Graduated Guidelines for Residential Construction (New South Wales)

Volume 1

Historical and Technical Background

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1.0 Introduction

The Mine Subsidence Board is a service organisation operating for the community in coal mining areas of NSW and is responsible for administering the Mine Subsidence Compensation Act. The Act provides for compensation or repair services where improvements are damaged by mine subsidence resulting from the extraction of coal.

The Act also gives the Board the responsibility of reducing the risk of mine subsidence damage to properties by assessing and controlling the types of buildings and improvements that can be erected in Mine Subsidence Districts. These Graduated Guidelines are an innovative tool for use in that context. Applicants should not assume they will be given subdivision approval on the basis of houses within the subdivision meeting the requirements of these building guidelines.

The Graduated Guidelines consist of two companion documents issued by the Mine Subsidence Board and apply only to lots with single residential structures constructed in accordance with the Building Code of Australia. They apply only to those areas within Mine Subsidence Districts where future mining is planned or possible.

The two documents provide prospective owners, builders and designers of residential properties with design guidelines that are applicable in proclaimed Mine Subsidence Districts. The guidelines are based on current technology and may be varied in the future as additional information becomes available.

For structures other than residential, advice should be sought from officers of the Board.

This document, Volume 1, describes the historical and technical background to the Graduated Design Guidelines. Volume 2, which may be used without reference to Volume 1, contains the application and design procedures.

In brief, the Guidelines provide a technical framework within which applications for consent for the construction of residences in proclaimed Mine Subsidence Districts may be evaluated and processed.

The Guidelines have been drafted to be compatible with the performance criteria for residential structures as defined in AS 2870 and the Building Code of Australia.

Note: Where reference is made to AS 2870 in this document, it is to be understood that the reference is to the current edition of AS 2870.

The current version of AS 2870 is AS 2870-1996 as at November 2000.

2.0 Background and Overview

Reports of subsidence damage in the Newcastle area date from late last century. Kapp (1) reported damage to houses in Wickham, 4 km west of Newcastle in the 1890s.

Continuing damage to structures led to a Royal Commission in 1908 and, subsequently, to the passage of the Mine Subsidence Act of 1928 and the formation of the Mine Subsidence Board. The 1928 Act was replaced by the Mine Subsidence Compensation Act, 1961.

Coal mining methods in New South Wales have evolved from hand excavation in conjunction with conventional bord and pillar methods to mechanised retreat longwall mining in the early 1960s.

Comprehensive subsidence monitoring and investigation programs were not initiated until the 1970s. Whilst the time span between the commencement of mining and the commencement of detailed monitoring may appear unusual, the position was not dissimilar to that found overseas. In the U.K. the National Coal Board published the benchmark reference Subsidence Engineers' Handbook in 1965, whilst a revised addition of this work was published in 1975 (2). In New South Wales the Department of Mineral Resources published a series of three handbooks titled “Mining Subsidence in New South Wales – Surface Subsidence Prediction...” in the Southern Coalfield (1985), the Newcastle Coalfield (1987) and the Western Coalfield (1991).

As coal mining operations extended closer to existing and projected urban areas the competing objectives of the coal industry (to maximise coal extraction from known and recently discovered deposits) and urban expansion (to maximise land use) came sharply into focus.

From the 1970s onwards, the Mine Subsidence Board issued construction guidelines to the building industry for construction within proclaimed Mine Subsidence Districts. (In this document the term building industry refers specifically to residential construction rather than the broader construction industry).

The publication in 1986 of AS2870 – Residential Slabs and Footings Code – brought a degree of standardisation to the design of residential footing systems that previously had been lacking.

Whilst AS 2870 identified a site class "P" as being relevant to areas susceptible to Mine Subsidence the designer was faced with considerable difficulty in identifying an appropriate design protocol. Clause 5.6 in the 1986 version of AS 2870 advised:

5.6 DESIGN FOR MINE SUBSIDENCE SITES.

5.6.1 Application. Footings and slabs on sites subject to mine subsidence shall comply with the requirements of the appropriate authority.

