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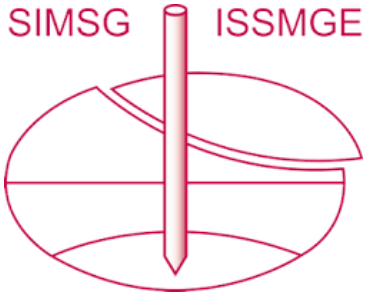

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Assignment of AS2870 Soil Suction Change Profile Parameters to TMI Derived Climatic Zones for NSW

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Summary The 1996 edition of AS2870 "Residential Slabs and Footings – Construction" assigns design suction change (H_s) values according to regional climatic zones for Melbourne and Victoria. These climatic zones are delineated by Thornthwaite Moisture Index (TMI) contours. Separately, the Standard also provides recommended soil suction change profiles for certain locations across Australia (as defined by Δu and H_s).

This paper presents recommended soil suction change profiles for NSW linked to regional climatic zones delineated using TMI contours. This provides a basis for deriving design soil suction profile parameters for any location within NSW.

1. INTRODUCTION

Australian Standard AS2870–1996 "Residential Slabs and Footings – Construction" provides two methods for classifying sites; namely by identification of the soil profile, and estimation of the characteristic surface movement (y_s).

The value y_s is a function of soil reactivity as measured by the soil shrinkage index (I_{ps}) and the design soil suction change profile. The design soil suction profile is defined by the parameters Δu and H_s. The parameter Δu is the design suction change at the soil surface expressed in pF units. The parameter H_s is the design depth of suction change, in metres, below which it is assumed that changes in soil suction do not occur. For simplicity the soil suction change values are assumed to decrease linearly from a maximum value at the surface to zero at the depth H_s. AS2870–1996 (Table 2.4) provides a list of recommended soil suction change profiles for eleven discrete locations throughout Australia. No guidance is given for determining appropriate soil suction change parameters at locations other than those listed in Table 2.4, apart from a notation at the foot of the table which reads "the variation in H_s depends largely on climatic variation".

AS2870 (Tables D1 and D2) presents recommended H_s values for "Melbourne and Environs" and "Victoria" respectively. These H_s values differ according to climatic zone. Climatic zones for "Melbourne and Environs" and "Victoria" are mapped in Figures D1 and D2. The climatic zones are delineated by Thornthwaite Moisture Index (TMI) contours as shown below in Table 1.

Table 1. Climatic zone definitions.

Climatic Zone	Description	TMI Range
1	Alpine/wet coastal	+40 < TMI
2	Wet temperate	+10<TMI<+40
3	Temperate	-5<TMI<+10
4	Dry temperate	-25<TMI<-5
5	Semi-arid	TMI < -25

AS2870 provides soil suction profiles for only a very limited number of locations outside Victoria. Given this, the methodology adopted and principal objectives of this paper are to:

- present a NSW climatic zone map based on TMI contours;
- collect site specific soil suction profile data from numerous sources including consultants, government departments and universities;
- group soil suction data into climatic zones and generate scatter plots of soil suction results against depth for each climatic zone;
- assess the scatter plots to define suction profile parameters Δu and H_s for each climatic zone;
- use the results of this work to recommend design suction profile parameters for NSW based on TMI contour defined climatic zones;

- identify areas where more data or research is needed.

The use of TMI derived climatic zones for assigning design soil suction profile parameters has potential application across Australia. However, the focus of this paper is the application of this method within NSW.

2. NSW CLIMATIC ZONE MAP

2.1 Base Map

Figure 1 presents the proposed climatic zone map for NSW. The climatic zones are delineated by Thornthwaite Moisture Index (TMI) contours. The climatic zones adopted are the same as those used in AS2870-1996 for Victoria i.e. the zone descriptions and corresponding TMI ranges are the same as those presented in Table 1.

The TMI contour map has been reproduced from Aitchinson and Richards (1965) which presents a 1:5,000,000 scale TMI contour map for Australia derived from computed TMI values from 600 weather stations across Australia.

