Verification of pile modelling technique in *FLAC3D*

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Scope

- Is the performance of the "*FLAC3D pile element*" dependent on the mesh configuration?
- What are the mesh configuration rules to achieve optimum performance?
- Benchmarking with:
  - results of the "*FLAC3D liner element*" and conventional pile analysis software;
  - results of conventional pile group analysis software.

Investigatory Single Pile Analysis

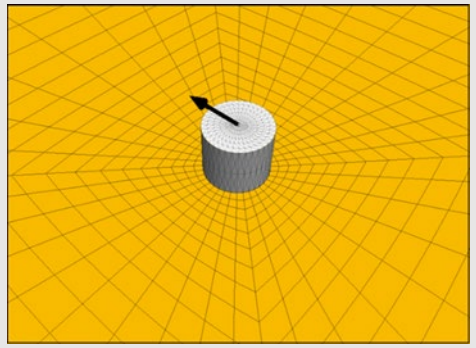
1200mm diameter single pile in elastic soil subject to lateral loading:

- **Model A:** Pile modelled with "*FLAC3D liner element*"
- **Model B:** Pile modelled with "*FLAC3D pile element*"

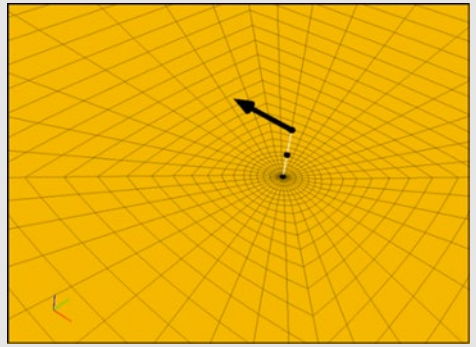
Both models adopting the same mesh

and the same loading

Model A

