

13th Australia
New Zealand
Conference on
Geomechanics

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Working platforms for tracked plant – BR 470 guideline and a revised approach to stabilisation design with multiaxial hexagonal geogrids

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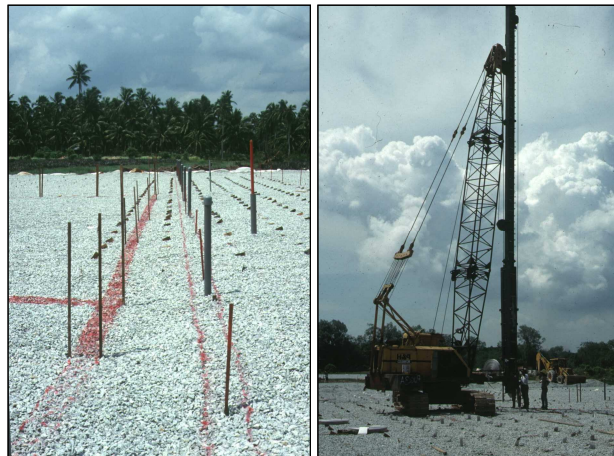
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Introduction

- Working platforms are frequently required on construction sites
- To support heavy machines for installation of piles or vertical drains
- Short term use so considered as temporary



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Introduction

- In some cases working platforms are used for longer term purposes
- For example as working platforms in fabrication yards
- This image shows such an example



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Introduction

- In some cases working platforms are used for longer term purposes
- For example as working platforms in fabrication yards
- This image shows such an example
- Crane loadings can be very heavy



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Introduction

- In some cases working platforms are used for longer term purposes
- For example as working platforms in fabrication yards
- This image shows such an example
- Crane loadings can be very heavy
- This crane was driven off the treated platform area resulting in fatalities



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Introduction

- Working platforms can and should be designed as engineered structures
- This is the aim of this paper and presentation



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BR 470: introduction

- BR 470 published by BRE (UK) in 2004: "Working platforms for tracked plant"
- A good practice guide to the design, installation, maintenance and repair of ground-supported working platforms for tracked plant
- Includes general recommendations and a detailed method of calculation
- Then in 2011 BRE published a "review seven years on" covering the use of structural geosynthetic reinforcement
- Evidence of some use of BR 470 in ANZ



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BR 470: targets and limitations

- Principal target is to promote safety
- Working platform should be appreciably stronger than the subgrade
- Subgrade: $s_u > 20$ kPa and $s_u < 80$ kPa
- Platform thickness: $D > 0.5W$ or 300mm and $D < 1.5W$
- Load factors:

Load case	Platform required?	
	No	Yes
Case 1 (unlikely to recover)	2.0	1.6
Case 2 (likely to recover)	1.5	1.2

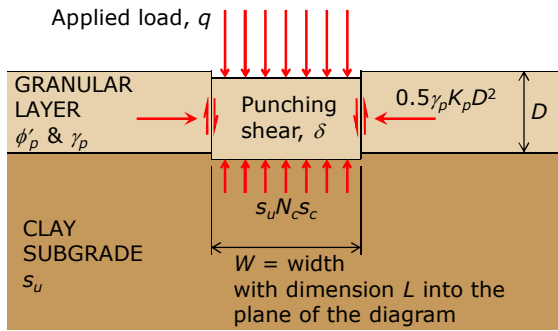


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BR 470: method of calculation



$$R = s_u N_c s_c + \frac{\gamma_p K_p D^2 \tan \delta \times s_p}{W}$$

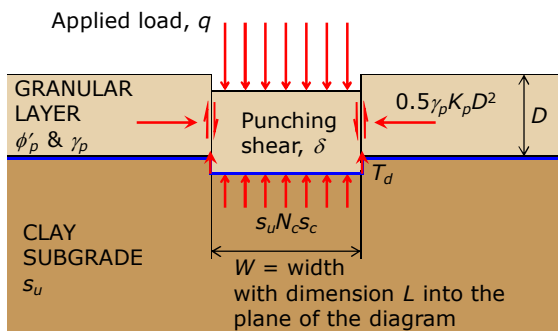


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BR 470: method of calculation with geosynthetic reinforcement



$$R = s_u N_c s_c + \frac{\gamma_p K_p D^2 \tan \delta \times s_p}{W} + \frac{2T_d s_p}{W}$$