2.2 Corrections to Base Map

The superimposition of these contours over a much larger scale map of NSW introduced potential inaccuracies. These potential inaccuracies have been checked and where necessary corrected by:

- comparing the 'fit' with a larger scale TMI map produced for the Hunter Valley and Newcastle by Fityus, Walsh and Kleeman (in print).

- comparing the 'fit' along the Victorian border with AS2870-1996 Figure D2;

- comparing the climatic zone boundaries with a topographic map of NSW to identify anomalies;

- checking that plotted pF data for specific locations within a climatic zone was consistently spread about a clearly defined equilibrium pF value; and

- testing the assigned climatic zones for specific localities against the authors' experience of climate in those areas.

The following adjustments were made:

- Newcastle and Hunter Valley.
  The +40TMI, +10TMI, -5TMI and -25TMI contours were adjusted to more closely match the more rigorously defined TMI contours for the Hunter Valley presented in Fityus, Walsh & Kleeman (in print).

- Victorian Border and Southern Alps.
  For consistency with AS2870-1996 Figure D2 the -25TMI contour was straightened in the vicinity of Tocumwal and Echuca; the -5TMI, +10TMI and +40TMI contours were moved east in the vicinity of Albury; and the +40TMI contour was moved eastwards in the Southern Alps and Delgate areas.

  The +40TMI contour was redefined around the southern Alps to envelop all of the alpine areas. As a result the +10TMI contour is closed off south of Canberra.

- South Coast.
  The +10TMI contour was closed off west of Geroa so that the coastal townships from Kiama to Greenwell Point are placed in Zone 2 rather than Zone 3.

- Western Sydney.
  Initially Western Sydney was placed in Zone 3. However, the scatter plot of the Western Sydney pF data presented in Coffey & Partners (1985) showed an equilibrium pF value more consistent with the Zone 2 plot. This data was regrouped in Zone 2 and the +10TMI contour shifted southwards placing Western Sydney in Zone 2.

- Central West.
  Based on local knowledge of Central West climates the -5TMI and -25TMI were shifted westwards to place Bathurst, Molong and Cudal in Zone 3 and Forbes, Parkes and Eugowra in Zone 4.