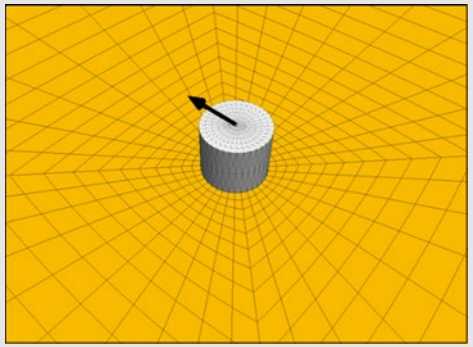


Model B

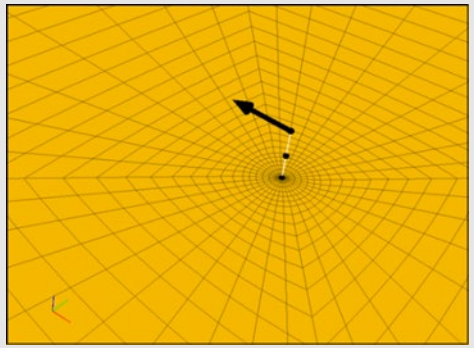


Findings of Single Pile Analysis

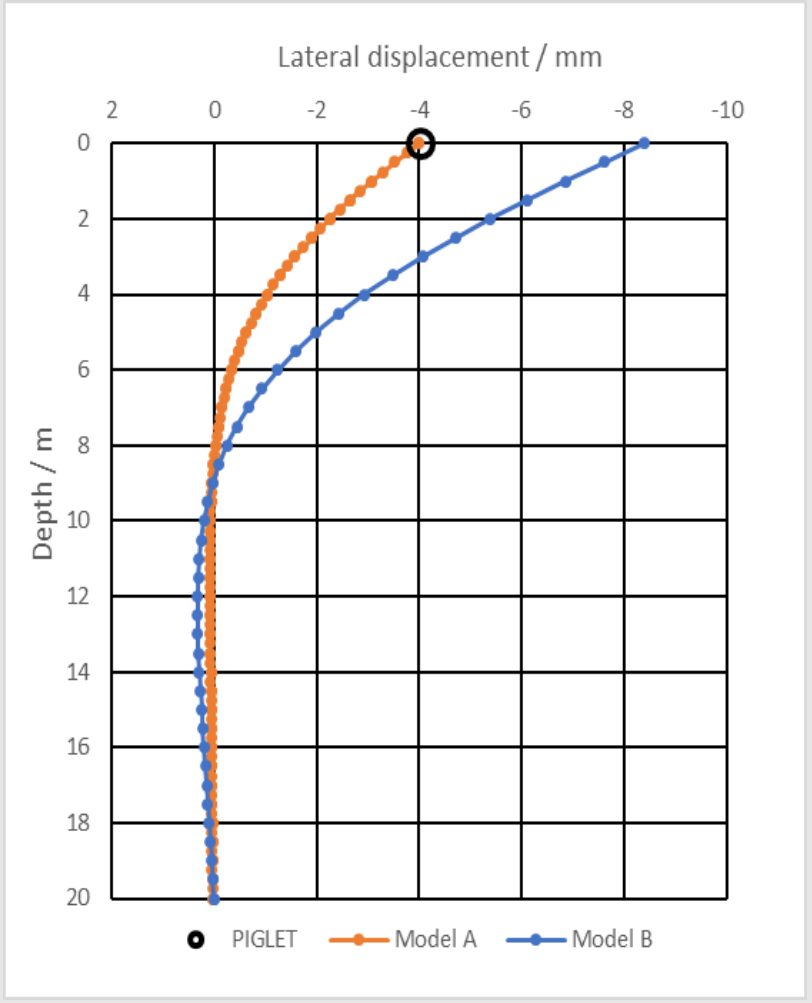
- Lateral deflection of Model B significantly higher than that of Model A
- Conventional pile analysis software *PIGLET* gave matching results to Model A – Issues with Model B?



Model A



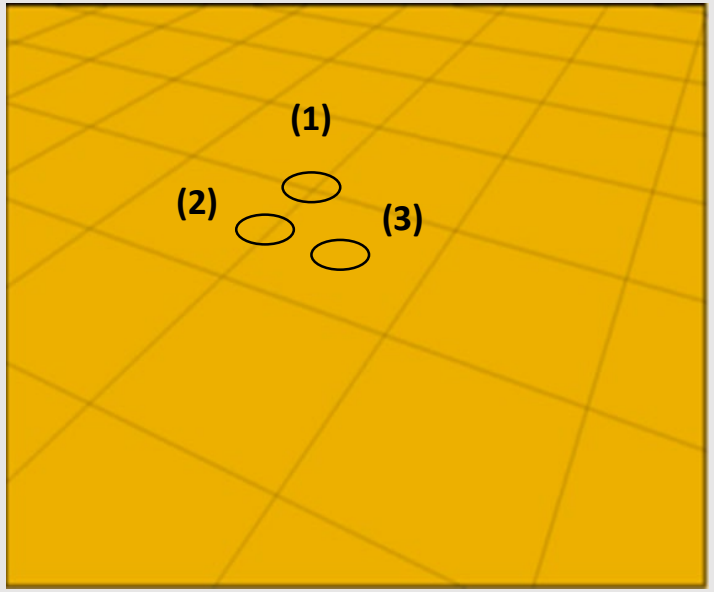
Model B



Further investigatory analyses

Additional analyses carried out:

- with different grid size "*block mesh*"
- using "*FLAC3D pile elements*"
- pile located at various relative positions to the "*block*"



Location of pile

(1) Junction of 4 adjacent blocks
(2) Edge between 2 adjacent blocks
(3) Centre of a block

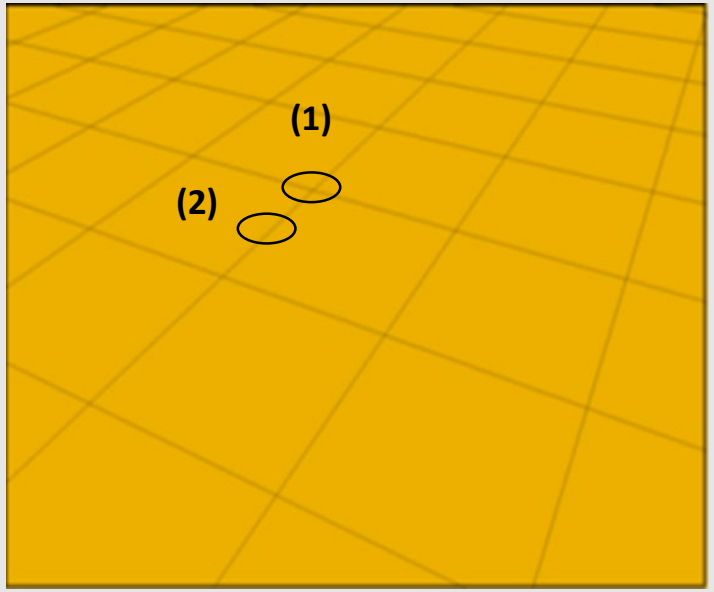
Findings of investigatory analysis

Finding ONE

Location of "pile element"

