Presenter

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20 Years Experience as a Forensic Engineer investigating:

- Reactive Soil damage to structures.
- Excavation and Shoring Failures.
- Landslides.
- Mine Dam and Levee failures.

Investigated the cause and designed stabilisation for Mascot Towers following it's evacuation.

1

INTRODUCTION

Design for Reactive Soils and AS2870

Design for Reactive Soils and AS2870

This presentation will:

a) **What a Reactive Soil is.**
b) **How a Reactive Soil behaves.**
c) **What are some of the risks of Reactive sites.**
d) **Does the use of collapsible void formers and Piles resolve these issues.**
e) **What practices you can implement to manage your risk.**

2

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WHAT IS A REACTIVE SOIL

AS2870 defines a Reactive Soil as:

Site consisting of a clay soil that swells on wetting and shrinks on drying by an amount that can damage buildings on light strip footings or unstiffened slabs. Includes sites classified as Class S, Class M, Class H1, Class He or Class E in accordance with Clause 2.1.

Class	Foundation	Characteristic Movement
S	Slightly reactive clay site.	0 to 20mm
M	Moderately reactive clay site.	20mm to 40mm
H1	Highly reactive clay site, which may experience high ground movement from moisture changes	40mm to 60mm
H2	Highly reactive clay site, which may experience very high ground movement from moisture changes	60mm to 75mm
E	Extremely reactive clay site	Greater than 75mm

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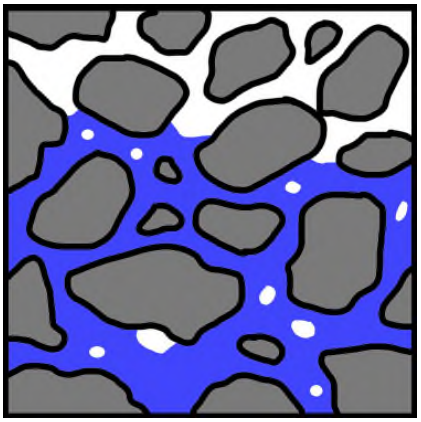
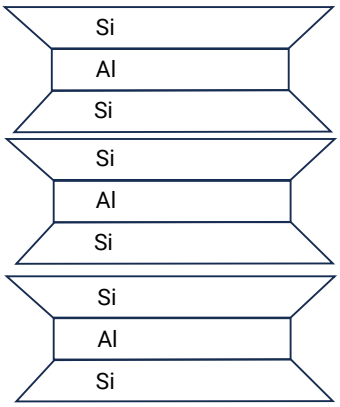
WHAT IS A REACTIVE SOIL

Traditional Inert Soil



Reactive Inert Soil



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WHAT IS A REACTIVE SOIL

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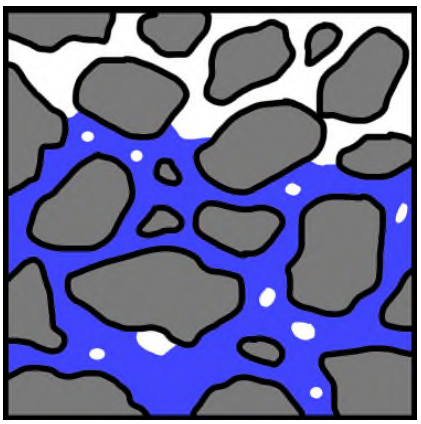
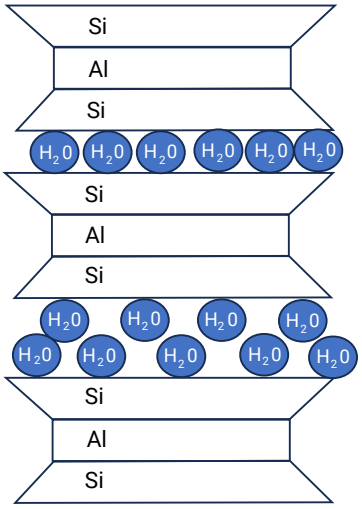
Traditional Inert Soil



