFS BENEFITS:

INSULATION
HABITAT
ECOSYSTEMS
LIVEABILITY
STORMWATER REDUCTION
ACOUSTIC
DURABILITY OF MEMBRANE
FILTRATION OF POLUTANTS

Intent

Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat



Optimize location of green roof / weight

Protect structure by detailing to minimize leakage:
Small drainage areas
Reduce shrinkage cracks
Reduce dowels thru membranes
Scuppers at external walls

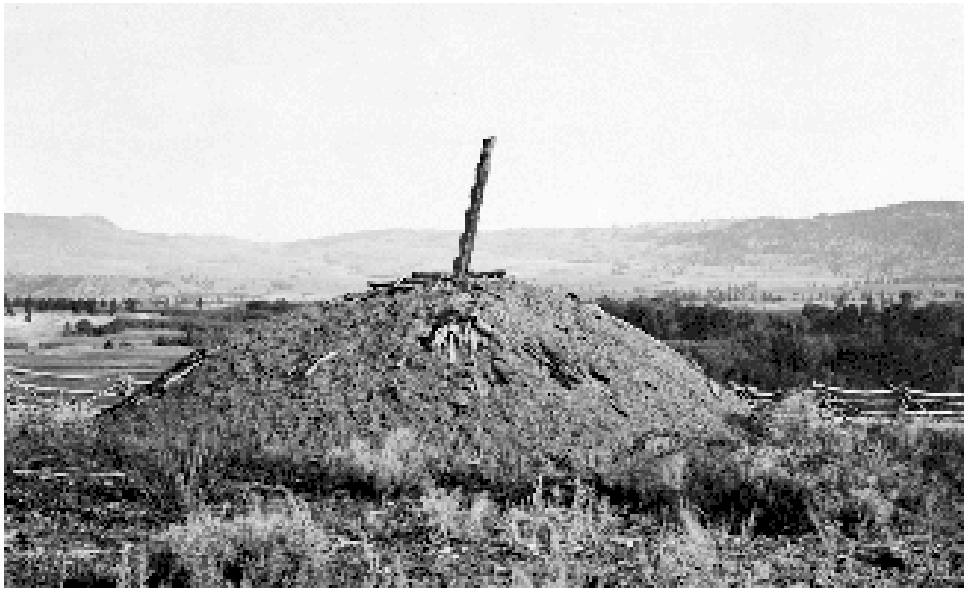
Structural impact of green roof weight

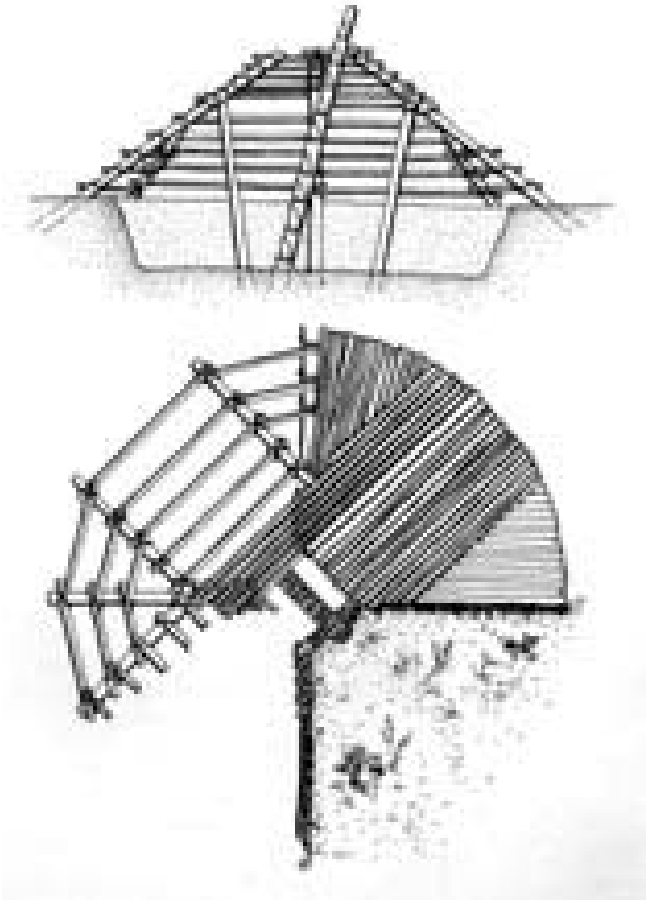
Intensive green roofs 8” dp and more
Extensive green roofs <8” dp