- at the edges or at a junction of a "*block*"-

produced different results depending on the direction of lateral loading



Location of pile

(1) Junction of 4 adjacent blocks
(2) Edge between 2 adjacent blocks

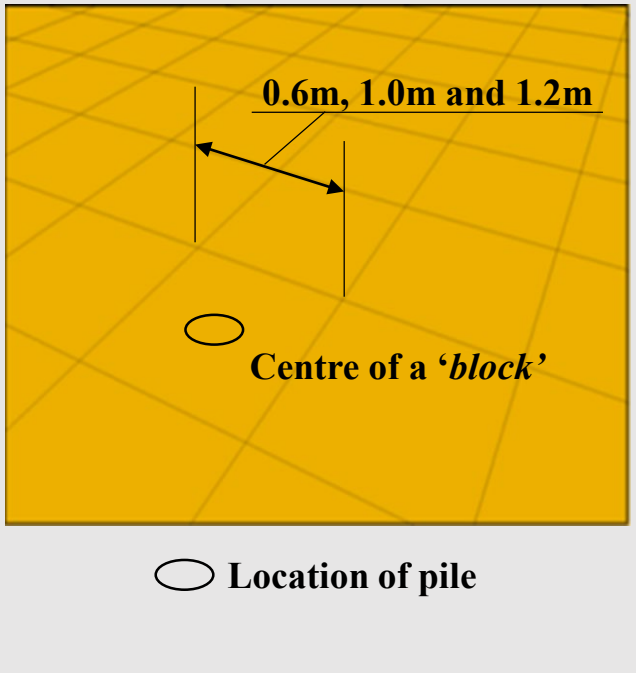
Findings of investigatory analysis

Finding TWO

Sizing of the "Block" in relation to the pile diameter (1200mm)

- **1200mm** square *"Block"* (in plan) mesh predicted lower deflections and bending moments compared to **Model A** results
- **600mm** square *"Block"* (in plan) mesh predicted higher deflections and bending moments compared to **Model A** results
- **1000mm** square "*Block*" (in plan) **[section area of the "*Block*" matches cross-sectional area of the pile]** showed good match in bending moments and deflections to **Model A** results.

