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The performance of a monopiled gravity based structure in cohesionless soil

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Background

- The monopiled-GBS structure (MGBS) is essentially a conventional GBS structure with a projecting monopile or caisson for offshore foundation applications.
- The GBS is rigidly connected to the monopile and the system relies on the self-weight of the GBS to drive the projecting monopile into the seabed for potential deep water deployment. After installation additional ballast can be added to the GBS.
- Previous studies by Stone & Diakoumi (2021), Stone *et al* (2018) and Arshi (2016) of a coupled MGBS or monopiled-footing in cohesionless soil have shown that the GBS or bearing plate should develop a positive contact with the underlying soil and thus the applied vertical loads should exceed the vertical pile capacity.
- Stone & Diakoumi (2021) presented results of a physical model study on MGBS in sand.

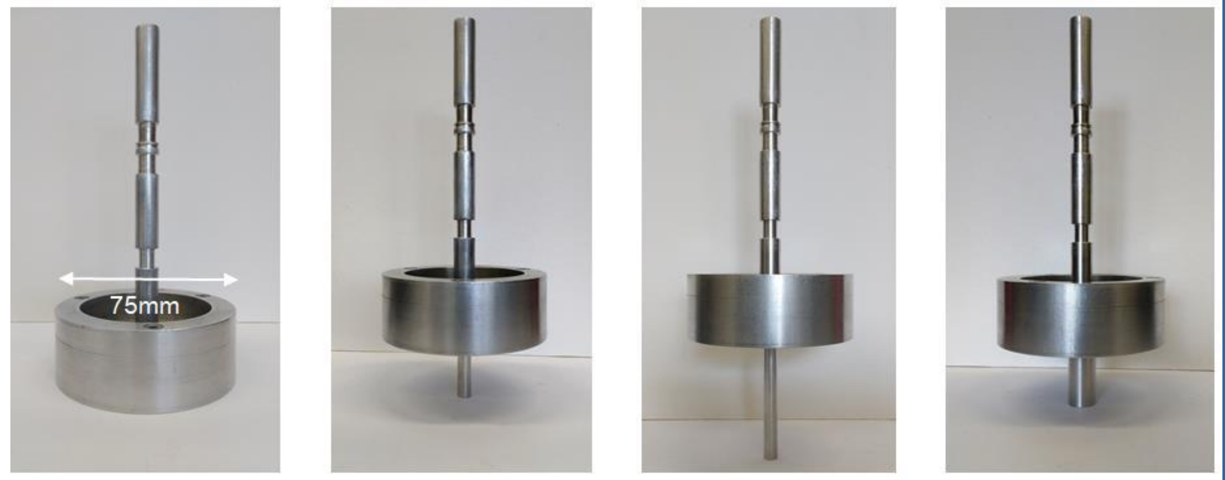


Figure 1: Typical GBS and MGBS arrangements

Aim

This study investigates the performance of MGBS under monotonic loading in sand using three dimensional finite element modelling.

Methodology

- Plaxis 3D by Bentley is used in this study. A very dense sandy soil bed (Dr=90%) is initially modelled.
- The mast and GBS are modelled and installed for test 1; the mast, GBS and monopile of various geometries are installed for the rest of the tests.
- The numerical model for GBS is calibrated against the physical modelling results presented by Stone & Diakoumi (2021). The MGBS is designed to be self-installing and thus sufficient vertical weight is placed on GBS to overcome the installation resistance of the monopile.
- A lateral force is applied at the mast.

