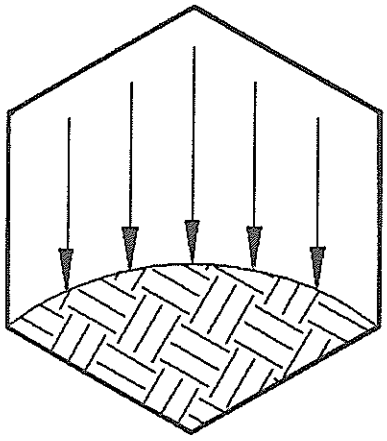
THE FOUNDATION AND
FOOTINGS SOCIETY (Vic) Inc.



RESIDENTIAL SITE INVESTIGATION HANDBOOK

SPECIAL PROVISIONS FOR SITE INVESTIGATIONS AND THE DESIGN OF RESIDENTIAL SLABS AND FOOTINGS FOR VICTORIAN CONDITIONS

Second Edition - July 1997

$16.00

PREFACE

The Foundations and Footings Society of Victoria was formed in 1991. The basic intentions of the Society were to hold regular meetings to discuss issues related to the industry and to formulate methods to deal with any problems. The general aims of the Society are as follows:

1. *Promote a higher standard of geotechnical investigation for residential, industrial and low rise commercial buildings.*

2. *Exchange technical information with all related professionals and building practitioners.*

3. *Provide input to the relevant Australian building codes and standards.*

4. *Develop appropriate handbooks and guidelines for site investigations, footing construction and footing repair relevant to Victorian conditions.*

5. *Encourage affiliate membership amongst related professional groups and/or organizations*

This handbook was first issued in February 1992. A major review was carried out in 1996 by the committee of The Foundations and Footings Society with the assistance of participating members. The revised documentation was approved for publication at the Annual General Meeting of the Society in 19 November 1996.

This handbook will be continually reviewed and updated to include details on "current good practice".

For further information contact
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SECTION 1 GENERAL

1.1 USE

This handbook is prepared for the use of members of the Foundation and Footings Association (Vic.) Inc. It may be used by other persons when checking or reviewing the work of members.

1.2 APPLICATION

The principle adopted in the preparation of this handbook is to specify concisely the procedures for good practice for site investigations for Victorian conditions at the date of issue. The handbook is applicable to domestic dwellings up to two stories high, and commercial and institutional buildings of similar size and construction, and is intended to apply as a supplement to AS2870 - 1996.

This handbook has an emphasis on investigation of foundations for shallow footing systems but is not intended to deal with collapsible soils, soft clays, dispersive soils, sink-holes, deep filling, landslip areas, mining subsidence, organic soils, earthquake effects or the detailed design requirements for piered footings.

1.3 REFERENCE DOCUMENTS

AS 2870 - 1996	Residential Slabs and Footings - Construction
AS 2870 - 1996	Supplement - Residential Slabs and Footings - Construction - Commentary
AS 1289 (Set)	Methods of Testing Soils for Engineering Purposes
AS 1726 - 1993	Geotechnical Site Investigations
AS 2159 - 1995	Piling - Design and Installation
AS 3798 - 1993	Guidelines on Earthworks for Commercial and Residential Developments

Footings and Foundations for Small Buildings in Arid Climates, June 1979 : The Institution of Engineers, Australia (SA Division)

The Structural Analysis of Footings on Expansive Soils : P.W. Mitchell

The Analysis of Stiffened Rafts on Expansive Clays : P.F. Walsh.

1.4 STATUTORY REQUIREMENTS

Notwithstanding anything contained in this publication, all construction must comply with the requirements of the Building Code Australia and all local building regulations.