It is recommended that this clause be used where the design is carried out by a qualified engineer to specified subsidence parameters or for subsidence prone areas not covered by a mine subsidence authority.

Note: Mine subsidence can subject footing systems and the houses they support to severe movements including lateral strain, settlement, slope and curvature. Lateral strains are of particular concern, as they are not encountered so severely in other forms of foundation movement. Frequently, the subsidence is associated with the removal of a specific coal seam and after this event, conditions become stable and repairs are possible. The performance expectations in Appendix A are particularly relevant to this form of foundation movement. The recommendations given in this clause are limited and the designer may need to seek additional information.

5.6.2 Design to reduce the effects of lateral strain. In order to minimise the effect of lateral strain (tension and compression) the design should comply with the following recommendations:

a. The footing system should be selected to suit lateral strain conditions. Slabs-on-ground or stiffened rafts are recommended. Deep beams or piers should be avoided unless adequate slip joints are provided between the beams and the supporting piers.
b. Except on reactive clays, friction forces should be reduced by over-excavating the trenches and introducing a layer of compacted sand beneath the footing and compressible material at the sides of the footing and edge beams.
c. The amount of reinforcement in both footings and slab panels should be increased above that required for other structural actions to resist tensile and compressive forces.
d. The lateral strength should be increased by designing footings to withstand lateral earth pressure, and by decreasing grid beam spacing.

5.6.3 Design to reduce the effect of curvature. In order to reduce the effect of curvature, the strength and stiffness of the footing system should be designed to accommodate the expected curvature in accordance with the general principles in Appendix E.

5.6.4 Superstructure design. The superstructure design should comply with the general recommendations for reactive sites (see Appendix F) and the following:

a. Sewerage and stormwater lines should not be connected to the footing system to allow regrading after total settlement has taken place. All plumbing connections to the building should allow for movement.

b. Provision should be made where possible for relevelling and simple restoration.

c. Complete articulation of both the superstructure and the footing system should be considered where large curvatures are expected.

d. Where possible, the walls should be of uniform structural stiffness. Otherwise, control joints should be introduced between components of different stiffness or to isolate brittle elements.

Shortly after the publication of AS 2870 - 1986, the Board adopted a prescriptive approach in providing advice to interested parties. The Board supplied the following subsidence parameters for the design of buildings in proclaimed mine subsidence districts:

Maximum Subsidence	-	m
Maximum Tensile Strain	-	mm/m
Maximum Compressive Strain	-	mm/m
Maximum Tilt	-	mm/m
Maximum Curvature	-	km radius

At the same time, the Board took the view that certain forms of construction would not be permitted in certain mine subsidence areas. Included amongst these were two storey construction, large building footprints and/or irregular building footprints.

These Graduated Design Guidelines are an attempt at providing some rational scientific basis for the design of residential construction in proclaimed mine subsidence areas.

2.1 Future Procedures

The Graduated Design Guidelines are to be implemented in a multi tiered manner.

Such an approach enables the Guidelines to be applied in two (2) ways.

First, different skill levels on the part of building designers may be accommodated. This has been achieved by defining three (3) levels of design responsibility as shown in the table below:

Level 1: Design of the Structure must comply with AS 2870 and the BCA. The design may be carried out by a builder, a qualified Building Designer, or a Professional Designer. The design drawings must be submitted to the Mine Subsidence Board for approval.

Level 2: Design of the structure must be certified (not necessarily carried out) by a Consulting Civil and/or Structural Engineer for the site specific mine subsidence parameters. The design drawings must be submitted to the Mine Subsidence Board for approval.