Vancouver Library Square,
BC Canada

Green roofs on Pit Houses

Drawing provided courtesy of the Canadian Museum of Civilization

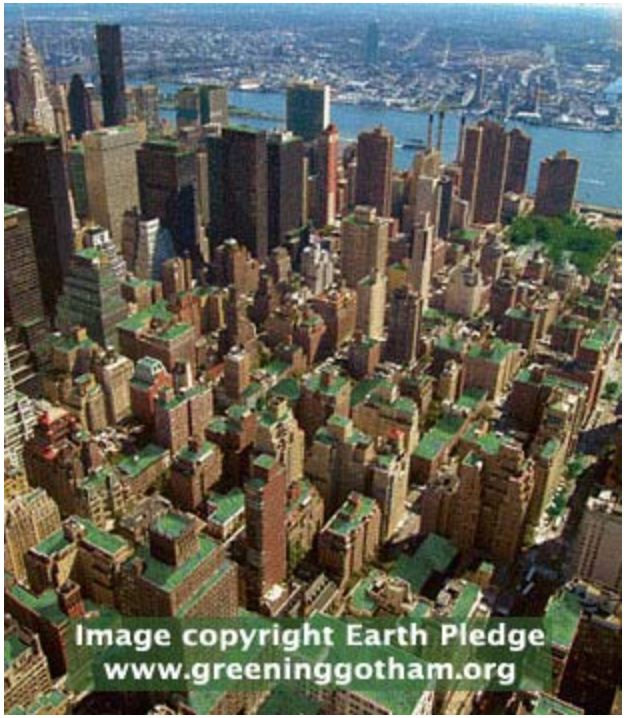




These pit houses were dug about a meter or more into the ground, usually round in shape, and covered over by logs, sod and earth. Most were about ten to eighteen metres in diameter and were warm and comfortable.

Cities of Green Roofs

Peter Zumthors Val Thermal Baths, Switzerland



WATER

HOW CAN STRUCTURE AFFECT WATER USE?

Storage of water
Water collection
- Integrate structure with collection of water

ISLAND MEDICAL BUILDING, UVIC

Read Jones Christoffersen
Consulting Engineers

Eco-Integration
sustainable design consulting

REDUCTION OF ENERGY AND STRUCTURE

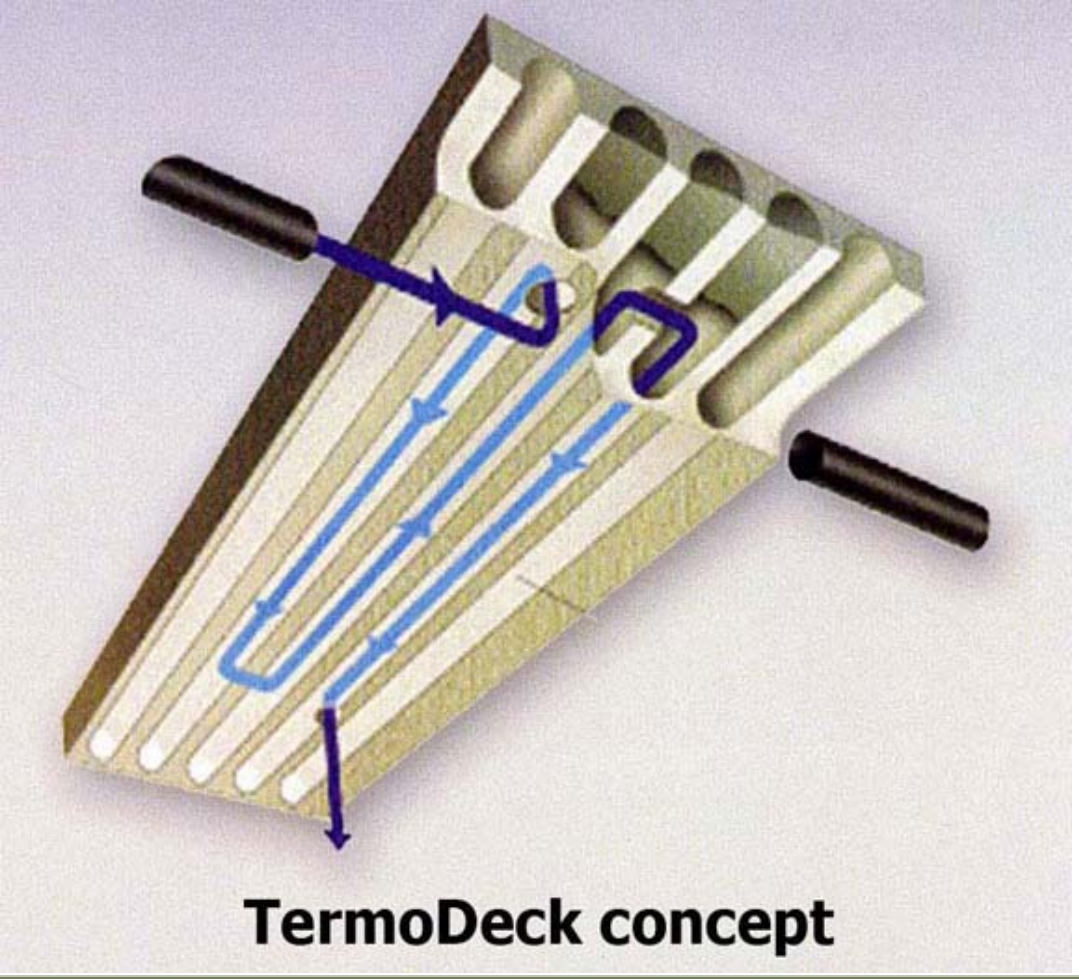
Using the mass of structure to reduce energy demand:

- Use of material as heat sink (Passive Haus)
- Radiant floor / wall heating
- Use of structure to form ducts:
    - termodeck

BC GAS BUILDING, SURREY

Nine 20-metre-long concrete Earth Tubes pre-temper outside air prior to entering the building's air handling unit, reducing energy requirements by up to 16%.

rjc Read Jones Christoffersen
Consulting Engineers



TermoDeck concept

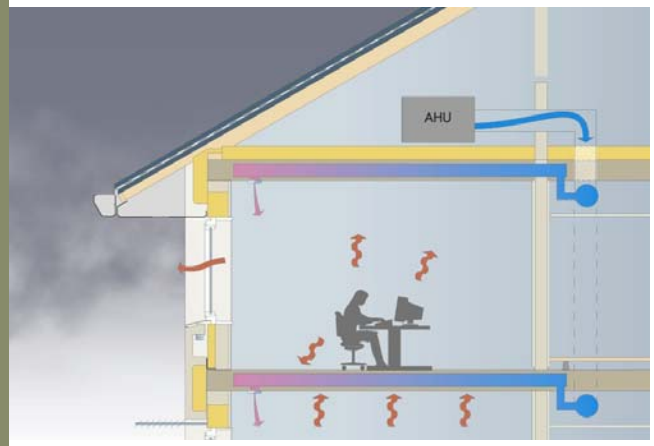
- Use of standard hollow core slabs
- Developed in Scandinavia in 1970s
- Hollow cores are connected to air handling ducts

Read Jones Christoffersen
Consulting Engineers

Eco-Integration
sustainable design consulting

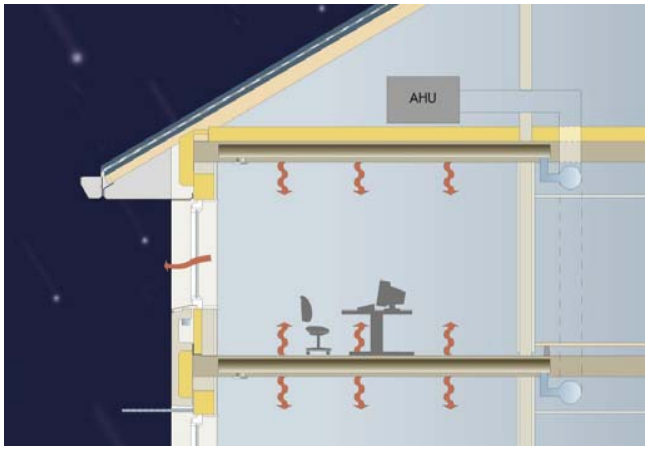
THERMODECK

Cold Climates



Day time

- Supply air fans are running with warm air
- Building structure stores the surplus heat



Night time

- Supply fans are off
- Stored energy is retained, providing comfort the next morning
- On very cold nights, warm air may be circulated through slabs

Eco-Integration
sustainable design consulting

rjc Read Jones Christoffersen
Consulting Engineers

Centre for Manufacturing and Design Technologies, Sheridan College

Brampton, Ontario

Diamond & Schmitt Architects with RJC

- Floor and roof slabs efficiently absorb heat generated from lighting, machinery and re-radiated solar gains in classrooms
- Distribute heat to the space in locations and times that heating is req'd
- Fans bring cool outside air into the cores of the concrete floor slabs during the evening and cool the slabs for distribution of this cooling to the space at the time and location req'd
- Second time use in Canada, but the system has been in use in Europe for about 10 years

Eco-Integration
sustainable design consulting

rjc Read Jones Christoffersen
Consulting Engineers

Exterior-insulated Concrete Walls:

Advantages

- Concrete Wall adds mass
- Concrete on inside provides thermal mass and increases thermal comfort
- No thermal bridging from concrete