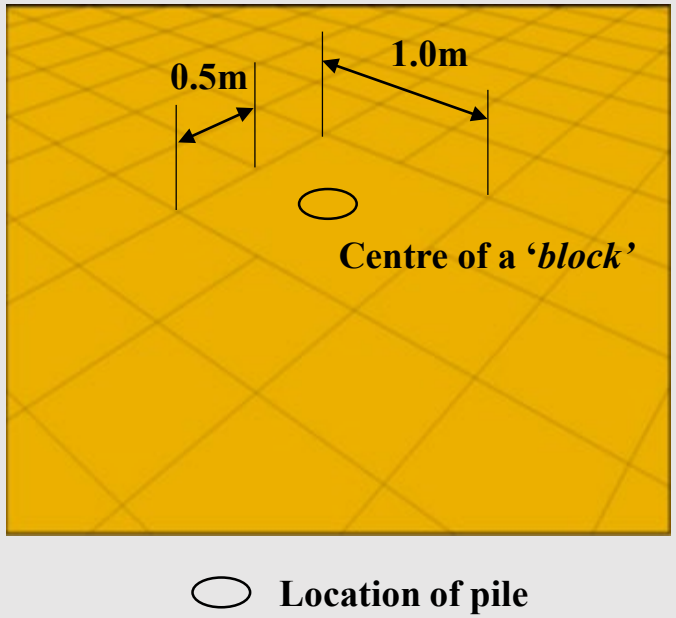
Model C



Further investigatory analysis

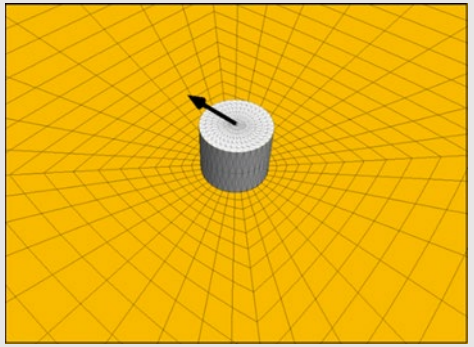
- Further analysis with zones surrounding the central *'block'* discretized with 0.5m x 0.5m mesh (Model D)
- Elastic soil and Mohr-Coulomb soil cases considered

Model D

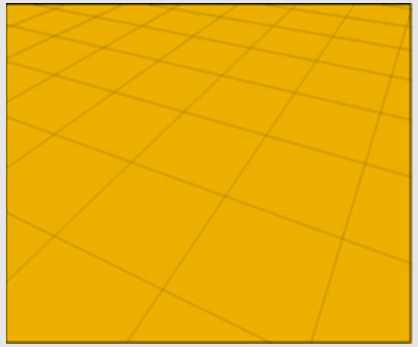


Summary of Single Pile Results

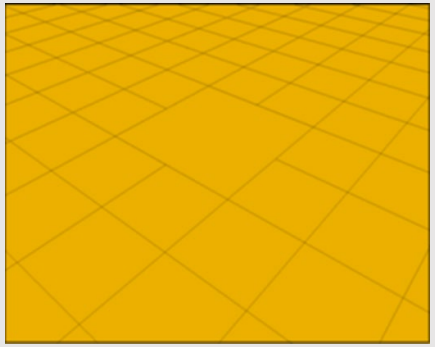
Model A



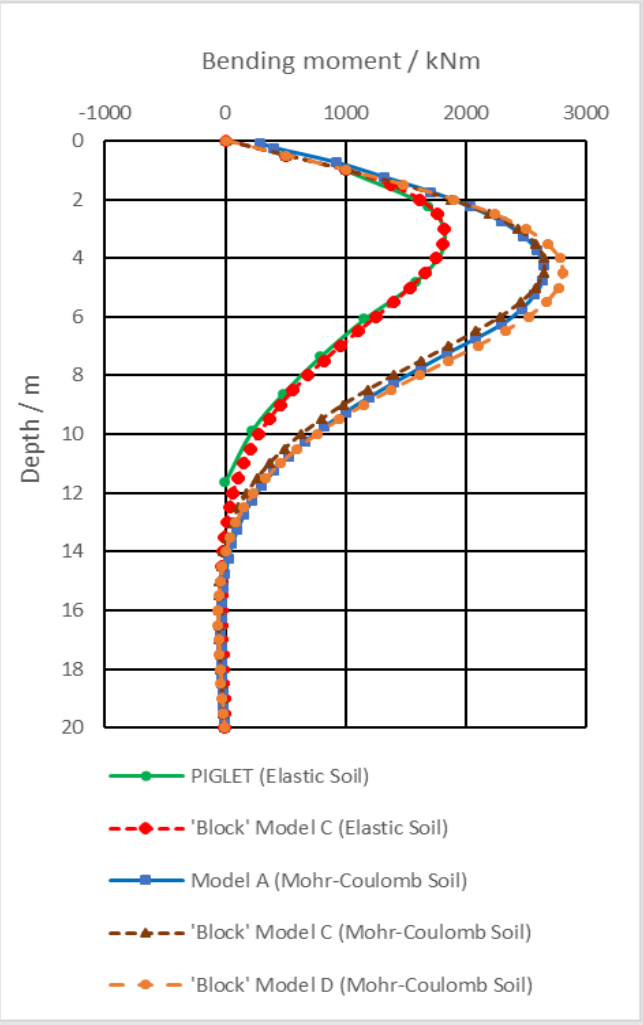
Model C



Model D



- Model A: Pile modelled with "*FLAC3D liner element*"
- Model C: Pile modelled with "*FLAC3D pile element*" at the centre of 1.0m x 1.0m '*block*' surrounded by 1.0m x 1.0m mesh
- Model D: Pile modelled with "*FLAC3D pile element*" at the centre of 1.0m x 1.0m '*block*' surrounded by 0.5m x 0.5m mesh



