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AWGEOTECHNICAL

RevB 11th October 2017
9th February 2016

Rebecca Boresch
Fraggar Planning & Development

SYDNEY MARKETS NSW 4701

Our Reference **AWG40793**

Your Reference 36281

Site Address

No.7

Cooleena Road

ELANORA HEIGHTS

Commission

Slope Stability Assessment

1. Construction Proposal

1.1. At the time of writing there is no actual construction proposal for this site.

1.2. The purpose of this report is to determine whether or not a satisfactory building area can be identified in the rear section of this site.

1.3. The proposal is to subdivide the existing allotment into two(2), and provide access to the rear via a new easement down the western side (right hand side looking into the allotment).

1.4. The construction proposal is contained in a series of drawings of which we have sighted twelve(12) sheets by:

- Architecture and Drafting drawn by Laurin Trevena.
- Revision B, dated 21st May 2017.

1.5. Although these drawings post-date our field testing carried out onsite in December 2015, the proposed building footprint is within the limits of our field testing, therefore is still relevant.

2. Site Description

2.1. The site is on the southern side of the street and slopes down towards the rear.

2.2. The front section of the site (which will become Lot 1) has an older style brick dwelling on it, and is the least steep area of the site.

2.3. Just beyond the existing dwelling is a rock outcrop, which trends east-west and can be seen in the adjoining allotments.

Rock outcrop within adjoining western property

2.4. The existing ground slope in the area of the proposed building envelope varies from 9-10^{O} in the east to 19-20^{O} in the west (see attached site sketch).

2.5. Beyond this proposed building footprint is a break of slope, where the slope steepens to between 25-30^{O}.

2.6. The vegetation around the existing dwelling is mainly trees, garden and grasses.

2.7. The vegetation in and around the proposed building footprint is mainly grasses, scattered trees and there is some rock outcropping.

2.8. On the steep slope at the rear, initially there are some small trees with very dense undergrowth, then further down the slope the vegetation has been cleared.

2.9. At the break of slope down to the steeper area at the rear is a fence and a crude surface drain/bund, which is obviously in place to capture and divert surface waters away from this steeper area.

3. About Your Report

3.1. The purpose of this report is two-fold;

3.1.1. To specify to all stakeholders in this project (particularly any future owners of the proposed dwelling), the risks as we have assessed associated with construction proceeding on this site with respect to slope instability. Our assessment is based on both our experience and specific guidelines provided by both the local authority and by the Australian Geomechanics Society. It is up to each stakeholder whether they accept the risk.

3.1.2. To build a structure which will service the needs of future owners.

3.2. Since 1985 the Australian Geomechanics Society has produced guidelines for assessing the potential of slope instability which have been widely accepted and also included in such standards as AS 2870-1996. In 2000, these guidelines were updated, are now known as "Landslide Risk Management Concepts and Guidelines" and conform to the requirements of AS/NZS 4360-1995 "Risk Management".

3.3. In 2007, these AGS guidelines were further revised and updated, and are now known as the AGS 2007 Landslide Risk Management (LRM) Guidelines.

3.4. To prepare a full interpretation of the site we need various parameters including a correlation between landslide events and basic frequency. This correlation is normally determined by a detailed historical research project, generally commissioned by the local authority. This historical research is beyond the scope of our commission and we are unaware of such a report from the local authority.

3.5. As the purpose of this report is to build a new dwelling, parameters are also needed to facilitate an appropriate engineer designed footing system. We therefore have also given parameters in accordance with AS2870-2011.

3.6. AS 2870-2011 contains a system of classifying soils based on the ability of the soils to change volume with changes in soil moisture. These classes are Class A, Class S, Class M, Class H1, Class H2 and Class E (Class E being most severe). It should also be noted that AS2870-1996 does not offer "crack free" or "distress free" performance. It offers performance criteria, ensuring a "low probability of foundation failure" provided "abnormal moisture conditions", such as over watering, bad drainage, leaky pipes or nearby trees are not allowed to exist or develop.

3.7. AS 2870-2011 also has a "P" classification for sites which include;

- Fill which has not or cannot be certified in accordance with AS 3798-2007.
- Soft or collapsing soils.
- Mining subsidence problems.
- Slope instability problems.

