

Talk on “Challenges Related To Offshore Foundations – NGI Experience”

by Dr. Gue Chang Shin



Dr. Gue Chang Shin is currently a Committee Member of IEM Geotechnical Engineering Technical Division (GETD). He was formally with Norwegian Geotechnical Institute (NGI) in Norway and is currently attached with NGI-G&P in Malaysia.

It was a great honour for the Geotechnical Engineering Technical Division (GETD) of IEM, to have Mr. Karl Henrik Mikklebo, the Director for Offshore Energy of the Norwegian Geotechnical Institute (NGI), to deliver an IEM GETD evening technical talk at the Tan Sri Prof. Chin Fung Kee Auditorium, Wisma IEM on 22nd October 2013. The talk was chaired by Engr. Dr. Gue Chang Shin and attended by 75 participants.

The speaker started with a slide showing the winter storm conditions acting on an offshore oil platform indicating the harsh conditions a platform may be subjected to during a storm. The type of foundations for such conditions has to be designed carefully. The audience were informed that the oil and gas industry is moving into deeper water (>500m). In conditions where fixed platforms are no longer feasible; floating production & storage facilities and fixed subsea systems have been developed.

The speaker highlighted that new foundation concepts require new geotechnical solutions and additional soil parameters. The undrained shear strength, s_u depends on loading conditions and strain rates or time to failure and cyclic properties of soil are crucial in the design. Figure 1 shows the elements along a failure surface follow different stress paths; in which can be simulated by triaxial compression & extension and Direct Simple Shear (DSS) tests.

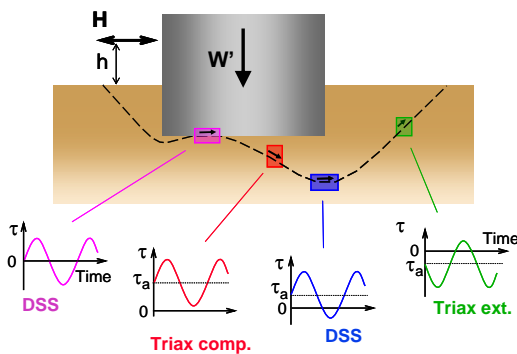


Figure 1: Potential failure surface beneath foundation under vertical, horizontal and static moment & cyclic loads.

The speaker continued his talk on Gravity Based Structure (GBS) foundations. A GBS foundation is placed on a site in a matter of days in contrast to onshore foundations where loadings increase gradually during the construction period. This leads to various geotechnical considerations for design.

of GBS foundations which include, skirt penetration analysis for platform installation, analysis of load transfer from structure to the soil and cyclic loads.

The speaker moved on to offshore pile foundations. The geotechnical considerations for offshore pile foundations include; estimation of soil resistance during driving, self-weight penetration and initial stability, pile driving response and time effects on axial pile capacity. NGI has considered time effects on piles in several projects related to re-evaluation of bearing capacity or life time extension of platforms. Time effects shall be used with caution, taking into consideration of loading history and cyclic loading during the life time of the pile foundation.

The speaker continued on jack-up platforms (Figure 2). The geotechnical considerations for jack-up platforms include spudcan penetration analysis, stiffness of footing and the cyclic effects on foundations. There are various on-going studies at NGI such as, interaction between jack-up spudcan foundation and adjacent piled foundation, and interaction between jack-up spudcan foundation and adjacent pipelines.



Figure 2: Jack-up platform

The speaker moved on with anchors for mooring of offshore floating structures. He introduced various anchors used such as, suction anchors (Figure 3), plate anchors (Figure 4), torpedo anchors (Figure 5) and fluke anchors (Figure 6).



Figure 3: Suction anchor



Figure 4: Plate anchor



Figure 5: Torpedo anchor



Figure 6: Fluke anchor

A suction anchor is a large diameter cylinder; open-ended at the bottom and closed at the top. The suction anchor is installed by applying under-pressure ('suction') to its interior after it is allowed to penetrate under its own weight. The difference between the hydrostatic water pressure outside the cylinder and the reduced water pressure inside provides a differential pressure that acts as a penetration force in addition to the weight.

A plate anchor is installed by dragging the anchor through the soil or by pushing it in by gravity and/or underpressure. Fluke anchors are installed by dropping on the seabed and pulled to

installation depth. Design considerations include, accuracy of the position after dropped & pulled in the seabed and pulling capacity from the installation vessel.

Torpedo anchors are free fall piles that have the advantage of being easier and faster to install. The holding capacity will depend on penetration depth. The capacity analyses must evaluate the disturbance in the soil around the pile from installation and the amount of set-up with time. Torpedo anchors are not likely to be fully vertical at the end of penetration, and the effect of inclination at the end of penetration must be taken into account in design.

The speaker reminded that cyclic loading shall be considered in design. A video of a monster wave (up to 20m high) was shown impacting on an offshore platform. The importance of cyclic loadings for the offshore foundation design is again emphasised.

The speaker then moved on to offshore wind towers (Figure 7). Wind towers are slender and in large numbers covering a large area while oil platforms are usually a single big and robust unit. New subsurface investigation strategies have to be used as they involve a large area in variable ground conditions. A combination of geophysical survey and geotechnical investigation can be utilised.

NGI recently developed a constitutive model, the UnDrained Cyclic Accumulation Model (UDCAM) for the calculations that account for strength and stiffness degradation due to cyclic loading. This has been used in design of monopiles for the wind towers which leads to more economical design compared to conventional design approach.

The speaker introduced the concept of pre-piling (Figure 8) for offshore wind towers, in which installation of piles using mobile piling templates. Pre-piling is a cost efficient concept but requires precision during piling and under water metrology.

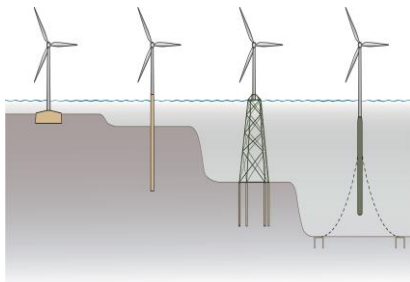


Figure 7: Types of wind tower



Figure 8: Pre-piling

The speaker brought us from the past up to the forefront of offshore foundations, enlightening us with the challenges and geotechnical considerations for various types of offshore foundations. The importance of cyclic loadings in design of offshore foundations was also highlighted. The technical talk ended with rounds of applause from the audience at 7:00pm, the appreciation momento was presented by the technical division deputy chairman, Ir. Yee Thien Seng to Mr. Karl Henrik Mokkelbost (Figure 9).



Figure 9: Presentation of momento and certificate of appreciation to Mr. Karl Henrik Mokkelbost by the technical division deputy chairman, Ir. Yee Thien Seng