Summary of Single Pile Results

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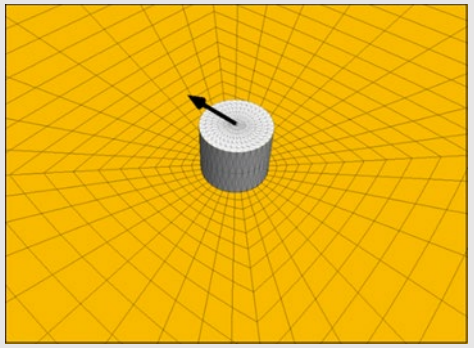
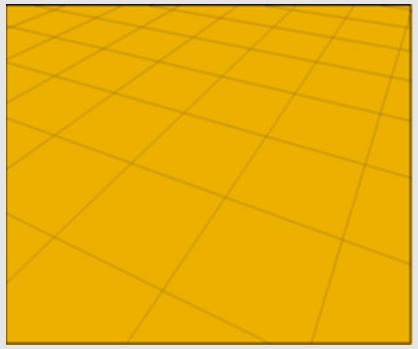
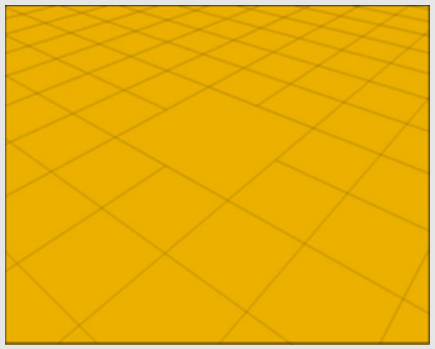


Model C



Model D



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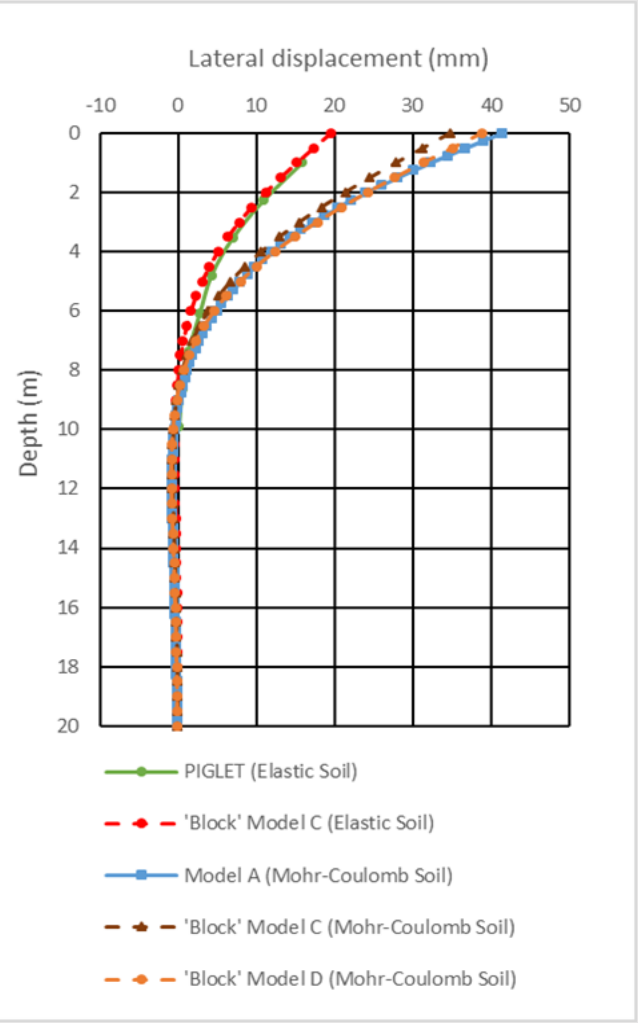


Single Pile Investigatory Analysis Conclusion

- Performance of modelling piles with "*FLAC3D pile element*" is dependent on mesh configuration.
- In "square-block" FLAC3D model, best performance could be achieved when modelling piles with "*FLAC3D pile element*" provided

  - the plan area of the "*block*" in which the pile is located matches with the actual cross-sectional area of the pile