3.8. AS 2870-2011 in Clause 1.3.3 also has provision to classify sites as Class P if "abnormal moisture conditions" are present. For proposed new structures, these conditions include;

- Recent removal of an existing building or structure likely to have significantly modified the soil moisture condition under the proposed plan of the building.
- Unusual moisture conditions caused by drains, channels, ponds, dams or tanks which are to be maintained or removed from the site.
- Recent removal or proposed removal of large trees prior to construction.
- Trees too close to a footing being allowed to continue to grow after construction.[1]

[1] *Reference: CSIRO sheet BTF-18*

3.9. For extensions to existing structures or assessments of existing structures, these abnormal moisture conditions also include;

- Growth of tree too close to a footing.[1]
- Excessive or irregular watering of gardens adjacent to the house.
- Lack of maintenance of site drainage.
- Failure to repair plumbing leaks.

4. Report Limitations

4.1. In Section 4 of the 2000 AGS guidelines, the following advice is offered (in part);

> *The variety of approaches that can reasonably be adopted to analyse landslide risk can result in significant difference in outcome for the same situation when considered separately by different practitioners.*
>
> *It is difficult to accurately analyse risk for low probability events.*
>
> *Most of the limitations are inherent in any approach to assessing landslides. Risk analysis has the benefit of encouraging a systematic approach to a problem and promoting a greater understanding of consequences. In many situations, an indicative estimate of the probability of a hazard and an assessment of the consequences can be readily conducted.*
>
> *Some of the inputs to the analysis may be largely judgmental.*
>
> *The risk can change with time, because of natural processes and development.*

4.2. The contents of this report are based on the expertise and experience of the author, representing the company. Our commission didn't extend to assessing instability due to previous existing or proposed sub-surface mining or earthquakes, nor did it extend to testing to comply to the relevant Contaminated Land Act.

4.3. The opinions and recommendations made in this report are based on the assumption that the test results are representative of the true site conditions. Even under optimum circumstances, actual conditions may differ from those reported to exist. Economic and time constraints necessarily limit the practical extent of any investigation. We therefore cannot accept responsibility for conditions encountered on this site, outside the areas tested, which are different to those reported. This report may only be reproduced in full, if any doubt exists to the number of pages in this report we should be contacted. The original copies of this report are signed in blue ink.

4.4. The opinions expressed in this report are based on our relevant local experience, including a number of slope stability risk appraisals and geotechnical investigations on other properties and on land over a period of some 20 years.

4.5. Our opinions and conclusions on the stability of the land are presented in our interpretation of the framework of the Australian Geomechanics Society's publication *Practice Note Guidelines for Landslide Risk Management 2007* (reference 1), described and referenced in the report.

4.6. An owner's decision to acquire, develop or build on land within an area such as this involves the acceptance of a level of risk. It is important to recognize that soil movements are an ongoing geological process, which may be affected by development and land management within the site or on adjoining land. Soil movements may cause visible damage to structures even where the risk of slope failure is considered low. This report is intended to assess the risk to slope failure, apparent at the time of inspection.

5. Investigation Programme

5.1. Because of limited access, our testing was carried out with a hand auger. These test sites were not formally surveyed, therefore their locations on the attached site sketch should be treated as approximate.

5.2. Numerous disturbed samples were collected and hand classified.

5.3. The Soil Shrinkage Index (Ips) of the strata was estimated, from a shrink/swell test (Ips) which was achieved via a retrieved tube sample.

5.4. The resistance of the strata to the 9kg Dynamic Cone Penetrometer was tested and recorded.

5.5. A Pocket Penetrometer (PP) was used to determine the undrained shear strength (qa), converted to an undrained cohesion (ca) which in turn was used in Skempton's Theorem (1954) to determine the allowable bearing pressure.

5.6. We inspected the site and nearby surrounds.

5.7. A percolation test was carried out adjacent to our test sites and the results of these tests are reported elsewhere.

