

Casing mounted method used for geotechnical drilling in Lavan

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ABSTRACT: The paper aims to present a modified casing mounted method for geotechnical drilling used in Persian Gulf. The present geotechnical investigation was undertaken for a SBM project which is located at 4.5 km South-West of Lavan Island in a water depth of 55 m. The geotechnical investigation of the project includes the drilling of 5 boreholes, undisturbed sampling and also CPT probing adjacent to boreholes. The depth of boreholes into the seabed was 60 m.

A floating barge of 12000 kN was utilized for geotechnical investigation. The horizontal movements of the barge were minimized by means of mooring anchors. Tension forces of mooring cables were measured during the drilling operation to predict any horizontal movement of the barge. The vertical movements were compensated by installing the drilling machine on a modified vertical casing pipe.

The following results were achieved out of successful implementation of the project:

- Accurate active control on horizontal movements of the barge by four anchors and force measurements were successfully experienced.
- A light casing mounted method for installation of drilling system was designed and experienced.

1 INTRODUCTION

1.1 *Marine geotechnical investigation in Iran*

Considering the existence of offshore resources of oil & gas in Iran, a large number of geotechnical investigations have been implemented in Persian Gulf. Borehole drilling and undisturbed sampling in water depth of less than 20m are generally implemented using jack-up barges (*Fagher & Pahlavan, 2000*) in Persian Gulf and Caspian Sea for near shore projects. Lessons learned from using jack-up barges for geotechnical drilling in Iranian waters have been described by Fagher and Pahlavan (*2000*.) Qualitative investigations and disturbed sampling into very deep water have been also performed in Caspian Sea in a water depth of about 700m using shallow samplers.

For high quality geotechnical drilling and sampling in water depth of more than 20m, it is common practice to install the drilling machine on a floating vessel and to use an appropriate heave-compensator. Heave compensators can isolate drilling bits and

sampling devices from the vertical movement of the floating vessel due to fluctuation of water. When a floating vessel is used, drilling is usually undertaken through a moon pool at the centre of vessels. A seabed frame is also used to perform CPT. For the presented geotechnical investigation; it was not possible to adopt common methods of practice to isolate drilling bits and sampling devices from the movement of the vessel. The use of a conventional seabed frame was not also practical due to a very soft surface layer encountered.

Geotechnical investigations at the site of the SBM project, 4.5 km on South-West of Lavan Island, a famous island for its oil and gas related projects in the area, were due to be performed by Falat-e-Ghareh Oil Company, a subsidiary of National Iranian Oil Company. These investigations consist of reconnaissance survey of pipeline route (4.5 km long from Lavan to the site), and geotechnical investigation of SBM installation site (1.5 by 1.5 square km). Water depth was 55m at SBM installation site and the depth of boreholes into the seabed was 60 m. The use of underwater piles was considered as an alternative to anchor SBM.

1.2 Installation methods for drilling Equipments in Sea

The installation of geotechnical drilling equipment in sea must be normally carried out over a kind of fixed or floating platform. The applied platforms are of three types (*Mori, 1981*):

- Platforms supported by ground which are jack-up barges, fixed platform or temporary scaffoldings.
- Immersed platforms which are placed under water and drilling are controlled by divers or carried out by means of a remote control system.
- Floating vessels which are used with a heave compensator and also an appropriate mooring system to control vertical and horizontal movements.

The use of floating vessels is the most common method of installation for drilling equipments in deep waters. Heave compensators are used to isolate drilling bits and sampling devices for the vessel. A heave compensator also minimizes the pressure variations on the drilling bit and the disturbance of soil under the bit. A heave compensator is, in fact, a combination of some springs and dashpots (*Chaney, 1991*), which are connected to drilling rod to exert a certain tension force. This causes the transfer of a part of drilling rod weight to the deck of the vessel through an A-frame.