Reactive Soil



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CLIMATE CYCLES – WET TO DRY

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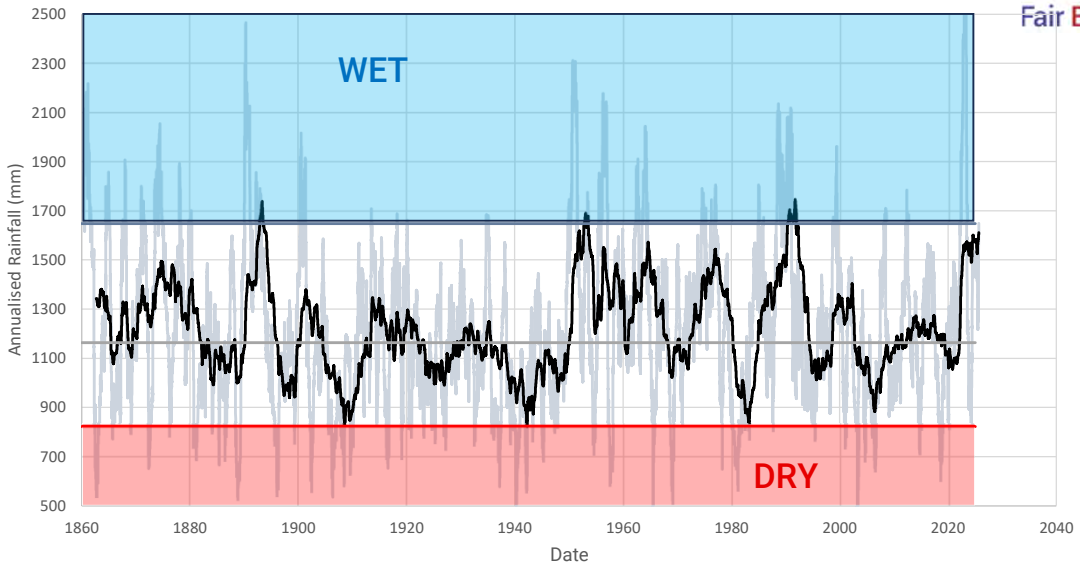
Annual Rainall for Sydney City - 1860 to 1925



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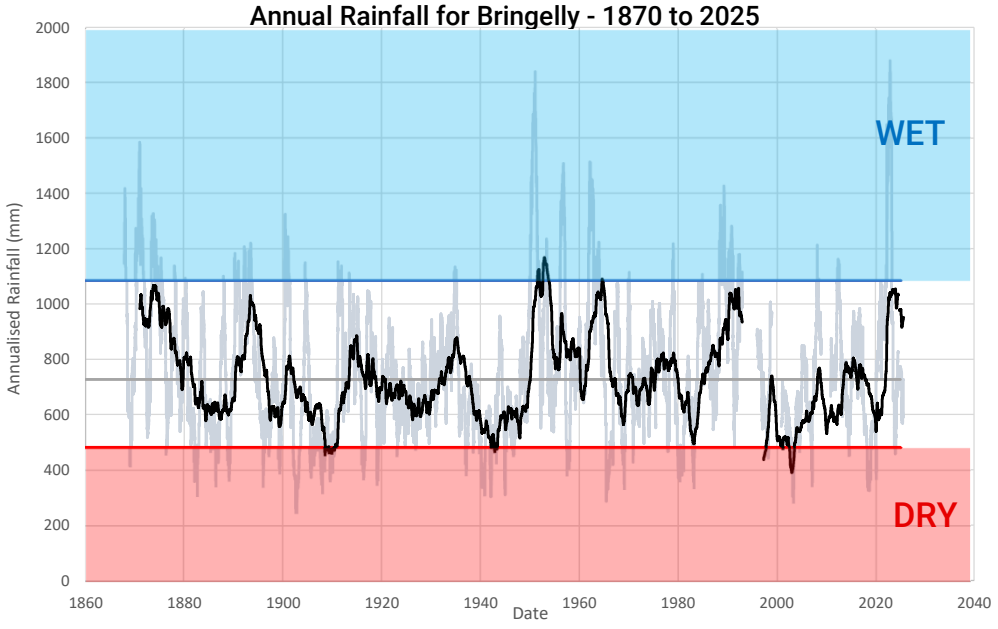
CLIMATE CYCLES – WET TO DRY



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WET DRY CYCLES IN AS2870

AS2870 describes the reactivity in Section 2.3

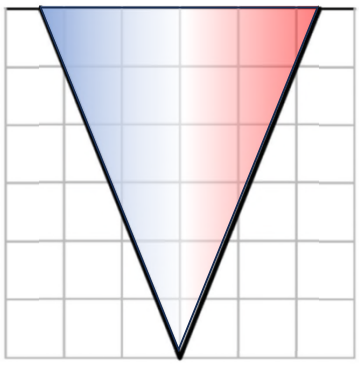
The Characteristic Surface Movement y_s is the Soil Suction Change multiplied by the soil specific reactivity or Instability Index

