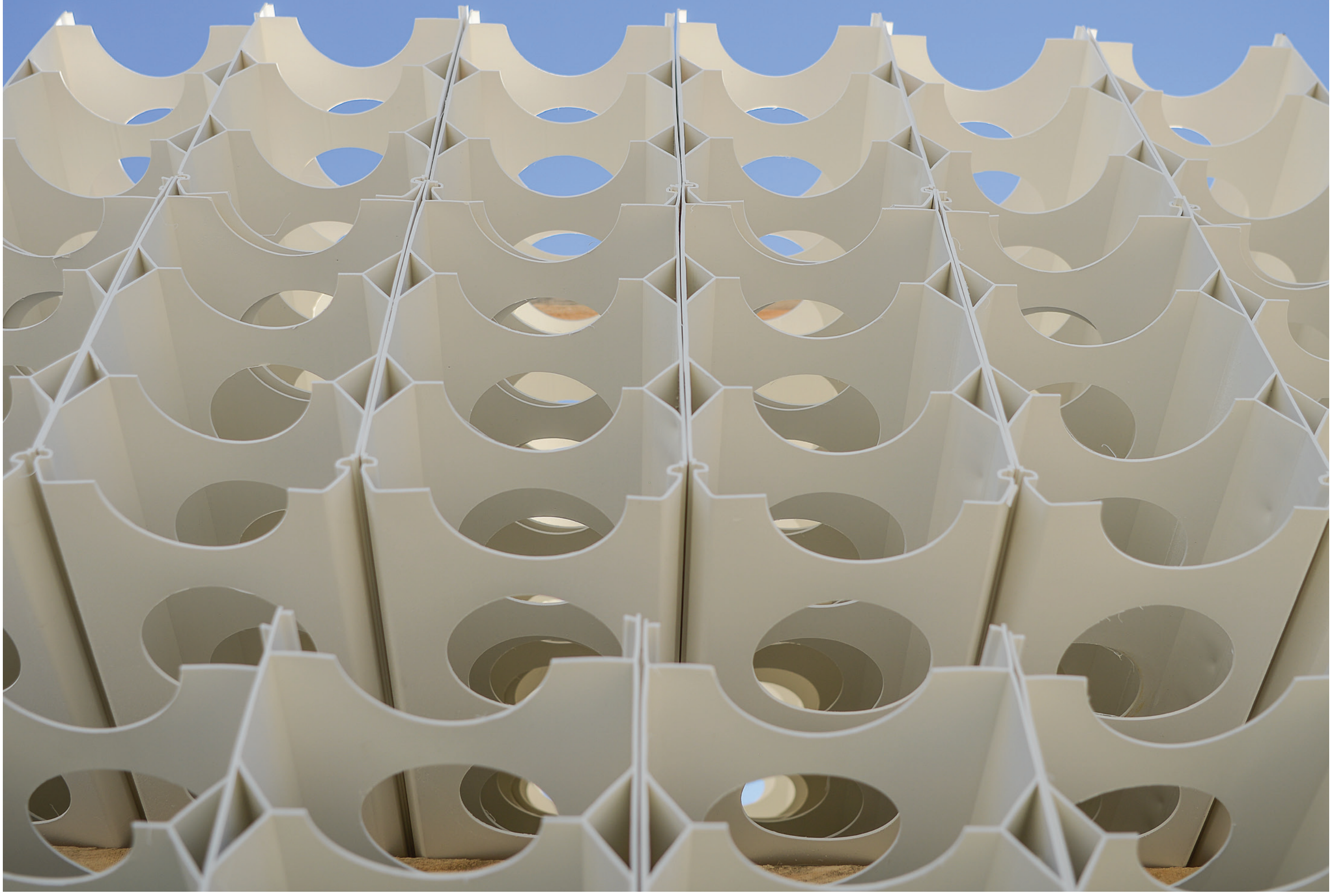

DINCEL STRUCTURAL WALLING

# DINCEL STRUCTURAL WALLING

## CONVENTIONAL DESIGN FOR MINE SUBSIDENCE

A GUIDE TO DESIGNING FOR

# MINE SUBSIDENCE

MINE SUBSIDENCE BOARD

PUTTING SERVICE AND THE NEEDS OF PEOPLE FIRST



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DINCEL STRUCTURAL WALLING

## INTRODUCTION

This information is provided by the Mine Subsidence Board as general guidance only and in no way can replace the services of a professional consultant on a particular project.