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BR 470: development

- Basic guidelines are satisfactory
- Some concerns with method of calculation
- Does not take account of geogrids which create stabilisation of the platform material



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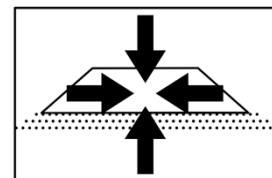


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ISO 10318:2018 definitions and pictograms

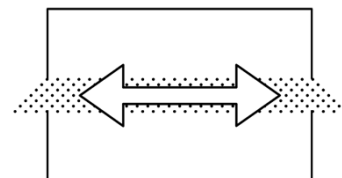
- Stabilisation

improvement of the mechanical behaviour of an unbound granular material by including one or more geosynthetic layers such that deformation under applied loads is reduced by minimising movements of the unbound granular material



- Reinforcement

use of the stress-strain behaviour of a geosynthetic material to improve the mechanical properties of soil or other construction materials



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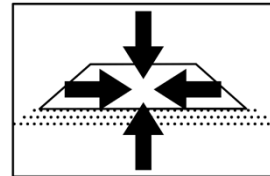


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ISO 10318:2018 definitions and pictograms

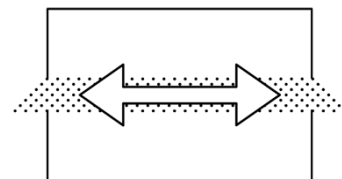
- Stabilisation (geogrid operating at low strain SLS)

improvement of the mechanical behaviour of an unbound granular material by including one or more geosynthetic layers such that deformation under applied loads is reduced by minimising movements of the unbound granular material



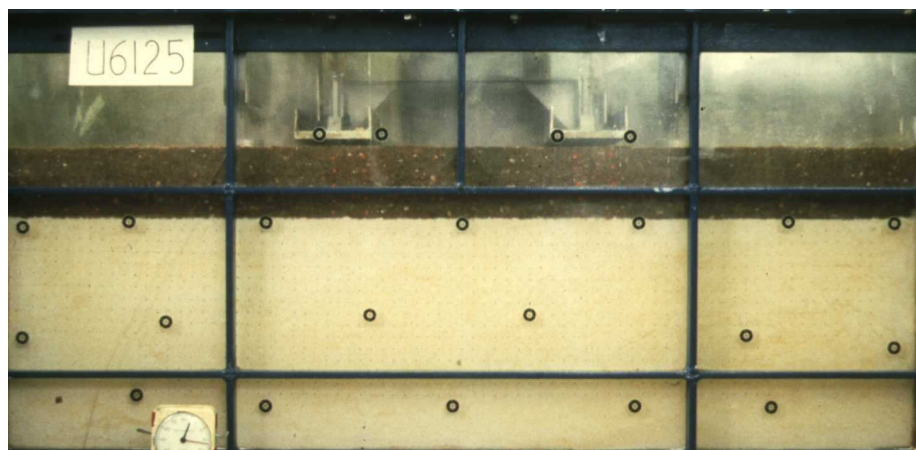
- Reinforcement (geosynthetic operating at relatively high strain ULS - BR 470)

use of the stress-strain behaviour of a geosynthetic material to improve the mechanical properties of soil or other construction materials



**Bearing capacity: granular layer over soft clay
Understand better the load transfer mechanism**

- Co-author Dr Andrew Lees goes back to basics to tackle the problem
- Model foundation test from 1980's



Bearing capacity: granular layer over soft clay
Understand better the load transfer mechanism