SECTION 2 SITE INVESTIGATION

2.1 OBJECTIVES OF THE INVESTIGATION

2.1.1 The investigation should obtain sufficient data to enable the rational design of a footing system.

2.1.2 The investigation should determine by consultation with the client the details of the proposed building and siteworks including:

a) size, shape and location of building
b) building use (e.g. residential, industrial)
c) type of construction (e.g. articulated solid brick, brick veneer, tilt-up panels)
d) cut/fill proposals
e) preferred footing systems
f) proposed changes to site conditions (e.g. removal or retention of trees, existing buildings, etc)

2.1.3 The objectives of the investigation should include the identification, determination and assessment of the following within the area of influence for the proposed building and to the depths indicated in Section 2.3.2:

a) subsurface conditions
b) strength of foundation strata
c) ground water levels
d) recommendations for suitable footing systems
e) recommendations for founding depths and allowable bearing pressures
f) the effect of works and vegetation on adjoining land, for example the effect of excavations adjacent to existing footings
g) surface features including terrain, vegetation and drainage
h) development effects including tree retention and/or tree removal, cut and fill operations
i) determination of factors that can reasonably be identified at the time of the investigation that may result in abnormal moisture conditions (e.g. removal of trees, buildings etc)

2.2 METHODS OF INVESTIGATION

2.2.1 **Use of Existing Information.** Reasonably accessible and documented data should be taken into account during the site investigation. This data may include:

a) local knowledge and performance of existing footings
b) geological maps
c) regional terrain classification maps
d) topographical maps
e) areal photographs

Note that geological maps should not be relied upon to be completely correct at all times, particularly where geological contacts exist. The geological maps were not intended to be accurate to the scale of individual building lots.

2.2.2 **Drilling and Sampling Equipment.** Soil sampling may be carried out by any of the following methods :

a) hand auger
b) solid or hollow spiral auger (must be screwed and removed at less than 300mm intervals)
c) dynamic or hydraulic push tube
d) hydraulic hammer
e) back-hoe pits (not within 3m of proposed buildings) - Pits must be adequately reinstated
f) coring, including diamond drilling
g) wash boring

Drilling and sampling should be undertaken preferably by a suitably experienced Engineering Geologist, however testing may be carried out by an Engineer or Technician provided that they have appropriate geotechnical experience.

2.2.3 **Field Testing Equipment.** Drilling and sampling may be supplemented by one of the following:

a) standard penetrometer tests
b) dynamic cone penetrometer
c) Perth Sand (Clegg) penetrometer
d) vane shear
e) static cone penetrometer
f) geophysical methods

Note that when using the listed equipment care must be taken to ensure that the results of such testing procedures are not treated as absolute. It must be recognised that these results should be interpreted by a suitably experienced Engineering Geologist or Engineer before they can be considered to be meaningful.

2.3 PHYSICAL EXTENT OF INVESTIGATION

2.3.1 Number of Test Locations.

2.3.1.1 The minimum number of test locations for a single detached building should be three (3).

2.3.1.2 Where there are multiple detached buildings (including bulk sub-division type investigations), there should be at least one test location in the area of each building.

2.3.1.3 For residential, commercial or industrial buildings the minimum number of test locations should be related to the approximate area covered by the proposed buildings, in accordance with the following:

Approx. Building Area (m^2)	Minimum No. of Test Locations
0 - 100	2
100 - 300	3
300 - 600	4
600 - 1000	5

2.3.1.4 The number of test locations must also be sufficient (at the discretion of the investigating practitioner) to enable the rational design of the footing system. Additional test locations may be required under some circumstances.

2.3.1.5 Where significant soil profile variation is found within the building area the minimum number of test locations may need to be increased to satisfy Clause 2.3.1.4.

2.3.2 Depth of Investigation

a) The minimum depth of investigation should be 1.5m or 0.75 times the depth of suction change *Hs* as given in Table 2.4 of AS2870 - 1996 (which ever is deeper) unless rock is encountered or in the opinion of the classifier, further drilling is unnecessary for the purpose of identifying the soil profile in accordance with Clause 2.2.1 (a) of AS2870. However in all cases at least one in three of the test investigations should be taken to a depth equal to at least twice the footing width below the expected founding level with an absolute minimum depth of 1.5m. An increased depth of investigation will be required if soft layers are common in the area.

b) The depth of investigations may be reduced where natural rock is encountered.

c) If fill is encountered the depth of investigation should be increased to sufficient depth to confirm the underlying soil profile.

d) Where doubt exists the founding depths should be inspected during construction of the footings and suitable investigations should be carried out to confirm the supporting strata.