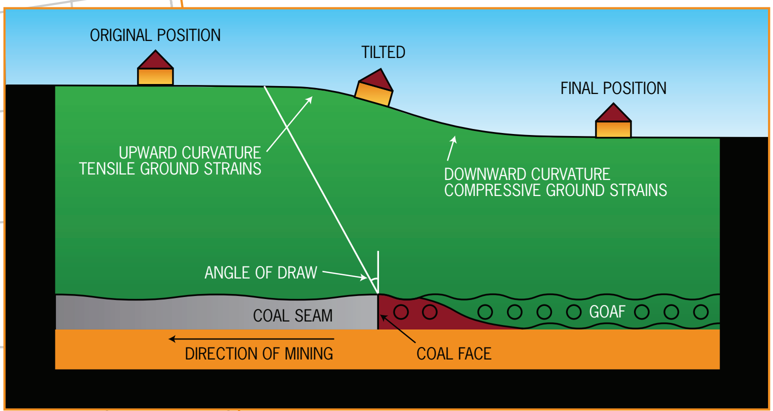
The Mine Subsidence Board is a service organisation operating for the community in coal mining areas of NSW and manages the scheme of compensation as provided for in the Mine Subsidence Compensation Act.

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 which can be erected in Mine Subsidence Districts.

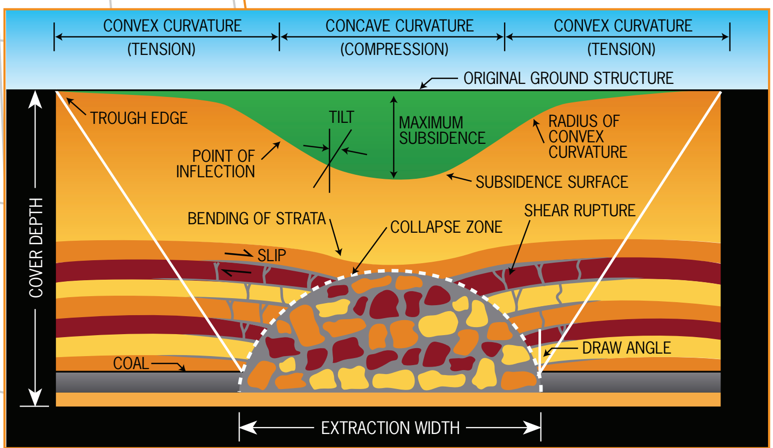
## EFFECTS OF MINING

*Movement of the ground surface following the underground extraction of coal results in the following:*

1. *Vertical subsidence*
2. *Horizontal displacement*
3. *Horizontal strains*
4. *Curvature*
5. *Tilt*




Surface Effects of Longwall Mining - Long Section ▲




Surface Effects of Longwall Mining - Cross Section ▲

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.

Generally it is the strains and curvature that damage structural elements of buildings. If strains in the ground are transferred into the structure, the tensile and compressive strains may cause building elements to crack, shear or buckle.

Tilt does not normally cause structural damage, however, in severe cases it may affect the usage of a building.

At the design stage it is possible to select a type of structure that, with appropriate detailing, will allow the structure to accommodate these subsidence effects. Designers aim to provide a structure where any damage is non structural and the building remains:

**a) Safe - no danger to users**
**b) Serviceable - available for its intended use**
**c) Repairable - damaged components economically replaceable**

## DESIGN OF STRUCTURES

### Design for Vertical Subsidence

In general terms, 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.



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### Design for Horizontal Displacements

Horizontal movements due to mining occur in such a way that points on the surface move in towards the centre of the subsidence trough. Differential movements result in strains. Overall horizontal movements are generally small except where there are unusual topographical features such as steep slopes, gorges or geological features.