- Without geogrid
- Narrow punching shear
- Relatively shallow shear surfaces



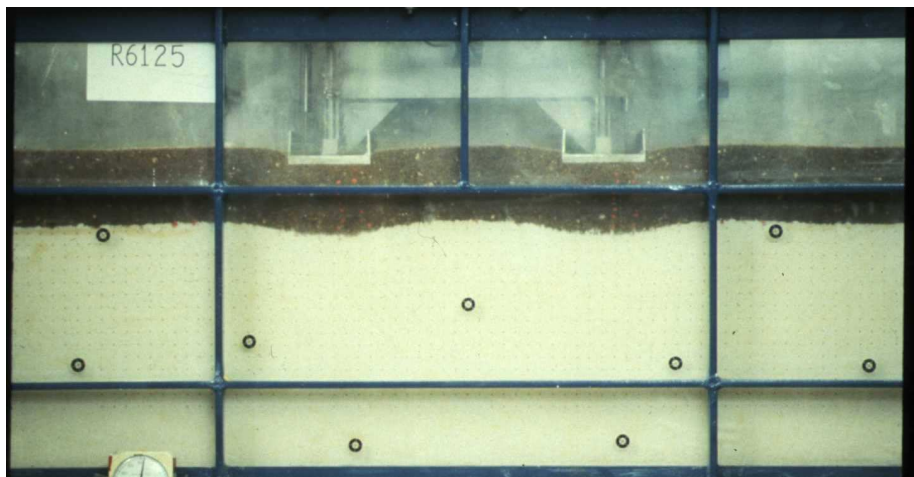
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Bearing capacity: granular layer over soft clay
Understand better the load transfer mechanism

- With geogrid
- Much smaller deformation at same load SLS
- Wider punching shear



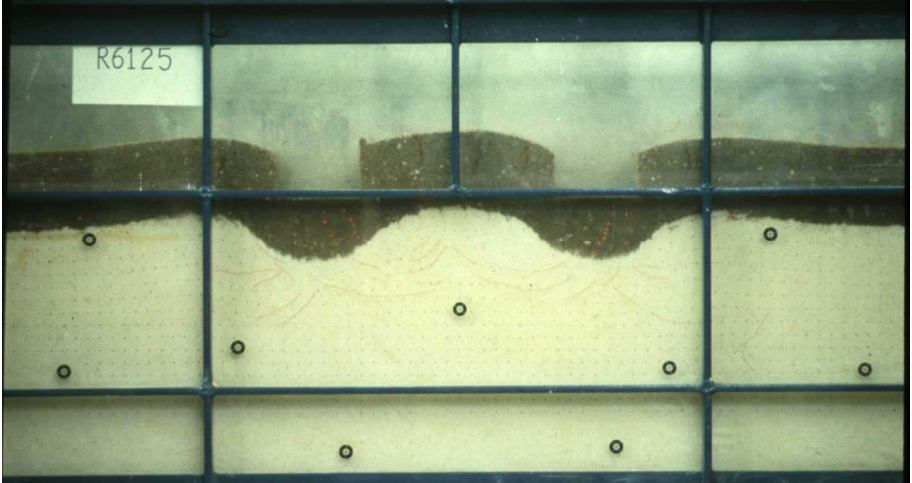
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Bearing capacity: granular layer over soft clay
Understand better the load transfer mechanism

- With geogrid
- Much smaller deformation at same load SLS
- Wider punching shear
- Deeper shear surfaces at ULS



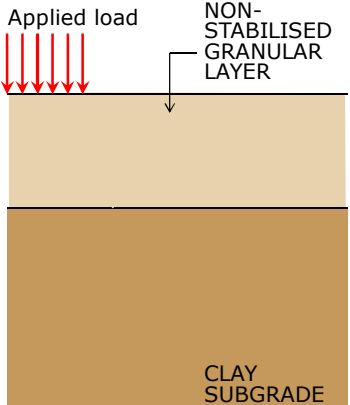
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Bearing capacity: granular layer over soft clay
Effect of stabilisation on load transfer efficiency

- Granular layer without stabilisation
- Apply surface load



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Bearing capacity: granular layer over soft clay Effect of stabilisation on load transfer efficiency

- Granular layer without stabilisation
- Apply surface load
- Creating mechanism of punching shear

Applied load

NON-STABILISED GRANULAR LAYER

Some surcharge transfer

Subgrade shear plane

CLAY SUBGRADE

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Bearing capacity: granular layer over soft clay Effect of stabilisation on load transfer efficiency

- Granular layer without stabilisation
- Apply surface load
- Creating mechanism of punching shear
- Granular layer with stabilisation
- Comparing behaviour

