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SOIL INVESTIGATION

FOOTING CONSTRUCTION REPORT

STRUCTURAL CALCULATIONS

DATE: 15th January, 2020

SITE: 19 Alexander Avenue
CAMPBELLTOWN

CLIENT: Mr & Mrs Blefari

PROPOSED CONSTRUCTION: Two Storey Part Articulated Brick Veneer, Part Lightweight, Part Articulated AAC Panel Veneer Town Houses (5 of)

FOOTING SYSTEM: Standard Raft/Strip Footings

REFERENCE NUMBER: 180386

CONTENTS

SECTION A

SPECIAL NOTES FOR HIGHLY REACTIVE (CLASS H1-D H2-D AND E-D) SITES

In the following situations particular precautions are to be observed to minimise the soil movement and therefore ensure a satisfactory performance of the house footings.

(A) New residence located over site of demolished building with timber floor or suspended concrete floors

- The existing soil under the original building is usually desiccated and hence in a contracted state.
- When the new concrete slab is constructed, the dry soil will gain moisture and swell over time.
- Movement of the footing system and hence the walls can be expected up to four years after construction. The majority of movement occurs within the first two years.
- This movement will result in repair work to the walls and ceiling and also possibly the floor and wall tiling.

To minimise these effects the site of the original building must be pre wet to at least close the cracks in the soil prior to placing the underfloor fill and trenching the new footings.

(B) Raft concrete floor addition to existing residence with strip footings and timber floors or suspended concrete floors

- The existing soil conditions are similar to (A) above and hence the same precautions are required.

To minimise the effects of soil movement, the site of the proposed addition must be pre wet to at least close the cracks in the soil prior to placing the underfloor fill and trenching the new footings.

(C) Removal of mature trees on site of proposed residence

- The existing soil conditions are similar to (A) above. After the removal of trees the dry soil will gain moisture and swell over time.

To minimise these effects after the trees are removed the area must be pre wet to at least close the cracks in the soil prior to placing the underfloor fill and trenching the new footings.

(D) Houses or additions built in summer

- Sites consist of extremely reactive clay with potential soil movements greater than 70mm when they dry out or are wetted up.

To minimise these effects the site of the proposed house should be pre wet to at least close the cracks in the soil prior to trenching the new footings.

(E) Addition to existing residence

- Because the footings for the addition are not an integral part of the original house footings system, it is difficult to eliminate movement between the existing and new building. A hinge is basically formed at the addition/existing house footing interface.

- The addition tends to tilt and "walk" away from the existing house as a result of drying out or wetting up of the soil.

To minimise the effects of tilting, corner piers are to be constructed as shown on the footing layout plan. Also a movement joint is to be provided in the roof, ceiling, wall and floor junction between the existing house and the new construction.

(F) Addition abuts existing masonry wall that is to be tiled or rendered

- Where an addition abuts an existing masonry wall, particular care is to be taken with the wall finish. If the existing masonry wall is to be tiled to form part of the wet area of the addition, cracks will appear at the joint.

- For this reason it is recommended that a new wall is provided in front of the existing wall. This new wall is to be located on the new footing system of the addition.

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The following footings are considered to be adequate for the proposed structure.

DESIGNATION	**DEPTH**	**WIDTH**	**REINFORCEMENT**	**LIGATURES**
A	700	300	3 N16 T & B	W6 @ 1000 (*)
B	600	300	3 N16 T & B	W6 @ 1000 (*)
FLOOR SLAB	100		SL92 Top (u.n.o.)	

(*) Reduce ligature spacing to 300 cts. between piers.

SITE INSPECTION: MUST BE CARRIED OUT BY THE ENGINEER AT THE FOLLOWING STAGES:

1. After trenching and before the plastic membrane is placed.
2. After placement of all reinforcement.
3. As requested by the Client/Contractor/Engineer.

NOTE:

Each inspection will incur an additional charge of $220.00 (Includes G.S.T).

Travel charges are applicable outside a 30km radius from the G.P.O.

PLEASE NOTIFY THE ENGINEER 24 HOURS PRIOR TO INSPECTION.

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SLAB SURFACE: The slab surface is to be minimum 200mm above bench level.

FOOTING TRENCHING: Footings must be founded minimum 150mm into firm natural ground or 300mm via piers.

ARTICULATION: Control joints in brickwork where shown on the Footing Layout Plan.
Provide control joints in lightweight cladding in accordance with manufacturer's specifications.
Control joints in the AAC panel where shown on the Footing Layout Plan and strictly in accordance with AAC panel manufacturer's written instructions and specifications.

STORMWATER: Shall be discharged at the street water table via sealed P.V.C. pipes.

NOTE:

1. Before external paving and site works are commenced, the vapour barrier from under the external footings is to be extended up the face of the footing to at least the top of finished pavement level. Soil, fill or paving are not to touch the concrete face. The footing must always be isolated with an impervious plastic membrane. The aim is to prevent moisture ingress into the house slab by capillary action.

2. We have attempted to account for the effects of trees in the proposed works by designing for a greater soil movement than would otherwise occur. However due to the complex tree root geometry, variable moisture extraction by the tree and the difficulty in predicting future tree growth, a precise design for the effects of trees is outside current knowledge. The owner must be aware that although precautions have been taken for the effects of the trees in our design, some distortion must be accepted.

3. Following the demolition of a dwelling with a timber floor or suspended concrete floor and/or the removal of mature trees, the new building site is to be prewet using drippers or weeper hoses for a minimum of two hours per day for two weeks or longer if necessary until all cracks have closed. For a cleared site, if cracks are visible it must be prewet as noted above.

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SOIL ASSESSMENT: The soils on this site consisted of moderately to highly reactive clay horizons to the extent of testing.

SITE CLASSIFICATION: H1-D

SITE CLASSIFIER: Lelio Bibbo Consulting Engineers Pty. Ltd.

Foundation	Character	Class
Sand and rock	Stable	A
Silt and some clay		S
Moderately reactive clay	Reactive	M
Highly reactive clay		H1
Very Highly reactive clay		H2
Extremely reactive clay		E
Sand	Controlled fill	A
Material other than sand		A to P
Mine subsidence	Problem	P
Uncontrolled fill		
Landslip		
Soft		
Collapsing soils		

Class	Characteristic Soil Movement
S	ys ≤ 20mm
M	20mm < ys ≤ 40mm
H1	40mm < ys ≤ 60mm
H2	60mm < ys ≤ 75mm
E	ys > 75mm

D – Denotes deep seated moisture changes

NOTE: The purpose of the soil investigation is to provide the Engineer with sufficient information to enable a site classification to be made. The information obtained at each borehole location is: the possible presence of fill material; natural soil profile; bearing strength and soil reactivity. The complete geological picture of the site can not be determined by borelogs alone. A more extensive investigation may be undertaken if the client has a purpose and makes a request.

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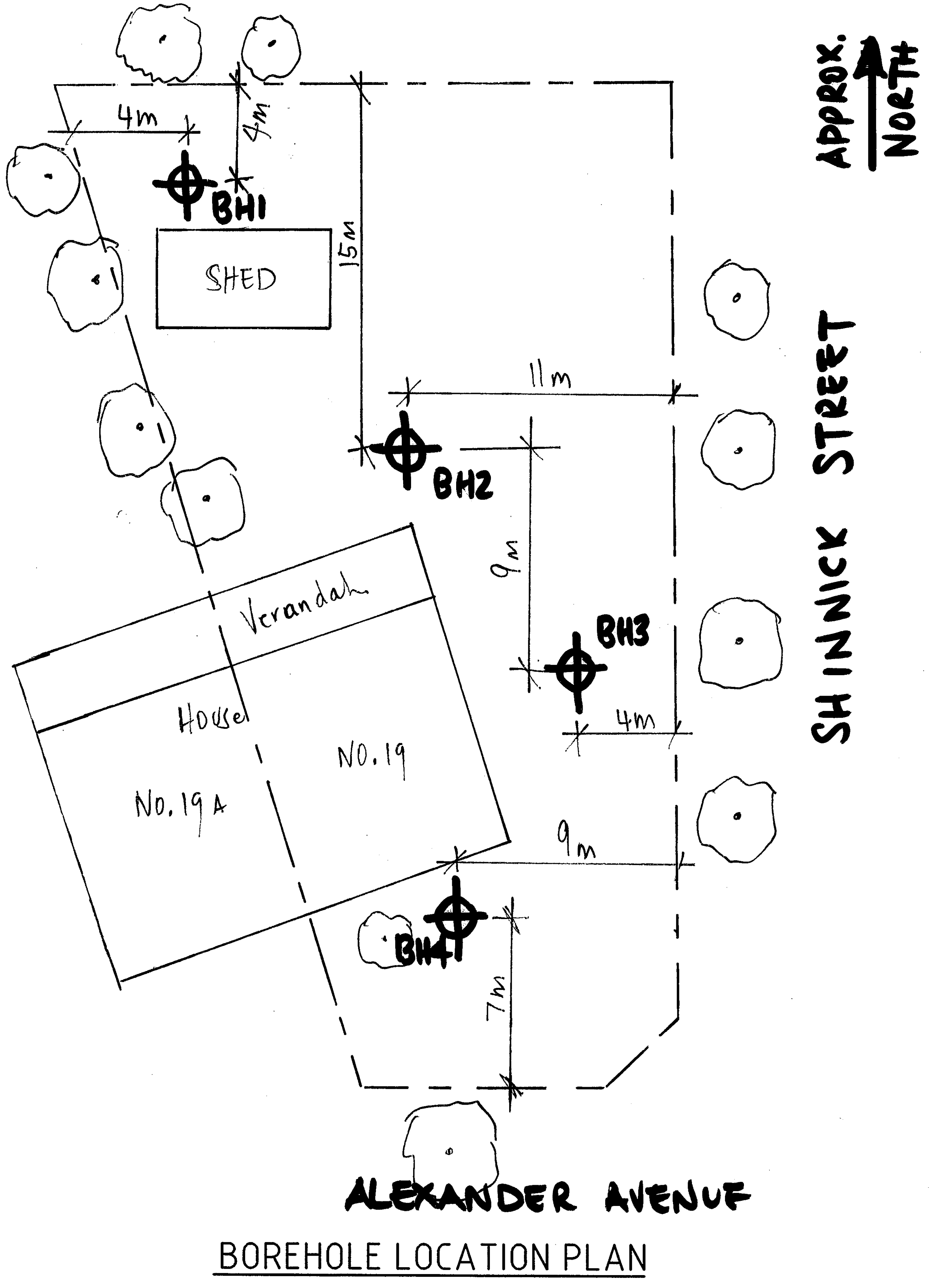
SITE:	19 Alexander Avenue CAMPBELLTOWN	**JOB NO:**	180386
		LOGGED BY:	F.E.
		SAMPLING METHOD:	Rig
		DATE:	January, 2020

HOLE 1	HOLE 2	HOLE 3	HOLE 4	SOIL DESCRIPTION	TEXTURE	COLOUR	M.C.	REACT	EST Ips	BRG	SYMBOL
0-300	0-400	0-200	0-100	CLAY silty sandy	Firm	Grey brown	Dry	LM	.015	M	CL
-	-	200-700	100-550	CLAY silty	Hard	Reddish brown	Dry	M	.02	M	CL
300-750	400-1200	700-1400	550-1450	CLAY silty	Hard	Red brown	Damp	H	.03	M	CH
750-1500	1200-2000	-	-	CLAY silty, limey patches	Very firm	Brown, light brown patches	<PL	MH	.025	M	CL-CH
-	-	1400-2250	1450-2000	CLAY silty sandy, calcareous	Firm	Light brown mottled	Dry	MH	.022	M	CL-CH
1500-1900	-	-	-	CLAY silty sandy	Very firm	Grey brown	Damp	MH	.025	M	CL-CH
1900-2400	2000-2900	-	-	CLAY sandy silty, abundant gravels	Very firm	Brown/grey mottled	Dry	M	.02	M	CL-GP
2400	2900	2250	2000	Refusal (gravels)							

Soil Classification: H1-D

Water Table: Not met in test holes.

Bulletin 46, Geological Survey of S.A., "The Soil & Geology of the Adelaide Area".



BOREHOLE LOCATION PLAN

site	LELIO BIBBO CONSULTING ENGINEERS PTY LTD	date JAN 2020
19 ALEXANDER AVENUE CAMPBELLTOWN	ABN 80 752 110 403 civil · structural 40 franklin street adelaide s.a. 5000 phone 8212 7966 fax 8212 4911	scale N.T.S. ref. no. 190386

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CALCULATION OF FREE SWELL. BORE 1

180386

Depth H = 4.0 m.
Surface Suction = 1.2 pF.

HORIZ.	D_1	D_2	*Ips.*	*alpha* α	*Ipt.*	Y_s
1	0.000	0.300	0.015	1.000	0.015	5.2
2	0.300	0.750	0.030	1.000	0.030	14.1
3	0.750	1.500	0.025	1.000	0.025	16.2
4	1.500	1.900	0.025	1.000	0.025	6.9
5	1.900	2.400	0.020	1.000	0.020	5.6
6	2.400	3.000	0.020	1.000	0.020	4.7
7	3.000	4.000	0.020	1.300	0.026	3.9
8	4.000			1.000	0.000	

FREE SWELL, Y_s = 56.5 mm.
Y_{mc} = 39.5 mm.
Y_{me} = 28.2 mm.

CALCULATION OF FREE SWELL. BORE 2

Depth H = 4.0 m.
Surface Suction = 1.2 pF.

HORIZ.	D_1	D_2	*Ips.*	*alpha* α	*Ipt.*	Y_s
1	0.000	0.400	0.015	1.000	0.015	6.8
2	0.400	1.200	0.030	1.000	0.030	23.0
3	1.200	2.000	0.025	1.000	0.025	14.4
4	2.000	2.900	0.020	1.000	0.020	8.4
5	2.900	3.000	0.020	1.000	0.020	0.6
6	3.000	4.000	0.020	1.300	0.026	3.9
7	4.000			1.000	0.000	
8	0.000			1.000	0.000	

FREE SWELL, Y_s = 57.2 mm.
Y_{mc} = 40.0 mm.
Y_{me} = 28.6 mm.

CALCULATION OF FREE SWELL. BORE 3

Depth H = 4.0 m.
Surface Suction = 1.2 pF.

HORIZ.	D_1	D_2	*Ips.*	*alpha* α	*Ipt.*	Y_s
1	0.000	0.200	0.015	1.000	0.015	3.5
2	0.200	0.700	0.020	1.000	0.020	10.7
3	0.700	1.400	0.030	1.000	0.030	18.6
4	1.400	2.250	0.022	1.000	0.022	12.2
5	2.250	3.000	0.022	1.000	0.022	6.8
6	3.000	4.000	0.022	1.300	0.029	4.3
7	4.000			1.000	0.000	
8	0.000			1.000	0.000	

FREE SWELL, Y_s = 56.0 mm.
Y_{mc} = 39.2 mm.
Y_{me} = 28.0 mm.

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CALCULATION OF FREE SWELL. BORE 4

Depth H = 4.0 m.
Surface Suction = 1.2 pF.

HORIZ.	D_1	D_2	*Ips.*	*alpha* α	*Ipt.*	Y_s
1	0.000	0.100	0.015	1.000	0.015	1.8
2	0.100	0.550	0.020	1.000	0.020	9.9
3	0.550	1.450	0.030	1.000	0.030	24.3
4	1.450	2.000	0.022	1.000	0.022	8.3
5	2.000	3.000	0.022	1.000	0.022	9.9
6	3.000	4.000	0.022	1.300	0.029	4.3
7	4.000			1.000	0.000	
8	0.000			1.000	0.000	

FREE SWELL, Y_s = 58.4 mm.
Y_{mc} = 40.9 mm.
Y_{me} = 29.2 mm.

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CALCULATION OF FREE SWELL. BORE 1 - TREE EFFECTS

Depth H = 4.0 m.
Surface Suction = 1.2 pF.

Group of Trees

HORIZ.	D_1	D_2	Ips.	alpha α	Ipt.	$\Delta U_{layer(tree)}$	Y_{tmax}	Y_t	Y_s
1	0.000	0.300	0.015	1.000	0.015	0.021	0.094	0.094	5.2
2	0.300	0.750	0.030	1.000	0.030	0.073	0.984	0.984	14.1
3	0.750	1.500	0.025	1.000	0.025	0.156	2.930	2.930	16.2
4	1.500	1.900	0.025	1.000	0.025	0.236	2.361	2.361	6.9
5	1.900	2.400	0.020	1.000	0.020	0.299	2.986	2.986	5.6
6	2.400	3.000	0.020	1.000	0.020	0.375	4.500	4.500	4.7
7	3.000	4.000	0.020	1.300	0.026	0.486	9.722	9.722	3.9
8	4.000	0.000	0.000	1.000	0.000	0.278	0.000	0.000	0.0

FREE SWELL, Y_s = 56.5 mm.
Y_t = 23.6 mm.
$0.7Y_s+Y_t = Y_{mc}$ = 63.1 mm.
$0.5Y_s = Y_{me}$ = 28.2 mm.