### Design for Horizontal Strain

Ground strains occur as a result of differential 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.

Both tensile and compressive strains can generate damage in buildings. In most buildings, the materials are generally weaker in tension than compression, hence tensile forces are the more difficult to accommodate.

Tensile strains can cause cracks in brickwork, internal linings such as plasterboard, pulled joints in pipework, cracks and separation of joints in paving.

Compressive strains can cause spalling of brickwork, crushing of components, closure of door and window openings, buckling of materials, buckling of pipes, paving and other components.

Not all strain in the ground will be transferred into the structure. This is due to a number of factors including foundation type, ground material, the presence of sliding layers, the location and orientation of the mining in relation to the structure and so on.

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.

Footings can be designed to minimise the effect of strains on the superstructure by making them as shallow as possible and by placing them on slip layers. When deep foundations are unavoidable, the forces imposed can be reduced by excavating trenches around the structure. These trenches are placed as near as practical to, and extend to just below the underside of, the foundation. They can be backfilled with a compressible material which is strong enough to support the sides of the excavation but more compressible than the natural soil. This fill will crush and not transfer all of the forces to the foundation. Coke, slabs of expanded polystyrene foam, vermiculite, cork and void formers have been used for this purpose.

Various techniques have been used to allow footings to slip relative to the foundation material. The sides and bottoms of footings and slabs are kept as smooth as practical and are often poured on slip layers that incorporate plastic or bituminous membranes over layers of granular materials (sands). Exaggerated slopes are used on transition zones between stiffening beams and slabs to facilitate shearing actions.

The use of concrete slab on ground 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.

### Design for Curvature

Curvature results from differential settlement across the ground surface and is considered 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.

The effects of ground curvature can be minimised by panelling and articulating walls to move without developing strains or cracks or causing doors and windows to jam. Vertical articulation joints are provided at appropriate intervals and at sections where the wall stiffness changes. Damage due to curvature can also be minimised by eliminating brickwork above windows, doorways and arches. If such details are included, special attention must be paid to provision of bond beams and strengthening panels that incorporate arches.

### Design for 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.

Structures subject to tilt are only adversely affected if they remain in a significant permanent tilt at the conclusion of subsidence. This normally occurs when a structure is located on the edge of 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. Suspended flooring systems can be relevelled economically where access is available to the supporting bearers and joists.

If sufficient ceiling height has been provided in the original design, and if appropriate detailing has been adopted, it may be possible to relevel floor slabs by adding a topping layer to recover original grades.

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. This research will continue in an attempt to find solutions to the relevelling issue.

### Combined Effects

In reality the damage that occurs to a building is a result of a combination of some or all of these parameters. The deformation of the ground surface as a result of subsidence can lead to both curvature and strain affecting a structure with the possibility of tilts affecting the serviceability.

Generally a building should be designed taking a conservative approach and assuming a full transfer of strains and displacements from the ground to the structure.

## OTHER REQUIREMENTS

### Pothole Type Subsidence

Where movements of the ground surface occur over old shallow abandoned underground mine workings it can result in a localised depression or 'pothole' in the surface. The majority of these types of subsidence are generally small, however, the design parameter used by the Board is for a potential pothole up to 5 metres in diameter.

**For further information on designing for pothole subsidence refer to the Mine Subsidence Board brochure "Designing For Pothole Subsidence".**

## MINE SUBSIDENCE BOARD REQUIREMENTS

Approval must be obtained from the Mine Subsidence Board prior to any building activity or extensions for sites within Mine Subsidence Districts. The Board may grant unconditional approval of the application or stipulate certain conditions that must be met prior to final approval. In some extreme cases, where the risk of mine subsidence damage is too great, the Board may refuse a building application.

Architectural plans submitted to the Mine Subsidence Board for approval must show the location and detailing of articulation/ control joints in brickwork to comply with the requirements of the Building Code of Australia and best building practices.

Please contact any of the Board's offices for further information and advice.



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## PRACTICE

It is essential that good building practice be complied with in conjunction with any design features. The correct placement and detailing of articulation joints, detailing of brickwork above windows and doors, internal wall detailing and so on are all important to achieve a structure that is capable of handling the subsidence movements.