Applied load

NON-STABILISED GRANULAR LAYER

Some surcharge transfer

Subgrade shear plane

CLAY SUBGRADE

Applied load

MECHANICALLY STABILISED GRANULAR LAYER

More surcharge transfer

Wider punching shear

Shear plane forced deeper and wider

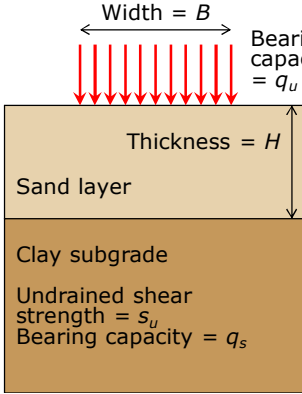
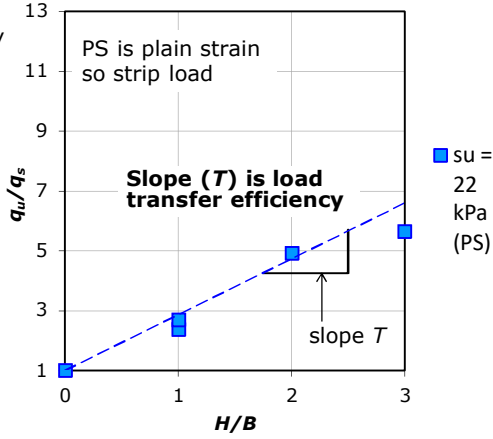
CLAY SUBGRADE

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Bearing capacity: granular layer over soft clay Defining the load transfer efficiency T


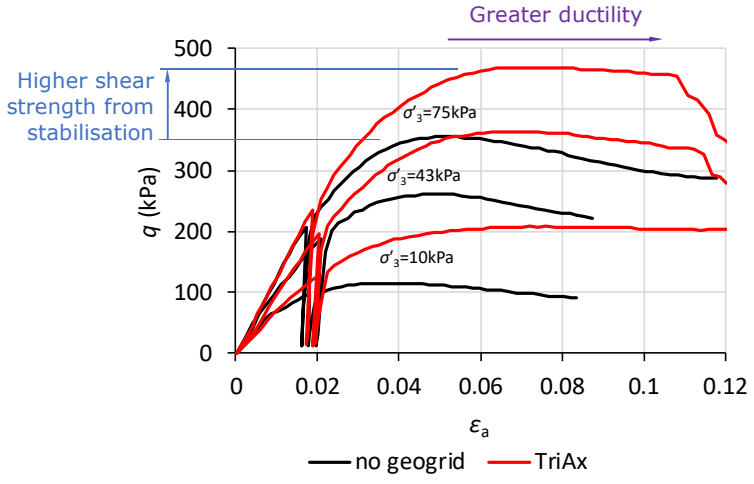
- Based on centrifuge testing
- Relationship between surface bearing capacity (q_u) and subgrade bearing capacity (q_s) versus aspect ratio H/B
- Slope of the line is $T =$ load transfer efficiency

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Bearing capacity: granular layer over soft clay 0.5m diameter triaxial tests to establish composite behaviour

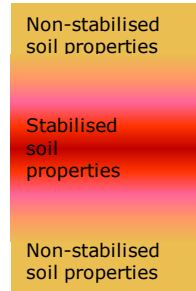
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Bearing capacity: granular layer over soft clay
0.5m diameter triaxial tests to establish composite behaviour



- Obtain constitutive model parameters for various granular materials without and with various types of stabilisation geogrid



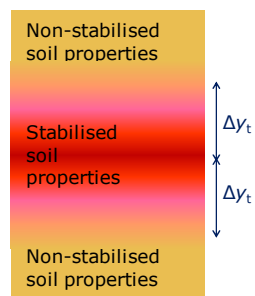
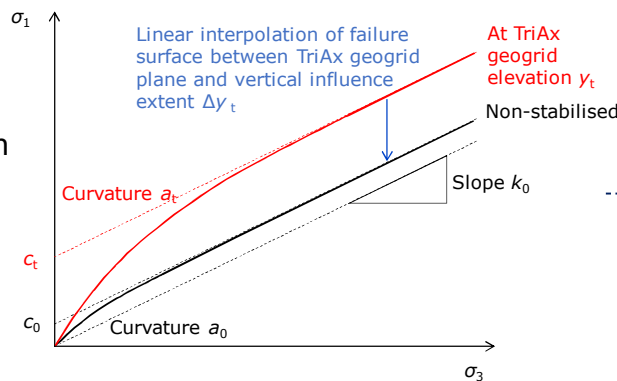
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Bearing capacity: granular layer over soft clay
Develop a new FEA constitutive model for the composite