CALCULATION OF FREE SWELL. BORE 2 - TREE EFFECTS

Depth H = 4.0 m.
Surface Suction = 1.2 pF.

HORIZ.	D_1	D_2	Ips.	alpha α	Ipt.	$\Delta U_{layer(tree)}$	Y_{tmax}	Y_t	Y_s
1	0.000	0.400	0.015	1.000	0.015	0.028	0.167	0.167	6.8
2	0.400	1.200	0.030	1.000	0.030	0.111	2.667	2.667	23.0
3	1.200	2.000	0.025	1.000	0.025	0.222	4.444	4.444	14.4
4	2.000	2.900	0.020	1.000	0.020	0.340	6.125	6.125	8.4
5	2.900	3.000	0.020	1.000	0.020	0.410	0.819	0.819	0.6
6	3.000	4.000	0.020	1.300	0.026	0.486	9.722	9.722	3.9
7	4.000	0.000	0.000	1.000	0.000	0.278	0.000	0.000	0.0
8	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.0

FREE SWELL, Y_s = 57.2 mm.
Y_t = 23.9 mm.
$0.7Y_s+Y_t = Y_{mc}$ = 64.0 mm.
$0.5Y_s = Y_{me}$ = 28.6 mm.

CALCULATION OF FREE SWELL. BORE 3 - TREE EFFECTS

Depth H = 4.0 m.
Surface Suction = 1.2 pF.

HORIZ.	D_1	D_2	Ips.	alpha α	Ipt.	$\Delta U_{layer(tree)}$	Y_{tmax}	Y_t	Y_s
1	0.000	0.200	0.015	1.000	0.015	0.014	0.042	0.042	3.5
2	0.200	0.700	0.020	1.000	0.020	0.063	0.625	0.625	10.7
3	0.700	1.400	0.030	1.000	0.030	0.146	3.063	3.063	18.6
4	1.400	2.250	0.022	1.000	0.022	0.253	4.740	4.740	12.2
5	2.250	3.000	0.022	1.000	0.022	0.365	6.016	6.016	6.8
6	3.000	4.000	0.022	1.300	0.029	0.486	10.694	10.694	4.3
7	4.000	0.000	0.000	1.000	0.000	0.278	0.000	0.000	0.0
8	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.0

FREE SWELL, Y_s = 56.0 mm.
Y_t = 25.2 mm.
$0.7Y_s+Y_t = Y_{mc}$ = 64.4 mm.
$0.5Y_s = Y_{me}$ = 28.0 mm.

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CALCULATION OF FREE SWELL. BORE 4 - TREE EFFECTS

Depth H = 4.0 m.
Surface Suction = 1.2 pF.

HORIZ.	D_1	D_2	Ips.	alpha α	Ipt.	$\Delta U_{layer(tree)}$	Y_{tmax}	Y_t	Y_s
1	0.000	0.100	0.015	1.000	0.015	0.007	0.010	0.010	1.8
2	0.100	0.550	0.020	1.000	0.020	0.045	0.406	0.406	9.9
3	0.550	1.450	0.030	1.000	0.030	0.139	3.750	3.750	24.3
4	1.450	2.000	0.022	1.000	0.022	0.240	2.899	2.899	8.3
5	2.000	3.000	0.022	1.000	0.022	0.347	7.639	7.639	9.9
6	3.000	4.000	0.022	1.300	0.029	0.486	10.694	10.694	4.3
7	4.000	0.000	0.000	1.000	0.000	0.278	0.000	0.000	0.0
8	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.0

FREE SWELL, Y_s = 58.4 mm.
Y_t = 25.4 mm.
$0.7Y_s+Y_t = Y_{mc}$ = 66.3 mm.
$0.5Y_s = Y_{me}$ = 29.2 mm.

SOIL BORELOG NOTES

SOIL CLASSIFICATION
Soils are classified in accordance with the "Unified Soil Classifications System", and where possible with special reference to Bulletin 46, Geological Survey of S.A. "The Soils and Geology of the Adelaide Area".

REACTIVITY
Reactivity is defined as the potential for a soil to undergo changes in volume with variation in moisture content. The reactivity is measured in terms of the "Instability Index"(Ips%).

Reactivity	Instability Index		
Very low	0.0	to	0.5%
Low	0.5%	to	1.0%
Low to Medium	1.0%	to	1.5%
Medium	1.5%	to	2.0%
Medium to High	2.0%	to	2.5%
High	2.5%	to	3.5%
Very High	3.5%	to	5.0%
Extremely High	5.0%	to	6.0%

MOISTURE CONTENT
Moisture content is measured as being relative to the plastic limit of the soil.

BEARING STRENGTH
Bearing strength is visually assessed, and relates to the in-situ strength at the time of logging. Bearing strength varies significantly with changes in soil moisture content, and it must be noted that any siteworks which expose and enable saturation of soils, may result in a reduction in bearing strength.

Very Low	< 50 kPa
Low	50 – 100 kPa
Medium	100 – 200 kPa
High	200 – 400 kPa

SITE CLASSIFICATION

FOUNDATION	CHARACTER	CLASS	Ys (mm)
Sand and Rock Silt and some Clay	Stable	A S	0 ≤ 20
Moderately Reactive Clay Highly Reactive Clay Very Highly Reactive Clay Extremely Reactive Clay	Reactive	M H1 H2 E	20 ≤ 40 40 ≤ 60 60 ≤ 75 >75
Sand Material other than Sand	Controlled fill	A A to P	
Mine Subsidence Uncontrolled Fill Landslip Soft Soils Collapsing Soils	Problem	P	

APPENDIX C
CLASSIFICATION OF DAMAGE DUE TO FOUNDATION MOVEMENTS
(Normative)

Classification of damage with reference to wall is given in Table C1. Classification of damage with reference to concrete floors is given in Table C2.

TABLE C1
CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 1)	Damage category
Hairline cracks	<0.1 mm	0 Negligible
Fine cracks that do not need repair	<1 mm	1 Very slight
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2 Slight
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weather tightness often impaired	5 mm to 15 mm (or a number of cracks 3 mm or more in one group)	3 Moderate
Extensive repair work involving breaking out and replacing sections of walls, especially over doors and windows. Window frames and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15 mm to 25 mm but also depends on number of cracks	4 Severe

NOTES:

1 Where the cracking occurs in easily repaired plasterboard or similar clad-framed partitions, the crack width limits may be increased by 50% for each damage category.

2 Crack width is the main factor by which damage to walls is categorized. The width may be supplemented by other factors, including serviceability, in assessing category of damage.

3 In assessing the degree of damage, account shall be taken of the location in the building or structure where it occurs, and also of the function of the building or structure.

TABLE C2

CLASSIFICATION OF DAMAGE WITH REFERENCE TO CONCRETE FLOORS

Description of typical damage	Approx. crack width limit in floor	Change in offset from a 3 m straightedge centred over defect (see Note 1)	Damage category
Hairline cracks, insignificant movement of slab from level	<0.3 mm	<8 mm	0 Negligible
Fine but noticeable cracks. Slab reasonably level	<1.0 mm	<10 mm	1 Very slight
Distinct cracks. Slab noticeably curved or changed in level	<2.0 mm	<15 mm	2 Slight
Wide cracks. Obvious curvature or change in level	2 mm to 4 mm	15 mm to 25 mm	3 Moderate
Gaps in slab. Disturbing curvature or change in level	4 mm to 10 mm	>25 mm	4 Severe

NOTES:

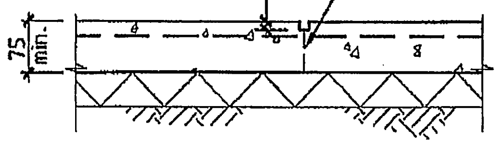
1 The straightedge is centred over the defect, usually, and supported at its ends by equal height spacers. The change in offset is then measured relative to this straightedge, which is not necessarily horizontal.

2 Local deviation of slope, from the horizontal or vertical, of more than 1:100 will normally be clearly visible. Overall deviations in excess of 1:150 is undesirable.

3 Account should be taken of the past history of damage in order to assess whether it is stable or likely to increase.

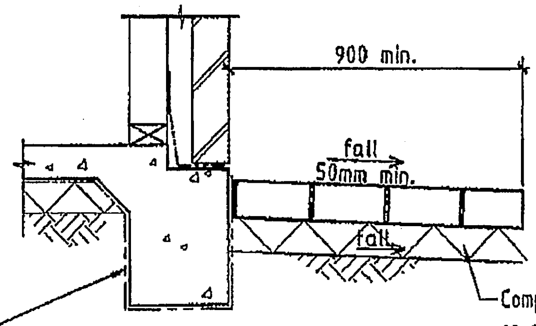
TYPICAL PERIMETER PAVING DETAILS

Sheet 1

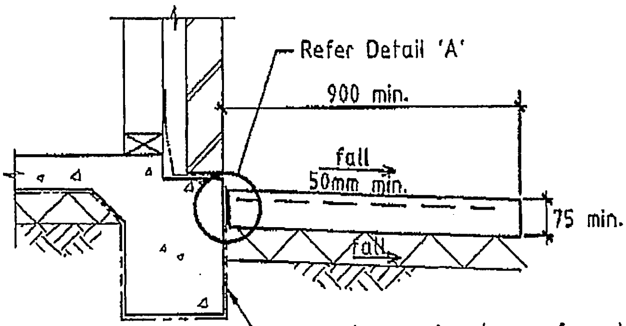


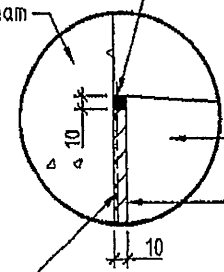
Note:
Control joints shall be provided at 2 metre centres maximum each way. Control joints are required on all slabs which are placed separately and will not receive floor finishes.

Typical Control Joint in Paving



Section Through Masonry Paving



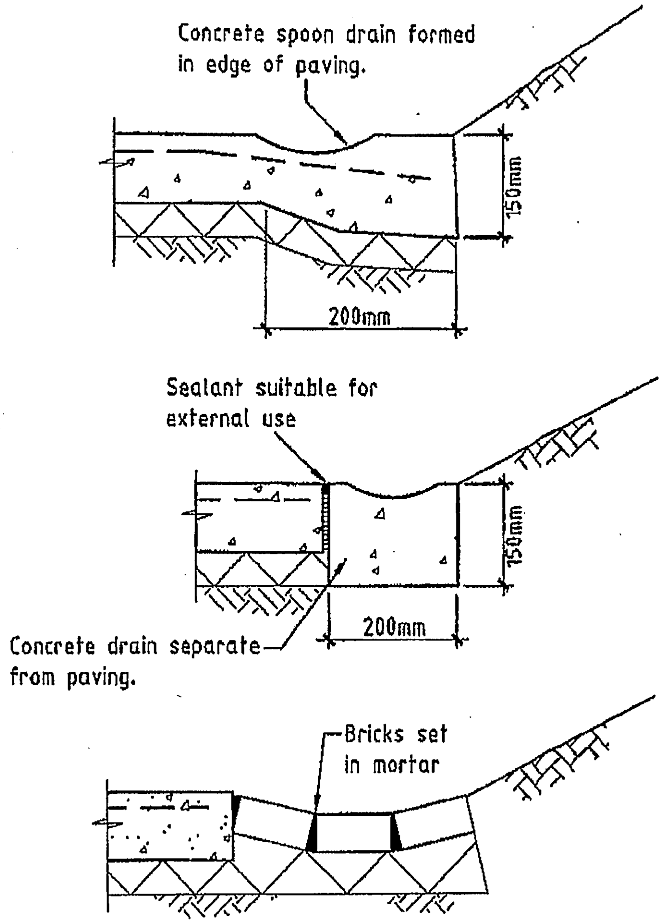


Detail A

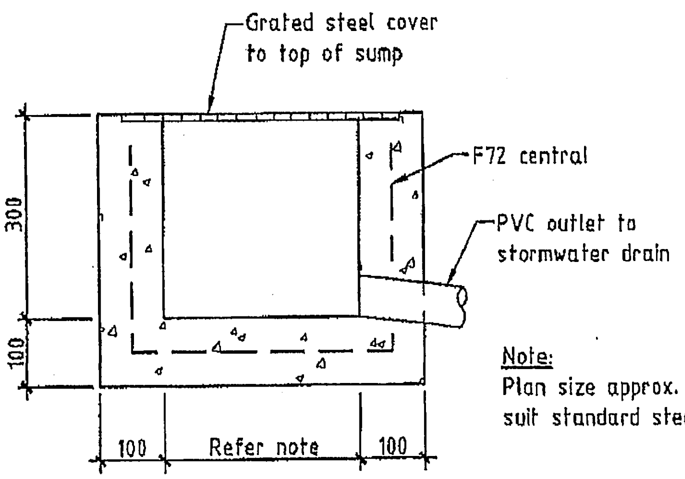
Section Through Concrete Paving

Note:
Paving must be installed on all sites except Class S.
Soil or paving must always be separated from the footings with impervious membrane in order to prevent moisture ingress through to the concrete slab by capillary action.

TYPICAL PERIMETER PAVING DETAILS



Spoon Drain Details

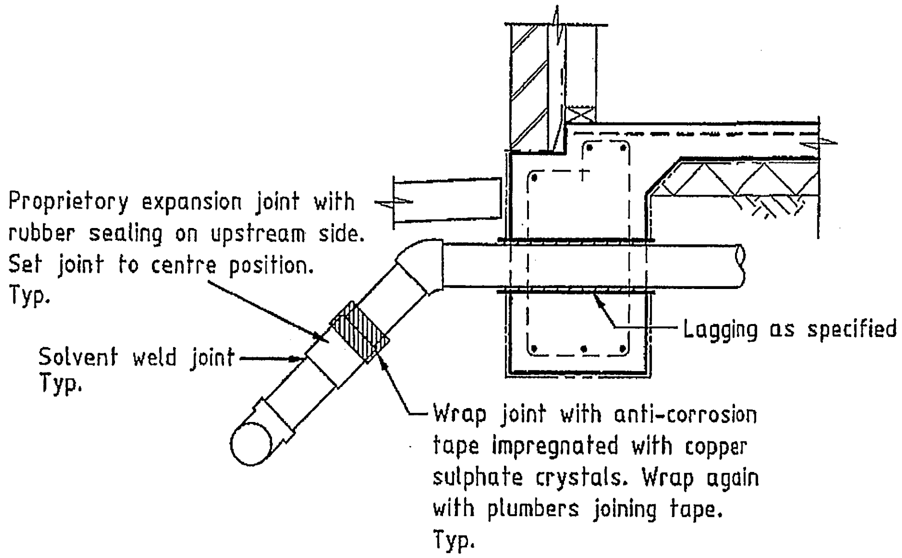


Note:
Plan size approx. 300 square to suit standard steel cover sizes.