2 THE APPLIED SYSTEM IN LAVAN SBM PROJECT

2.1 Used Barge

The local availability of equipments and environmental conditions, including wave climate and seabed condition could substantially affect applied system in geotechnical investigations. The applied method in the geotechnical investigation of Lavan SBM project was based upon a general feasibility study conducted one year before the commencement of Lavan project for similar conditions in the region (*SAHEL Consultant Engineers, 1997*).

To implement the geotechnical investigation of the project, a barge of 12000 kN, as shown in Figure 1, was utilized. The barge is 42.2m long, 12.1m wide, 3m high; it has a draft of 0.5m. The required geotechnical equipments, power supply and personnel's recreational facilities were provided on the barge. A crane was also placed on the barge to perform required lifting for the drilling process and supporting activities.

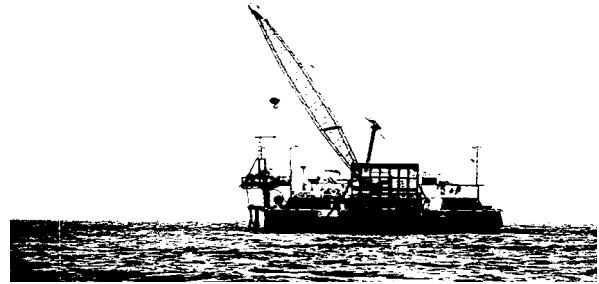


Figure 1: The barge used in Lavan SBM Project

2.2 The control of horizontal movements

Using 4 or 6 anchors and mooring cables, with sufficient length, it is possible to fix drilling floating vessels on sea in water depths of maximum 300m (*DeFruiiter & Richard, 1983*). For very deep waters, it is more common to take the advantage of dynamic positioning.

In LAVAN Project, 4 anchors of 700 ton were applied to control the horizontal movements of the barge. Horizontal motion were measured with resolution of 10 mm using differential positioning system (DGPS). Total horizontal limits of the platform were +0.5m during the operation. The drilling had to stop when the horizontal limits were reached. Considering very soft seabed encountered, the shape and weight of the anchors were designed in a way that horizontal component of the mooring cables forces could be supported. The design of the anchor shape was out of the scope of presented paper (*SAHEL Consultant Engineers, 1998*). To install anchors, a tug boat was utilized. However, the installed anchors and cables were in a loose condition before wind, wave or current forces to be applied on the vessel. A fairly large horizontal displacement of the vessel would be required to convert mooring cables from loose to tight condition. Such a horizontal movement should be minimized to prevent any damage to drilling system. Therefore the pre-stressing of mooring cables was considered after the anchors installation. To create pre-stressing force through mooring cables, an electric winch was used. However the length of the cables should be continuously adjusted within tide periods. Therefore, measurements of the cable forces were undertaken to perform appropriate actions for the length adjustments of the cables. Considering the measured forces, any considerable barge movements were predicted and loosening or tightening of the cable were implemented before any considerable horizontal movement. In order to monitor displacement of the barge,

differential Position System (DGPS) was also used on the barge. Using the above mentioned method, it became possible to control the horizontal movements of the barge; in a way that drilling from seabed surface down to the depth of 60m, into the ground, came to practicability.

2.3 Drilling System and Control of Vertical Movement

Wire line boring rods were utilized for drilling. The external diameter of the rod is 88.9mm and the internal diameter, 77.8mm. Wire-line system proved to be successful to facilitate the drilling process. A borehole of 60m deep was drilled within 48 hours.

The hired barge did not have any moon pool so the drilling machine was installed on the side of the barge, Figure 2.