- Carry out parametric study for wide variety of working platform design parameters using FEA
- Derive relationships between T and s_u for a wide range of conditions



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Bearing capacity: granular layer over soft clay Developing a new design method

- Without geogrid for strip load and square/round load
- Interpolate for intermediate cases

s_u (kPa)	T (No geogrid, B/L = 1)	T (No geogrid, B/L = 0)
0	8	8
5	3.5	1.2
10	2.5	0.8
20	1.8	0.5
30	1.4	0.4
40	1.2	0.35
60	1.0	0.3
80	0.9	0.28
100	0.8	0.25

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Bearing capacity: granular layer over soft clay Developing a new design method

- Without geogrid for strip load and square/round load
- Interpolate for intermediate cases
- Adding mechanical stabilisation effect of "Geogrid A"

s_u (kPa)	T ("Geogrid A", B/L = 1)	T (No geogrid, B/L = 1)	T ("Geogrid A", B/L = 0)	T (No geogrid, B/L = 0)
0	8	8	8	8
5	6.8	3.5	3.0	1.2
10	4.5	2.5	2.0	0.8
20	3.2	1.8	1.5	0.5
30	2.8	1.4	1.2	0.4
40	2.5	1.2	1.1	0.35
60	2.2	1.0	1.0	0.3
80	2.0	0.9	0.9	0.28
100	1.8	0.8	0.8	0.25

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Bearing capacity: granular layer over soft clay Verifying design method against a case study

Total load = 115t
 Base area = 4m²
 Pressure on base = 290 kPa
 Bearing capacity of soil ≈ 43 kPa

2.0m square slab

Extremely soft dredged silt

Compacted sand (0.9m)

Compacted crushed rock (0.65m)

3 slabs @ 5t

5 slabs @ 20t

2 layers of Geogrid A

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Bearing capacity: granular layer over soft clay Verifying design method against a case study

$B = L = 2m$

$q_u = 290$
kPa

$H = 1.55m$

Stabilised granular layer

Soft silty clay subgrade
 $s_u = 7$ kPa
 $q_s = 43$ kPa

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Bearing capacity: granular layer over soft clay Verifying design method against a case study

$B = L = 2\text{m}$
 $q_u = 290\text{ kPa}$
 $H = 1.55\text{m}$
Stabilised granular layer
Soft silty clay subgrade
 $s_u = 7\text{ kPa}$
 $q_s = 43\text{ kPa}$

Calculations

$$\frac{q_u}{q_s} = 1 + T \frac{H}{B}$$

$$\frac{290}{43} = 6.7 = 1 + T \frac{1.55}{2}$$

$$\rightarrow T = 7.4$$

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Bearing capacity: granular layer over soft clay Verifying design method against a case study

$B = L = 2\text{m}$
 $q_u = 290\text{ kPa}$
 $H = 1.55\text{m}$
Stabilised granular layer
Soft silty clay subgrade
 $s_u = 7\text{ kPa}$
 $q_s = 43\text{ kPa}$

s _u (kPa)	T (Geogrid A, B/L = 1)	T (No geogrid, B/L = 1)	T (Geogrid A, B/L = 0)	T (No geogrid, B/L = 0)
7	7.4 (Load test)	-	-	-
10	6.0	3.5	3.0	1.5
20	4.0	2.0	1.5	1.0
30	3.0	1.5	1.2	0.8
40	2.5	1.3	1.1	0.7
50	2.2	1.2	1.0	0.6
60	2.0	1.1	0.9	0.6
80	1.8	1.0	0.8	0.5

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Working platforms for tracked plant – BR 470 guideline and a revised approach to design using stabilisation geogrids

- Working platforms are structures which should be designed
- BR 470 provides guidelines and load factors for two load cases
- The method of calculation in BR 470 does not provide for the use of stabilisation geogrids
- This has been investigated starting with fundamental research to establish new constitutive models for the soil/geogrid composite
- This model has been used in an extensive FEA to develop a design method based on the “transfer efficiency”, T
- This is referred to as the T-value method
- The development follows the guidance of BR 470, with the objective of preserving safety, being formulated according to the geotechnical discipline and validated by well documented case studies

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