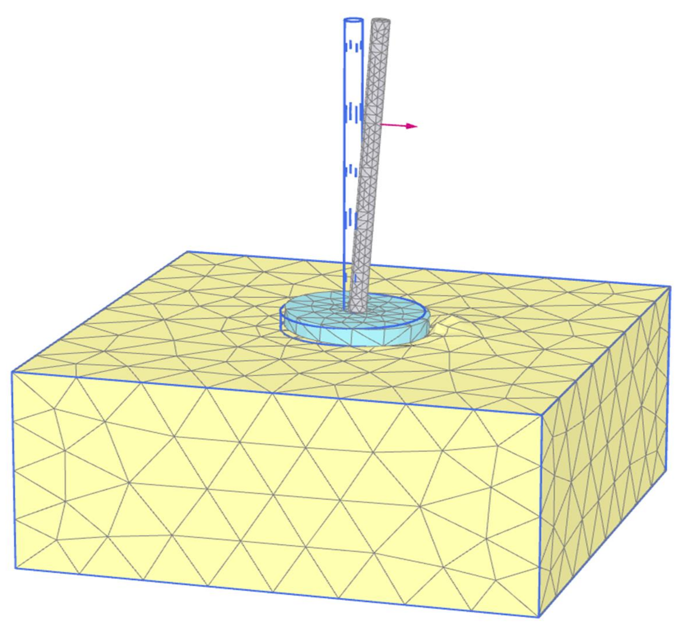
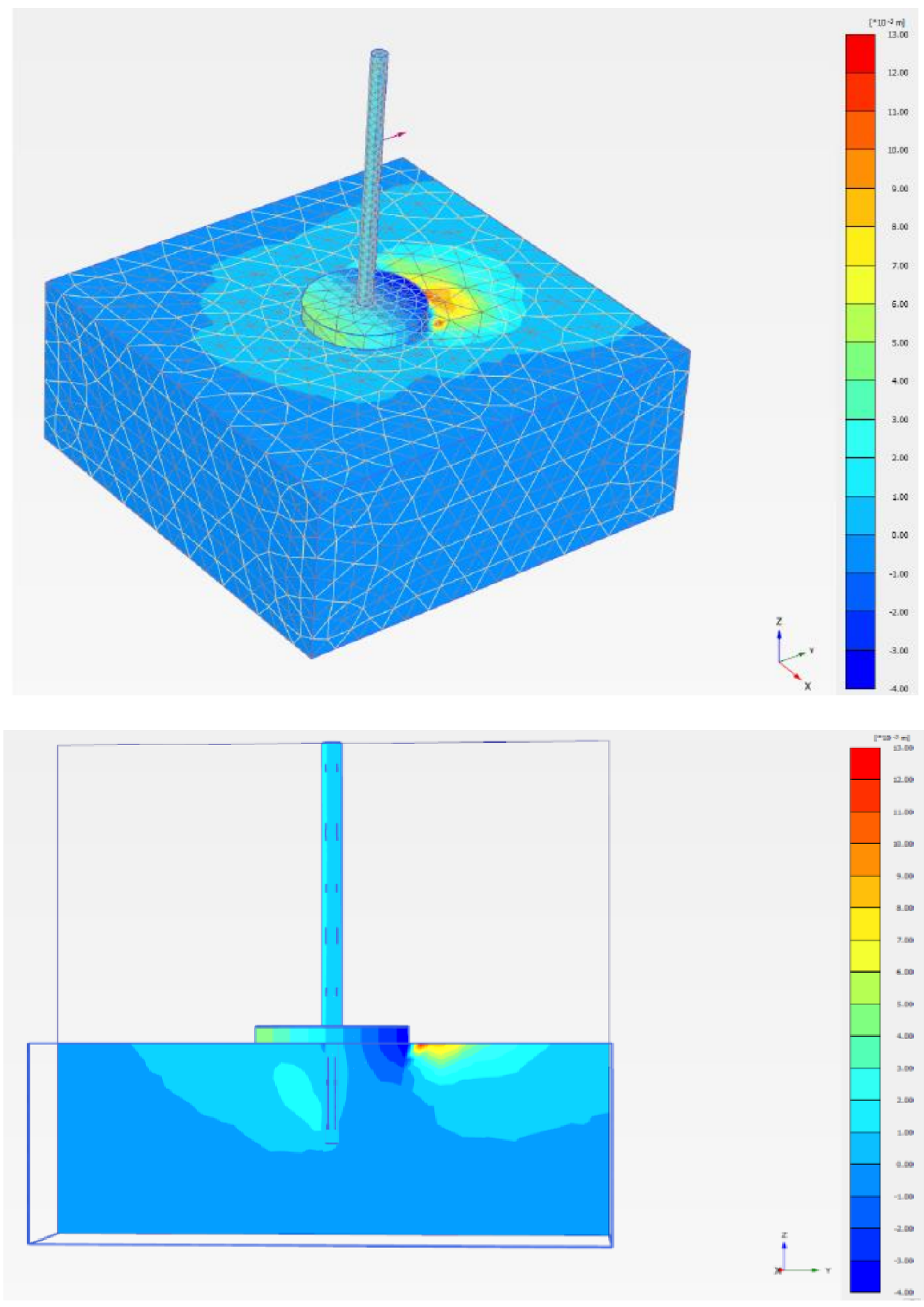


Figure 2: Numerical model of soil bed and MGBS. Lateral force applied at mast.

Results

- Lateral load versus lateral displacement curves are plotted for all models (fig. 5).
- Numerical results show good agreement with the experimental results presented by Stone & Diakoumi (2021) (fig.5).
- The response of the GBS alone is dominated by friction.