Soil Suction Change

In this presentation, I will be using the following Site Parameters:

Hs = 4.0m
Crack Depth = 2.0m
Iss = 4.0% - obtained from lab test to AS1289.7.1.1

This results in a y_s of 107mm or Class E-D



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WET DRY CYCLES IN AS2870

What happens when we construct a Building

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9 In Wet conditions, the soil swells by 60mm

At the center of the house, small changes ~20mm

In Dry conditions, the soil shrinks by 65mm

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WET DRY CYCLES IN AS2870

What happens when we construct a Building

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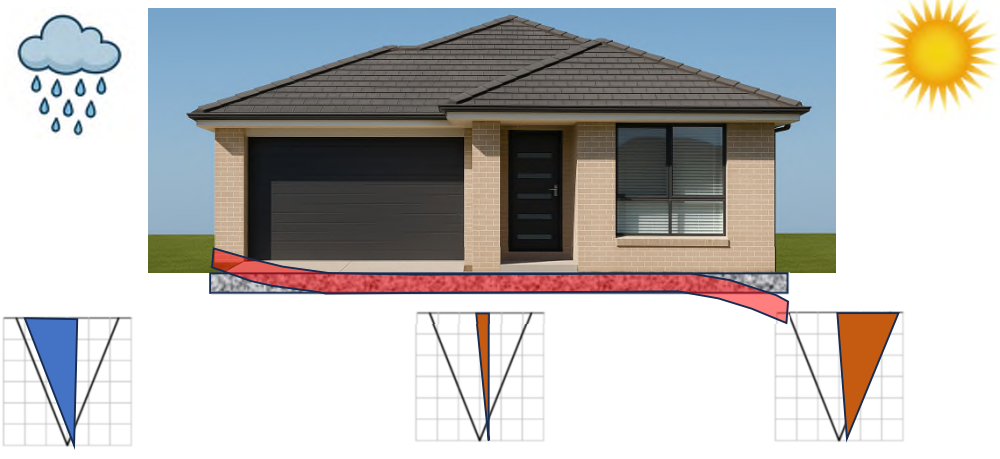

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In Dry conditions, the soil shrinks by 65mm

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WET DRY CYCLES IN AS2870

What happens when we construct a Building – in the Wet

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11

WET DRY CYCLES IN AS2870

What happens when we construct a Building – in the wet

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WET DRY CYCLES IN AS2870

What happens when we construct a Building – in the Dry

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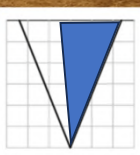
WET DRY CYCLES IN AS2870

What happens when we construct a Building – in the Dry



If the Dry / drought persists for a few years, center of the house swells by ~65mm

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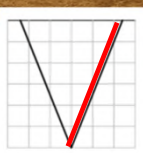
WET DRY CYCLES IN AS2870

What happens when we construct a Building – in the Dry



If the drought breaks 2 months after construction then the middle of the house is still dry

The exterior of the house can swell by 90mm

15

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WET DRY CYCLES IN AS2870

What happens when we construct a Building – in the Dry

Clause 5.2.2 requires the minimum height of the slab above finished ground level to be 150mm.

But if the building is constructed at a Dry time, for our example site when the site becomes Wet, that 150mm will be reduced to about 40mm!

External pavements will differentially rise and fall. If it is built in the Dry with the minimum 50mm fall, in the wet it would have a reverse fall towards the building!

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WHAT IS A GILGAI

AS2870 defines a Gilgai as:

Soil surface feature associated with reactive clay sites, characterised by regularly spaces and sized depressions on virgin land.