Level 3: Approval is unlikely to be issued by the Members of the Mine Subsidence Board due to known mine subsidence parameters. The design drawings and all supporting documentation must be submitted to the Mine Subsidence Board for approval. Each application will be considered on its individual merit and if permission to proceed is given then design and certification of the structure must be carried out by a Consulting Civil and/or Structural Engineer.

Second, the Mine Subsidence Board will maintain an ongoing but redefined role as the provider of relevant design parameters.

The Board's officers will be the first point of contact with members of the public seeking guidance on building in proclaimed Mine Subsidence Districts. Advice given may be general or site specific depending on the nature of the enquiry.

The Board's officers will provide definitive advice as to the relevant MSB Design Index value for the proposed design. Further, they will be able to offer alternative solutions in the event that a particular form of construction may be unacceptable.

2.2 Definitions

The following definitions have been adopted in order to address:

- the terminology used,
- the roles of the relevant parties, and
- the scope of application of the Guidelines.

Articulation	A method of constructing walls so that they can move in harmony with their footings while minimising cracking and window and door jamming.
Articulated Full Masonry	Full masonry construction in which special provision is made for movement by articulation.
Articulated Masonry Veneer	Masonry veneer construction in which the provision for articulated masonry has been applied to the masonry veneer.
Builder	The builder is the person or organisation responsible for the construction of the entire building. The builder should be experienced in construction and, where required by State legislation, should be licensed.
Building Designer	The building designer is the person or organisation responsible for the design of the building. The building designer may be the builder or a draftsperson experienced in residential building construction.
Certification	Certification by a Consulting Civil and/or Structural Engineer to the effect that any improvement constructed to meet the specifications of the final drawings will be safe, serviceable and repairable taking into account the site specific mine subsidence parameters.
Clad Frame	Timber or metal frame construction with the exterior wall clad with timber or sheet material not sensitive to minor movements. Includes substructure masonry walls up to 1.5 m high.
Consulting Engineer	Where so required by these Guidelines the Consulting Civil and/or Structural Engineer is to be a professional engineer who has been admitted to the National Professional Engineers Register (NPER) as administered by The Institution of Engineers, Australia or is eligible for admission as such. *Note: NPER registration in either Civil or Structural Colleges is acceptable.* See also "Professional Designer".
Footing	Construction which transfers the load from the building to the foundation.
Footing Slab	Concrete floor supported on the ground with a separately poured edge strip footing.
Footing System	General term used to refer to slabs, footings, piers and pile systems that transfer load from the structure to the foundation.
Foundation	Ground which supports the building.
Framed Double-leaf Masonry	Construction with masonry double-leaf external wall and framed internal walls.
Full Masonry	Construction with masonry double-leaf external walls and masonry single-leaf internal walls without full articulation.
House	Detached single dwelling constructed as Class 1, or Class 10a as defined in the Building Code of Australia, with limitations as stated in this Standard.