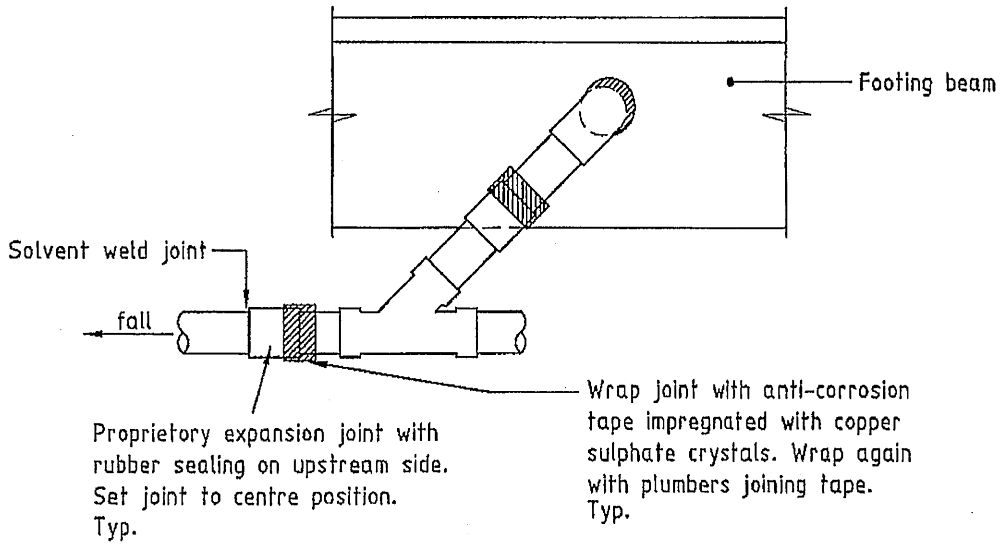
Concrete Sump Detail

EXPANSION JOINT DETAILS

REQUIRED FOR ALL SEWER AND STORMWATER DRAINS ON REACTIVE SOILS (CLASS H1, H2 & E)



Section

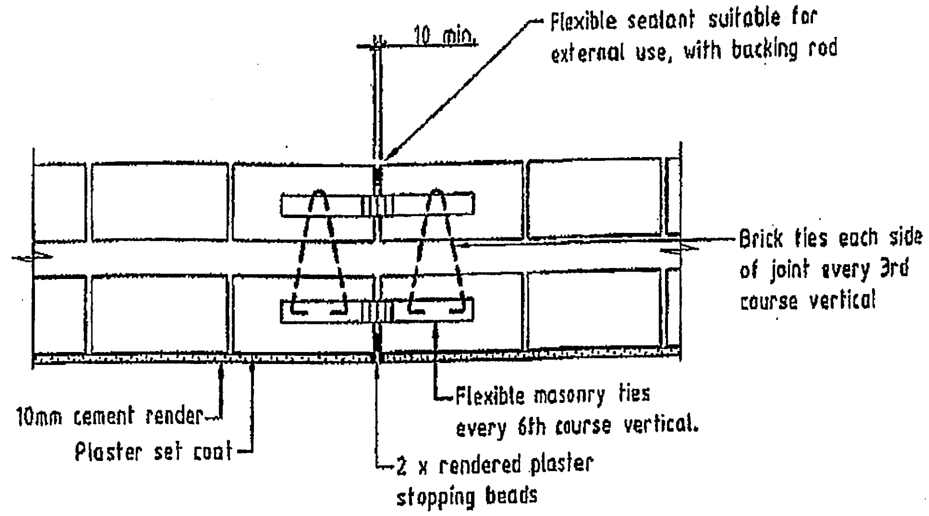


Side Elevation

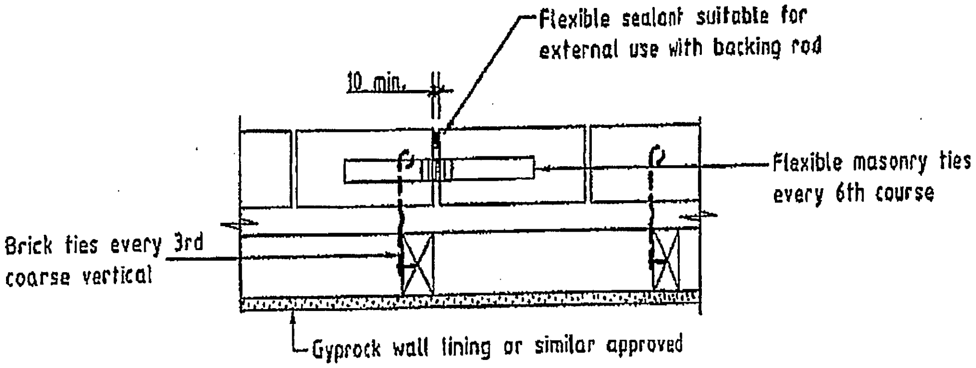
Notes:

1. All penetrations through the footing beam shall be lagged as specified on the Footing Layout Plan.
2. Unless noted otherwise, all expansion joints are to provide a minimum 150mm of movement, 75mm each way from the centre position.
3. Provide expansion joints at all pipe locations where sewer pipes, (100 dia. or larger), and stormwater pipes penetrate the external footing beam. At each riser a second expansion joint is required, downstream of the junction to the main sewer.

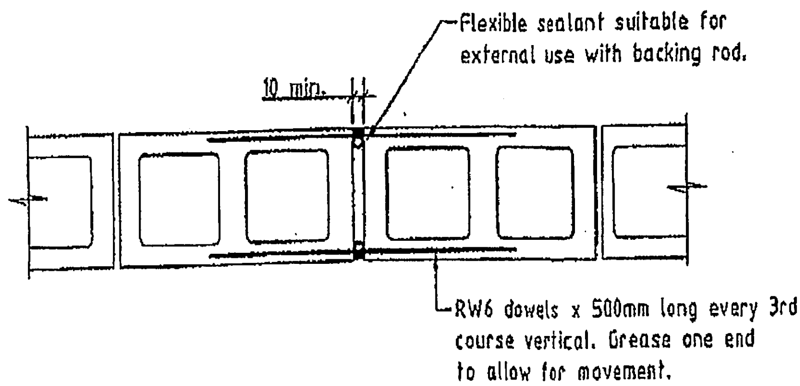
TYPICAL CONTROL JOINTS IN MASONRY WALLS



Double Brick Cavity Wall



Brick Veneer Wall

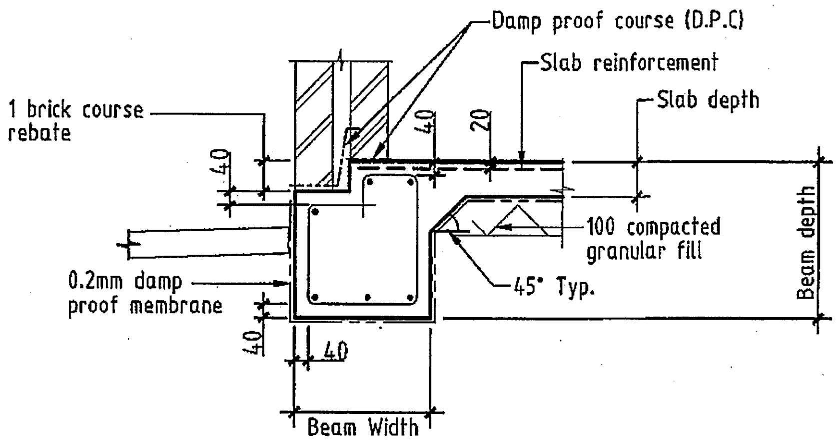


Hollow Block Wall

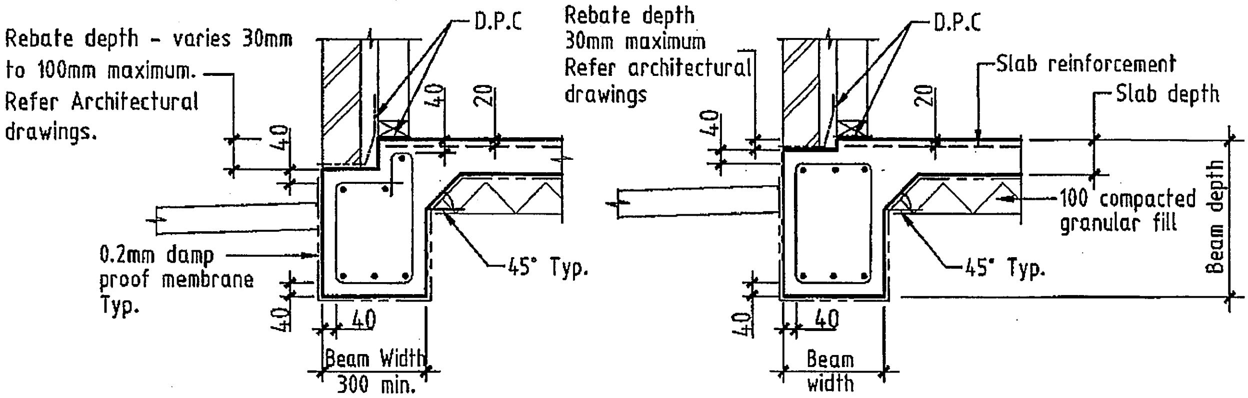
REFER FOOTING LAYOUT PLAN FOR CONTROL JOINT LOCATIONS

TYPICAL RAFT FOOTING DETAILS

EXTERNAL BEAMS



Solid Brick Construction

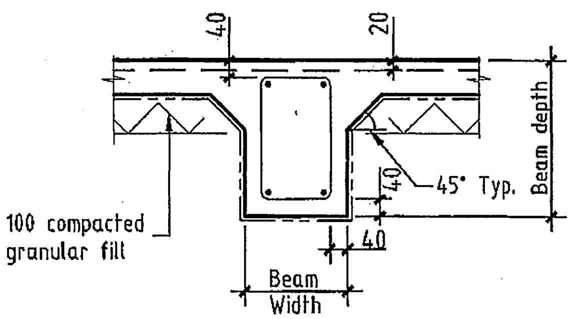


Brick Veneer Construction

NOTE:

Dimensions given are concrete cover to reinforcement unless noted otherwise. Typical.

INTERNAL BEAMS



Solid Brick or Brick Veneer Construction

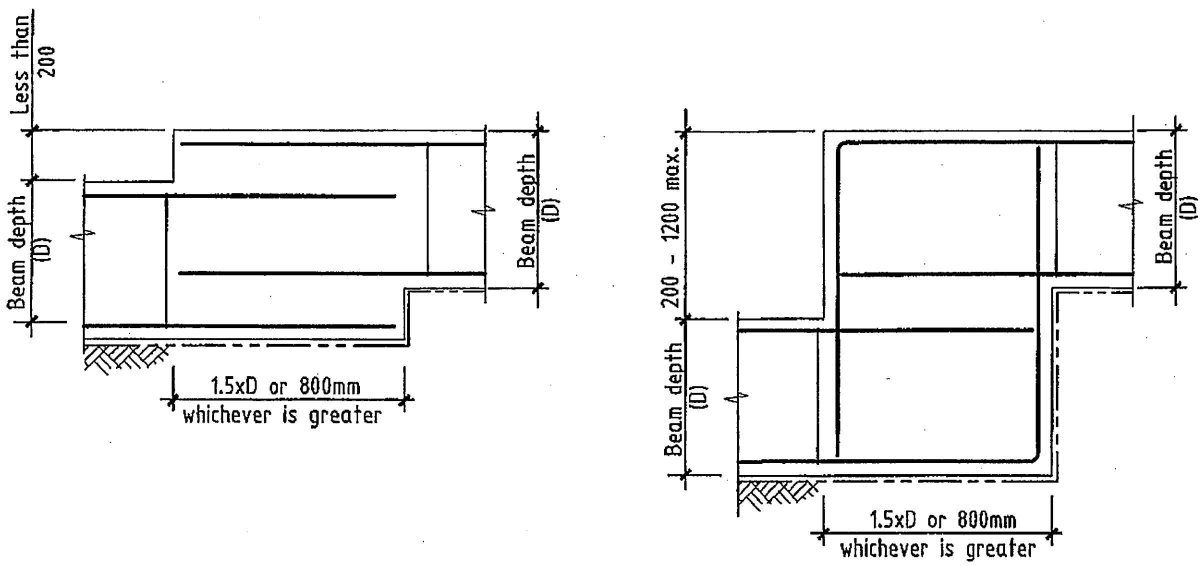
NOTE:

External and Internal Footings

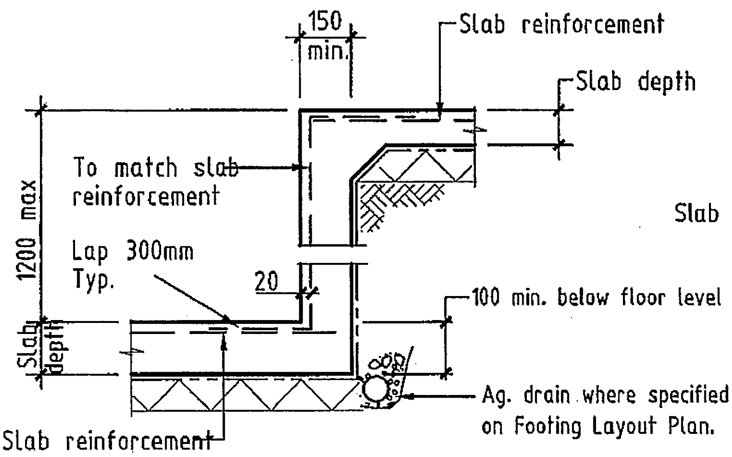
1. Where beam depth exceeds 700, the plastic membrane is not required across the base of the trench. Increase bottom cover to reinforcement to 50.
2. Where beam depth exceeds 1200, provide two layers of damp proof membrane full depth, to both faces of beam.