2.4 TESTING

Samples obtained or observed should be assessed by the visual-tactile procedure by an Engineering Geologist or Engineer with appropriate expertise and local experience. Field testing may be supplemented by recognised Australian Standard laboratory tests. N.A.T.A. registration is not required for moisture content testing. All samples for laboratory testing should be correctly stored and delivered promptly so as to preserve the field moisture conditions.

2.5 REPORTING

2.5.1 General

The report should describe in detail the works commissioned by the client so that once they accept and use the report they are agreeing that the commission as stated in the report is satisfactory and they do not require any further information.

The report should include a "Scope" section stating the basis of the findings and recommendations. This section should also clarify the limitations of the investigation and should clearly list related documents (i.e. AS2870 - 1996 and CSIRO Technical Note 10-91). Consideration should be given to stating that report recommendations are <u>not</u> to be considered as an engineering design.

To attempt to address the problem of the unrealistic expectations of most new building owners the report should include a reference as to what is reasonable in terms of footing performance and should clarify that some movement and distress is inevitable - reference should be made to Appendix B of AS2870 - 1996. The report could also point out that although the probability of a significant footing failure is low under normal moisture conditions, if abnormal moisture conditions are allowed to occur the probability of failure is much higher.

The site investigation report should also include the following :

a) description of proposed building construction
b) objectives of the investigation
c) identification and description of the site
d) methods of investigation and testing
e) location of all boreholes and test sites
f) investigation logs
g) date of investigation
h) test results
i) bearing pressure recommendations related to depth
j) recommendations for standard footing systems or a recommendation for engineer design
k) specific construction and site requirements relevant to the footings recommended
l) site geology (this should not just be based on the geological maps)
m) ground water observations
n) site classification
o) a clear statement on the owner's responsibilities with regard to trees and site maintenance

Emphasis should be placed on site conditions that may affect footing performance The report should include specific recommendations with regard to the action required to ensure adequate performance of the proposed footings (removal of trees, installation of barriers, drainage requirements, etc). The report should not rely on general notations.

2.5.2 Site Sketch Plan

A site sketch plan should be provided to allow clear identification of the site and should include the following :

a) approximate slope of the ground surface including embankments and existing site works
b) approximate tree locations and approximate tree heights
c) borehole and test locations
d) existing structures and underground services
e) proposed building envelope
f) date, scale, north point
g) lot identification and street
h) any other relevant information

Relevant site features, including trees, on adjoining sites should also be indicated.

2.6 BASIS FOR SOIL DESCRIPTIONS

2.6.1 General

The engineering classification of soils should be in accordance with the classification system given in Table A1 of Australian Standard AS 1726 - 1993 Geotechnical Site Investigation.

In the soil description the terms used should be presented in a logical and consistent order which distinguishes between *composition, condition and structure* of the soil.

2.6.2 Order of Description of Properties of the Soil.

a) Composition of Soil :
   - i) Soil Name (use block letters)
     Note that the presence of fill should be indicated at this stage
   - ii) "Unified" classification group symbol (use block letters) in accordance with Table A1 - Australian Standard AS 1726 - 1993
   - iii) Plasticity or particular characteristics of soil
   - iv) Colour of soil
   - v) Secondary soil components

b) Conditions of Soil :
   The following conditions should be described
   - i) Consistency or relative density
   - ii) Moisture condition

c) Structure of Soil :
   The following aspects of structure may be noted
   - i) Zoning
   - ii) Defects
   - iii) Cementing

d) Additional Observations
   Certain additional observations may be included, such as
   - i) Soil origin, ALLUVIUM, COLLUVIUM, SLOPE WASH, RESIDUAL SOIL, TOPSOIL
   - ii) Other matters believed to be significant