Infill Slab	Footing system incorporating perimeter strip footings together with sub floor brickwork, the inner leaf of which supports a reinforced concrete slab, the remainder of which is supported directly on compacted filling material placed within the surrounding brickwork.
Masonry	Stone, brick, terracotta block, concrete block, or other similar building unit single or in combination assembled together unit by unit.
Masonry Veneer	House construction consisting of a load-bearing frame clad with an outer leaf of masonry.
Maximum Differential Footing Movement	The maximum movement of a footing relative to a line joining the ends of the footing system (or, in the case of double curvature, joining the points of contraflexure).
Mine Subsidence	Vertical settlement, horizontal movement, curvature, tilt and lateral strain produced at the surface as a result of underground mining
Mine Subsidence Board	The Mine Subsidence Board's Charter is set out in the Mine Subsidence Compensation Act, which provides a scheme of compensation where improvements on the surface are damaged by subsidence following the extraction of coal or shale anywhere in NSW.
One-Storey	Construction with wall height, excluding any gable, not exceeding 4.2 m and including only one trafficable floor.
Outbuilding	Detached building such as a carport, private garage, shed or the like
Pad Footing	Concrete footing used to support a pier or stump.
Professional Designer	A Professional Designer may be a Consulting Engineer or an appropriately qualified Registered Architect admitted to practise by the Royal Australian Institute of Architects.
Repairable	The materials used and their method of utilisation must allow damage after subsidence to be repaired or replaced economically.
Safe	The occupants and users of the building must not be at risk from loss of integrity of the structure.
Serviceable	The building must be able to continue to be used for the purpose for which it was designed.
Shall	Indicates that a statement is mandatory.
Should	Indicates a recommendation
Slab	General term used to refer to slab-on-ground, stiffened rafts, footing slabs, stiffened footing slabs and waffle rafts
Slab Panel	Part of a slab between beams
Slab-on-Ground	Concrete floor supported on the ground and incorporating integral edge beams
Stiffened Raft	Concrete slab on ground stiffened by integral edge beams and a grid of internal beams
Strip Footing	Footing of rectangular section
Two-Storey	Construction with wall height, excluding any gable, not exceeding 8.0 m and including two trafficable floors
Veneer	Construction of either masonry veneer or articulated masonry veneer
Waffle Raft	A stiffened raft with closely spaced ribs constructed on the ground and with slab panels suspended between ribs.

2.3 Application of the BCA to Mine Subsidence Graduated Design Guidelines

In recognition of the recently introduced legislative changes relating to the Development/Building Approval process in New South Wales, **the Graduated Design Guidelines have been framed in a way which is compatible with the BCA and the Australian Standards adopted by Reference in Table 1.41 of the BCA.**(5)

"The BCA is a uniform set of technical provisions for the design and construction of buildings and other structures throughout Australia. It allows for variations in climate and geological or geographic conditions". (5, Introduction).

The BCA classifies Class 1 and 10 buildings as follows:

> **Class 1** - one or more buildings, which in association constitute -
>
> a. **Class 1a** - a single dwelling being -
>   i. a detached house; or
>   ii. one or more attached dwellings, each being a building, separated by a *fire resisting wall*, including a row house, terrace house, town house or villa unit, or
>
> b. **Class 1b** - a boarding house, guest house, hostel or the like with a total floor area not exceeding 300 m^2 and in which not more than 12 persons would ordinarily be resident.
>
> which is not located above or below another dwelling or another Class of building other than a *private garage*.
>
> **Class 10** - a non-habitable building or structure being -
>
> a. **Class 10a** - a non habitable building being a *private garage*, carport, shed or the like; or
> b. **Class 10b** - a structure being a fence, mast, antenna, retaining or free-standing wall, *swimming pool* or the like.

At part 2.1 of the BCA the three (3) fundamental aims of the document are stated with relevance to class 1 and class 10 building.

These aims are as follows:

> ***Objective:***
>
> *The **objective** is to -*
>
> a. *safeguard people from injury caused by structural failure; and*
> b. *safeguard people from loss of amenity caused by structural behaviour; and*
> c. *protect **other property** from physical damage caused by structural failure.*
>
> ***Functional Statement:***
>
> *A building or structure is to withstand the combination of loads and other actions to which it may be reasonably subjected.*
>
> ***Performance Requirement:***
>
> *A building or structure including its materials and components must be capable of sustaining at an acceptable level of safety and serviceability -*
>
> a. *the most adverse combination of loads (including combinations of loads that might result in a potential for progressive collapse); and*
> b. *other actions, to which it may reasonably be subjected.*

2.4 The Concept of Serviceability Design

There are many and diverse attempts in current technical literature aimed at defining serviceability.

International Standards suggest that structural serviceability should include two basic groups of mechanical properties:

(1) **Safety or load bearing capacity**, ie resistance of various actions without collapse or total disability of the structures or their elements, and

(2) **Serviceability**, ie the ability of structures and their elements to perform adequately in normal use.