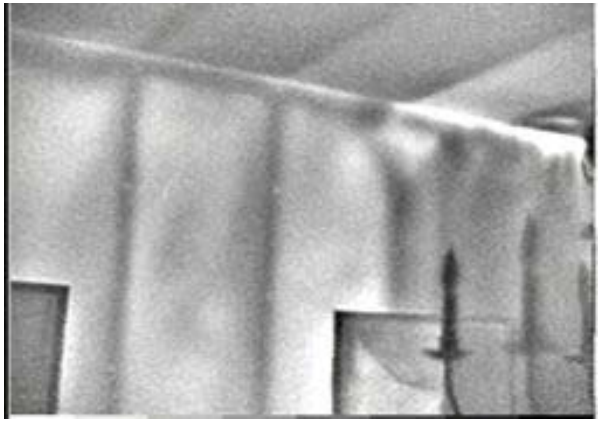
LIFE SCIENCES CENTRE, UBC

Eco-Integration
sustainable design consulting

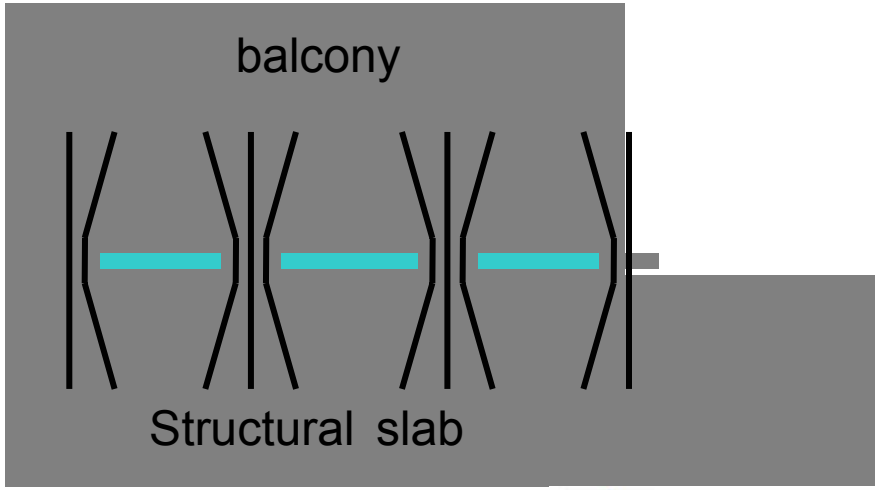
Read Jones Christoffersen
Consulting Engineers

THERMAL BREAKS:

Structural Penetrations



Infrared showing cold bridging of studs



Eco-Integration
sustainable design consulting

Read Jones Christoffersen
Consulting Engineers

WILLIAM FARRELL BUILDING

Building Reuse

Reusing existing buildings:

- Decreases landfill from demolition
- Decreases material consumption for new building

Structural Engineer's Role:

- Explore economic / practical ways to seismically upgrade:
  - Fyfe (fibre reinforced fabric)
  - Bracing
  - Mini piles
- Be creative with solutions to limit disruption

Seismic upgrading is a specific area of expertise and will become increasingly in demand

MATERIALS & RESOURCES

BUILDING REUSE

CHILD & ADOLESCENT HEALTH
CENTRE OF BC
LEED REGISTERED

Read Jones Christoffersen
Consulting Engineers

MATERIALS & RESOURCES

CREDIT 2
CONSTRUCTION WASTE MANAGEMENT

CK Choi Building

How can design of structure affect construction waste management?

- Use materials that can be recycled if there is surplus waste
- Specify waste management plan in specifications
- Design to reduce waste produced (currently would not get point but good design practice)
    - Use plywood dimensions where possible for laying out concrete
    - Rebar lengths so reduce cut offs
    - Prefabricated materials factory produced to reduce waste created

The landfill
*Throw it **away**….But where is **away**?*

Read Jones Christoffersen
Consulting Engineers

MATERIALS & RESOURCES

CREDIT 3
RESOURCE REUSE

Resource Reuse is **Salvage Materials** (not recycled materials)

