WORKING PLATFORMS
Design of granular working platforms for construction plant - A guide to good practice

Mark Davies
Director, RNP Associates
Introduction

- Why?
- CPA “Ground Conditions for Construction Plant”
- TWf “Working Platforms”
- Analytical method for EC7
- Other matters
Definition

- Granular platforms for construction operations
- With and without reinforcement/stabilisation
- Carrying mobile construction plant
- Actions from wheels, tracks and outrigger pads
Consequence of Poor Ground Support

- A major cause of overturning resulting in ...
  - Serious injury and fatalities
  - Delays to programmes
  - Potential prosecution
  - Uninsured costs / increased premiums
  - Damage to reputation / loss of business
MEWP / concrete pump
Crawler Crane / Piling Rig
Mobile Cranes / Telehandlers
CPA “Ground Conditions for Construction Plant”

- Sponsored by Strategic Forum Plant Safety Group (SFPSG)
- Started mid 2011 & published late 2014
- Primarily aimed at SMEs and site supervisors
- Coverage of technical matters is necessarily limited
- References TWf document for detailed technical advice
- Free from the Construction Plant-hire Association at www.cpa.uk.net
Load Transfer

- **Rigid Pad Load Central**
  - even load spread
  - reduced deformation
  - increased load capacity

- **Pad Not Rigid Enough**
  - load concentrated in centre
  - excessive deformation
  - reduced load capacity
  - POSSIBLE COLLAPSE!

- **Load Not Central**
  - load concentrated on one side
  - excessive deformation
  - reduced load capacity
  - POSSIBLE COLLAPSE!
Load Transfer - example
Enough bearing area?
Bearing area too large?
TWf “Working Platforms” Guide

- Provide technical guidance not suited to CPA document
- Address the issue of (perceived) excessive platform thickness
  - Reduce cost & time for installation
  - Reduce carbon and waste
- FREE ISSUE advice for all - but particularly for graduates
- New guide positioned with SP123 and BR470
- Develop a consistent analytical method for Eurocode 7 covering design situations not currently provided for
Document overview

- **Section 1 - General Matters**
  - legislation, responsibilities, reliability and economy, HS&E

- **Section 2 – Current Methods & Guidance**
  - Bearing capacity methods, LR1132, SP123, BR470, EC7, in-situ tests, manufacturer’s advice, other guidance, research papers, software

- **Section 3 – Overall Design**
  - Brief, design life, check category, information needed (ground, plant, materials), detailing, info for construction (drawings etc)

- **Section 4 – Analytical Design**
  - Platform mechanics, functional requirements, actions, partial factors, stability calculation methods, recommended method for EC7

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Progress

- TWf Working Group 5 formed January 2013
- Draft for Discussion published for comment end of 2015
- Comments received and (mostly!) incorporated 2016
- Comparative study with existing methods completed 2017
- Final version to be published 2017?
  - Peer review at Imperial College
  - Final proof read & formatting
Analytical Methods

**WITHOUT GEOSYNTHETIC**
  - BS 8004:2015
  - PAS 8812:2015

**REINFORCED / STABILISED**
- BS 8006:2010
  - Manufacturer’s Methods

**NOT CODIFIED**
- soft-firm cohesive or granular single layer
- soft clay single layer

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Overview of analytical methods

- Existing analytical models considered
  - bearing capacity formula & dispersal
  - CIRIA SP123
  - BRE BR470

- All could be used as a basis for an EC7 method (for a plain granular platform)

- Assumptions need to be considered

- Gaps in knowledge need to be considered
Bearing Capacity & Dispersal

- Based on Terzarghi’s approach
- Bearing capacity formula for shallow footings
- Angle of dispersal traditionally taken to be 1h:2v
- With geo-synthetics can be taken to be 1h:1v or better
- Overall Factor of Safety
Bearing Capacity & Dispersal

- Underestimates maximum vertical pressure on formation
- Doesn’t consider horizontal shear on formation
- Doesn’t consider strength of platform
- Doesn’t consider variance in angle of dispersal
Based on Milligan, Jewell, Houlsby & Burd