TYPICAL RAFT FOOTING DETAILS

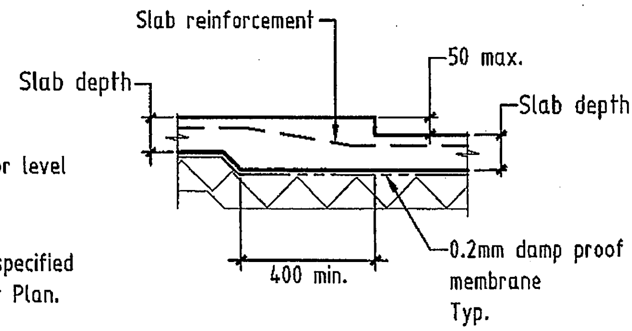
Sheet 2



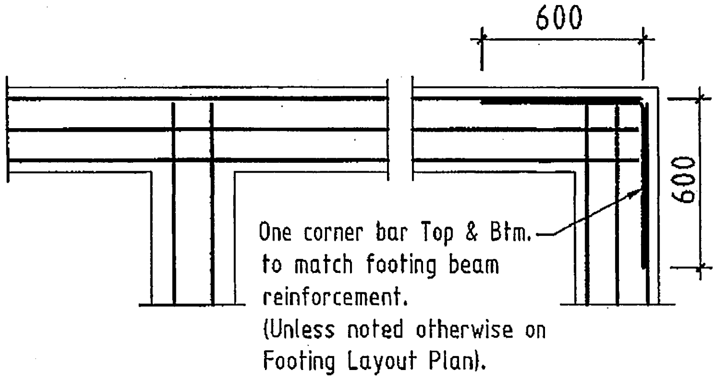
Step in Footing Beam



Step in Slab Detail



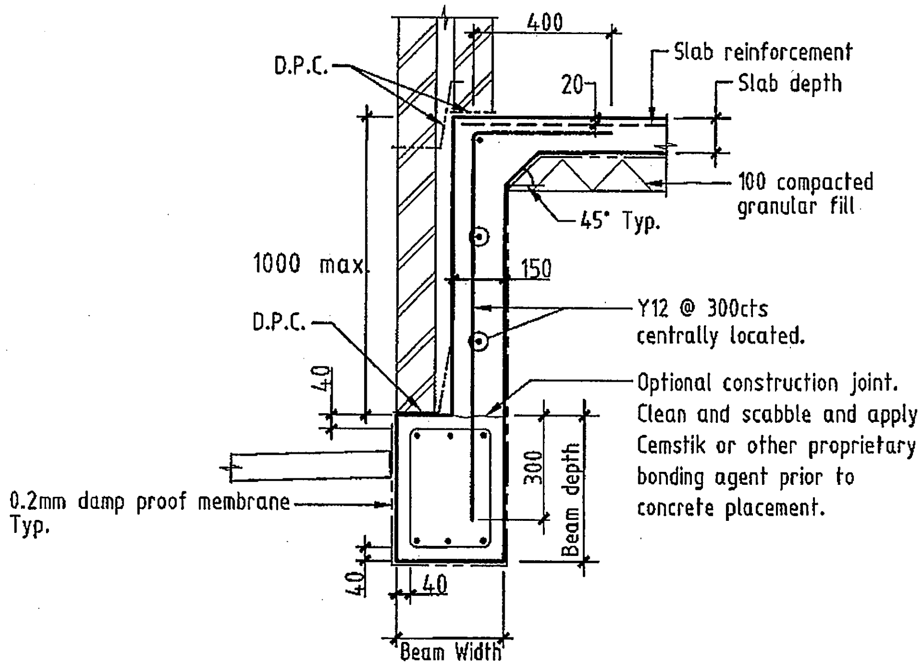
Slab Setdown

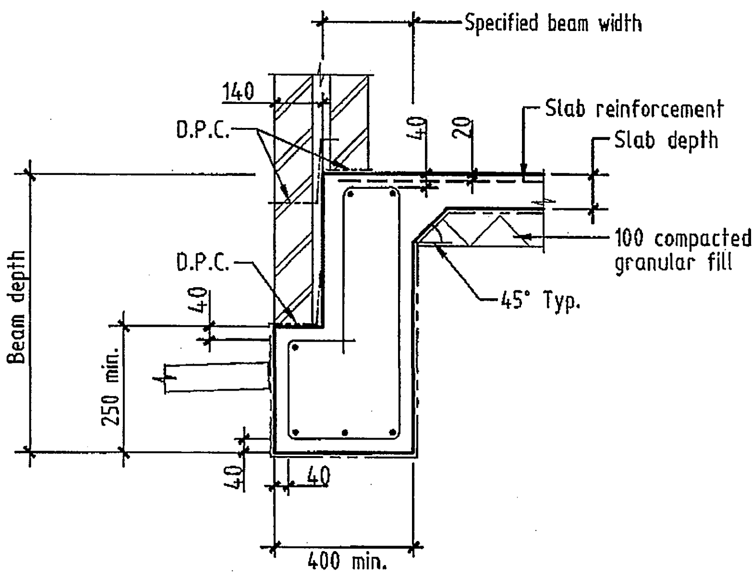


Footing Junction

TYPICAL RAFT FOOTING DETAILS

Sheet 3





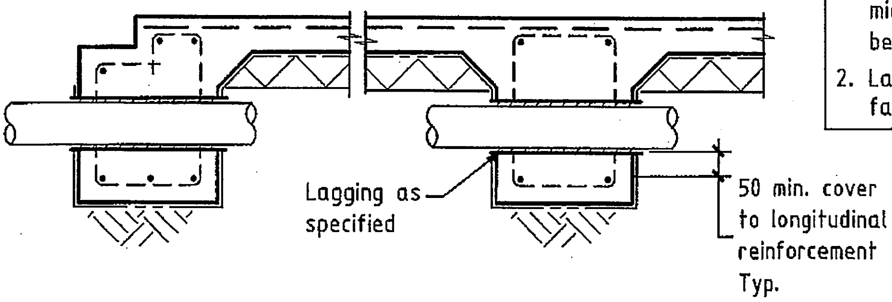
ALTERNATIVE DEEP REBATE DETAILS

Brick Veneer or Solid Brick Construction

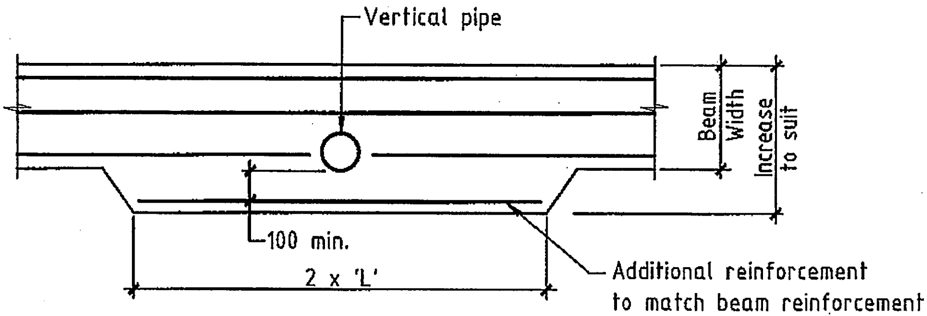
TYPICAL RAFT FOOTING DETAILS

PIPE PENETRATIONS

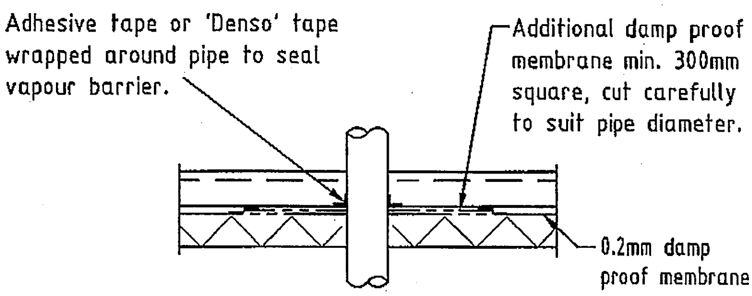
Note:
1. Pipe penetration to be through middle third of footing beam depth.
2. Lagging must extend to both faces of footing beam.



Through Footing Beams

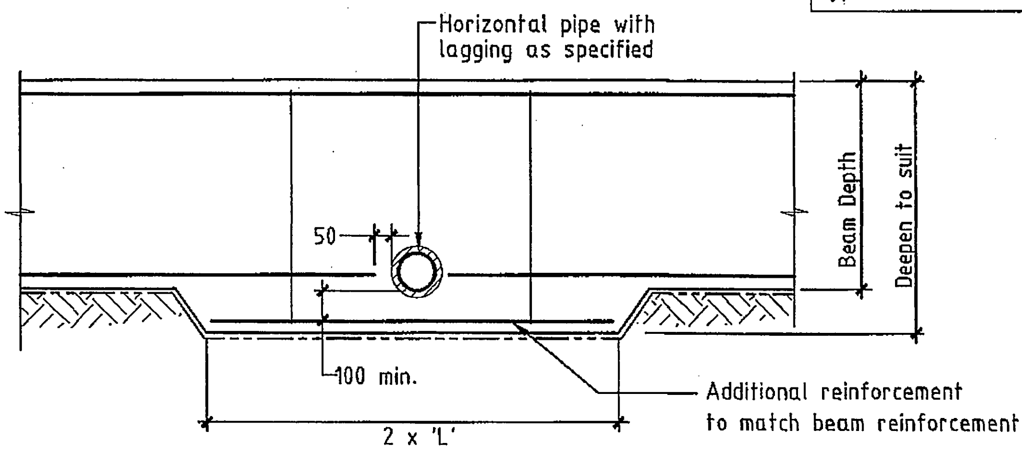


Vertical Pipe through Footing - Plan View



NOTE:
'L' denotes the reinforcement lap length as noted on the Footing Layout Plan. Typical.

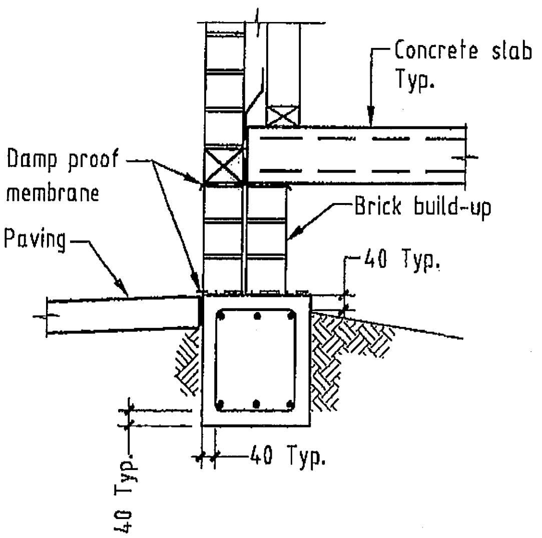
Vertical Pipe Through Slab



Horizontal Pipe Through Bottom of Footing

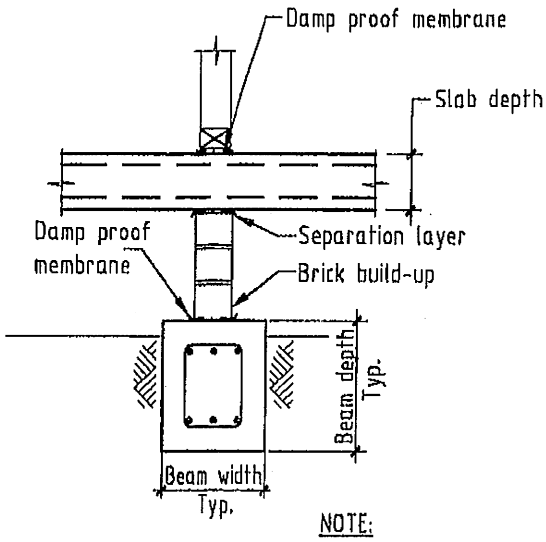
TYPICAL STRIP FOOTING DETAILS

Sheet 1



Note : Paving must be located below damp proof membrane.

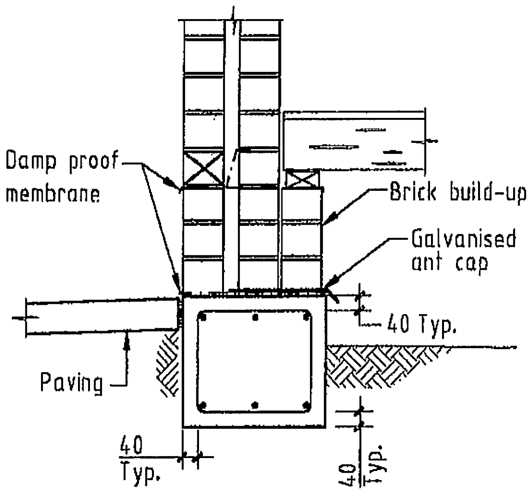
External Beam



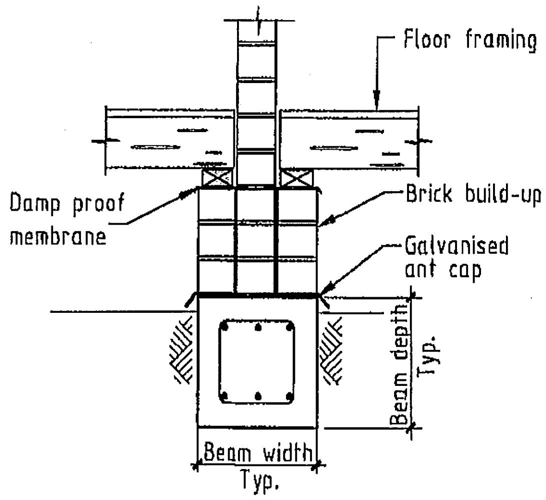
NOTE:
Dimensions given are concrete cover to nearest reinforcement unless notes otherwise.
Typ.

Internal Beam

SUSPENDED CONCRETE FLOOR



External Beam

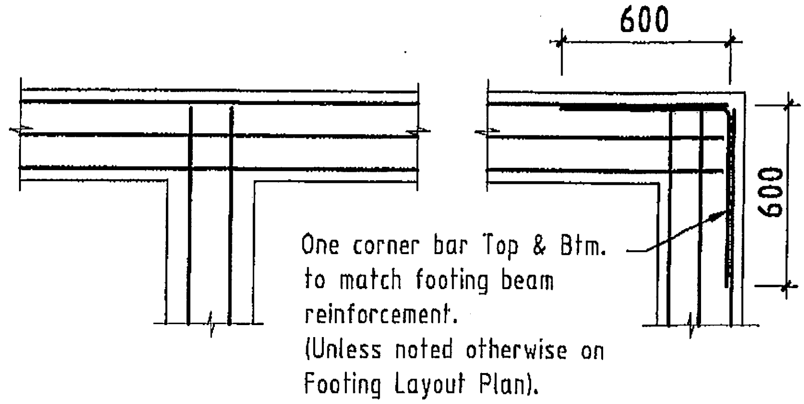


Internal Beam

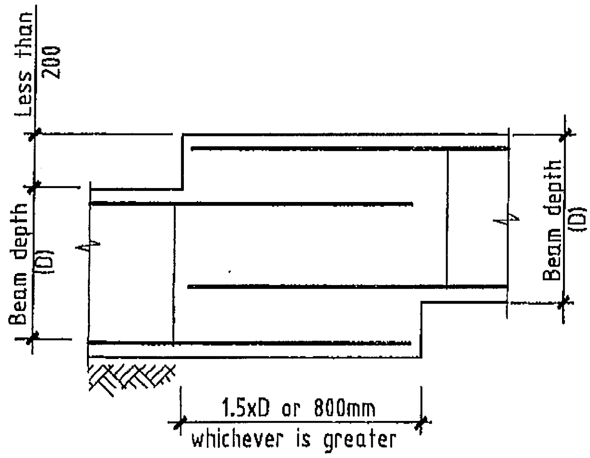
TIMBER FRAMED FLOOR

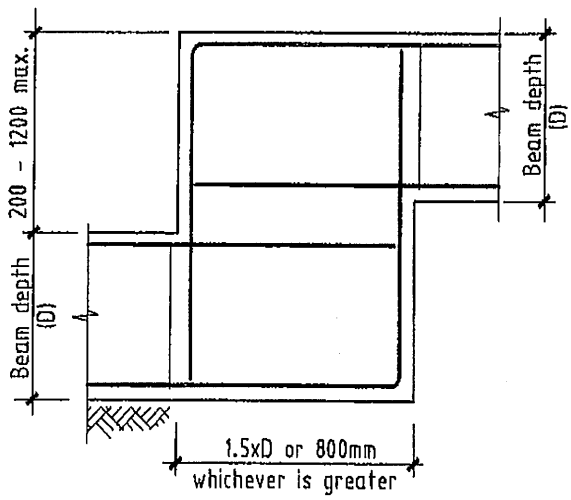
NOTE:
Where strip footing beam depth exceeds 700 on Class H-D and E-D sites provide two layers of plastic membrane to both faces of the footing.

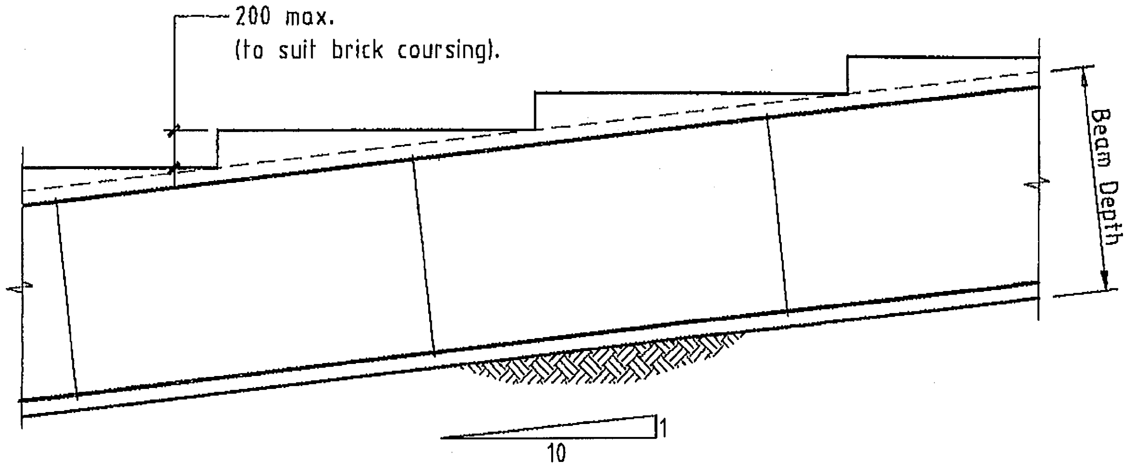
TYPICAL STRIP FOOTING DETAILS



Footing Junction





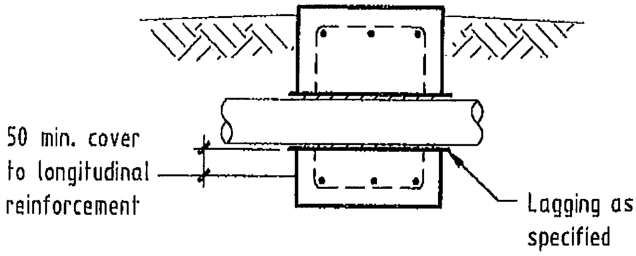


Step in Footing Beam

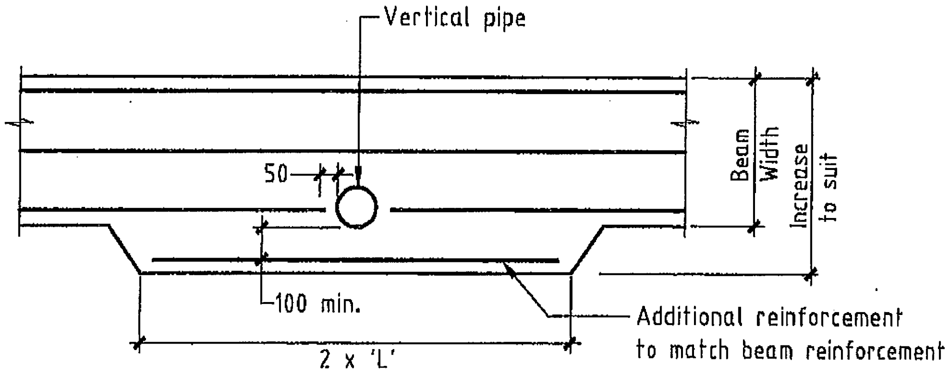
TYPICAL STRIP FOOTING DETAILS

PIPE PENETRATIONS

Note:
1. Pipe penetration to be through middle third of footing beam depth.
2. Lagging must extend to both faces of footing beam.