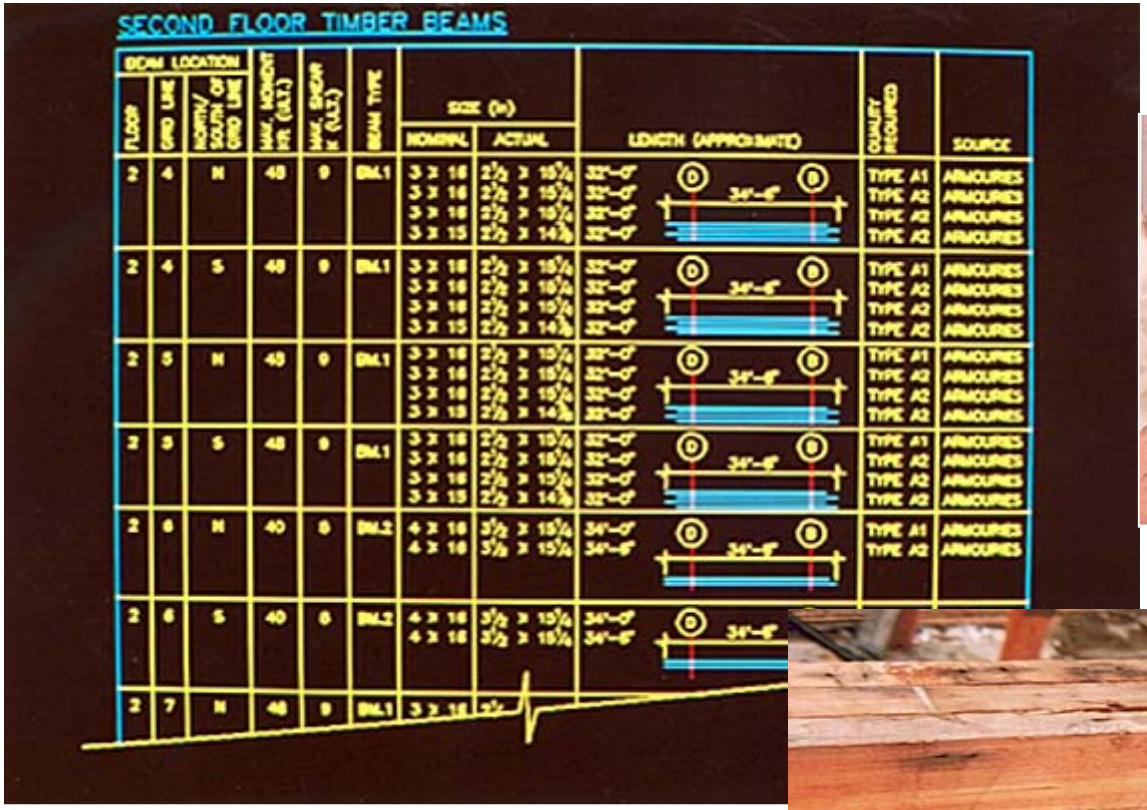
Examples of structural salvage materials:

- Steel beams
- Timber beams
- Timber decking
- Brick / masonry
- Concrete lock blocks
- Retaining Walls: Allan blocks
- Tilt up panels?

CK Choi Building, UBC Canada

Read Jones Christoffersen
Consulting Engineers

CK Choi Building, UBC Canada



Read Jones Christoffersen
Consulting Engineers

CK Choi Building, UBC Canada

Read Jones Christoffersen
Consulting Engineers

MATERIALS & RESOURCES

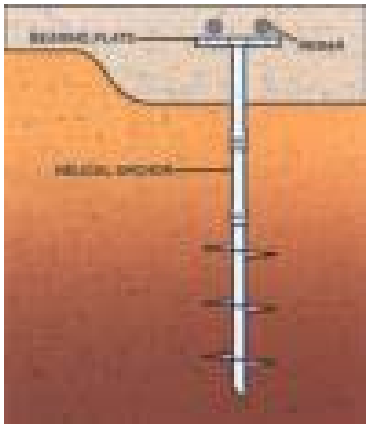
RESOURCE REUSE

Not currently rewarded by LEED but consider designing for
disassembly

Choose materials that can be used again in the future and not end in the landfill

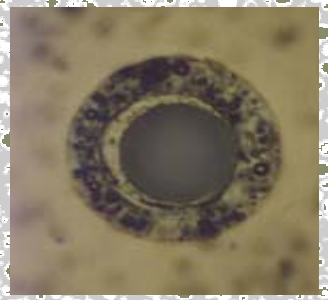
INNOVATION & DESIGN PROCESS

Demountable Buildings



MATERIALS & RESOURCES

RECYCLED CONTENT



LEED uses a template to calculate the collective recycled content of all the materials on the project

Examples of structural materials with recycled content:

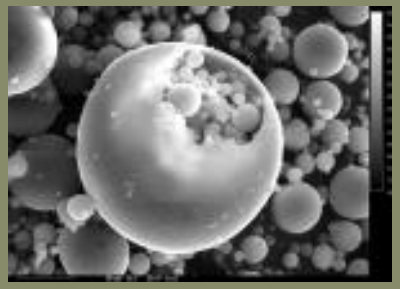
- Concrete
  - Supplementary Cementing Materials
  - Aggregate
  - Water
- Reinforcing Steel
- Structural Steel