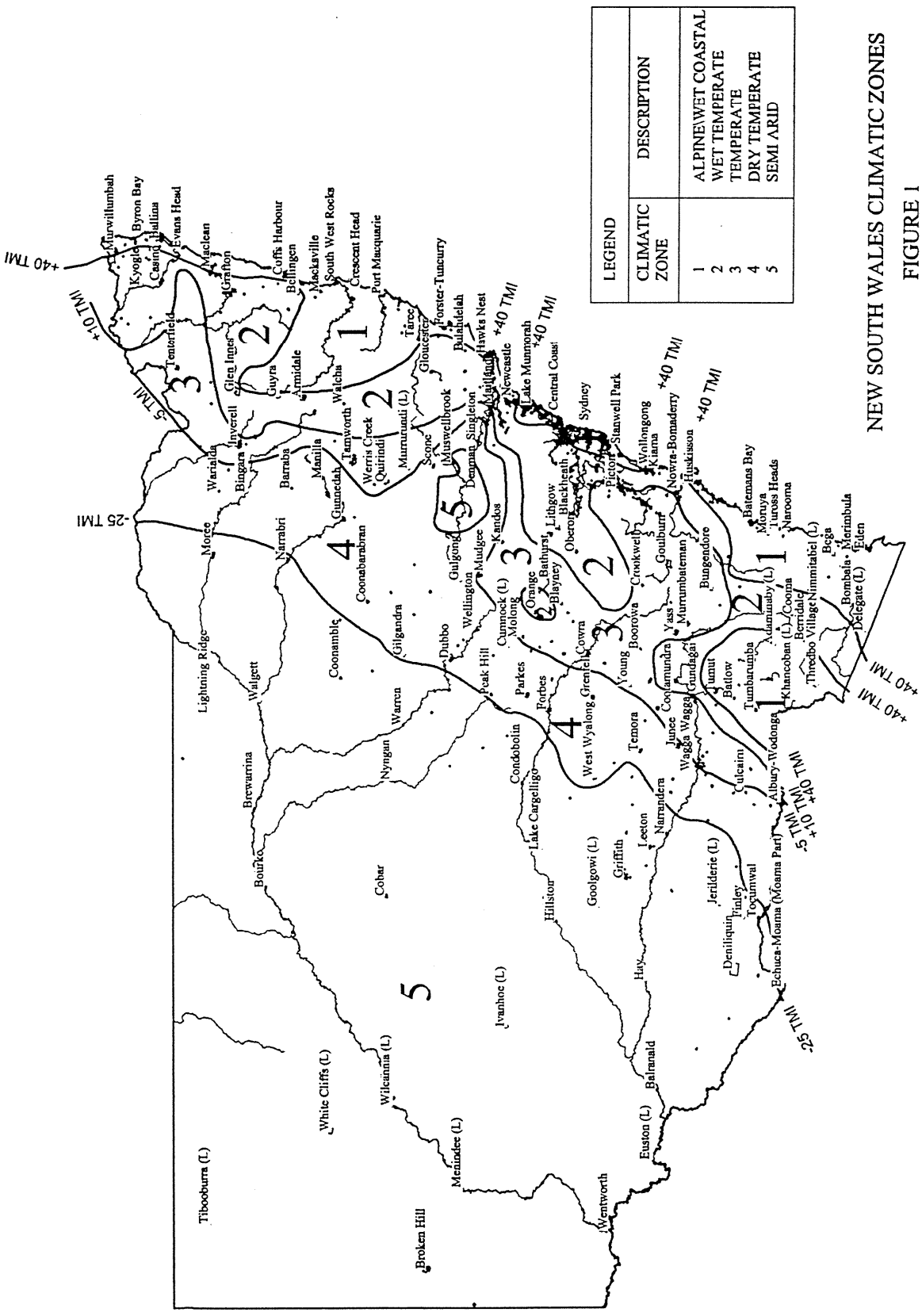
3. SOIL SUCTION DATA

3.1 Sources

Measured values of total soil suction (pF) on samples taken at discrete depths (m) below the ground surface were collected from various sites within NSW. Two sources of information were considered, namely published and unpublished information. Accessing of information from each of these sources will be discussed in turn.

3.2 Published Information

A literature search was undertaken using the following topic search words; soil suction, soil suction change profile, AS2870, Thornthwaite Moisture Index and Thornthwaite. Two databases were accessed through the Institution of Engineers, Australia and Austroads. This search revealed a scarcity of published information. Three papers contained relevant data, as listed below. Full reference details of these papers are given in the bibliography.



NEW SOUTH WALES CLIMATIC ZONES

FIGURE 1

1. "The Establishment of a Reactive Soil Test Site Near Newcastle", Allman, Smith and Sloan (1994).

2. "Soil Aridity During Occasional Drought in South Eastern Australia" Aitchison (1970).

3. "Sydney Swelling Soils Study - Analysis of Data" Coffey & Partners for the Builders Licensing Board of NSW (1985).

3.3 Unpublished Information

Due to the scarcity of published information a concerted effort was made to access any other available data from consultants, government departments and universities. The following organisations were contacted by telephone:

Arup Geotechnics, Australian Soil Testing Laboratories, Coffey Partners International, Department of Housing, Department of Public Works & Services, D J Douglas & Partners, Longmac Associates/GHD, PPK Environment & Infrastructure Pty Ltd., Robert Carr and Associates, SMEC Testing Services, Standards Association of Australia, Sydney University, University of Newcastle, University of NSW.

Again a scarcity of information was apparent. The primary source of information obtained was from work undertaken by the Bathurst and Sydney offices of Longworth & McKenzie, for the following government bodies: Bathurst City Council, Bathurst Orange Development Corporation, Department of Housing, Dubbo City Council, Gilgandra Shire Council, Moree Plains Shire and Warren Shire Council.

3.4 Presentation of Suction Data

The accessed data was collated and sorted into the Climatic Zones delineated by the TMI map presented in Figure 1. The geographic location of the sites within the various climatic zones is presented in Table 2. No data was obtained for Zone 1.

Table 2. Geographic location for various zones.