2.6.3 Composition of Soil

In describing the composition of a soil the following aspects should be addressed:

a) Plasticity Clay and silt, both alone and in mixtures with coarser material, may be described according to their plasticity, as follows -

Descriptive Term	Range of Liquid Limit
low plasticity	< 35%
intermediate plasticity	> 35% < 50%
high plasticity	> 50% < 80%
very high plasticity	> 80%

b) Particle Characteristics (coarse-grained soil) The characteristics of the coarse grains forming the soil should be described in the following terms:

i) Particle size. Report in millimetres or by use of subdivisions in Table A1 - Australian Standard AS 1726 - 1993, or use the following descriptive terms:

* *Well graded* - having good representation of all particle sizes from the largest to the smallest.

* *Poorly graded* - with one or more intermediate sizes poorly represented.

* *Gap graded* - with one or more intermediate sizes absent.

* *Uniform* - essentially of one size.

ii) Particle shape. Report shape as follows:

* Equidimensional particles may be described as *rounded* or *angular*.

* *Flaky* or *platy* - essentially two dimensional particles with the third dimension small by comparison.

* *Elongated* - essentially one dimensional particles with the other two dimensions small by comparison.

c) Colour The colour of a soil is described in the MOIST condition using simple terms, such as -

black	white	grey
red	brown	orange
yellow	green	blue

These may be modified as necessary by *pale*, *dark*, *mottled*. Borderline colours may be described as a combination of these colours (e.g. red-brown).

Predominant colour should be mentioned first.

The report should also state that colour alone should not be used to identify soil as it can change with moisture content.

2.6.4 Condition of Soil

The condition of a soil may be described in the following terms.

a) Observed Field Moisture Condition This is described by the appearance and feel of the soil using one of the following terms:

i) *Dry* - looks and feels dry; cohesive soils usually hard, powdery or friable, granular soils run freely through the hands. (In general 'Dry' does not apply to clay soils in the Melbourne region).

ii) *Moist* - soil feels cool, darkened in colour, granular soils tend to cohere, cohesive soils usually weakened by moisture but no free water on hands when remoulding.

iii) *Wet* - soil feels cool, darkened in colour; granular soils tend to cohere, cohesive soils usually weakened and free water forms on hands when handling.

iv) *Saturated.*

b) Consistency (cohesive soils) Consistency of essentially cohesive soils may be described in terms of a scale of strength (see Table 2.1).

In the field the undrained shear strength can also be assessed using a pocket penetrometer for firm to very stiff soils or a hand vane for very soft to firm soils.

c) Relative Density (non-cohesive soils) The consistency of essentially non-cohesive soils is described in terms of the density index. It is not possible to make an assessment of the density index without some form of test on an undisturbed or in situ sample. The listed terms should not, therefore, be used in description unless other evidence is available.

These soils are inherently difficult to assess, and normally a penetration test procedure (SPT, Perth Sand (Clegg) Penetrometer or Scala Penetrometer) is used in conjunction with published correlation tables. Alternatively, in situ density tests can be conducted in association with minimum and maximum density tests performed in the laboratory. Table 2.2 lists terms applicable to these soils.

2.6.5 Structure of Soil

The following aspects of structure may be described:

a) Zoning A sample may consist of separate zones of soils differing in colour, grain size or other properties. The patterns of these zones are described using the following terms.

i) *Layer* - i.e. zone is continuous across exposure or sample

ii) *Lens* - i.e. a discontinuous layer of different material, with lenticular shape

iii) *Pocket* - i.e. an irregular inclusion of different material

The thickness, orientation and any distinguishing features of the zones should be described.

The boundaries of the zones are described as *sharp regular, sharp irregular, gradual.* The thickness of any transition zone should be recorded.

b) Defects Any defects should be noted. Defects may include the following:

i) open shrinkage cracks
ii) infilled shrinkage cracks
iii) rootlets (less than 1mm)
iv) roots (note size)

SECTION 3 SITE CLASSIFICATION

3.1 Natural Class A, Class S, Class M, Class H and Class E Sites

Site classification should be in accordance with AS2870 - 1996 Section 2.