MATERIALS & RESOURCES

RECYCLED CONTENT

SUPPLEMENTARY CEMENTING MATERIALS FLY ASH

NATURAL POZZOLAN



FLY ASH

8% of global CO2 emissions is due to cement production

1 TONNE OF CEMENT:

- Releases 1 tonne of CO_2
- Consumes 5 million BTU of energy
- Uses 2 tonnes of raw materials

FLY ASH:

- Is a waste product or the coal industry
- Benefits include:
  - Improved concrete properties
  - Environmental
  - Economic
- Challenges include:
  - Lower early strength gain
  - Curing

CASE STUDY

TECHNOLOGY ENTERPRISES FACILITY III UBC - 2002

UBC TEF III
CERTIFIED
LEED SILVER

Overcoming the early strength gain issues:

- Options to achieve a higher early strengths with fly ash concrete
  - Lower the water/cement ratio and add plasticizer
  - Add an accelerator
  - Reduce the air content
- Alternate options researched
  - Formwork adaptation
  - Insitu tests
  - Hybrid systems
  - Permanent formwork

Eco-Integration
sustainable design consulting

rjc Read Jones Christoffersen
Consulting Engineers

SPECIFYING CEMENT REDUCED CONCRETE

Dockside Green, Victoria

Guidelines for % Cement Reduction

Element	Range in Vancouver
Highest in footings (minimal impact on schedule, minimal finishing required, lowers heat of hydration in core & crane raft footings)	40% - 50%
Mid-Range in vertical elements (usually limited by formwork stripping and winter conditions)	35% - 45%
Lower in horizontal elements (finishing, curing, and formwork stripping time can impact costs)	10% - 40%
Low in C-1 exposure class (HVFA concrete exposed to freeze-thaw and deicing has scaling concerns)	15% Maximum

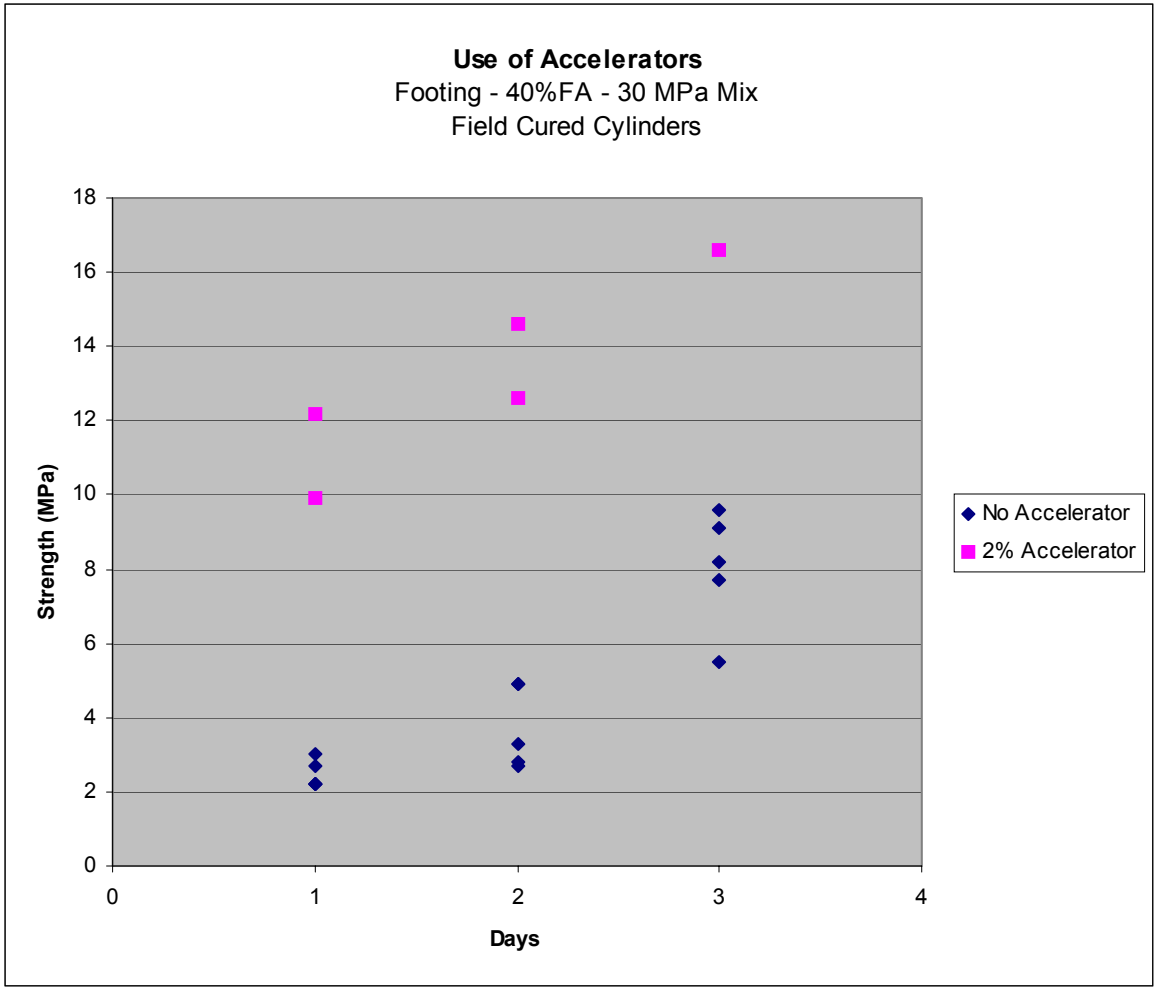
Greatest concrete component is usually slabs (40-60%)