  - the pile is located away from the "*block*" boundaries, preferably near the central region of the "block"

  - the "*blocks*" surrounding the "*block with pile*" could be formed using finer grid to improve accuracy

Verification with Pile Group Analysis

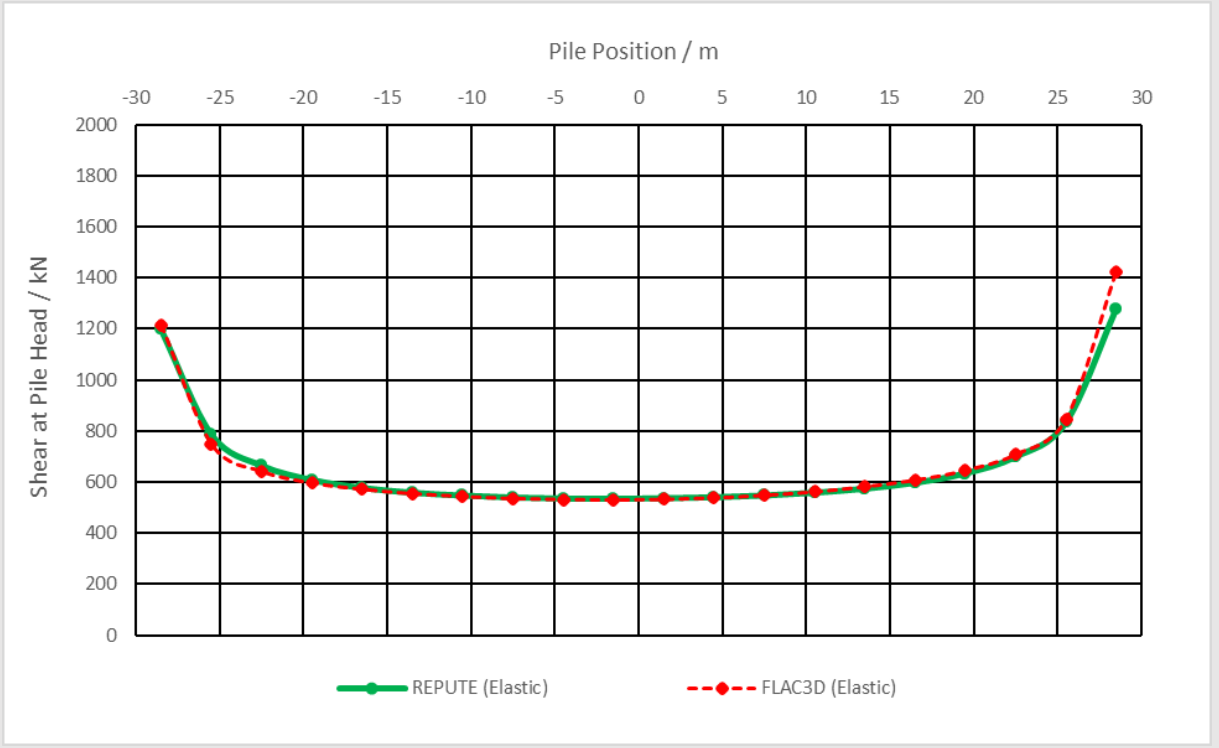
The **Rules** established for single pile modelling were extended to pile group subjected to lateral loading adopting Model D configuration with:

- Elastic Soil
- 66 piles modelled
- 60m x 15m with 2m thick concrete pile cap
- 4 rows of irregularly spaced piles
- Lateral load applied to pile cap 66,000 kN

Results of Pile Group Analysis

Shear load distribution at the pile head compared with the results of conventional pile group analysis program *REPUTE*.

Encouraging matching results demonstrate the validity of single pile modelling RULES.



Summary

"FLAC3D pile element" can be used successfully to model single pile and pile groups by appropriately configuring the *FLAC3D* mesh:

Rule 1: adopt a square grid in plan with a single grid area equivalent to the physical cross-sectional area of the pile.

Rule 2: locate the pile element near the central region (away from the grid boundaries) within the grid in which the pile is located.

Rule 3: improved accuracy could be achieved by adopting a finer grid surrounding the zones in which the piles are located and thus to suit the overall modelling requirements.

Any Questions Please