Zone 2 Wet Temperate	Zone 3 Temperate	Zone 4 Dry Temperate	Zone 5 Semi-Arid
Grahamstown	Bathurst	Dubbo	Deniliquin
Newcastle	Canberra-	Gilgandra	Coleambally
Western	Belconnen	Albury	Finley
Sydney	Holbrook		Hay
	Yass		Moree
			Warren

The total soil suction values (u) versus depth for the various climatic zones are presented graphically in Figures 2 to 5.

4. SOIL SUCTION PARAMETERS FOR CLIMATIC ZONES

All of the soil suction data points for Zones 2 to 5 are plotted in Figures 2 to 5 respectively. The exception is the set of data for Gininderra, Canberra from Aitchison (1970). These pF values were uncharacteristically low and have not been plotted.

The characteristics of the AS2870–1996 design suction profile are:

- the design suction change decreases linearly from a maximum value Δu at the surface to zero at a depth H_s; and
- below H_s the soil suction is at a constant equilibrium value.

In interpreting the data plots, the following procedure was followed for each plot:

- the equilibrium soil suction value was identified;
- an inverted triangular shaped envelope was drawn to provide a boundary to the area of high data point density; outliers and the 'fuzzy' edges to these data sets were excluded.
- the apex of the triangle was interpreted as the design depth of suction change, H_s and the base width the design suction change at the surface, Δu.

The interpreted values of H_s, Δu, and the equilibrium soil suction for each climatic zone plot are presented in Table 3.

Table 3. Interpreted suction profile parameters for climatic zones.

Climatic Zone	Description	Hs (m)	Δ u (pF)	Equilib Soil Suction (pF)
2	Wet Temperate	1.8 to 2.0	1.5	3.8
3	Temperate	2.3	1.2 to 1.5	4.1
4	Dry Temperate	3.0	1.2 to 1.5*	4.2
5	Semi-arid	4.0	1.5 to 1.8	4.4

NOTE: * Due to a lack of wet weather data for Zone 4 (i.e. left of the equilibrium pF value) an upper bound Δu value of 1.5 has been inferred.