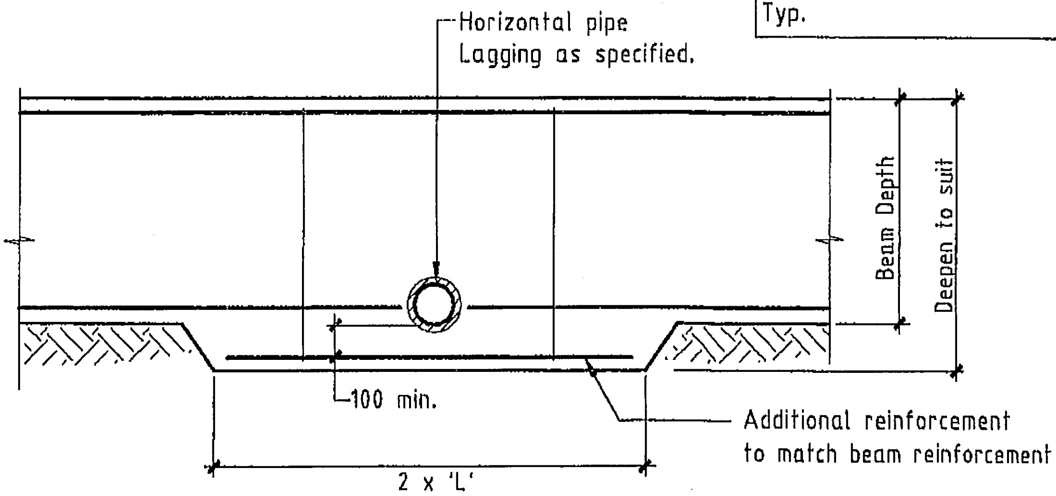


Through External Footing Beam



Vertical Pipe through Footing - Plan View

NOTE:
'L' denotes the reinforcement lap length as noted on the Footing Layout Plan.
Typ.



Horizontal Pipe Through Bottom of Footing

SECTION B

SPECIFICATION – FOOTING CONSTRUCTION REPORT

BUILDING CONSTRUCTION AND SITE MANAGEMENT

The details in this report contain advice designed to minimise risk to the building. It is an important document and should be kept in a safe place. It is essential that this report be supplied to subsequent owners so that they are aware of the consequences of making changes to the building and garden. Without this information, they may instigate changes to site management that could jeopardize the long term serviceability of the building.

GENERAL

The following information represents the basis on which the Footing Construction Report has been prepared. It should be noted that the intention of the footing design is to prevent cracking exceeding the Category of Damage classed as slight. (Refer to Table C1 on page 4 of the attached CSIRO document). It is emphasised that in the event of leaking water or sewer pipes or a significant departure from site management requirements contained in this report, the above category of damage becomes inapplicable. It is important for owners to understand that reactive clays move because of moisture changes. It is neither possible nor economical to design for extreme conditions at the site. The building owners MUST familiarize themselves with the attached CSIRO document, Sheet No. 10-91 of August 1996: "Guide to Home Owners on Foundation Maintenance and Footing Performance" by Dr P.F. Walsh. This document gives sound advice on garden establishment and matters pertaining to site management. It is a document which is being used nationally to inform home owners of their responsibilities in respect of the performance of their house footings. For notes and details concerning earthworks, concrete and steel reinforcement, building construction and articulation, services, paving requirements and site drainage, the owner is advised to read Section B of this report in its entirety.

SOIL BORELOGS

The soil profiles, as indicated by the test bores, form the basis of the footing recommendations contained within this report. The footings have been selected on the basis of the recognised characteristics of the soil profile. Unless otherwise stated these characteristics have been visually assessed and relate to known performance of the soils under optimum conditions of site development and use. It has been assumed that aspects of site drainage, paving and landscaping which are described in this report have been or will be implemented. <u>Where all of these aspects do not form part of the building contract, it is a mandatory requirement that they be carried out within a period stated in the construction report.</u> It is neither economically possible nor practical to determine every sub surface feature on a site. Because of this, any variation or discrepancy in soil type, colour, or horizon depth must be referred to the Engineer immediately. The Engineer will, as part of the mandatory list of inspections, inspect all trenches prior to placement of polythene for a raft or reinforcement for a strip footing.

The footing recommendations given are in general use and should perform within the limitations outlined elsewhere. Alternative footing types will be considered if required.

After completion of primary earthworks the site must be prepared for footing construction. Ideally, for raft construction, soils beneath the house area should be kept in a moist condition. For strip footings with timber floors the building area should be kept as dry as possible.

For rafts, provide a level working surface of a minimum compacted thickness of 100mm of quarry rubble or other approved material. The selected material must be free at the surface of any sharp aggregate which could damage the vapour barrier.

NOTE

The level of the finished surface may be dictated by Local Council requirements or statutory requirements given the relationship between finished floor level, external paving and/or the sewer floor gully. This must be taken into account when building platform levels are established.

ARTICULATION

It should be realised that there are many factors which may affect the performance of the building. Visible cracking can be caused by shrinkage of roof timbers, crazing of plaster, expansion of brickwork (brick growth) and shrinkage of concrete as well as the most commonly attributed cause, viz. footing distortion. Generally, minor cracking is of no significance and will not detract from the performance or durability of the building. It is uneconomical, if not impossible, to eliminate all such imperfections. It is generally recommended that masonry walls (and in areas of very high soil movement and timber framed walls) be articulated at all or some openings. Articulated involves the incorporation of movement joints at doors and windows and in long lengths of wall. The location of the control joints will be given in this Footing Construction Report.

It should be noted that significant economies in footing costs may be achieved by using an articulated structure. Where either expansive or collapsing soils are encountered, special care must be taken to ensure that flexible service connections are used so as to allow for different soil movement. Similarly, where new masonry abuts existing masonry, full height mastic filled joints shall be used. Because it is very difficult to prevent tilting of the extension relative to the existing building, the extension must be constructed so as to permit relative movement between the new and existing building. The provision for relative movement applies to all work including floors, tiling, wall and ceiling finishes etc.

SERVICES

Unless approved otherwise, service trenches must be positioned so that the distance between the trench and the edge of the footing is not less than the depth of the trench.

If this cannot be achieved the Engineer must be notified BEFORE footing construction commences so that appropriate alternatives can be made to the footing design. Service penetrations are permitted through footings subject to the following requirements:

A Sleeves shall be placed at the mid depth of the footing and a minimum of 50mm cover shall be provided between the sleeve or pipe and the reinforcing steel. Where this is not achieved the following must be done.

1 Provide additional reinforcement correctly placed and lapping 50 bar diameters either side of the sleeve.

2 Where the sleeve is close to the bottom reinforcement additional excavation must occur below the pipe and the bottom reinforcement placed and lapped so as to provide the correct cover.

IT IS GENERALLY UNACCEPTABLE TO HAVE PIPES PLACED BETWEEN PARALLEL REINFORCEMENT. WHERE THIS CANNOT BE AVOIDED ADDITIONAL STEEL AS DIRECTED BY THE ENGINEER MUST BE PROVIDED.

B Where pipes pass through a footing beam they must be wrapped in closed cell polyethylene or similar material approved by the Engineer so as to allow relative movement between the footings and the pipes.

NOTE: Use 20mm thick generally and 40mm on Class H2 and E sites.

SITE PREPARATION

1 Scrape vegetation and roots off site.
2 Grade site so water drains away from footing area.
3 Use approved compacted fill under floor slabs.
4 Trench footings to suit finished floor level. Ensure footings are fully trenched or <u>piered</u> to natural ground.
5 Use minimum 0.2mm branded plastic membrane under slabs and footings.

PRE WET

Applies to highly reactive sites when specified, when the soils are in a dry state.

Watering may be carried out using garden sprinklers for approximately two (2) hours daily for a period of seven (7) to ten (10) days or until all visible cracks in the soil have closed up. This watering must be carried out before the underfloor fill is placed. After watering, construction must commence within three (3) days.

SITE DRAINAGE

Because moisture variation (i.e. wetting or drying) is the main cause of movement in clay soils, the achievement of effective drainage is of the utmost importance. It reduces the chance of the footings having to cope with the extremes of soil movement. The following list covers the common causes of moisture variation.

WETTING UP OF SOIL

1 Leaking sewer or water pipes.
2 Down pipes discharging too close to the house.
3 Sloping sites and inadequate drainage causing water to pond or collect close to the house
4 See page on sloping sites caused by water travelling on the topsoil-clay interface. Cut off drains are required in this situation.
5 Garden or lawn watering immediately adjacent to the footings. As a general rule this is not acceptable and must not be done except with the explicit approval of the Engineer.
6 Septic tanks with inadequate soakage trenches.
7 Flooding during house construction.

DRYING OUT OF SOIL

1 The non provision of paving particularly on the north and west sides of the house coupled with the non establishment of a garden.
2 A change from an established garden situation to a native garden coupled with a substantially reduced level of watering.
3 The most common cause of drying out by far is that caused by trees being planted too close to the house. Single trees should be planted a distance from the house not less than expected mature height of the tree, Where there is more than one tree in a row or group, this distance should be increased to one and a half times the expected mature height of the largest tree in the group.

NOTE: The stormwater drainage system should be completed by the finish of construction of the house. Lawns and gardens should be established soon after.

EARTHWORKS

1 MATERIALS

Where specified in the Footing Construction Report, selected approved site materials, excluding topsoil or organic rich soil, may be used for compacted fill. Alternatively, where site materials are unsuitable because of their nature or moisture content, quarry rubble or other approved fill material may be used.

2 COMPACTED FILL ON STEEP SITES

Where the surface of an area which is to receive fill is steeper than 1 (vertical), in 8 (horizontal), a series of benches shall be excavated along the contour over the whole of the area which will be receiving fill. This will stabilise the fill against downhill slip. The Engineer must be contracted if further information or clarification is required.

3 STANDARD OF COMPACTION (REFER TO TABLE A)

The standard of compaction of fill for the various material types given, shall not be less than that noted in table A. The specified standard of compaction shall be provided to an area extending not less than one metre beyond the perimeter of the building and shall also be provided beneath any filled driveways or other trafficable pavements. The footings specified in the report have been designed assuming that the building will achieve the specified compaction. Not withstanding this, no footing beam shall be founded on fill materials unless the Engineer has checked its compaction standard and given written acceptance of its compliance with the specification. To achieve the above compaction requirements, vibrating smooth drum rollers , (for granular materials), or vibrating sheepsfoot rollers, (for clays), are required. Take care with vibrating rollers, particularly if there are houses constructed on adjacent allotments. Contact the Engineer if in doubt regarding this. If the builder elects to place fill without the use of compaction equipment, the fill will be assumed to be incapable of supporting any building load. Accordingly, any concrete slab over such fill will be increased in thickness and have an additional layer of bottom fabric reinforcement. Refer to the standard details for the specified footing type which show these additional requirements. The Engineer may waive this requirement if the inspection and/or checking of fill shows it will be able to support floor slabs or other loads.

NOTE

Although Adelaide and environs is not noted as a problem area for soil slippage, attention should be given to this possibility on sloping sites. It is recommended that on steep sites an Engineer should assess the risk of slip failures prior to commencement of footing design. This would of course necessitate a visit to the site and if a problem is envisaged, a slope stability analysis may be necessary to key the fill to prevent sliding. This aspect must be examined when the site works plan is prepared.

TABLE A

TYPE OF FILLING MATERIAL	RECOMMENDED COMPACTION EQUIPMENT	TARGET DENSITY	MINIMUM ACCEPTED DENSITY	COMMENT	LAYER THICKNESS FOR LARGE ROLLER (62T, 72T)	LAYER THICKNESS FOR HAND ROLLER OR VIBRATORY PLATE
Quarry rubble, well graded quarry scalpings, crushed rock	Smooth drum vibratory or dead weight roller	95% of E 2.1	92%	Easy materials to compact provided moisture content is near optimum	Maximum 200mm loose thickness	Maximum 75mm loose thickness
Fine sands	Smooth drum vibratory roller	75% Relative Density	70%	Difficult to compact – keep moisture level above optimum when compacting	Maximum 200mm loose thickness	Maximum 100mm loose thickness
Silty or sandy clays Low plasticity	Sheepsfoot or smooth drum vibratory roller	95% of E 1.1	92%	Compacts with some difficulty – keep moisture near or just above optimum when compacting.	Maximum 150 – 200mm loose thickness for sheepsfoot roller and 75-100mm for vibratory roller	Not applicable to this material
Silty clays or clays – medium to high plasticity	Sheepsfoot vibratory roller	92% of E 1.1	92%	Difficult to compact – keep moisture level at or just below optimum when compacting	Maximum 150 – 200mm loose thickness	Not applicable to this material

NOTES:

1. Based on Australian Standard AS1289.
2. Materials of a very high plasticity should not be used as fill.

PAVING REQUIREMENTS

A Concrete pavements shall have a thickness of not less than 75mm. Where the soil class given in the Footing Construction Report is class M or greater it is recommended that concrete paving be reinforced with SL62 fabric in a single top layer, placed 30mm from the finished surface.

B Control joints shall be provided at a maximum 1200mm spacing.

C Pavements shall not be less than 900mm and preferably 1200mm in width and shall have a crossfall of not less than 50mm per 1000mm width, unless noted otherwise.

D For class H1, H2, and E sites it is recommended that paving be constructed at the end of winter, when the site soils are wet, so that crossfalls constructed in the paving will not be reduced. It is important however that, if the house is occupied during the winter period and no paving is provided, the soil surface around the perimeter of the house is maintained in a well drained state until such time as paving is installed.

If, on these soils, it is necessary to construct paving at other times of the year, e.g. the end of summer, the crossfall provided should not be less than 70mm.

E Paving shall be constructed on a firm clean base. Ensure that all building debris is removed from the perimeter of the house. Provide a compacted quarry rubble base if necessary to elevate paving to achieve the necessary crossfall.

F The paving shall not be constructed above any damp-proof course or built-in damp-proof membrane.

G On reactive soil sites it may be found that paving separates horizontally from the perimeter of the house. It is important that any gap between the pavement and footing be immediately sealed with a flexible mastic sealant or expanding foam type sealant.

EXCAVATION

It is imperative that the owner, or agent, provide sufficient supervision of the cut and fill operation in order to ensure that the following requirements for satisfactory completion of the cut and fill and drainage scheme proposal are adhered to.

1 Vegetation and roots must be scraped off and removed from the site prior to cutting and filling.

2 The extent of the cut and fill outside the building line should not be exceeded with respect to the following requirements. Cut or fill on the boundary should not exceed 600mm (unless a suitable retaining wall is specified).

3 Cut on the boundary should not undermine any structure that exists on an adjacent property.

Generally vertical cut or fill within the property, (i.e. not on the boundary), should not exceed 900mm unless approved by the Engineer or a suitable retaining wall is specified.

Where bank heights do not exceed 1500mm and the natural slope of the site does not exceed 1 in 5, the batter slopes recommended below may be used for stability purposes.

DESIRABLE BATTER SLOPES

These surface slopes are only appropriate where the natural surface slope does not exceed 1 vertical to 5 horizontal.

MATERIAL	SURFACE SLOPE
Heavy Clay	One Vertical to One Horizontal
Sands and Cohesionless Soils	One Vertical to Two Horizontal
Friable and Sandy Cohesionless Soils	One Vertical to One and a Half Horizontal
Weathered Rock in Good Condition	One Vertical to Half Horizontal
Sound Rock	Nearly Vertical

NOTES

Embankments should be protected from damage arising from surface erosion or ground water flow.

If a retaining wall has been specified the cut or fill should not exceed the design height of the specified retaining wall.

Slopes and gradings of the cut bench or platform shown on the cut and fill plans are to be strictly adhered to in order to allow for the site to be drained. In particular, a temporary trench may need to be cut into the platform at the base of cut banks to provide a drain. This drain should fall sufficiently to the low side such that water does not pond.

UNDER FLOOR FILL

100mm thick minimum clean granular material shall be used.

DAMP PROOF MEMBRANE

A damp proof membrane shall be provided throughout the underside of all habitable areas. Laps are to be 300mm minimum at the joints. Penetrations by plumbing or other pipes shall be well taped to seal against dampness. The membrane shall be 0.2mm polythene, (Fortecon or equivalent), and shall comply with the requirements of AS2870. Prior to placement of concrete all other perforations of the membrane shall be sealed.

CONCRETE

All concrete is to comply with AS3600. All concrete shall be normal grade 20MPa, (i.e. F'c = 20MPa at 28 days), and have a slump of 80mm maximum, unless otherwise stated. All concrete shall be mechanically vibrated. Concrete shall not be placed without the approval of the Engineer when the shade temperature is likely to exceed 34 degrees Celcius. Maximum size of aggregate 20mm.