CASE STUDY

BISON COURTYARD
BANFF, ALBERTA 2004

Use of accelerators:

- Doubled strength gain in first three days



STRUCTURAL SYSTEMS

HIGH-RISE RESIDENTIAL STUDY, VANCOUVER, B.C.

FLAT PLATE CONCRETE

Conventional Fly Forms modified

Proprietary Form Systems

(Peri Sky Deck or similar)

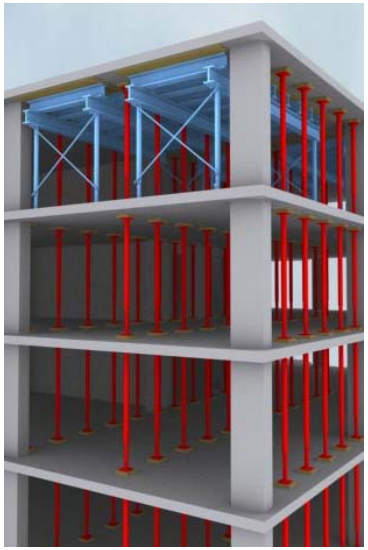
Disadvantages

- Additional cost of for system or propping

Advantages

- Forms can be stripped at a lower early strength
- 4-day cycle can be achieved with HVFA concrete

PROPRIETARY FORM SYSTEM



CONVENTIONAL FLY FORMS MODIFIED

Read Jones Christoffersen
Consulting Engineers

ABBOTSFORD HOSPITAL,
ABBOTSFORD, BC

DE-MATERIALIZATION

C&W HEALTH CENTRE OF BC

INNOVATION

BUBBLEDECK

A two-way precast hybrid 'hollow' flat plate system

Advantages

- Lightweight system capable of large spans
- Lighter systems translates to less gravity and seismic load = smaller columns and footings
- Precast base allows use of high SCM concrete without affecting schedule
- Easy to erect on site, no formwork erection, little site rebar placement
- Precast soffit can be exposed

rjc Read Jones Christoffersen Consulting Engineers

MATERIALS & RESOURCES

RECYCLED CONTENT

Reinforcing Steel
Structural Steel

5100 Structural Steel Specification Excerpt:

1.8 Submittals

Submit documentation for recycled content of structural steel. A breakdown of post-consumer and post-industrial recycled content should be specified. A mill certificate shall be provided

2.1 Materials

Structural steel as specified herein or on the drawings shall contain the highest recycled content available (a minimum of 95% where possible).

MATERIALS & RESOURCES

CREDIT 5
REGIONAL MATERIALS

Intent

Support indigenous resources
Reduce the environmental impacts of transportation

Could become a specific goal on the project:

E.g. Gold River Project
Sechelt Library

Our role is to know the materials that are local to the project and specify what is realistic:

Read Jones Christoffersen
Consulting Engineers

MATERIALS & RESOURCES

RAPIDLY RENEWABLE MATERIALS

Paper tube Structures

Centre d'Interpretation du Canal de Bourgogne France

“Shigeru Ban is a master of materials. He uses paper, wood and bamboo structurally, as well as more conventional materials such as steel glass and concrete..”

RAIC/AIBC Festival of Architecture 2006

MATERIALS & RESOURCES

RAPIDLY RENEWABLE MATERIALS

Bamboo Scaffolding
Hong Kong

Bamboo Structure

Bamboo Bikes

MATERIALS & RESOURCES

CERTIFIED WOOD

Intent

Encourage environmentally responsible forest management

FSC = Forest Stewardship Council

Sourcing of FSC Wood:

Abbotsford Hospital

- Eco-Lumber – plywood

Responsible wood choices:

- Pine beetle
- drowned forests
- Old growth forests
- Abundant locally grown
- Renewable

MATERIALS & RESOURCES

DURABLE BUILDING

Intent:
Minimize materials use and construction waste over a building's life resulting from premature failure of the building and its constituent components and assemblies

New credit – not in US LEED

Based on CSA S478-95 Guideline on Durability in Buildings

Durability and Structure

- Protection of materials
- Access for maintenance
- Material knowledge

Projects:
Abbotsford Hospital
Gulf Island Operations Centre

INDOOR ENVIRONMENTAL QUALITY

LOW-EMITTING MATERIALS

Intent
Reduce harmful indoor air contaminants affecting installers and occupants

How does this affect Structure?