Design serviceability parameters relate, therefore to accepted criteria for acceptable deformations, displacements, vibrations or other mechanical indicators associated with structural performance.

International Standard ACE 6241/3 (13) nominates three basic groups:

a. human comfort, comprising:
    - o appearance requirements (to limit annoying visual effects due to deformation and cracking in structural components), and
    - o physical requirements (to limit discomfort due to vibration, penetration of air, dust and sound);

b. structural requirements (to limit local damage including stress, strain, excessive cracking and to guarantee such properties as water tightness, drainage, and proper functioning of any attached elements such as doors and windows;

c. equipment requirements (to guarantee proper functioning of equipment, pipes, ducts and their related supports).

In the context of mine subsidence impacts, serviceability refers to the ability of a structure to continue to be used for the purpose for which it was designed following the effects of mine subsidence movements on the structure.

3.0 Performance Aspects of the Proposed Graduated Design Guidelines

Note:	Where reference is made to AS 2870 in this document, it is to be understood that the reference is to the current edition of the AS 2870 unless stated otherwise. The current version of AS 2870 is AS 2870-1996 as at August 2000.

Adoption of specific performance targets in the framing of the Graduated Design Guidelines is complementary to the philosophical basis of AS 2870.

In the preface to the current (1996) edition of AS 2870 it is stated (4):
"The purpose of this Standard is to establish performance requirements and specific designs for footing systems for foundation conditions commonly found in Australia and to provide guidance on the design of footing systems by engineering principles".
The BCA and AS 2870 address the matter of design for mine subsidence areas by way of the process of the classification.

Part 3.2.4 - Site Classification of the BCA requires the foundation where building footings are to be located to be classified in accordance with AS 2870.

In Table 3.2.4.1 of the BCA the General Definitions of Site Classes adopted in AS 2870 are repeated. Site Class P refers to sites in mine subsidence prone areas. Class P sites require design by engineering principles in accordance with Section 4 of AS 2870.

It is important to emphasize that compliance with the Board's requirements does not imply that all design requirements for a particular project have been met. The Building Designer is at all times responsible for ensuring that any statutory or good practice design requirements be complied with.

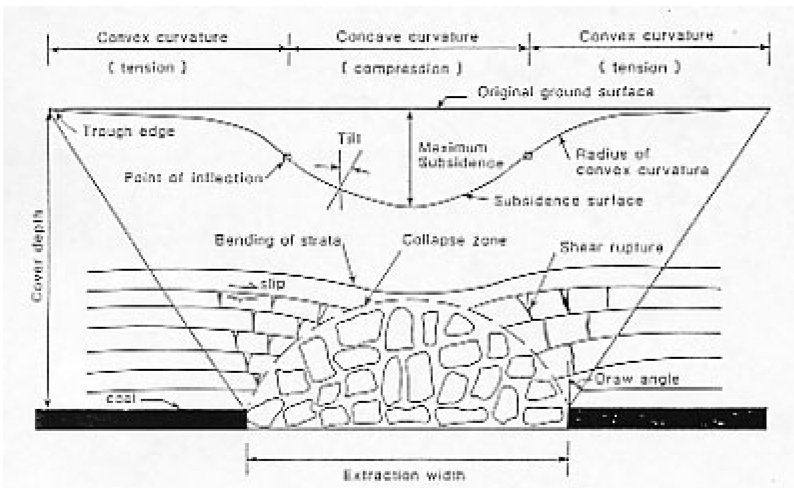
The major considerations when designing for mine subsidence are as follows:

- Design for vertical subsidence
- Design to accommodate strains
- Design to accommodate curvature
- Design to accommodate tilt.