5.8. The referenced documents were studied.

6. Findings – The Strata

6.1. The strata encountered is recorded on the attached log sheets.

6.2. On the relevant 1:100,000 geological map, this site plots within the Mesozoic aged Hawkesbury Sandstone, however in the steeper area of the site at the rear, visually we believe we have identified a much younger colluvium/hillwash which is too small in extent to be plotted on the geological map.

6.3. No water table was encountered during our testing, nor do we expect a water table to adversely affect this site, however this does not exclude the possibility that after rains, subsurface waters will pond and seep into excavations where a permeable layer of strata overlies a less permeable layer. If this occurs, it should only be of nuisance value to a competent contractor, and it should only occur during and after rains.

6.4. The sample* retrieved to the laboratory and tested for its shrink/swell (Iss) parameter was as follows:

TS No.	Depth (mm)	Shrink	Swell	Iss	Initial moisture content	Insitu Density
2	500-800mm	5.7%	0.2%	3.2%	27.4%	$1.93t/m^3$

* Sample was remoulded prior to testing.

6.5. There was no filled ground encountered in our testing programme.

6.6.1 Rock was encountered as follows:

TS No.	Hand Auger Refusal	DCP Refusal
1	200mm	300mm
2	1600mm	1800mm

6.6.2 With a 9kg Dynamic Cone Penetrometer, we probed for rock within a 5metre radius of our test site No.1 and consistently refused at depths shallower than 500mm and we are confident that this is the bedrock level in this area.

6.6.3 Our test site No.2 encountered soil over bedrock at about the 1600mm level, therefore the rock outcropping in and around our Test No.2 will be floaters/boulders.

7. Slope Stability Observations

7.1. Slope stability problems manifest themselves over long periods of time (sometimes thousands of years) and over a five to ten year period, inherently unstable land may appear stable, unless an event such as prolonged heavy rain triggers instability. Pre-existing slope stability problems are identified through subtle changes in the land form, growth patterns in trees and the long term performance of man made structures (nearby buildings, fences, poles, kerbs, roadways etc.). Attention must also be paid to the soil strata, soil moisture and ground slope.

7.2. There is no evidence in the existing dwelling or driveway of any distress which could be attributed to slope instability.

7.3. There is no evidence in the kerbs, roadway or power poles etc. that these infrastructure features have been adversely affected by slope instability.

7.4. One could argue that random trees have been affected by soil creep during their lifespan such as this tree:

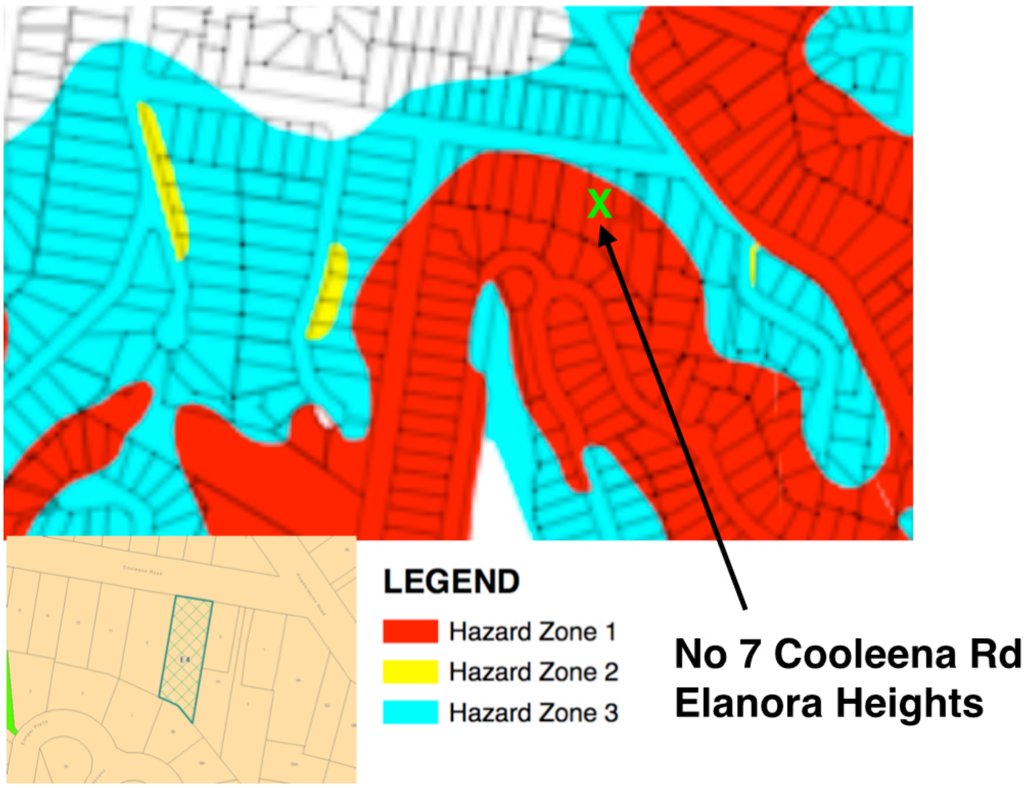
However there are other influences which can produce growth patterns like this.