Figures 3 & 4: Distribution of lateral displacements in one of the MGBS numerical models (D6 L60)

- The addition of a monopile to the GBS has a significant beneficial effect on the lateral capacity of the GBS (fig. 5)
- The effect of the addition of the pile is more significant for the longer pile where the greater lateral resistance of the pile combines with the lateral resistance of the GBS to produce a greater ultimate capacity.
- Assuming the same amount of positive contact between the GBS and the underlying soil, doubling the length of the monopile results in almost 100% increase in the ultimate lateral capacity of the MGBS.

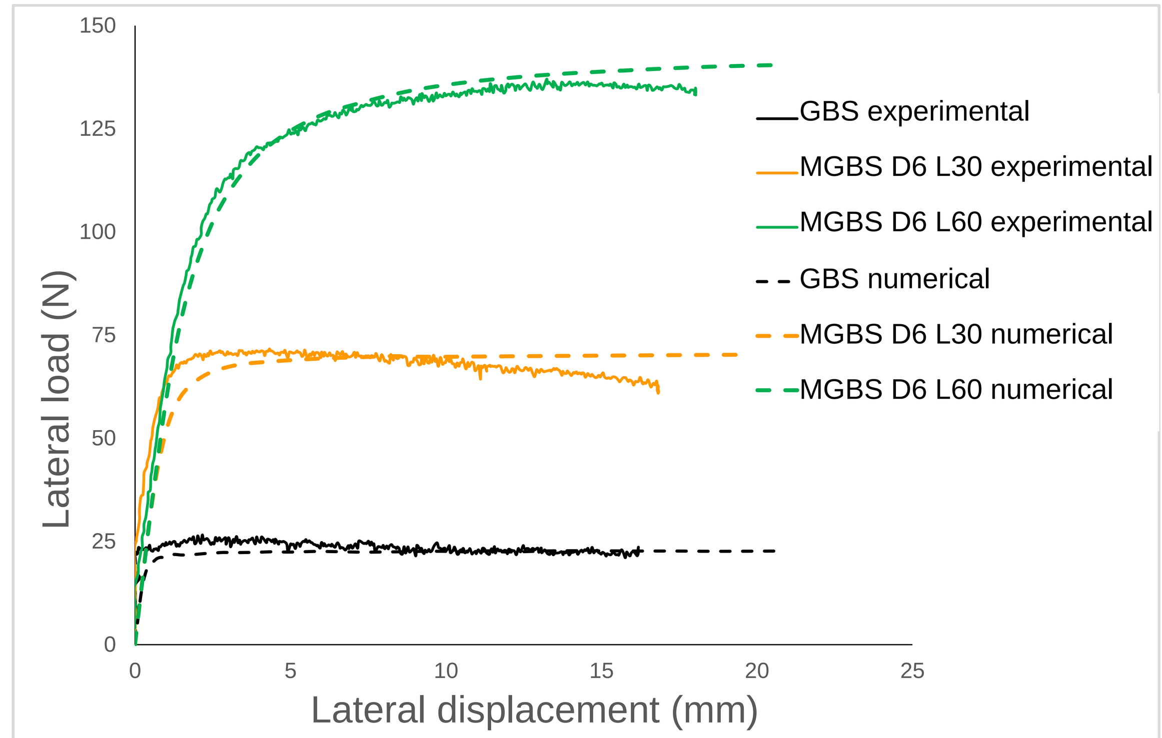


Figure 5: Experimental and numerical results of lateral load vs lateral displacement for GBS and MGBS models.

Conclusions

- Numerical results on MGBS models have shown vey good agreement with physical modelling results.
- The ultimate lateral capacity of the GBS can be significantly enhanced by the presence of a monopile extending beneath its base.
- Increasing the length of the pile increases the ultimate lateral capacity but reduces the overall lateral stiffness.

References

- Stone, K. & Diakoumi, M. (2021).Performance of a self-installing monopiled gravity base structure under lateral loading. International Journal of Physical Modelling in Geotechnics. 21, (5), p. 268-274.
- Stone, K., Tillman, A. & Vaziri, M. (2018). An investigation on the performance of a self-installing monopiled GBS structure under lateral loading. *Proceedings of 9th International Conference on Physical Modelling in Geotechnics.* London, ISBN 978113855975.
- Arshi H.S. (2016). Physical & numerical modelling of hybrid monopile-footing foundation systems. PhD thesis, University of Brighton.

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