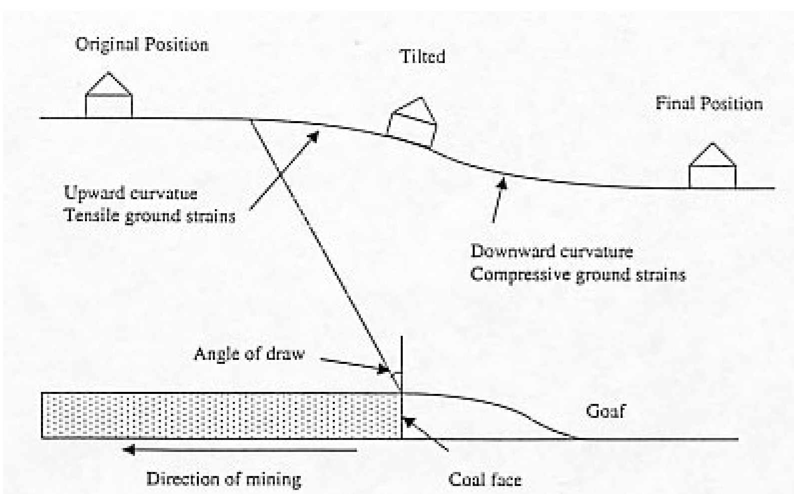
Not all mining results in subsidence nor does all subsidence cause damage to surface structures.

Engineering and architectural considerations can significantly minimise the risk of all types of structures experiencing mine subsidence damage. Special design and detailing techniques are adopted to allow structures, including buildings, roads, railways, services, etc, to withstand anticipated movements from earthquakes and unstable foundation material. Mine subsidence is just another form of ground movement that can be designed for. Design principles and techniques that allow structures to accommodate ground movement resulting from mine subsidence have been used extensively in England and Europe since the 1920s and in Australia since the 1960s.

The diagrams below show the surface effects of longwall mining in a typical cross section and longitudinal section. The diagrams are exaggerated and not to scale.



Cross Section



Longitudinal Section

3.1 Design for Vertical Subsidence

In general terms, vertical ground subsidence represents a rigid body movement that has no effect on surface structures. As such, it is seldom a significant factor in the design of individual buildings. Structures will be left at a lower level but this normally has no adverse effect on them except in the case of buildings in close proximity to watercourses that may pose a flooding problem. Generally services such as drainage would subside with the building so no differential movement would occur.

Where geological conditions are present which may induce stepping such as along fault or fissure lines, differential vertical movement may be an issue. However, such geological features are often hidden beneath the surface soils and it is unlikely that their presence will be known at design stage unless a detailed site investigation has been undertaken.

This situation is most likely to be of relevance over areas larger than most residential dwelling footprints. Services such as water, sewerage and drainage may require additional care in design and detailing.

3.2 Design to Accommodate Strains

Ground strains occur as a result of differential horizontal movement between two points causing a change in length of the surface between the two points. If the length of the surface increases, a tensile strain is induced and if the length of the surface reduces, a compressive strain is created.

Tensile and compressive horizontal ground strains are of relevance in the design of footing systems in mine subsidence areas. Tensile strains may cause cracking in brickwork and wall linings, joint separation in plumbing and cracks or separation to paving slabs. Compressive strains may cause crushing or spalling of brickwork, buckling of building components and closure of door and window openings.

In general terms, ground strains are transferred into footing systems by friction beneath and beside the footing elements. The obvious solution, therefore, is to reduce such friction and - wherever possible - separating the footing structure from the soil. This may be achieved by providing a slip layer between the structure and the ground to allow the ground to move without damaging the structure.

The use of concrete slab on grade footing systems is now close to 90% in NSW with the emergence in recent years of the waffle raft system as the preferred reinforced concrete slab footing system. This is a fortunate outcome as the waffle raft system is ideal as a mechanism for isolation of the superstructure from horizontal ground strains.

3.3 Design to Accommodate Curvature

Curvature results from differential settlement and is considered as the most damaging of the mine subsidence parameters to impact on a building. Curvature is normally defined by the deflection ratio or the radius of curvature.
In practice, damage from mine subsidence will often be a result of the combination of curvature and ground strains.