Some publications relevant to the description and implementation of these best practice procedures are referenced below.

1) Technical Note 61 - "Articulated Walling", Cement and Concrete Association of Australia
2) Techniques 11 - "Articulation Joints & Control Gaps for Full Brick Houses", Clay Brick and Paver Institute
3) Australian Standard AS2870
4) The Building Code of Australia

## REFERENCES


1) R.G. Hanson., "Designing For Subsidence". Mine Subsidence Board Annual Review 1988-89.
2) Holla L., "Mining Subsidence in New South Wales - 2. Surface Subsidence Prediction in the Newcastle Coalfield." NSW Department of Mineral Resources.
3) Australian Standard AS2870.
4) The Building Code of Australia.


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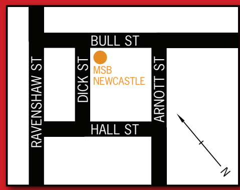


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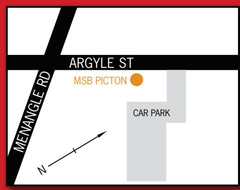


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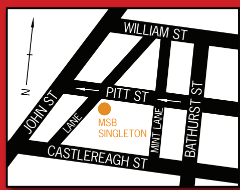


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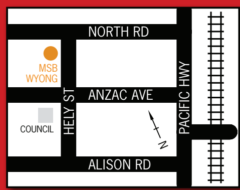


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# DESIGNING FOR “POTHOLE” SUBSIDENCE

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# DESIGNING FOR POTHOLE SUBSIDENCE

## INTRODUCTION

*Engineering and architectural considerations can significantly minimise the risk of all types of structures experiencing mine subsidence damage.*

*The interaction between structures and a moving ground surface has been a matter of importance to engineers, architects and the community for centuries.*

*'Structures', includes all types of buildings, roads, railways, drains, services, etc. They can be designed for areas with unstable foundations or that are prone to earthquake loadings, with special design and detailing techniques adopted, to allow the structures to withstand anticipated movements.*

*Design principles and techniques that allow structures to accommodate ground movement resulting from mine subsidence have been adopted extensively in England and Europe since the 1920's and in Australia since the late 1960's.*

MINE SUBSIDENCE BOARD

## WHAT IS 'POTHOLE' SUBSIDENCE

Where movements of the ground surface have occurred over old shallow abandoned underground mining it can result in a localised depression, 'potholes' or holes in the ground surface. The majority of these types of subsidences are generally small, however the design parameter used by the Board is 5,000mm (5 metres). Subsidences occur primarily in the Newcastle area, and in parts of Lake Macquarie, Maitland, Hunter Valley, Lithgow and parts of the South Coast region.

At the design stage, it is possible to select a type of structure that, with appropriate detailing, will allow the building to accommodate these subsidence effects. Designers aim to provide a structure where any damage is non-structural and the building remains:

**a) Safe - no danger to users**
**b) Serviceable - available for its intended use**
**c) Repairable - damaged components repaired economically**

Normally the Board's surface development guidelines for building in these areas would be single storey timber or steel frame clad with weatherboard or other similar materials. However, single storey brick veneer or two storey lightweight buildings can only be constructed subject to certain design condition, such as:

1. The building is to be designed for a pothole of nominal diameter 5 metres. It must cater for any subsidence of up to 5 metres in diameter occurring at any location around or under the dwelling and remain safe, serviceable and repairable. The designers must take into account the requirements of Australian Standard 2870.1.
2. Drawings must be submitted prior to the commencement of construction and certified by a qualified structural engineer, to the effect that improvements constructed meet the specification of such final drawings and will be safe, serviceable and repairable if a pothole of up to 5 metres occurs under or near the dwelling.
3. Concrete "raft" or "infill" floors are not permitted by the Board in these areas. Access or crawl space must be provided under the floor to allow for filling by the Board if a subsidence does occur at the property. Non structural concrete floors on the ground are allowed in garages or non habitable areas such as store rooms or laundries.
4. The height of the foundation brickwork is not to exceed 1.5 metres.This height is measured from the finished ground level to the under side of the floor bearers or damp course level.
5. The typical type of floor system which would be approved by the Board is the conventional bearer and joist system which is constructed of either timber or steel. This system can be supported on normal isolated sleeper piers to comply with council requirements, provided they are not supporting load bearing internal walls.