7.5. Within the nearby surrounds of the proposed building envelope, the majority of trees appear unaffected by soil creep (particularly the older trees) whereas some of the younger trees do have non-vertical growth patterns.

7.6.1 The Pittwater council have their own slope instability hazard maps, which have three(3) zones as follows;

TS No.	Possibility of a landslide event
1	Possible to Almost Certain
2	Unlikely
3	Rare to Barely Credible

7.6.2 The majority of this subject site plots within the Hazard Zone 1, and a local area at the front plots within Hazard Zone 3.



8 Landslide Risk Assessment and Management

8.1.1 We believe that the council map, although reflecting what the zones are on a broad scale, does not accurately reflect the transition from Hazard Zone 1 to Hazard Zone 3 onsite.

8.1.2 In our opinion, the break of slope at the rear of this site is the true boundary between Hazard Zone 1 and Hazard Zone 3, and the wire fence onsite should arbitrarily be considered to reflect this boundary.

8.2 Assuming that our recommendations are followed which will be for the proposed footing system to be founded 100% on bedrock, using the principles in the 2007 AGS Landslide Risk Management guidelines, we believe the following is true for the proposed building envelope:

a) Source of Risk: upslope, downslope*, across slope and within the slope:

*Assuming a 2metre buffer zone is allowed for between Hazard Zone 1 and Hazard Zone 2.

b) Likelihood of event: Barely Credible (10^{-8})

c) Consequence to property: Insignificant (0.5%)

d) Final Risk to property: Very Low

8.3.1 With respect to the steep area at the rear, please note:

- Some of the trees are already growing at about 30^{O} to the horizontal which indicates active instability.
- According to the council zoning system, we place this site at the upper end of Hazard Zone 1, which has a likelihood of "Almost Certain".

8.3.2 The significant question to answer about this site at the rear is whether with continued active instability, will it retrograde upslope and adversely affect the proposed designated building envelope.

9 Conclusions & Recommendations

9.1 We believe that the proposed building envelope is suitable for residential development and that all structural footings must be founded on the bedrock, which has an allowable bearing pressure of 500kPa at a 300mm socket.

9.2 If a 2metre wide buffer zone is created at the break of slope between the steeper area at the rear and any proposed structural footing, this will be sufficient to provide protection from the downslope unstable area retrograding upslope into the building zone.

9.3 For elements not on rock in the proposed building envelope (such as floor slabs) the shrink/swell result indicates a ys in the range of 41-50mm, however with nearby trees, total ground movements due to the wetting and drying of the soil will be in the order of 65-75mm.

9.4.1 For the steeper area at the rear, we have not carried out any subsurface testing, but as stated elsewhere in this report, we do expect there to be some colluvium/hillwash over the insitu weathered soils.

9.4.2 We cannot estimate the depth of the hillwash/colluvium or the depth to bedrock.

9.4.3 This is not to say that this area is not buildable, its just a statement about not having sufficient data to make recommendations for this area.

NOTE: If at any time in the future a proposal is put forward to construct something in this steep sloping area, then whether to proceed or not to proceed must be based on comprehensive geotechnical testing and good engineering.