These Guidelines adopt as their primary objective the tolerable limits for relative differential movement set out in Table 4.1 of AS 2870 and as reproduced below:

**MAXIMUM DESIGN DIFFERENTIAL MOVEMENT, Δ,
FOR DESIGN OF FOOTINGS AND RAFTS**

Type of construction	Absolute maximum differential footing movement, Δ, as a function of span, mm	Maximum differential footing movement, Δ, mm
Clad frame	L/300 <=	40
Articulated masonry veneer	L/400 <=	30
Articulated full masonry	L/800 <=	15

Much of the literature describes various studies over the past 40 years in relation to “acceptable” damage threshold values.

One of the more thorough literature reviews was carried out in 1974 by Burland and Wroth (6).

More recent Australian studies include Holla (7), Bray and Branch (8), and Granger (9).

Waddington (12) compiled the results of various researchers in a table that illustrated the relationship between allowable deflection ratios, the length of structures, and the “acceptable radius of curvature” resulting from ground subsidence. These results have been reframed in the following table for the five types of construction identified in Table 4.1 of AS 2870 referred to previously.

<table>
<tr><th>Radius of Curvature</th><th colspan="4">Building Length (m)</th></tr>
<tr><th>(km)</th><th>10.0</th><th>20.0</th><th>30.0</th><th>40.0</th></tr>
<tr><td>0.25</td><td></td><td rowspan="2"></td><td rowspan="4"></td><td rowspan="6"></td></tr>
<tr><td>0.50</td><td>CF</td></tr>
<tr><td>0.75</td><td rowspan="2">AMV</td><td rowspan="3">CF</td></tr>
<tr><td>1.00</td></tr>
<tr><td>1.25</td><td rowspan="19">AFM</td><td rowspan="3">CF</td></tr>
<tr><td>1.50</td><td rowspan="3">AMV</td></tr>
<tr><td>1.75</td><td rowspan="3">CF</td></tr>
<tr><td>2.00</td><td rowspan="2">AMV</td></tr>
<tr><td>2.50</td><td rowspan="15">AFM</td></tr>
<tr><td>3.00</td><td rowspan="14">AFM</td><td>AMV</td></tr>
<tr><td>4.00</td><td rowspan="13">AFM</td></tr>
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</table>

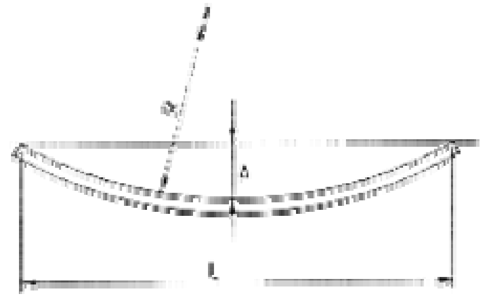
Legend: CF: Clad Frame MV: Masonry Veneer
AMV: Articulated Masonry Veneer AFM: Articulated Full Masonry

These results have been used, in conjunction with the Burland and Wroth(6) deflection/curvature relationship, to assign weighting values in the subsequent formulation of the MSB Design Index.

[Note: The mathematical relationship adopted is that adopted by Burland and Wroth viz:

$$\Delta = \frac{L^2}{8R}$$

When Δ = deflection
L = length of structure
R = radius of curvature



A singular advantage of adoption of these parameters is the elimination of building height as a relevant variable. This is of particular importance given the present desire of the project home building industry to offer a range of single and two storey dwellings in all market segments.

The height of a building clearly influences the magnification effect of any angular distortion in the superstructure. However, the values adopted, when linked with careful attention to detailing of articulation joints, eliminate (to some extent) the need for consideration of building height for the majority of residential structures as defined by AS 2870. An overall limitation of 8.0m to ridge height has been adopted for these Guidelines, this value being generally consistent with current Australian Standards of relevance, and the BCA.