Panel floor systems of lightweight concrete or similar and load bearing walls must be supported on footings which have been designed to span a nominal diameter pothole of 5 metres.

**NOTE:** The risk of residential structures sustaining damage can be reduced by adopting good building practices and incorporating design features such as the use of articulated joints or panelised brickwork, in accordance with the Building Code of Australia.

These features should be considered by the designer when detailing structures for pothole areas. If the requirements of the Board have been complied with, the dwelling is covered for compensation under the Mine Subsidence Compensation Act. If mine subsidence damage does occur, the owner simply has to lodge a claim and repairs will be carried out by the Mine Subsidence Board.

The Board's expert staff would be pleased to assist you with further enquiries or provide you with any of our other brochures

The Mine Subsidence Board will provide interpreter services free of charge to people of non-English speaking backgrounds.



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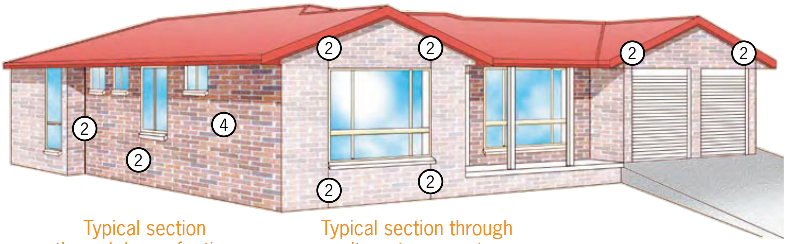
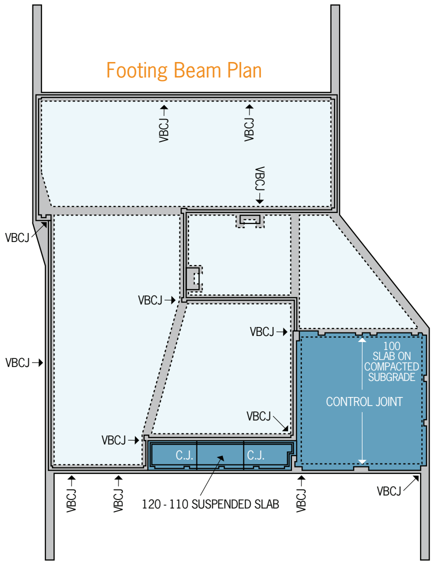
DINCEL STRUCTURAL WALLING

## SINGLE STOREY BRICK VENEER CONSTRUCTION

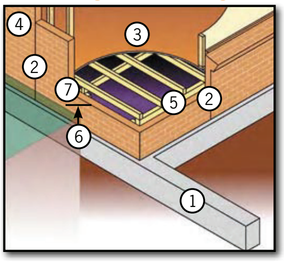
**1** Engineer Designed Reinforced Concrete Pothole Footing
**2** Control Joint
**3** Standard Subfloor Timbers
**4** Brick Veneer Construction
**5** Damp Proof Course
**6** Foundation Brickwork (Height Not To Exceed 1.5m)
**7** Engaged Brick Piers
**8** Brick Isolated Pier
**9** Concrete Pad Footing To Engineer Requirements
**10** Concrete Panel Floor System



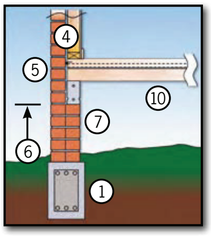



Footing Beam Plan

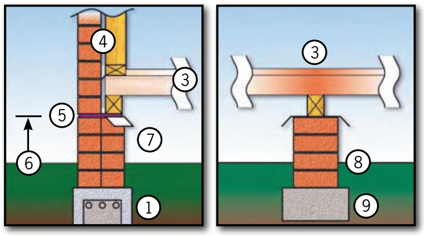
Typical section through beam footing



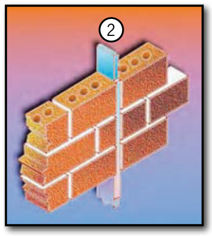
Typical section through alternate concrete panel floor system