CURING

Curing may be achieved by covering the concrete surface with a polythene sheet for a minimum of 7 days, alternatively suitable curing compounds may be used.

REINFORCEMENT

Where splicing is required, the following minimum lap lengths are to be used:

N12	N16	N20	N24	N28	N32	N36
600mm	800mm	1000mm	1200mm	1600mm	1800mm	2000mm

CONCRETE COVER

Clear cover to reinforcement shall be a minimum 40mm to unprotected ground, 40mm to external exposure, 30mm to a membrane in contact with the ground and 20mm to an internal surface. Reinforcement in piers to have 75mm minimum cover.

SLAB AND FOOTING TOLERANCES

Footing and slab construction shall achieve the following dimensional tolerances:

A The cover to the reinforcement from the surface in contact with the ground shall be within +40mm of the specified cover.

B The cover to the reinforcement from the internal surface shall be within 10mm of the specified cover.

C The surface shall be generally within +10mm of level.

D The surface finishes shall be suitable for the specified floor coverings without further treatment. In the absence of any specification, a steel trowelled finish with a tolerance of +5mm from a 3m straight edge shall be used.

E The thickness of the slab and the width and depth of the footing beams shall not be less than the specified dimensions.

RECOMMENDED ADDITIONAL CONSTRUCTION AND ARCHITECTURAL REQUIREMENTS FOR REACTIVE CLAY SITES

1 GENERAL

These recommendations are additional to the general construction requirements given in Section B for footing systems on highly and extremely reactive sites (Classes H1, H2, or E), and should also be considered for houses on moderately reactive sites.

2 ARCHITECTURAL RESTRICTIONS

The following aspects of super-structural design and layout should be used to reduce the effects of movement.

(a) Detail brickwork in accordance with Paragraph 6 to minimise the possibility of damage.

(b) Internal and external walls should be straight where convenient.

(c) Isolate extensions from the original structure to allow for differential movement.

(d) Introduce articulation joints at abrupt changes in construction such as large openings or corners.

3 SITE DRAINAGE

Allotments containing reactive sites shall be provided with an adequate system of drainage designed in accordance with the following recommendations:

(a) Surface drainage of allotments for reactive sites for both footings and slabs should be considered in the design of the footing system, and care shall be taken with surface drainage of the allotment from the start of construction. The drainage system shall be completed by the finish of construction of the house.

(b) Particular attention should be given to ensuring that plumbing trenches do not introduce water to the foundation of the house. Specifically, the trenches should be sloped away from the house and should be backfilled with clay in the top 300mm within 1.5m of the house. Where pipes pass under the footing slab, the trench should be backfilled with clay or concrete to prevent the ingress of water beneath the footing.

(c) Subsurface drains should be avoided near footings on reactive clay sites as they can introduce water to the foundation if they become blocked. In some circumstances subsurface drains will be essential for drainage of steps in slabs and subsurface flows and care should be taken to ensure that they are free draining and able to be inspected and maintained. Subsurface drains should be protected by filters and geotextiles. Where possible the base of the subsurface trench should be capable of providing some drainage in the event of the main drain becoming blocked.

4 MIXED FOUNDATIONS

If the footing or slab is partly on rock and partly on reactive clay, such as a cut-and-fill site, considerable care should be taken. Every attempt shall be made to provide for structural continuity. Some specific allowance is to be made for movement in the superstructure near the junction of mixed foundation types. A suspended system with piers to the rock should be considered.

The footing depth may be reduced where founding in rock provided the structural integrity of the footing system is maintained. Approval must be given by the Engineer.

5 MASONRY DETAILING FOR HOUSES ON REACTIVE SITES

The detailing and construction of masonry should be carried out to minimise damage due to reactive movements in accordance with the following:

(a) Masonry over doors and windows should be avoided. As far as practical even non-articulated masonry should follow the recommendation given in TN61 "Articulated Walling", published by Cement and Concrete Association (Australia).

(b) Wingwalls and arches should be avoided or detailed in accordance with TN61, "Articulated Walling".

(c) Generally, high strength mortar should be avoided.

(d) Reinforced brickwork may be used to control the width of cracks and shall contain two 6.3mm hard drawn galvanized wires in each leaf of brickwork in the first mortar course near the footing or slab, but above the damp proof course if installed, and above and below any openings. The reinforcement shall continue where possible 600mm past any openings and shall be lapped by 400mm. This method shall not be used within 1km of the coast.

(e) Reinforced <u>blockwork</u> may also be used to control cracking.

6 PLUMBING AND DRAINAGE DETAILING

On reactive clay sites additional care is needed to reduce the risk of leaks near the footings and the following is mandatory:

(a) Penetration of the slabs and beams should be avoided if possible, but where necessary shall be lagged to allow for movement with closed cell polyethylene or similar material 20mm thick generally increasing to 40mm of class H2 and E sites.

(b) Connection of stormwater drains and waste drains shall include flexible connections.

(c) Septic tanks and associated soakage areas shall be located to minimise their effects on the foundation.

SECTION C

NOTES TO THE HOME OWNER

THESE INTRODUCTORY NOTES CONTAIN IMPORTANT INFORMATION AND PROVISIONS.

All sections of this report must be read and understood. If there are any queries this office must be contacted for further discussion or explanation.

The owner's attention is drawn to Appendix B of AS2870-2011 "Foundation Performance and Maintenance".

Appendix B of AS2870 is reprinted as the Annexure to "Guide to Home Owners on Foundation Maintenance and Footing Performance" by Dr. P. F. Walsh, CSIRO Division of Building, Construction and Engineering, Information Sheet No. 10-91, August 1996.

DESIGN LIMITATIONS

The footing design has been based upon the Australian Standard AS2870-2011 – Residential Slabs and Footings (incorporating all amendments).

The footings have been designed to provide a satisfactory level of performance – Category 1 to Category 2 at an economically achievable cost. Refer to Table C1 and C2 of Appendix C of AS2870-2011.

If a more rigid footing system is desired to restrict the level of performance to Category 1 or better, this office should be contacted.

NOTE: THIS RESTRICTION WOULD RESULT IN A CONSIDERABLE INCREASE IN COST OF FOOTING CONSTRUCTION.

The design of this footing system does not take into account distortion of the footings that may be caused by any of the following:

(a) Leakage or loss of water from a pipe, drain or sewer.

(b) Leakage or loss of water from a water tank, swimming pool, fountain, ornamental pool, fish pond or other like container of water.

(c) Surface water or water from a roof of any building that is allowed to flow over, or lie on, those parts of the site that are adjacent to the footings.

(d) The planting of a tree or shrub at a distance from the footings where such distance is not greater than the maximum height to which the tree or shrub is likely to grow.

(e) Excessive watering of lawn, tree, shrub, flower or other plants.

(f) Any other activity carried on beyond the boundaries of the site that affects the moisture content of the foundation.

(g) On class M, H1, H2 & E-D sites the ingress of water from a sewer, stormwater or any other trench.

CONDITIONS OF ACCEPTANCE OF THIS REPORT

The Engineer shall not be liable for any defect in, or damage to, the building arising from footing inadequacy or movement of the building, including its footings, caused by or contributed to by any breach of this agreement committed, permitted or allowed by the Client.

Where more than one person is named as the Client every provision shall bind all such persons jointly and each such person severally and instruction or information given by the Engineer by any one such person shall be deemed to be given by all other such persons.

Any builder or supervisor (and any of their respective servants or agents) engaged in the construction of the building, shall be deemed to be an agent of the Client.

The Client will, at times after receiving a Footing Construction Report from the Engineer, comply and procure compliance in all respects with all recommendations and directions contained in such Footing Construction Report.

THE CLIENT SHOULD BE AWARE THAT:

(a) Soil samples obtained at the site may not disclose all types of soil existing at the site.

(b) A more extensive investigation is costly and is usually not undertaken for domestic sites but should the Client wish, then the additional work can be carried out.

(c) Because of the current state of Engineering knowledge and matters beyond the control of the Engineer, the Engineer is unable to provide a specification for a footing that will ensure the prevention of movement and cracking of the building beyond the chosen design levels of performance.

SITE INSPECTIONS

The Engineer shall be engaged to carry out site inspections as noted in the Report and on any drawing.

A fee, additional to that already charged for the preparation of this report will be levied for each inspection carried out.

The Engineer may, and the Client hereby authorises the Engineer to:

(a) Make such modifications to the Footing Construction Report which the Engineer may deem necessary during the course of the construction of the building.

(b) Issue instructions (including an instruction to cease construction of the building) directly to any servant or agent of the Client to ensure construction of the building is in accordance with the Footing Construction Report and any modification thereof PROVIDED THAT:

  (i) If any modification as stated above would be likely to result in additional costs of construction of the building of more than $10,000.00, the Engineer may only issue an instruction to cease construction of the building in order to obtain the approval of the Client for such modification.

  (ii) The Client shall indemnify the Engineer in respect of all and any claims and demands made against the Engineer for any additional costs of construction of the building incurred by reason of any act, requirement or instruction of the Engineer made or given pursuant to this Clause.

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO PUBLISHING

BTF 18-2011 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870-2011, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume, particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Notes

1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class P is used for sites which include soft fills, such as clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soil subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater, further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

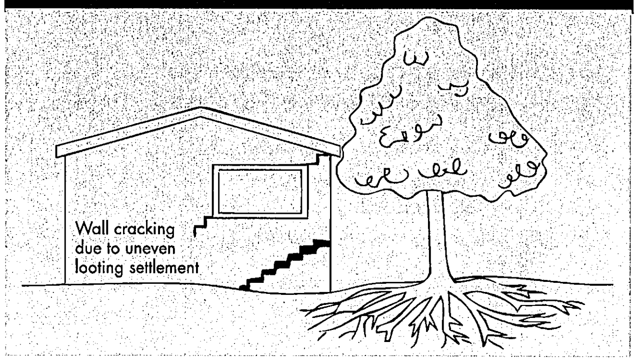
Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Trees can cause shrinkage and damage



Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation causes a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem. Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870-2011.

AS 2870-2011 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

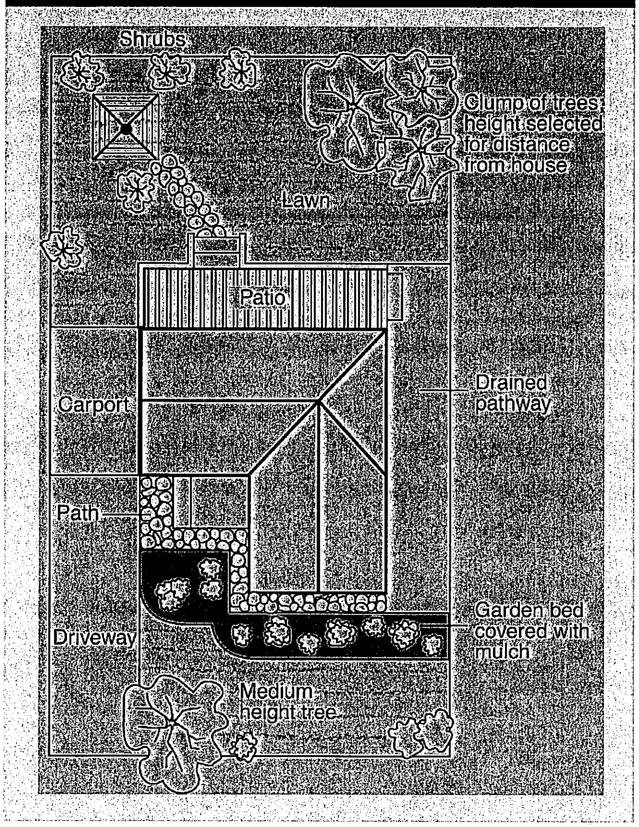
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving should

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly.	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired.	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 mm but also depends on number of cracks	4

Gardens for a reactive site



extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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SECTION D

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Job Number: 180386 Date: 15/01/2020 (15:59)

Code Oriented Raft Design (Version 8.0)
****

FOOTING DESIGN TO AS2870 - 2011
-- Raft Footing --

****
RECTANGLE 1 of 2 (40.2m x 6.1m) Residence 1 to Residence 5 (Critical)

THE FOLLOWING VALUES WILL BE USED:

External Wall Weight
- Side 1 ....= 0.8 kPa
- Side 2 ....= 1 kPa
- Side 3 ....= 0.8 kPa
- Side 4 ....= 1 kPa

Wall Height Externally
- Side 1 ....= 6.6 m
- Side 2 ....= 6.6 m
- Side 3 ....= 6.6 m
- Side 4 ....= 6.6 m

Roof Eaves Overhang
- Side 1 ....= 0 m
- Side 2 ....= 0 m
- Side 3 ....= 0 m
- Side 4 ....= 0 m

Internal Wall Weight ....= 0.5 kPa
Roof Type - Trussed
Roof Weight ....= 0.45 kPa
Wall Height Internally ....= 2.7 m
Internal Wall Length ....= 220 m
Slab Live Load ....= 4 kPa
Deflection Ratio ....= 1 / 600
E conc. long term (max) ....= 15.48 GPa
Hs ....= 4 m
Footing design modified for tree effects - Yes

Ys ....= 57 mm

Yt ....= 25 mm

Ym tree (centre) --> 0.7Ys + Yt = 65 mm

Ym (edge) --> 0.5Ys ....= 29 mm

Footing design accounts for tree removal - No

```
                              Side 1
                     -------------------------
                     |                       |
                     |           |           |
                     | (dir 1)   |           |
            Side 4   |   <-------+--------   |  Side 2
                     |           |           |
                     |           v (dir 2)   |
                     |                       |
                     -------------------------
                              Side 3
***********************************************************************
LOAD CALCULATION (Note: Footing self-weight is generated automatically)
-----------------------------------------------------------------------
External line load PE (kN/m)
  Wall load
    Side 1  (6.6 x 0.8)........................................= 5.28 kN/m
    Side 2  (6.6 x 1)..........................................= 6.60 kN/m
    Side 3  (6.6 x 0.8)........................................= 5.28 kN/m
    Side 4  (6.6 x 1)..........................................= 6.60 kN/m
  Roof eaves load
    Side 1  (0 x (40.2 + 0 + 0) / 40.2 x 0.45)................= 0.00 kN/m
    Side 2  (0 x (6.1 + 0 + 0) / 6.1 x 0.45)..................= 0.00 kN/m
    Side 3  (0 x (40.2 + 0 + 0) / 40.2 x 0.45)................= 0.00 kN/m
    Side 4  (0 x (6.1 + 0 + 0) / 6.1 x 0.45)..................= 0.00 kN/m
NOTE: Roof load (excluding eaves overhang) is borne on all 4 sides
  Contributing roof area
    Direction 1 (sides 1 & 3)  (113.31 m^2
    Direction 2 (sides 2 & 4)  (9.30 m^2
  Resulting roof load
    Direction 1 (sides 1 & 3)  (113.31 x 0.45 / 40.2).........= 1.27 kN/m
    Direction 2 (sides 2 & 4)  (9.30 x 0.45 / 6.1)............= 0.69 kN/m
  Footing self weight:-
    Direction 1 (0.6 x 0.3 x 24)...............................= 4.32 kN/m
    Direction 2 (0.6 x 0.3 x 24)...............................= 4.32 kN/m
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  PE (Side  1) ................................................= 10.87 kN/m
  PE (Side  2) ................................................= 11.61 kN/m
  PE (Side  3) ................................................= 10.87 kN/m
  PE (Side  4) ................................................= 11.61 kN/m
-----------------------------------------------------------------------
Distributed internal load W (kPa)
  Internal walls  (220 x 0.5 x 2.7 / (40.2 x 6.1))............= 1.21 kPa
  Slab self weight (0.1 x 24)..................................= 2.40 kPa
  Additional slab load ........................................= 1.50 kPa
  Footing self weight:-
    Direction 1       ((1 x 0.3 x (0.7 - 0.1) x 24) / 6.1)....= 0.71 kPa
    Direction 2       ((13 x 0.3 x (0.7 - 0.1) x 24) / 40.2)..= 1.40 kPa
  Live load ...................................................= 4.00 kPa
  Sub Total (Omega) ...........................................= 11.22 kPa
Longitudinal edge loads
  Direction 1       ((10.87 + 10.87) / 6.1)...................= 3.56 kPa
  Direction 2       ((11.61 + 11.61) / 40.2)..................= 0.58 kPa
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  W (Direction 1) .............................................= 14.78 kPa
  W (Direction 2) .............................................= 11.79 kPa
-----------------------------------------------------------------------
Total distributed load Q (kPa)
  Omega .......................................................= 11.22 kPa
  Line loads
    Direction 1       ((10.87 + 10.87) x 40.2) / (40.2 x 6.1) = 3.56 kPa
    Direction 2       ((11.61 + 11.61) x 6.1) / (6.1 x 40.2) .= 0.58 kPa
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Q ...........................................................= 15.36 kPa
```