9.5.1 The stormwater disposal method needs to be designed by a suitably qualified person and to aid in this design, we refer readers to our Soil Permeability Test of the 9th February 2016 (not attached).

9.5.2 The final discharge for this stormwater disposal may be in the 2metre buffer zone (see 9.2 above) and providing that the discharge is via a spreader, and not a concentrated discharge, this discharge will not adversely affect the geotechnical stability of the steep slope at the rear, or any other public or private assets down slope.

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QBCC No 616675 (Site Classifier)
TCC Accreditation No. CC4047U (Engineer-Geotechnical)

10 Report Limitations

10.1 The contents of this report are based on the expertise and experience of the author, representing the company. Our commission didn't extend to assessing instability due to previous existing or proposed sub-surface mining, slope stability or earthquakes, nor did it extend to testing to comply with the relevant Contaminated Land Act.

10.2 The opinions and recommendations made in this report are based on the assumption that the test results are representative of the true site conditions. Even under optimum circumstances, actual conditions may differ from those reported to exist. Economic and time constraints necessarily limit the practical extent of any investigation. We therefore cannot accept responsibility for conditions encountered on this site, outside the areas tested, which are different to those reported. Where the attached soil profiles are similar to each other, then we would expect little variation across the site, so if widely different soils are encountered then a further inspection of the site and/or further testing may be required. If the attached soil profiles are different across the site, then variations will be encountered during footing excavations. In these cases, the design engineer/client must make a decision whether to extend the geotechnical budget to do more testing or to cope with the variations during footing excavations. Regardless of the option chosen the final inspection before placement of concrete is critical and the person certifying this inspection should be competent in identification of strata.

10.3 This report may only be reproduced in full, if any doubt exists to the number of pages in this report we should be contacted. The original copies of this report are signed in blue ink.

11 References

7.6. The following papers, reports or books have been consulted in preparing this report;

1. Australian Geomechanics Society "2007 Landslip Risk Management Guidelines". 2007.
2. Australian Geomechanics Society (sub-committee on landslide risk management) "Landslide Risk Management Concepts and Guidelines" March, 2000.
3. AS 2870-1996 "Residential Slabs and Footings" by Standards Australia.
4. AS 2870-1996 Supplement 1-1996 "Residential Slabs and Footings-Construction-Commentary" by Standards Australia.
5. AS 3798-1996 "Guidelines on Earthworks for Commercial and Residential Developments" by Standards Australia.
6. Paul Walsh & Don Cameron "The Design of Residential Slabs and Footings" Standards Australia 1997.

We believe these are the most up to date publications available. Should other publications not listed are brought to our attention, then we reserve the right to modify this report if they contain information, which conflicts with this report.

Appendix

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	5×10^{-2}	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}		100 years		The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	5×10^{-3}	1000 years	200 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	5×10^{-4}	10,000 years	2000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	5×10^{-5}	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	5×10^{-6}	1,000,000 years	200,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

HEDRA

Housing Engineering Design & Research Association

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Understanding soils, trees and how they can affect your house.

This document is a plain language guide to what should be expected from the construction of single dwellings, townhouses or similar structures not situated vertically above or below another dwelling. It has been compiled by the HEDRA Task Force committee in the belief that the information contained is helpful to the parties mentioned, however no warranty of accuracy or reliability as to the information is given, and no responsibility for loss arising is accepted.

1. EXPLANATIONS

Footings (often incorrectly called foundations) are the "members" that support the building. They are commonly concrete slabs or timber floors supported by strips and stumps. (Fig 1, 2 & 3). **Foundation** is the soil or rock supporting the footings. **Reactive Clay foundations** are those that shrink and swell with changing moisture and cause the building and paving to sink or lift. **Reverse slope** is one that slopes towards the building. (Fig 18) **Sand foundations** do not shrink or swell but if they are loose they can cause the building to sink. **The Australian Standards** for building footing construction permits minor wall and floor movements. If the foundation conditions are changed after construction the floor and walls may move more than allowed-for by these standards. The designs for building footings in Australian Standard 2870 will perform adequately provided the building site and surrounds have "normal" foundation conditions which are maintained. If the building site and surrounds have "abnormal" moisture conditions, special provisions must be followed by the design engineer, builder and owners. **(AS2870 defines "abnormal" moisture conditions)**