The effects of ground curvature can be minimised by panelling and articulating walls to move without developing strains, cracks or causing doors and windows to jam. Damage due to curvature can also be minimised by eliminating brickwork above windows and doorways.

3.4 Design to Accommodate Tilt

Ground tilt results from a differential vertical subsidence between two points that changes the slope of the surface between the two points. Ground tilts that occur during the course of mining operations may be either a temporary or permanent phenomenon depending on their location in reference to the subsidence trough.

Small tilts generally do not affect the usage of a building and can be catered for by providing such things as generous falls for services. Tilts over 7 mm/m will start to affect the serviceability of the building and the type of construction will be restricted to allow economical repair. Conventional flooring systems can be relevelled economically where access is available to the supporting bearers and joists.

Domestic floor slabs are not normally strong enough to withstand relevelling by jacking. Other types of slabs may be designed with jacking points and sufficient strength to be relevelled after subsidence.

Considerable research effort has been expended in recent years in relation to designing footing systems that are capable of being relevelled if unacceptable tilts result from mining operations. Ongoing research and development will continue in an attempt to find economical solutions for the relevelling of concrete slabs and other footing systems.

However, recent literature (Holla, 1998) highlights the ongoing debate concerning the allocation of responsibility for payment for such systems. There are significant statistical and practical difficulties in attempting to identify sites on a site specific basis for possible proactive design methods.

The Graduated Design Guidelines do not suggest any specific procedures in order to accommodate unacceptable tilt values. Rather, the design of footing systems in regions where high tilt values are anticipated must be carried out at Design Responsibility Level 3.

4.0 Operational Aspects of the Graduated Design Guidelines

It was recognised early in the process of development of these Graduated Design Guidelines that their implementation would of necessity involve users in ongoing interaction with officers of the Mine Subsidence Board.

Given that the Board has legislative responsibility in proclaimed mine subsidence districts this is not unexpected.

At the same time, it has been the intention of the Board to formulate these Graduated Design Guidelines in a form that will facilitate flexibility of use by a wide range of participants in the building industry. It is also the intention of the Board to provide it's departmental officers with a mechanism that will facilitate consistent technical responses to queries or applications at all of the Board's offices, such responses being framed by reference to the Guidelines.

The proposed responsibility levels of such participants have been defined at section 2.1 of this document.

At all levels it will be a fundamental requirement that the published standards of good building practise are observed, particularly in relation to the correct detailing and construction of brickwork, and the fixing of internal wall and ceiling linings.

***** This aspect cannot be over emphasised. *****

The Graduated Design Guidelines incorporate several best practice publications. Adherence to the recommendations set out in these publications is a mandatory requirement of Application of the Guidelines.

4.1 Approved Construction Materials

Property owners and/or their builders will be required to construct dwellings that conform with the types of construction identified in Table 4.1 of AS 2870 (see section 3.3).

The consequence of this requirement is that the predicted curvature value for a particular site will be the principal factor in directing the site evaluation process.

Given the emphasis placed on curvature in the majority of literature currently available this approach is felt to be warranted.

5.0 Commentary and Conclusions:

The need for drafting and implementing some form of Graduated Design Guidelines for residential design in Mine Subsidence Board Districts has been evident for some time.

The Graduated Design Guidelines have been drafted in a manner which, it is hoped, will comply in large measure with present technical and legal imperatives.

It is widely recognised that mining induced subsidence is a very complex mechanism that is site specific. The response of individual building structures to mining induced subsidence is similarly complex and is a function both of the form (geometry) of a building and its component materials.

Recent analysis such as that carried out by Holla (11) suggests that statistical analyses of structures damaged by mine induced subsidence are far from precise guides for predicting future damage.

The Building Code of Australia and, by reference, AS 2870 provide the opportunity to formulate performance based design criteria for proclaimed mine subsidence areas which are consistent with the underlying design philosophies of these documents.

The Graduated Design Guidelines have been drafted accordingly.

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