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Code Oriented Raft Design (Version 8.0)
****

****
RECTANGLE 2 of 2 (13.2m x 11m) Residences 4 & 5

THE FOLLOWING VALUES WILL BE USED:

```
          External Wall Weight
                         Side 1 ..........= 1 kPa
                         Side 2 ..........= 0.8 kPa
                         Side 3 ..........= 1 kPa
                         Side 4 ..........= 1 kPa
          Wall Height Externally
                         Side 1 ..........= 2.7 m
                         Side 2 ..........= 2.7 m
                         Side 3 ..........= 2.7 m
                         Side 4 ..........= 2.7 m
          Roof Eaves Overhang
                         Side 1 ..........= 0 m
                         Side 2 ..........= 0 m
                         Side 3 ..........= 0 m
                         Side 4 ..........= 0 m
          Internal Wall Weight ...........= 0.5 kPa
          Roof Type - Conventional
          Roof Weight ....................= 0.45 kPa
          Wall Height Internally .........= 2.7 m
          Internal Wall Length ...........= 80 m
          Slab Live Load .................= 4 kPa
          Deflection Ratio ...............= 1 / 600
          E conc. long term (max) ........= 15.48 GPa
          Hs .............................= 4 m
          Footing design modified for tree effects - Yes

          Ys .............................= 57 mm

          Yt .............................= 25 mm

          Ym tree (centre) --> 0.7Ys + Yt = 65 mm

          Ym (edge) --> 0.5Ys ............= 29 mm

          Footing design accounts for tree removal - No
```

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Job Number: 180386 Date: 15/01/2020 (15:59)

Code Oriented Raft Design (Version 8.0)

****

```
                            Side 1
                   -------------------------
                   |                       |
                   |          |            |
                   | (dir 1)  |            |
          Side 4   |   <-------+--------   |  Side 2
                   |          |            |
                   |          v (dir 2)    |
                   |                       |
                   -------------------------
                            Side 3
*******************************************************************
LOAD CALCULATION (Note: Footing self-weight is generated automatically)
-------------------------------------------------------------------
External line load PE (kN/m)
  Wall load
    Side 1  (2.7 x 1)...................................= 2.70 kN/m
    Side 2  (2.7 x 0.8).................................= 2.16 kN/m
    Side 3  (2.7 x 1)...................................= 2.70 kN/m
    Side 4  (2.7 x 1)...................................= 2.70 kN/m
  Roof eaves load
    Side 1  (0 x (13.2 + 0 + 0) / 13.2 x 0.45)............= 0.00 kN/m
    Side 2  (0 x (11 + 0 + 0) / 11 x 0.45)................= 0.00 kN/m
    Side 3  (0 x (13.2 + 0 + 0) / 13.2 x 0.45)............= 0.00 kN/m
    Side 4  (0 x (11 + 0 + 0) / 11 x 0.45)................= 0.00 kN/m
NOTE: Roof load (excluding eaves overhang) is distributed internally as a slab UD
  Footing self weight:-
    Direction 1 (0.6 x 0.3 x 24)..........................= 4.32 kN/m
    Direction 2 (0.6 x 0.3 x 24)..........................= 4.32 kN/m
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  PE (Side  1) .........................................= 7.02 kN/m
  PE (Side  2) .........................................= 6.48 kN/m
  PE (Side  3) .........................................= 7.02 kN/m
  PE (Side  4) .........................................= 7.02 kN/m
-------------------------------------------------------------------
Distributed internal load W (kPa)
  Roof load ............................................= 0.45 kPa
  Internal walls  (80 x 0.5 x 2.7 / (13.2 x 11))..........= 0.74 kPa
  Slab self weight (0.1 x 24)...........................= 2.40 kPa
  Additional slab load .................................= 1.50 kPa
  Footing self weight:-
    Direction 1      ((3 x 0.3 x (0.7 - 0.1) x 24) / 11)..= 1.18 kPa
    Direction 2      ((3 x 0.3 x (0.7 - 0.1) x 24) / 13.2)= 0.98 kPa
  Live load ............................................= 4.00 kPa
  Sub Total (Omega) ....................................= 11.25 kPa
Longitudinal edge loads
  Direction 1      ((7.02 + 7.02) / 11)..................= 1.28 kPa
  Direction 2      ((6.48 + 7.02) / 13.2)................= 1.02 kPa
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  W (Direction 1) ......................................= 12.53 kPa
  W (Direction 2) ......................................= 12.28 kPa
-------------------------------------------------------------------
Total distributed load Q (kPa)
  Omega ................................................= 11.25 kPa
  Line loads
    Direction 1      ((7.02 + 7.02) x 13.2) / (13.2 x 11) = 1.28 kPa
    Direction 2      ((6.48 + 7.02) x 11) / (11 x 13.2) ..= 1.02 kPa
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
  Q ....................................................= 13.55 kPa
-------------------------------------------------------------------
```

Rectangle 1 of 2	DIRECTION 1	DIRECTION 2
L(m)	40.2	6.1
B(m)	6.1	40.2
P Edge (kN/m)	10.87	11.61
P Centre (kN/m)	0.00	0.00
W(kPa)	14.78	11.79
k(kPa/m)	1535.72	1535.72
Delta(mm)	20.0	10.2
No. of Beams	3	15
	CENTRE HEAVE	
Delta > Ymc ?	NO	NO
Edge Dist. (m)	2.312	2.312
M work (kNm/m)	60.75	47.09
I req(x10^6 mm4/m)	5743.51	1062.25
	EDGE HEAVE	
Delta > Yme ?	NO	NO
Edge Dist. (m)	1.744	1.220
M work (kNm/m)	11.76	20.61
I req(x10^6 mm4/m)	385.13	491.72

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Code Oriented Raft Design (Version 8.0)
****

Rectangle 2 of 2	DIRECTION 1	DIRECTION 2
L(m)	13.2	11
B(m)	11	13.2
P Edge (kN/m)	7.02	6.48
P Centre (kN/m)	0.00	0.00
W(kPa)	12.53	12.28
k(kPa/m)	1355.29	1355.29
Delta(mm)	20.0	18.3
No. of Beams	5	5
/////////////////////	CENTRE HEAVE	
Delta > Ymc ?	NO	NO
Edge Dist. (m)	2.312	2.312
M work (kNm/m)	46.37	49.99
I req(x10^6 mm4/m)	2962.35	2316.34
/////////////////////	EDGE HEAVE	
Delta > Yme ?	NO	NO
Edge Dist. (m)	1.744	1.744
M work (kNm/m)	20.13	24.70
I req(x10^6 mm4/m)	1007.41	1184.80

TRIAL FOOTING PROPERTIES :-

Edge Beams:
- Beam Width = 300 mm
- Beam Depth = 700 mm
- Reinforcement
  - top = 3 x N16 bars, 40 mm cover
  - bottom = 3 x N16 bars, 65 mm cover

Internal Beams:
- Beam Width = 300 mm
- Beam Depth = 700 mm
- Reinforcement
  - top = 3 x N16 bars, 40 mm cover
  - bottom = 3 x N16 bars, 65 mm cover

Slab:
- Thickness = 100 mm
- Reinforcement
  - layer 1 = 290 mm^2/m in both directions, 20 mm cover

Material Properties:
- Fsy = 500 MPa
- F'c = 20 MPa

A COMPARISON OF THE REQUIRED DESIGN PROPERTIES AND THOSE OBTAINED FOR THE ABOVE FOOTING SYSTEM IS TABULATED BELOW

- Note that where relevant, the properties are expressed in units per metre width of total footing cross section
- The I required values have been factored up to take account of the variation in the long term creep factor for concrete, refer to AS3600, clause 8.5.3.3

RECTANGLE 1 of 2 (40.2m x 6.1m)

BEAM DEFLECTED SHAPE	CENTRE HEAVE		EDGE HEAVE	
	REQUIRED	ACTUAL	REQUIRED	ACTUAL
DIRECTION 1				
Moment of Inertia (x 10^9 mm^4/m)	5.744 (Ireq)	8.328 (Ieff)	0.385 (Ireq)	8.328 (Ieff)
Flexural Strength (kNm/m)	60.8 (M*)	145.0 (øMu)	11.8 (M*)	77.3 (øMu)
Ductility Check (kNm/m)	104.9 (1.5Mcr)	181.2 (Mu)	69.7 (1.5Mcr)	96.6 (Mu)
Flange Width (m)	External 1.525	Internal 3.05		
DIRECTION 2				
Moment of Inertia (x 10^9 mm^4/m)	1.062 (Ireq)	4.242 (Ieff)	0.492 (Ireq)	5.693 (Ieff)
Flexural Strength (kNm/m)	47.1 (M*)	94.7 (øMu)	20.6 (M*)	57.9 (øMu)
Ductility Check (kNm/m)	62.5 (1.5Mcr)	118.3 (Mu)	50.4 (1.5Mcr)	72.4 (Mu)
Flange Width (m)	External 0.91	Internal 1.52		

RECTANGLE 2 of 2 (13.2m x 11m)

BEAM DEFLECTED SHAPE	CENTRE HEAVE		EDGE HEAVE	
	REQUIRED	ACTUAL	REQUIRED	ACTUAL
DIRECTION 1				
Moment of Inertia (x 10^9 mm^4/m)	2.962 (Ireq)	7.909 (Ieff)	1.007 (Ireq)	7.909 (Ieff)
Flexural Strength (kNm/m)	46.4 (M*)	139.3 (øMu)	20.1 (M*)	71.6 (øMu)
Ductility Check (kNm/m)	102.9 (1.5Mcr)	174.1 (Mu)	65.2 (1.5Mcr)	89.6 (Mu)
Flange Width (m)	External 1.375	Internal 2.75		
DIRECTION 2				
Moment of Inertia (x 10^9 mm^4/m)	2.316 (Ireq)	6.486 (Ieff)	1.185 (Ireq)	6.486 (Ieff)
Flexural Strength (kNm/m)	50.0 (M*)	112.4 (øMu)	24.7 (M*)	59.6 (øMu)
Ductility Check (kNm/m)	81.9 (1.5Mcr)	140.6 (Mu)	53.9 (1.5Mcr)	74.5 (Mu)
Flange Width (m)	External 1.4	Internal 2.5		

FOR FOOTINGS USE :-

EXTERNALLY:- 300 mm (Wide) x 700 mm (Deep)
- With 6 /N16 Bars - 3 Top And 3 Bottom

INTERNALLY:- 300 mm (Wide) x 700 mm (Deep)
- With 6 /N16 Bars - 3 Top And 3 Bottom

Lelio Bibbo
Consulting Engineers Pty Ltd

STRUCTURAL CALCULATIONS

JOB No.	180386
DESIGN:	JC
DATE:	January 2020
SITE:	19 Alexander Avenue, CAMPBELLTOWN

Lelio Bibbo Consulting Engineers Pty. Ltd.	CONSULT AUSTRALIA	Date 20/12/2019	Job 180386
Campbelltown		By JC	Sheet WS.1

CALCULATE SITE DESIGN GUST WIND SPEED.
Based on AS/NZ 1170.2 - 2011, SAA Loading Code, Part 2: Wind Loads

NOTE: WORKSHEET ONLY FOR FOLLOWING CONDITIONS - hz. < or = 10 m.

REF. NUMBER 180386

Region A1 (South Australia)
Importance Level: 2

Ultimate Limit State-
Annual Probability of Exceedance 500
V_{500} 45 m/s

Serviceability State-
Annual Probability of Exceedance 20
V_{20} 37 m/s

	NORTH	*EAST*	*SOUTH*	*WEST*	
M_d	0.9	0.8	0.85	1	
CAT.	3.0	3.0	3.0	3.0	
hz.	6.7	6.7	6.7	6.7	[m]
$M_{(z,Cat)}$	0.83	0.83	0.83	0.83	
M_s	0.95	0.95	0.95	0.95	
M_t	1.00	1.00	1.00	1.00	
V_s	**26.3**	**23.3**	**24.8**	**29.2**	[m/s]
p_s	**0.41**	**0.33**	**0.37**	**0.51**	[kPa]
V_u	**31.9**	**28.4**	**30.2**	**35.5**	[m/s]
p_u	**0.61**	**0.48**	**0.55**	**0.76**	[kPa]

Ultimate Limit State-
SITE DESIGN GUST WIND SPEED = **35.5** m/s.

Serviceability State-
SITE DESIGN GUST WIND SPEED = **29.2** m/s.

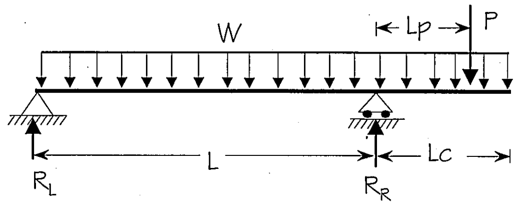
Adopt Wind Class = N1
within 5% to AS1684

Design Summary ***FLOOR BEAM DESIGN*** **Dwelling 1** **FB1**

Member:	300PFC	
Bending:	M+* = 26.2 < φMb (0.60, αm = 1.00) = 152.0 kNm	**OK (0.17)**
Bending:	M-* = 7.7 < φMb (0.50, αm = 1.00) = 152.0 kNm	**OK (0.05)**
Deflection:	δdl = L/1508 (3.8mm), δll = L/5398 (1.1mm)	**OK**
Deflection:	δdl = L/569 (-0.9mm), δll = L/1711 (-0.3mm)	**OK**
Reaction:	Left Rdl = 12.3kN, Rll = 3.1kN, R* = 19.3kN, Right Rdl = 26.6kN, Rll = 3.7kN, R* = 39.1kN	

Geometry

Span (L) =	5800 mm	Restrain by floor truss		
Cantilever (Lc) =	500 mm past right support			
Effective segment length (Le) =	600 mm	αm =	1	
Canti. Effective segment length (Lec) =	500 mm	αm.c =	1	



Loadings

Uniform Dead Loads

					Additional load	
Roof load (wdl) =	0.45 kPa	×	700 mm	+	0.00 kN/m =	0.32 kN/m
Floor load (wdl) =	0.60 kPa	×	600 mm	+	0.00 kN/m =	0.36 kN/m
Wall load (wdl) =	1.00 kPa	×	3500 mm	+	0.00 kN/m =	3.50 kN/m
Other load (wdl) =	0.00 kPa	×	0 mm	+	0.00 kN/m =	0.00 kN/m
Include Selfweight (sw) =	Y (Y)es, (N)o				sw =	0.40 kN/m
					∑ wdl =	4.58 kN/m

Uniform Live Loads

					Additional load	
Roof load (wll) =	0.25 kPa	×	700 mm	+	0.00 kN/m =	0.18 kN/m
Floor load (wll) =	1.50 kPa	×	600 mm	+	0.00 kN/m =	0.90 kN/m
Other load (wll) =	0.00 kPa	×	0 mm	+	0.00 kN/m =	0.00 kN/m
					∑ wll =	1.08 kN/m

Point Loads from Timber Beam 1.0(4.0)(4.6/2)-Wall

Dead Load (pdl) = 10.10 kN 0.4(4.6/2)-S/W Position (Lp) = T mm from RHS, (T)ip of cantilever

Live Load (pll) = 0.00 kN

Design Action

w* = 1.2*wdl+1.5*wll =	7.10 kN/m	Rdl.Left =	12.30 kN	Rdl.Right =	26.63 kN
P* = 1.35*pdl =	13.64 kN	Rll.Left =	3.09 kN	Rll.Right =	3.68 kN
		R*.Left =	19.27 kN	R*.Right =	39.12 kN
M*+ =	26.24 kNm at 2713 mm from LHS				
M*- =	7.71 kNm				

Capacity

Member: 300PFC φMsx = 152.0 kNm Ix = 72.40 x10^{6}

Between Supports		Cantilever	
For Le = 600	αm = 1	For Lec = 500	αm.c = 1
	φMbx = 152.0 kNm		φMbx.c = 152.0 kNm

Deflection

Between support						Tip of cantilever			
δdl =	3.8 mm	(down)	Span / 1508	at	2842 mm	δdl =	-0.9 mm	(up)	Span / 569
δll =	1.1 mm	(down)	Span / 5398	at	2900 mm	δll =	-0.3 mm	(up)	Span / 1711