The "reactivity" of clays is their capacity to shrink and swell with changing moisture and is classified as follows :

A	Reactivity absent
S	Slight reactivity
M or M-D	Moderate reactivity
H1 or H1-D	High reactivity
H2 or H2-D	Very High reactivity
E or E-D	Extreme reactivity

The greater the clay "reactivity" the greater the possibility of damage. Some minor cracking of walls is almost inevitable despite proper design, construction and maintenance. AS2870 suggests that cracks up to 1 mm wide are common and that cracks up to 5 mm may occur in clay sites subject to significant moisture changes. Some cracks are seasonal but if larger than 5 mm they are regarded as significant and should be investigated before becoming larger.

Fig. 1 Stiffened Raft

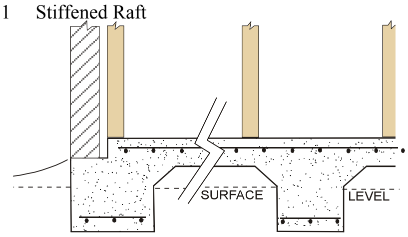


Fig 2 Waffle Slab

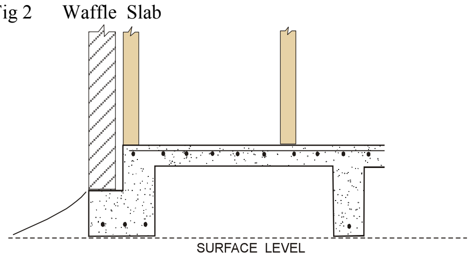
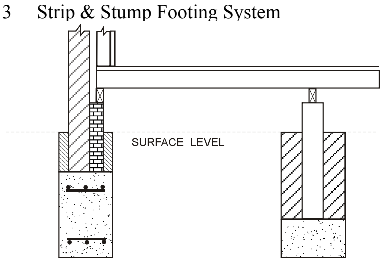


Fig. 3 Strip & Stump Footing System



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2. ENGINEERING
The engineer designs house footings to ensure that they can cope with the soil and environmental conditions assessed at the time of the site investigation and perform to their design potential.

3. BUILDING
In the construction of a building the builder needs to comply the Building Code of Australia, relevant Australian Standards, engineering specifications and contract documents. (Fig. 4) The following are important aspects the builder will need to address:

- Builders should ensure that owners understand that failure to maintain adequate drainage may result in damage to the structure.
- Well-drained foundation conditions, which will create "normal" soil moisture and adequate bearing capacity.
- Ensuring that excavations are well supported or are dug to avoid collapses. (Fig. 11)
- Constructing well-compacted and retained 'soil aprons' around the building to stop erosion.
- Special considerations if any excavations are to be dug near adjoining structures.(Fig. 11)
- Sloping the soil and paths away from the building by the minimum amount required by the building regulations to prevent water flowing towards the building foundations. (Fig. 10 & 18)
- Constructing soil drains or moisture barriers in sloping sites to prevent stormwater adversely affecting the building foundations.
- In highly or extremely reactive clay sites Australian Standard 2870 – "Residential slabs and footings" requires *mechanical flexible couplings* for sub-surface drainage pipes and for above-ground connections from the downpipe to the storm water drains. These allow for the movement of the soil and minimise the risk of pipe joints breaking and creating leakage problems. (Fig.6).

4. HOME OWNERS
The home owner should read and become familiar with the Site Classification report provided prior to construction and the type of footing system used in the building. To comply with Australian Standard 2870 – "Residential slabs and footings", and achieve acceptable performance and safety during the design life of the house, the owners shall maintain the garden and foundation soil moistures, paving and drainage systems. (Fig. 7)

Failure to maintain the foundation conditions can lead to cracking of walls and floors. Damage to a building that can be attributed to actions of the owner could diminish the builder's warranty obligations, leaving the owner responsible for the cost of repairs