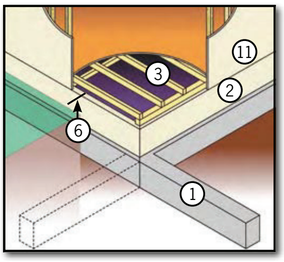
Typical section through brick veneer foundation



Articulation joint - external masonry wall

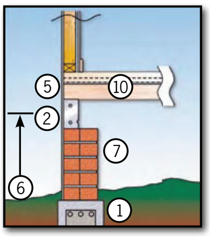


## 2 STOREY LIGHTWEIGHT CONSTRUCTION

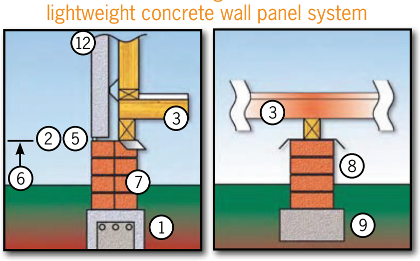


Typical section through beam footing

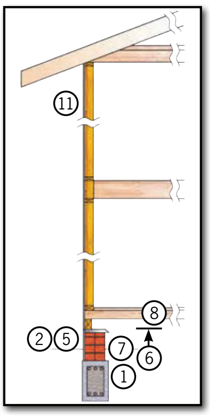
**1** Engineer Designed Reinforced Concrete Pothole Footing
**2** Control Joint
**3** Standard Subfloor Timbers
**4** Brick Veneer Construction
**5** Damp Proof Course
**6** Foundation Brickwork (Height Not To Exceed 1.5m)
**7** Engaged Brick Piers
**8** Brick Isolated Pier
**9** Concrete Pad Footing To Engineer Requirements
**10** Concrete Panel Floor System
**11** Lightweight Fibre Board Cladding with Applied Finish
**12** Lightweight Concrete Panel Walling System



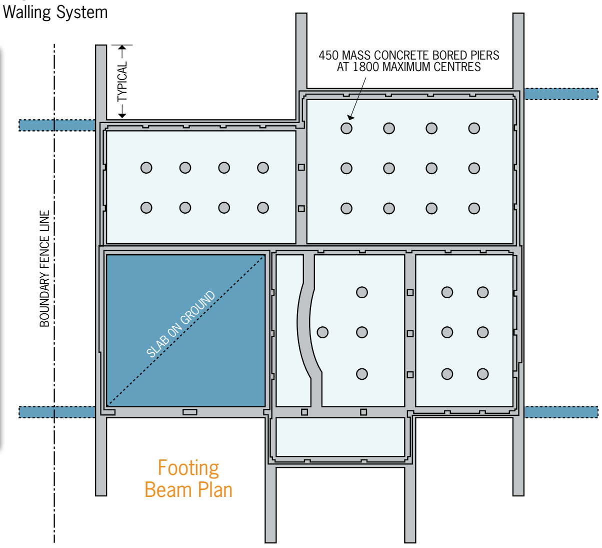
Typical section through alternate concrete panel floor system



Section through alternate lightweight concrete wall panel system



Typical section through 2 storey light weight fibre board clad with applied finish




Footing Beam Plan



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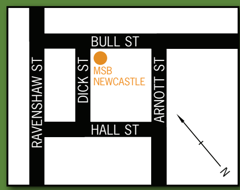


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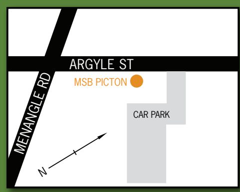


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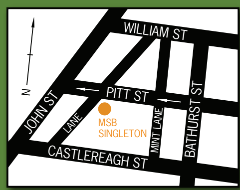


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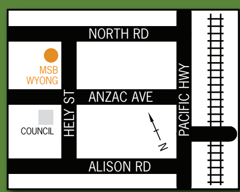


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