Computation of predicted ground movement may be carried out in accordance with Section 2.8 of this handbook.

3.2 Class P Sites

The classification of Class P sites should be in accordance with Section 2.4.4 of AS2870 - 1996.

3.3 Other Considerations

Consideration should be given to the proposed excavation and filling which may affect the site classification.

SECTION 4 GROUND MOVEMENT COMPUTATION

4.1. Potential ground movements of expansive soils may be computed on the basis of:

$$Ys = (Ipt \times H \times pF)$$

where
Ys = estimated surface movement
Ipt = instability index of a soil stratum
H = thickness of soil stratum
pF = design suction change at mean depth of soil stratum

4.2 In the Melbourne area Ys may be estimated by assuming a differential suction of pF = 1.2 (3.2 min. to 4.4 max.) at the surface, varying linearly to zero at a depth of H = 2.0m, or from the results of testing.

In other areas, values of pF and H may be estimated from other published data or from the results of testing.

4.3 Where a permanent water table is encountered, the depth H may be taken as the depth to the water table. Note that a perched water table may not be considered as a permanent water table.

4.4 Where rock is encountered, Ys should be estimated in accordance with Section 2.8.1, with Ipt = 0 for rock, provided that expansive clays do not occur below the rock.

4.5 The values of pF and H may be varied to suit local climatic conditions, if specific data is available.

4.6 Where existing trees (which are to remain) occur close to a proposed building, the value of pF at depth H may be varied linearly in accordance with the formula:

$$pF \text{ (at depth H)} = SV \left(1 - k \cdot \frac{dt}{ht}\right) \quad \text{but} > 0$$

where

SV = surface value of pF
dt = distance of the tree from the edge of the building
ht = mature height of the tree
k = factor based on soil classification

Site Classification *	k for Single Tree	Tree Groups
E1, E2	0.7	0.5
H	1.0	0.7
M	1.3	0.9

Note: * Classification prior to modification for tree effects.

1. The increased soil movement applies to the centre heave case only. No increase is required for the edge heave case.

2. The minimum value of dt may be taken as 0.5ht.

3. For Class A soils, the suction profile need not be varied for tree effects.

4.7 The Ipt of a soil below the depth of the investigation may be assumed to be that of the soil encountered at the base of the investigation.

TABLE 2.1

CONSISTENCY TERM - COHESIVE SOILS

Term	Undrained shear strength (kPa)	Field guide to Consistency
Very soft	< 12	Exudes between the fingers when squeezed in hand
Soft	> 12 < 25	Can be moulded by light finger pressure
Firm	> 25 < 50	Can be moulded by medium finger pressure
Stiff	> 50 < 100	Can only be remoulded by fingers with difficulty. Can be indented by thumb
Very stiff	> 100 < 200	Can be indented by thumb nail
Hard	> 200	Can be indented with difficulty by thumb nail

TABLE 2.2

RELATIVE DENSITY - NON-COHESIVE SOILS

Term	Density Index %	SPT 'N' Blows/300mm	Field Guide to Consistency
Very Loose	< 15	0 - 4	Ravels
Loose	> 15 < 35	4 - 10	Shovels easily
Moderately Dense	> 36 < 65	10 - 30	Shovelling difficult
Dense	> 66 < 85	30 - 50	Pick required
Very dense	> 85	> 50	Picking difficult

COMMENTARY

SECTION 2.6

EXAMPLE OF SOIL DESCRIPTIONS

a)	SILTY CLAY (CH)	High plasticity, light brown and grey, moist, stiff, some fine rootlets, slightly fissured.
b)	CLAYEY SAND (SC)	Well graded fine to medium sand component, medium plasticity fines, yellow, orange, red mottled, dry to moist, medium dense, some fine gravels, some sandy clay balls.
c)	FILL - SILTY CLAY (CH)	High plasticity, grey, dry to moist, very stiff, some gravel and rock fragments, poorly compacted.
d)	SAND	Poorly graded, coarse, angular, light grey, moist, dense, some silt.