Lateral shear on the formation reduces bearing capacity

Geo-synthetic resists lateral shear for full bearing capacity

Considers strain (Geo-synthetic strength at 2-5% strain)

Partial factor method considering ULS and SLS
CIRIA SP123

- Only applies to soft clay sub-grades
- Ignores friction between load and top of fill
- Ignores $\delta$ when assessing $K_a$ and $K_p$
- Relatively arbitrary guidance on $\beta$

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BRE BR470

- Based on Meyerhoff & Hanna
- Adopts a ‘punching’ failure model
- Geo-synthetic enhances the punching shear capacity
- Empirical load factors & “strain” factor on geo-synthetics
BRE BR470

- Applicable for cohesive and granular sub-grades but limited cohesive sub-grade limited ($c_u=20-80$kPa)
- Limited to single soil layer
- Ignores overburden of platform
BR470 - Problem with FoS

- BR470 1.6/1.2 for plain platforms
- EC7 combination 2 controls
- EC7 will allow for load case 2
  
  *EC7 cl2.4.7.1(5) Less severe [factors] than those recommended ... may be used for temporary structures ... where the likely consequences justify it.*

- Lumped factor exceeds BR470
  - 1.8/1.4 for cohesive subgrades
  - 3-4 for granular sub-grades!

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<tr>
<th></th>
<th>EC7</th>
<th>BR470</th>
<th>SP123</th>
</tr>
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<td>$\gamma_\alpha$</td>
<td>1.30</td>
<td>1.05-2.00</td>
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<tr>
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<td>n/a</td>
<td>2.00</td>
<td>1.5-2.00</td>
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SP123 – Problem with $\beta$

- Traditionally accepted as 1H:2V (Terzaghi)
- Physical tests suggested values up to 50°
- Numerical analysis (Burd & Frydman) provided a numerical derivation for cohesive sub-grades
  - very small values for strong sub-grade
  - larger values for soft subgrade
- No comparable method for a granular sub-grade

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Solving the $\beta$ Problem

- Use Boussinesq maximum effective pressure / effective area
  - Applies to all subgrades
  - Avoids having to determine $\beta$ directly
  - Can be extended to multiple soil layers
Basis of TWf Method

- Adopt SP123 model
  - Closer to the actual mechanism
  - Potentially adaptable for use with geo-synthetics
- Use Boussinesq maximum effective pressure / effective area
- Use $\delta$ from derivations by Hanna & Meyerhoff (for $K_a$ & $K_p$)
- Use benefit of overburden term (if appropriate!)
- Determine sub-grade capacity from EC7 / BS8004
- Presumed platform material capacity from BS8004
Comparative Study

- Comparing platform thicknesses derived from BR470 and bearing capacity with proposed TWf method
- 4nr load case 1 models, 3nr load case 2 models plus load models from BR470 worked examples
- 2nr each cohesive sub-grade strengths, granular sub-grade strengths and platform material strengths
- Total of 18nr case 1 combinations and 16nr case 2 combinations for each type of sub-grade
Granular – load case 1
Granular – load case 2

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Cohesive – load case 1
Cohesive – load case 2

The graph shows the relationship between BR470 platform depth (mm) and platform depth (mm) for Cohesive, Case 2, BR470 baseline, all results. The graph includes different lines and markers for load cases with FoS=2.0, FoS=1.5, and TWf, with linear approximations for each load case.
Use of tolerable settlement?

- Use of immediate settlement calculation
- Not current practice
- Insufficient ground data?
- May offer a suitable alternative for soft ground
- May become required as EC7 becomes fully adopted?

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Further Economy?

- Directly derived values allow reduced factors or more favourable parameters
- Providing greater ‘certainty’ = more economical platforms
  - Plant loadings – quality of data, actions, dynamics
  - Platform properties – specification, testing, inspection & maintainance
  - Sub-grade properties – better ground investigation
TWf Analytical Method offers
- EC7 compliant method
- Solution for multiple soil layers
- Economy for granular sub-grades

Possible further research may include
- Reliable small scale site tests for platforms?
- Determination of $\beta$ for granular sub-grades?
- Adaptation for use with geo-synthetics?
A question for you ...
... good practice?
QUESTIONS?