Fig. 4

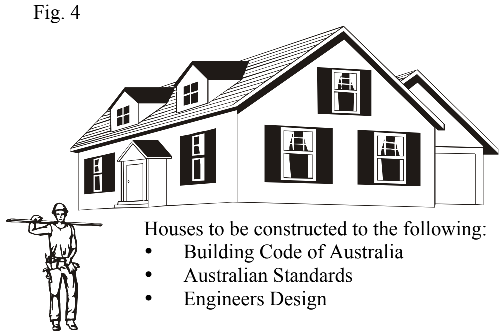


Fig. 5 Well Drained Sites

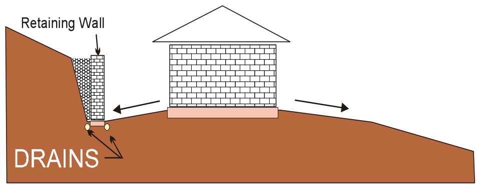


Fig. 6 Mechanical Flexible Couplings to reduce the potential of broken pipes in M/M-D, H1/H1-D, H2/H2-D & E /E-D sites plus all clay based sites with trees

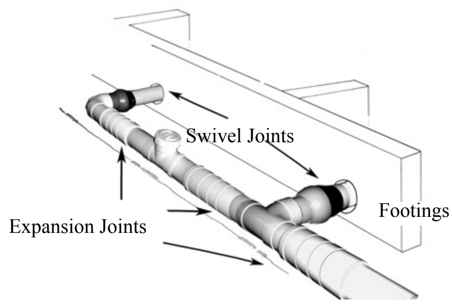


Fig.7

HOME OWNERS RESPONSIBILITIES

To maintain....

- ☑ GARDEN
- ☑ PAVING
- ☑ DRAINAGE SYSTEMS
- ☑ FOUNDATIONS

2

WORKS AFTER TAKING POSSESSION

In some cases foundation conditions are changed by the owner constructing new works such as:

- Constructing sheds or outdoor roofed areas without connecting the roof drainage to storm water lines.
- Constructing paving around the building without sufficient slope away from the building. (In sandy soils and low and moderate "reactivity" clays, a slope of 1:40 up to 1 metre away from the building is adequate. In highly reactive clays a slope of 1:20 works better. In large paved areas a drain and collection pit may be necessary). (Fig. 5 & 18)
- Australian Standard 2870, "Residential Slabs and Footings" requires soil drains and "normal" soil garden moisture in M, H1, H2, E, and P sites to be maintained by the owner. (Fig 10)
- Running machinery over shallow drain pipes may break them causing leaks and subsequent foundation movements.
- Any excavations close to building footings can cause them to sink by disturbing the foundation material or by drying the foundation clay. (Fig 11)
- Footings constructed in reactive clay sites during wet periods may be damaged if the garden is allowed to dry out excessively.
- Footings constructed in reactive clay sites during dry conditions may experience damage if the garden is watered unevenly or excessively.

5. LANDSCAPING AND TREES

Most modern allotments with clayey soils are too small to safely grow large trees without special footings. Generally the larger the root system of the tree(s) the greater the drying effect. If in doubt seek the advice of an expert arboriculturist and designing engineer.

If you are about to build in a clay area and you wish to grow, retain or remove trees near buildings, the builder should be advised of this prior to signing the building contract so that the engineer can design for these conditions.

- Trees can cause damage during their life and even for many months after their removal. If they do not receive sufficient water while alive their roots will dry the soil near buildings or under pavements.