4.1 Adhesives & sealants
4.2 paints and coatings
4.4 composite wood and laminate adhesives

Specify no added urea-formaldehyde
Material knowledge

Fibre Reinforced Glulam Beams

De-materialization

Designing for the loads

Wood
Advanced Wood Framing
Lattice roofs

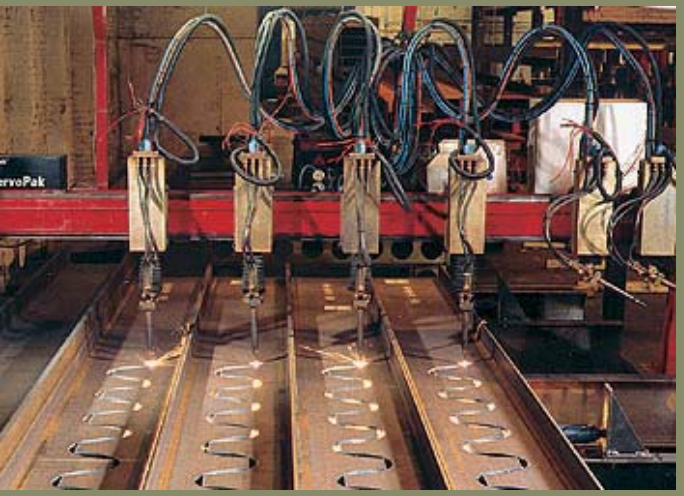
Concrete
Shell
Hollow core
Bubbledeck
Termodeck

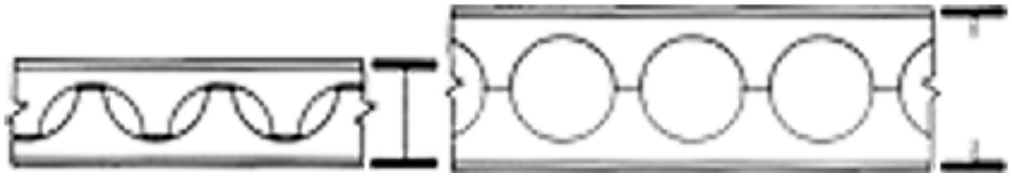
Steel
Castellated beams

Composite systems

Japanese Pavillion,
Hanover, Expo 2000

DE-MATERIALZATION & STRUCTURE TO MATCH FORCES





CELLULAR BEAMS / CASTELLATED BEAMS

- Efficient use of materials
- Aesthetic
- Economic

De-materialization: Bubbledeck

Read Jones Christoffersen
Consulting Engineers

Life Cycle Analysis

Athena Sustainable Materials Institute –
Life Cycle Assessment (LCA) or 'Ecoprofile'

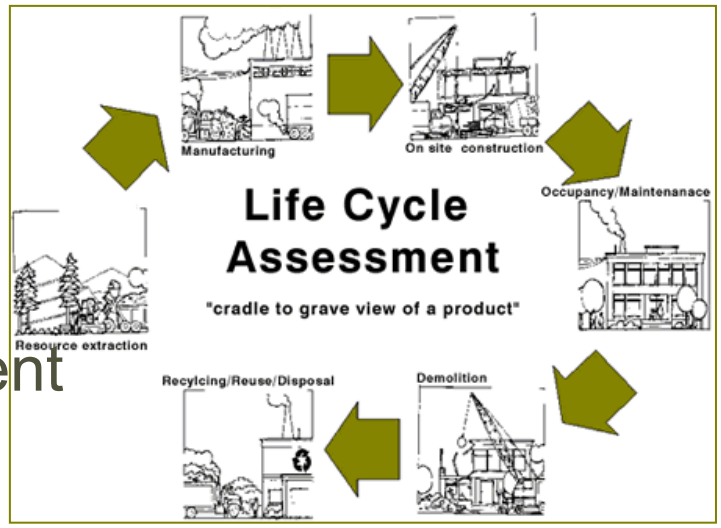
LCA tool developed since 1990

2 common measures of environmental assessment:

- Embodied Primary Energy GJ
- Global Warming in tonnes of carbon dioxide

LCA Stages

Product Manufacturing
On-site Construction
Maintenance and replacement
Building End Life



Next Steps…

Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has.

Margaret Mead

Diana Klein, LEED AP, P.Eng
dklein@eco-integration.com

Eco-Integration
sustainable design consulting