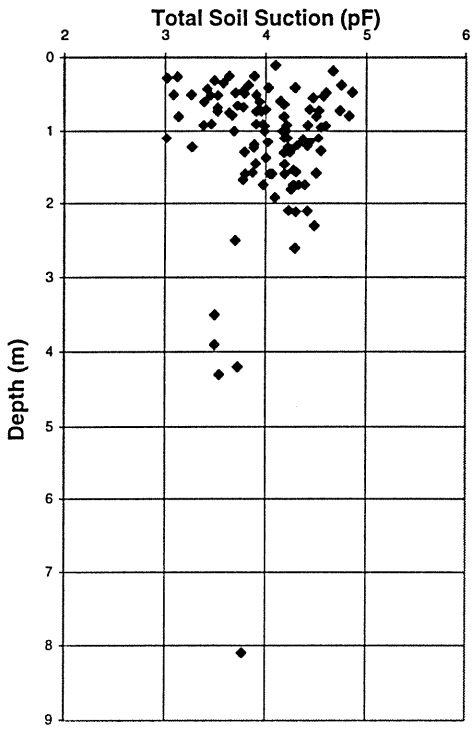


Figure 2. Zone 2 soil suction data

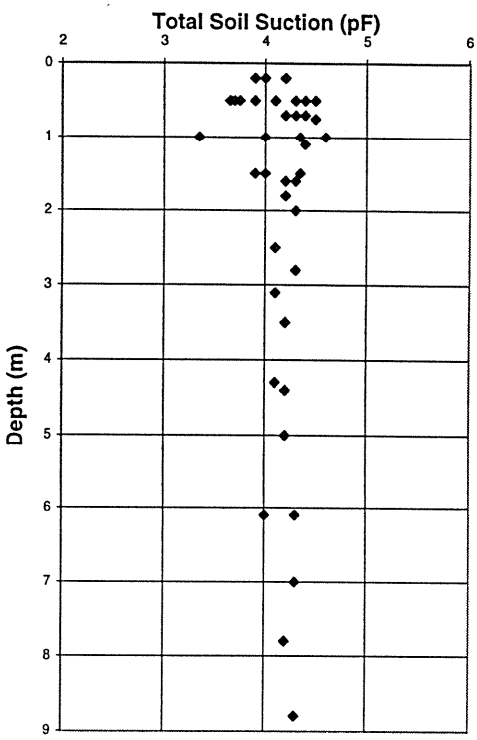


Figure 3. Zone 3 soil suction data

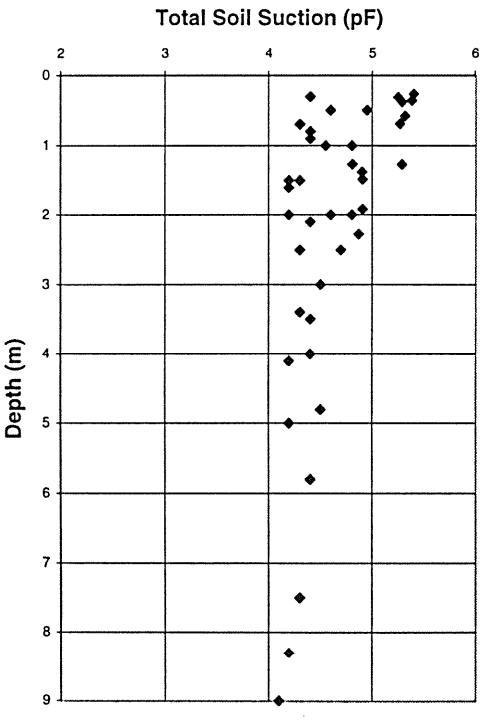


Figure 4. Zone 4 soil suction data

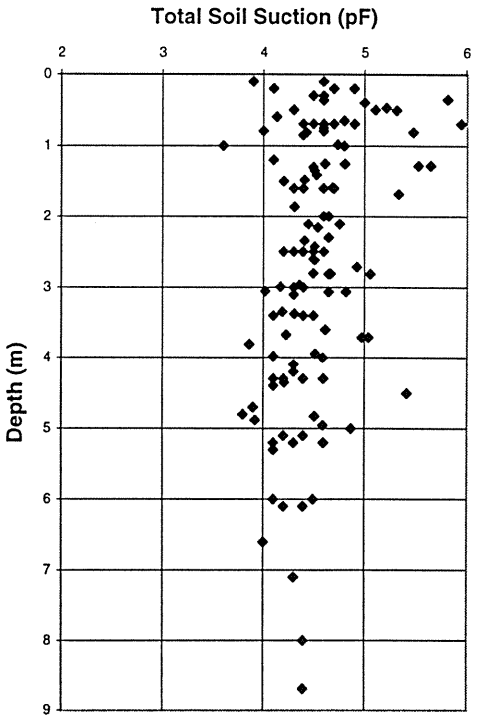


Figure 5. Zone 5 soil suction data

5. CONCLUSION

This paper presents a TMI contour delineated climatic zone map of NSW (Figure 1). Published and unpublished soil suction profile data was obtained and grouped according to climatic zones as defined in Table 1. Scatter plots of soil suction verses depth were presented for Climatic Zones 2 to 5. Values of soil suction profile parameters H_s and Δu were interpreted and presented in Table 3.

The information presented in this paper can provide a basis for deriving design soil suction profile parameters for any location within NSW.

The TMI contours used are based on a 1:5,000,000 scale map of Australia. Inaccuracies are possible from the superimposition of this data to a larger scale map of NSW. The authors have applied corrections where possible, however we note that local climatic anomolies may occur and should be adjusted based on local knowledge and/or other research information.

The authors have been unable to access soil suction information for Zone 1 and wet climatic suction data for Zone 4. Interpreted soil suction parameters could be assigned/refined when/if additional site data becomes available.

The information presented in this paper provides the foundation for further research and development in providing a rational basis for defining design soil suction parameters for any locality in NSW. This approach should be considered for adoption in future revisions of AS2870. Furthermore this approach has merit for similar applications in the remaining States of Australia.

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