Note: *Gilgais are formed by extreme, reactive soil movements. Soil profiles may vary markedly across sites with Gilgais.*

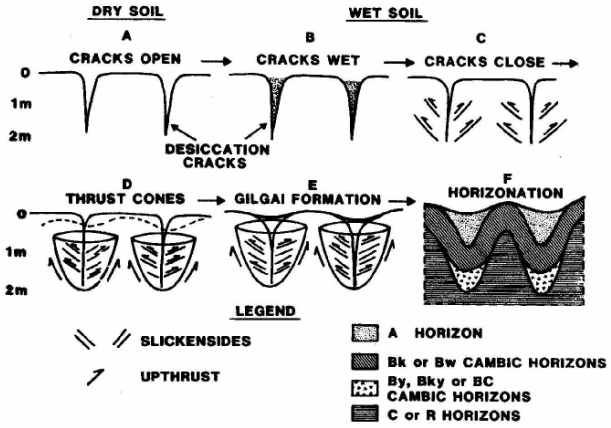

Figure from Wilding and Tessier 1998
Genesis of vertisol : shrink-swell phenomena

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17

17

ABNORMAL MOISTURE CONDITIONS

Design using AS2870 only covers 'Normal Sites'

Abnormal moisture conditions (Clause 1.3.3) include:

1. Removal of an existing building or structure.
2. Removal of trees prior to construction.
3. Presence of trees on the site or adjacent site.
4. Unusual moisture conditions caused by drains, pools, tanks etc.

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18

18

ABNORMAL MOISTURE CONDITIONS

Tree Impacts

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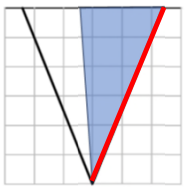
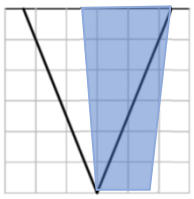
19



Without the Tree, Swell to the center of the house post-construction:

63 mm



With the Tree, Swell to the center of the house post-construction:

105 mm

Our normal site y_s = 107mm

19

ABNORMAL MOISTURE CONDITIONS

Tree Impacts on neighbouring site

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20

Where the trees are on a neighboring site, the effects depend on changes to the trees.

Are the trees young and growing, or are they mature?

What is the future lifespan of the trees, given AS2870 expects a design life of 50 years?

Should obtain advice from a qualified arborist about the trees to assess their impact.

20

ABNORMAL MOISTURE CONDITIONS

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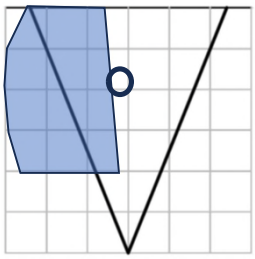
Leaking Pipes

Leaking pipes introduce significant localized swelling

1. The swelling is normally localized within a few meters of the location of the leak.
2. On reactive sites, it can induce significant heave and cracking to the structure.
3. Often the remedial solution is demolition of the building.
4. Leaking charged stormwater lines are the next major construction incident waiting to occur.



This example would induce about 70 mm of heave.

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ABNORMAL MOISTURE CONDITIONS

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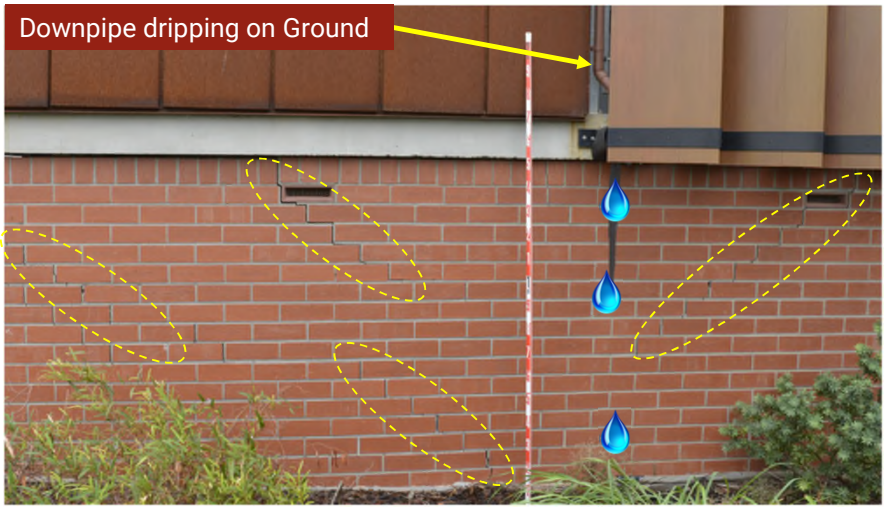

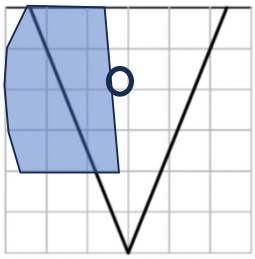

This example would induce about 70 mm of heave.