∴ADOPT: 300PFC

Restrain by floor truss

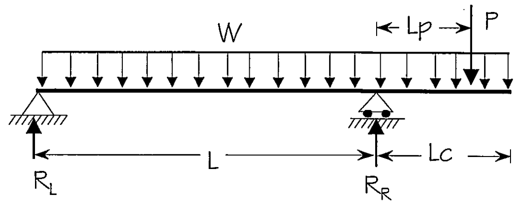
Lelio Bibbo Consulting Engineers Pty. Ltd.	CONSULT AUSTRALIA	Date 20/12/2019	Job 180386
Campbelltown		By JC	Sheet 2

Design Summary ***FLOOR BEAM DESIGN*** **Dwelling 2** **FB2**

Member:	300PFC	
Bending:	M+* = 3.3 < φMb (0.60, αm = 1.00) = 152.0 kNm	**OK (0.02)**
Bending:	M-* = 44.1 < φMb (0.60, αm = 1.00) = 152.0 kNm	**OK (0.29)**
Deflection:	δdl = L/4774 (-0.5mm), δll = L/94756 (0.0mm)	**OK**
Deflection:	δdl = L/451 (3.5mm), δll = L/3701 (0.4mm)	**OK**
Reaction:	Left Rdl = -1.4kN, Rll = 3.6kN, R* = 2.6kN, Right Rdl = 42.6kN, Rll = 14.9kN, R* = 76.3kN	

Geometry

Span (L) =	2600 mm	Restrain by floor truss		
Cantilever (Lc) =	1600 mm past right support			
Effective segment length (Le) =	600 mm	αm =	1	
Canti. Effective segment length (Lec) =	600 mm	αm.c =	1	



Loadings

Uniform Dead Loads

					Additional load	
Roof load (wdl) =	0.45 kPa	×	2600 mm	+	0.00 kN/m =	1.17 kN/m
Floor load (wdl) =	0.60 kPa	×	2500 mm	+	0.00 kN/m =	1.50 kN/m
Wall load (wdl) =	1.00 kPa	×	4000 mm	+	0.00 kN/m =	4.00 kN/m
Other load (wdl) =	0.00 kPa	×	0 mm	+	0.00 kN/m =	0.00 kN/m
Include Selfweight (sw) =	Y (Y)es, (N)o				sw =	0.40 kN/m
					∑ wdl =	7.07 kN/m

Uniform Live Loads

					Additional load	
Roof load (wll) =	0.25 kPa	×	2600 mm	+	0.00 kN/m =	0.65 kN/m
Floor load (wll) =	1.50 kPa	×	2500 mm	+	0.00 kN/m =	3.75 kN/m
Other load (wll) =	0.00 kPa	×	0 mm	+	0.00 kN/m =	0.00 kN/m
					∑ wll =	4.40 kN/m

Point Loads from Timber Beam 1.0(4.0)(5.2/2)-Wall

Dead Load (pdl) = 11.50 kN 0.4(5.2/2)-S/W Position (Lp) = T mm from RHS, (T)ip of cantilever

Live Load (pll) = 0.00 kN

Design Action

w* = 1.2*wdl+1.5*wll =	15.09 kN/m	Rdl.Left =	-1.37 kN	Rdl.Right =	42.56 kN
P* = 1.35*pdl =	15.53 kN	Rll.Left =	3.55 kN	Rll.Right =	14.93 kN
		R*.Left =	2.63 kN	R*.Right =	76.25 kN

M*+ = 3.25 kNm at 174 mm from LHS

M*- = 44.15 kNm

Capacity

Member: 300PFC φMsx = 152.0 kNm Ix = 72.40 $\times 10^6$

Between Supports		Cantilever	
For Le = 600	αm = 1	For Lec = 600	αm.c = 1
	φMbx = 152.0 kNm		φMbx.c = 152.0 kNm

Deflection

Between support					Tip of cantilever			
δdl =	-0.5 mm	(up)	Span / 4774	at 1612 mm	δdl =	3.5 mm	(down)	Span / 451
δll =	0.0 mm	(down)	Span / 94756	at 806 mm	δll =	0.4 mm	(down)	Span / 3701

∴ADOPT: 300PFC

Restrain by floor truss

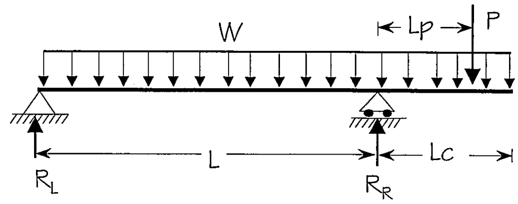
Lelio Bibbo Consulting Engineers Pty. Ltd.	CONSULT AUSTRALIA	Date 20/12/2019	Job 180386
Campbelltown		By JC	Sheet 3

Design Summary ***FLOOR BEAM DESIGN*** **Dwelling 4 - FB4 Similar** **FB3**

Member:	300PFC	
Bending:	M+* = 57.1 < φMb (0.60, αm = 1.00) = 152.0 kNm	**OK (0.38)**
Bending:	M-* = 17.4 < φMb (0.60, αm = 1.00) = 152.0 kNm	**OK (0.11)**
Deflection:	δdl = L/1037 (5.6mm), δll = L/1296 (4.5mm)	**OK**
Deflection:	δdl = L/426 (-2.8mm), δll = L/453 (-2.6mm)	**OK**
Reaction:	Left Rdl = 18.2kN, Rll = 13.6kN, R* = 42.1kN, Right Rdl = 33.5kN, Rll = 20.7kN, R* = 71.9kN	

Geometry

Span (L) = 5800 mm Restrain by floor truss
Cantilever (Lc) = 1200 mm past right support
Effective segment length (Le) = 600 mm αm = 1
Canti. Effective segment length (Lec) = 600 mm αm.c = 1



Loadings

Uniform Dead Loads

					Additional load	
Roof load (wdl) =	0.45 kPa	×	2800 mm	+	0.00 kN/m =	1.26 kN/m
Floor load (wdl) =	0.60 kPa	×	2800 mm	+	0.00 kN/m =	1.68 kN/m
Wall load (wdl) =	1.00 kPa	×	3500 mm	+	0.00 kN/m =	3.50 kN/m
Other load (wdl) =	0.00 kPa	×	0 mm	+	0.00 kN/m =	0.00 kN/m
Include Selfweight (sw) =	Y (Y)es, (N)o				sw =	0.40 kN/m
					∑ wdl =	6.84 kN/m

Uniform Live Loads

					Additional load	
Roof load (wll) =	0.25 kPa	×	2800 mm	+	0.00 kN/m =	0.70 kN/m
Floor load (wll) =	1.50 kPa	×	2800 mm	+	0.00 kN/m =	4.20 kN/m
Other load (wll) =	0.00 kPa	×	0 mm	+	0.00 kN/m =	0.00 kN/m
					∑ wll =	4.90 kN/m

Point Loads from Timber Beam 1.0(4.0)(1.7/2)-Wall
Dead Load (pdl) = 3.80 kN 0.4(1.7/2)-S/W Position (Lp) = T mm from RHS, (T)ip of cantilever
Live Load (pll) = 0.00 kN

Design Action

w* = 1.2*wdl+1.5*wll =	15.56 kN/m	Rdl.Left =	18.20 kN	Rdl.Right =	33.48 kN
P* = 1.35*pdl =	5.13 kN	Rll.Left =	13.60 kN	Rll.Right =	20.70 kN
		R*.Left =	42.13 kN	R*.Right =	71.92 kN
M*+ =	57.07 kNm	at 2708 mm from LHS			
M*- =	17.36 kNm				

Capacity

Member: 300PFC φMsx = 152.0 kNm Ix = 72.40 x10^6

Between Supports
For Le = 600 αm = 1
φMbx = 152.0 kNm

Cantilever
For Lec = 600 αm.c = 1
φMbx.c = 152.0 kNm

Deflection

Between support

δdl =	5.6 mm	(down)	Span / 1037	at	2784 mm
δll =	4.5 mm	(down)	Span / 1296	at	2842 mm

Tip of cantilever

δdl =	-2.8 mm	(up)	Span / 426
δll =	-2.6 mm	(up)	Span / 453

∴ADOPT: 300PFC
Restrain by floor truss

Lelio Bibbo **Consulting Engineers Pty. Ltd.**	CONSULT AUSTRALIA	Date 20/12/2019	Job 180386
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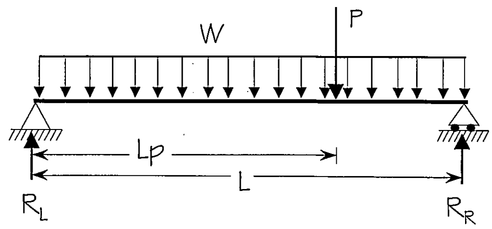
Design Summary ***LINTEL DESIGN*** **Dwelling 1** **L1**

Member:	300PFC	
Bending:	M+* = 67.1 < φMb (5100, αm = 1.13) = 70.9 kNm	**OK (0.95)**
Deflection:	δdl = L/791 (6.4mm), δll = L/1565 (3.3mm)	**OK**
Reaction:	Left Rdl = 20kN, Rll = 12.66kN, R* = 42.64kN, Right Rdl = 34.84kN, Rll = 14.76kN, R* = 63.95kN	

Geometry

Span (L) =	5100	mm
Effective segment length (Le) =	5100	mm
αm =	1.13	



Loadings

Uniform Dead Loads

								Additional load			
Roof load (wdl) =	0.45	kPa	×	1200	mm	+	0.00	kN/m =	0.54	kN/m
Floor load (wdl) =	0.60	kPa	×	2900	mm	+	0.00	kN/m =	1.74	kN/m
Wall load (wdl) =	0.80	kPa	×	3500	mm	+	0.00	kN/m =	2.80	kN/m
Other load (wdl) =	0.00	kPa	×	0	mm	+	0.00	kN/m =	0.00	kN/m
Include Selfweight (sw) =	Yes							sw =	0.40	kN/m
								∑ wdl =	5.48	kN/m

Uniform Live Loads

								Additional load			
Roof load (wll) =	0.25	kPa	×	1200	mm	+	0.00	kN/m =	0.30	kN/m
Floor load (wll) =	1.50	kPa	×	2900	mm	+	0.00	kN/m =	4.35	kN/m
Other load (wll) =	0.00	kPa	×	0	mm	+	0.00	kN/m =	0.00	kN/m
								∑ wll =	4.65	kN/m

Point Loads from FB1

Dead Load (pdl) =	26.60	kN	Position (Lp)=	4000	mm from LHS, (M)id span
Live Load (pll) =	3.70	kN			

Design Action

w* = 1.2*wdl+1.5*wll =	13.55	kN/m	Rdl.Left =	19.71	kN	Rdl.Right =	34.84	kN
P* = 1.2*pdl+1.5*pll =	37.47	kN	Rll.Left =	12.66	kN	Rll.Right =	14.76	kN
			R*.Left =	42.64	kN	R*.Right =	63.95	kN

M*+ = 67.08 kNm at 3146 mm from LHS

Capacity

Member: 300PFC φMsx = 152.0 kNm Ix = 72.40 $\times 10^6$

For Le 5100 αm = 1.13

φMbx = 70.9 kNm

Deflection

δdl =	6.4 mm	(down)	Span /	791
δll =	3.3 mm	(down)	Span /	1565

∴ADOPT: 300PFC

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Campbelltown		By JC	Sheet 5

Design Summary ***LINTEL DESIGN*** **Dwelling 4 - L3 Similar** **L2**

Member: 250PFC

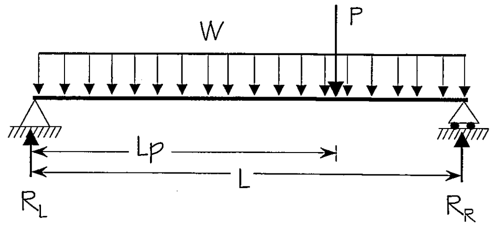
Bending: M+* = 62.9 < φMb (3100, αm = 1.13) = 81.2 kNm **OK (0.77)**

Deflection: δdl = L/1,077 (2.9mm), δll = L/2009 (1.5mm) **OK**

Reaction: Left Rdl = 23kN, Rll = 11.91kN, R* = 45.95kN, Right Rdl = 23.41kN, Rll = 11.91kN, R* = 45.95kN

Geometry

Span (L) = 3100 mm
Effective segment length (Le) = 3100 mm
αm = 1.13



Loadings

Uniform Dead Loads

						Additional load	
Roof load (wdl) =	0.45 kPa	×	1200 mm	+		0.00 kN/m =	0.54 kN/m
Floor load (wdl) =	0.60 kPa	×	600 mm	+		0.00 kN/m =	0.36 kN/m
Wall load (wdl) =	0.80 kPa	×	3800 mm	+		0.00 kN/m =	3.04 kN/m
Other load (wdl) =	0.00 kPa	×	0 mm	+		0.00 kN/m =	0.00 kN/m
Include Selfweight (sw) =	Yes					sw =	0.36 kN/m
						∑ wdl =	4.30 kN/m

Uniform Live Loads

					Additional load	
Roof load (wll) =	0.25 kPa	×	1200 mm	+	0.00 kN/m =	0.30 kN/m
Floor load (wll) =	1.50 kPa	×	600 mm	+	0.00 kN/m =	0.90 kN/m
Other load (wll) =	0.00 kPa	×	0 mm	+	0.00 kN/m =	0.00 kN/m
					∑ wll =	1.20 kN/m

Point Loads from FB3

Dead Load (pdl) = 33.50 kN   Position (Lp)= M mm from LHS, (M)id span
Live Load (pll) = 20.10 kN

Design Action

w* = 1.2*wdl+1.5*wll =	6.95 kN/m	Rdl.Left =	23.41 kN	Rdl.Right =	23.41 kN
P* = 1.2*pdl+1.5*pll =	70.35 kN	Rll.Left =	11.91 kN	Rll.Right =	11.91 kN
		R*.Left =	45.95 kN	R*.Right =	45.95 kN

M*+ = 62.87 kNm at 1550 mm from LHS

Capacity

Member: 250PFC   φMsx = 114.0 kNm   Ix = 45.10 $\times 10^6$

For Le 3100 αm = 1.13
φMbx = 81.2 kNm

Deflection

δdl = 2.9 mm (down) Span / 1077
δll = 1.5 mm (down) Span / 2009

∴ADOPT: 250PFC

COLUMN DESIGN **C5 - Critical (C1 - C11 Similar)**

Load From FB2 = 80 kN

N^*= 80.00 kN Column Height= 2800 mm

Try, 89x89x5.0SHS

Ecentricity= 89÷2+60=104.5mm

∴ M^* = 0.10 x 80.00 =8.36 kNm

Effective length factor

k_{ex}= 1.00

k_{ey}= 1.00

For 89x89x5.0SHS, Lex= 2.80 m Ley= 2.80 m αm = 1.00

ΦM_{sx}=	15.47 kNm	ΦN_s=	500.9 kN
ΦM_{sy}=	15.47 kNm	ΦN_{cx}=	308.1 kN
ΦM_{bx}=	15.47 kNm	ΦN_{cy}=	308.1 kN

Check for moment Capacity,

$$\Phi M_{ox} = \Phi M_{bx}\left(1- \frac{N_c^*}{\Phi N_{cy}}\right)$$

= 11.45 kNm **> M***

$$\Phi M_{ix} = \Phi M_{sx}\left(1- \frac{N_c^*}{\Phi N_{cx}}\right)$$

= 11.45 kNm **> M***

$$\Phi M_{rx} = \Phi M_{sx}\left(1- \frac{N_c^*}{\Phi N_s}\right)$$

= 13.00 kNm **> M***

∴ O.K.

∴ADOPT: **89x89x5.0SHS**

EARTHQUAKE ASSESSMENT TO AS 1170.4 - 2007

Location: Adelaide

Hazard Factor, Z: 0.10

Annual Probability of Exceedance, P: 1: 500

Probability Factor, k_p: 1.00 ⟶ $\therefore$ $k_p Z =$ 1.00 x 0.10 = 0.10 $\leq$ 0.11

Structure type: Domestic

Maximum Height of Structure, h_n: 6.7 m

Construction: Brick Veneer & AAC Panel Veneer

DESIGN OF DOMESTIC STRUCTURES OF HEIGHT LESS THAN OR EQUAL TO 8.5 METRES (TABLE A1)

Provision for lateral resistance:

Housing designed and detailed for lateral wind forces in accordance with AS 1684, AS 3600, AS 3700, AS 4100, AS/NZS 1664, AS 1720.1 or NASH Standard Part 1-2005

Wind loads to be determined in accordance with AS1170.2

Material type:

As per the relevant Standard

Specific deemed to satisfy limits:

As per the relevant Standard

Design required:

No specific earthquake design required