When a heave compensator is used, the drilling should be stopped even in a moderately rough sea conditions to prevent any harm to drilling operations. Available heave compensators could not isolate drilling rod from floating barges vertical fluctuations in a moderately rough sea conditions. To isolate fully the drilling machine from the vertical movement of the barge, the drilling machine was installed on a modified vertical casing pipe (Diameter=300mm). The casing was sited on the seabed using an special footing, designed for very soft seabed. It would be very difficult to handle large casings in offshore conditions so any diameter larger than 300mm was not accepted for the casing because of practical handling difficulties involved. However, such a small cross section of casing is not adequate to support the weight of drilling equipment and also the self-weight of the casing in a water depth of 55m. The casing is too long. To increase buckling capacity of the casing, a cylindrical steel tank, shown in Figure 3, was attached to the casing to prevent buckling. The submerged steel tank was fixed at the level of 10m below water surface and creates an upward vertical force on the casing. The system is schematically shown in Figure 4. The buckling of casing was prevented because the main length of the casing was in tension when the tank was fixed. This caused that the pipes of 30 cm/300mm with a thickness of 6mm could support vertical loads.

The drilling machine was installed on a platform on the top of the casing but the power unit was placed on the barge. The power was transferred via the linking cables/hoses to the drilling motor. The drilling personnel worked on the platform, as shown in Figure 2, on the top of the casing. Drilling rods were pushed down through the 12inches casing. A crane was used to help the erection and drilling processes.



Figure 2: The side drilling platform on the top of the vertical casing pipe.



Figure 3: Cylindrical steel tank fixed to the casing pipe to prevent buckling

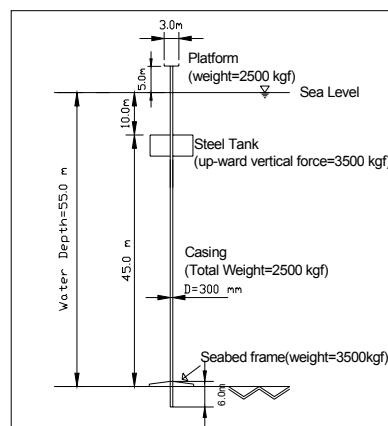


Figure 4: The schematic of steel tank and seabed frame

2.4 Sampling and In-Situ Tests

Borehole drilling was carried out by continuous coring. The ground materials were mostly silt and clay, with high percentage of carbonate, increasing in stiffness by depth. Thin-walled sampler went down

through HQ tubes and took samples, using the exerted pressure.

Seabed frame was difficult to be used for CPT probing because of the very soft seabed condition. Therefore, CPTs were undertaken from the platform fixed on the top of the casing. To provide required reaction force for drilling and CPT, a seabed reaction footing with the area of about 4 m² and weight of 3.5 ton, shown in Figure 5, was built. Due to the soft condition of the seabed, the (300mm) casing passed through the footing to a depth of 6m below seabed.

CPT probing was carried out adjacent to the boreholes. To avoid buckling the rod of the mechanical CPT equipment, the rod were passed through BQ rods.

Shear-Vane and Pocket Penetrometer tests were also done on the samples at site.



Figure 5: The seabed frame

3 CONCLUSION

Implementation of the mentioned operations resulted the following practical achievements:

- Drilling bits and sampling devices can be practically isolated from the vertical fluctuation of drilling floating vessels by means of casing mounted method, described in the paper.
- Buckling is the major criterion of structural design of casing when casing mounted method is used. To reduce the size of casing, it is practical to exert a tension forced by connecting an air cylindrical steel tank to the casing pipe.
- Wire-Line System proved to be successful to facilitate the drilling process when the mentioned casing mounted method is used.
- The described 4-anchor system is practically successful to control horizontal movements of drilling vessels for geotechnical borehole drilling.
- Pre-stressing of mooring cables is essential for successful control of horizontal move-

ments of floating vessels. It is also essential to continuously measure and adjust the length of the cables by means of electric winches within tide periods.

Using the above mentioned *casing mounted method*, it became possible to control the horizontal and vertical movements of the barge; in a way that drilling from seabed surface down to the depth of 60m came to practicability. It is a cost effective method and very easy to be mobilized.

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