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ABNORMAL MOISTURE CONDITIONS

Pre-existing Structures

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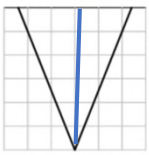

If the moisture equalizes, there will be about 60mm heave

23

23

PIERS AND VOID FORMERS

Piers and Collapsible Void Formers : Are they the Solution

Design for Reactive Soils and AS2870

1. Using piers and collapsible void formers is outside of AS2870.
2. The concept is to create a suspended slab isolated from the ground.
3. The piers must act as an ‘anchor’ against uplift during swell of the reactive clays.
4. The ground still moves, so interface issues must be addressed. The interface issues are more difficult to deal with than a slab on ground without piers.

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PIERS AND VOID FORMERS

Piers and Collapsible Void Formers : Are they the Solution

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Service Pipes

1. With a traditional Slab on Ground, sewer pipes below the slab move a similar amount to the slab, with only small (less than 20mm).
2. However, with a suspended slab fixed in space, the full differential movement occurs between the pipe and the slab. How do you manage the expansion and contraction of the penetration?

25

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PIERS AND VOID FORMERS

Piers and Collapsible Void Formers : Are they the Solution

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External Path Connections

1. With a traditional Slab on Ground, the external paths may rotate away from the house, but they move together.
2. However, with a suspended slab fixed in space, the full differential movement occurs. How are you going to manage the step from the front door to the path. One year it might be 20mm, two years later 130mm.
3. Can you just use a dowel connection to lock them together?

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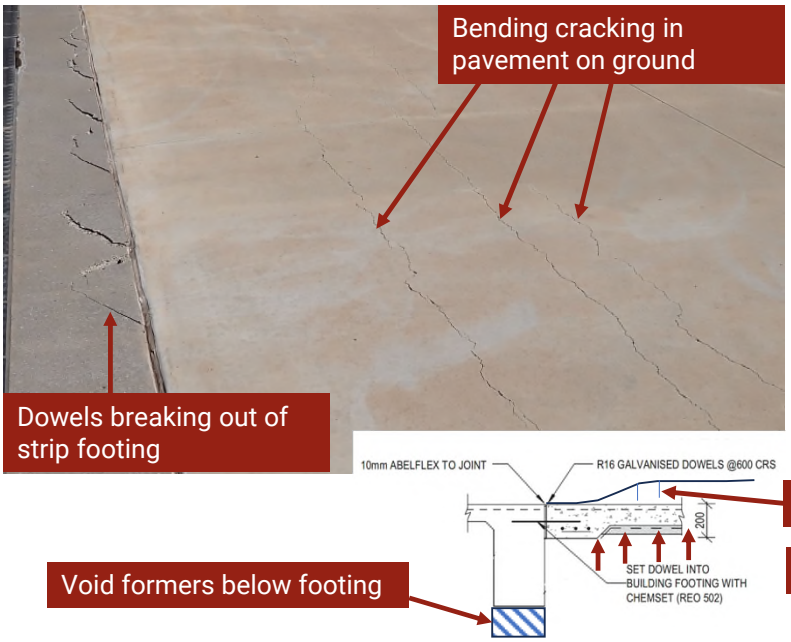
PIERS AND VOID FORMERS



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27

27

PIERS AND VOID FORMERS

Piers and Collapsible Void Formers : Are they the Solution

Driveways and Internal Garages

1. With a traditional Slab on Ground, the external driveway will move largely together with the house, even if they are not structurally connected.
2. However, with a suspended slab fixed in space, the full differential movement occurs. How are you going to manage the step between the Wet and the Dry.
3. Can your driveway or pavement be adjusted with minimal cost?

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SUMMARY

Design for Reactive Soils and AS2870

Design on Reactive Soils requires design for displacement and Climate.

a) The first thing when starting a design is to assess what vegetation and tree changes are going to occur. Recommend trees be removed as soon as authorised.

b) Include requirements for the design to be reviewed for climatic conditions at the time of Construction. Construction in the Dry can cause large displacements beyond design limits when the drought breaks.

c) You need to consider what happens when the services leak? How will your design accommodate the leak to prevent major damage.

d) Piles and Collapsible Void Formers are not a magic bullet, and introduce large interface issues that must be managed in the design.

29

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