Fig. 8 Drainage concerns

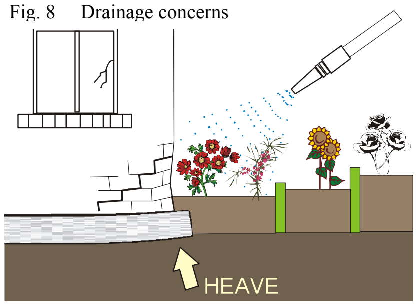


Fig. 9 Slab heave due to water ponding

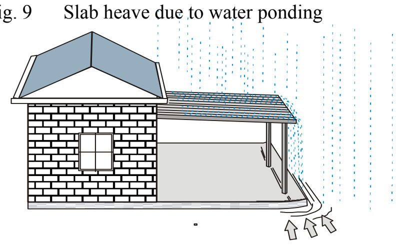


Fig. 10 Soil Drainage Plan

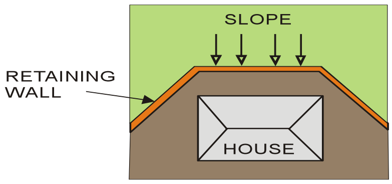


Fig. 11 De-stabilizing house foundations

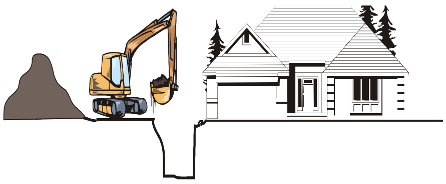
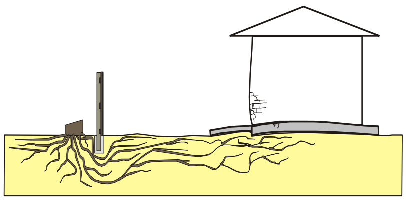


Fig. 12 Damage due to soil moisture changes



3

If you plan to remove trees after the building is constructed you should consult the designing engineer an expert arboriculturist or a geotechnical practitioner familiar with these problems.

Tree roots in sandy areas rarely cause any damage since sand does not shrink or swell, however if the root ball or large root is very close to a building it may grow and lift the footings of a light structure**.** (Fig. 13)

Foundation problems in clay sites may also be caused by :

- Excessive watering or under-watering of gardens.
- Watering systems that are overused or discharge water too close to building walls (Fig. 8)
- Constructing terraces, retaining walls or garden walls without good drainage. (Fig. 10)

6. POOR SITE MAINTENANCE

The change of foundation soil moisture is by far the greatest cause of building damage. Changes of drainage or garden watering conditions in adjoining properties can also create problems.

- A drainage system may be necessary if water flows near the building. All possible water leaks and sources should be repaired immediately, e.g.:
- Leaking or blocked roof gutters which cause water to overflow near building walls. (Fig. 14)
- Hot water systems relief valve pipes should be discharged into storm water lines. (Fig. 15)
- Air conditioners operating during hot, humid weather that discharge water near the building footings. (Fig.16)
- Leaking or overflowing water tanks near building footings. (Fig. 17)
- Land or paving that slopes towards the building and cause rain water to flow near the building. (Fig. 18)
- Water from the failure to repair plumbing leaks or leaky taps, hoses or by regularly washing cars in areas near building walls. (Fig. 19)
- Water flowing near buildings (even from neighbouring properties) must be diverted away from the footings or collected. (Fig. 20)

Fig. 13 Root Damage

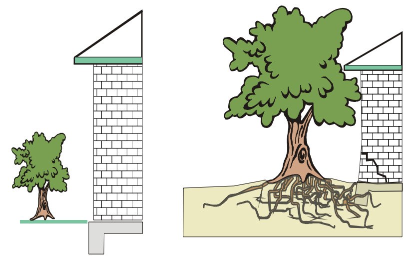


Fig. 14 Overflowing roof

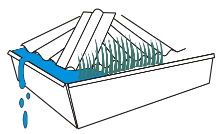


Fig. 15 Common leak source

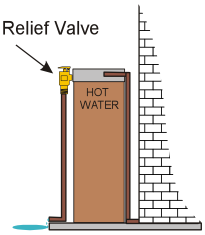


Fig. 16 Air con, up to 35 L/day loss

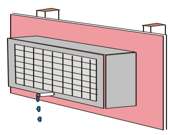


Fig.17 Leaky pipes

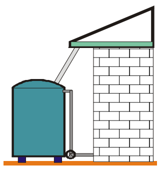


Fig. 18 Reverse Sloping paths

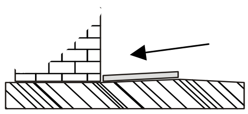


Fig 19 Leaking tap

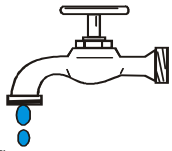


Fig. 20 Adjoining property water flows