Geotechnical Assessment for Cold Stacking of Semisubmersible MODU

Jean Audibert[1], Bernie Bernard[2] and James Brooks[3]

INTRODUCTION

With the downturn of the oil & gas industry, many rig operators have had to find suitable sites along the Gulf coast where they could cold-stack their rigs until oil exploration picks up again. This paper describes the results of a site investigation and foundation assessment for cold stacking a large, semisubmersible Mobile Offshore Drilling Unit (MODU) at the Keppel AmFELS dock facility located in the Brownsville ship channel, Brownsville, Texas.

The objectives of the investigation were to (1) determine the ship channel bottom topography using geophysical data collected at the site, (2) characterize the soil and foundation conditions at the site to predict final, after-ballasting pontoon penetrations, and (3) evaluate the potential for sliding of the semisubmersible rig during a hurricane event.

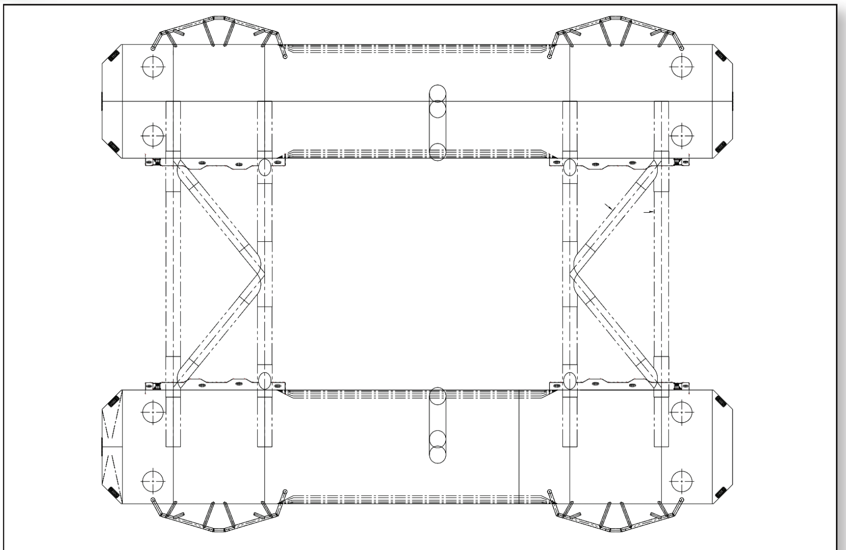

Figure 1. Plan view of pontoons

SEMISUBMERSIBLE RIG INFORMATION

The Mobile Offshore Drilling Unit (MODU) is a large semisubmersible, ABS Maltese Cross A1 column stabilized drilling unit. During cold-stacking, the foundation support for the rig will be provided by the two pontoons, which have a tank-type configuration (Figure 1).

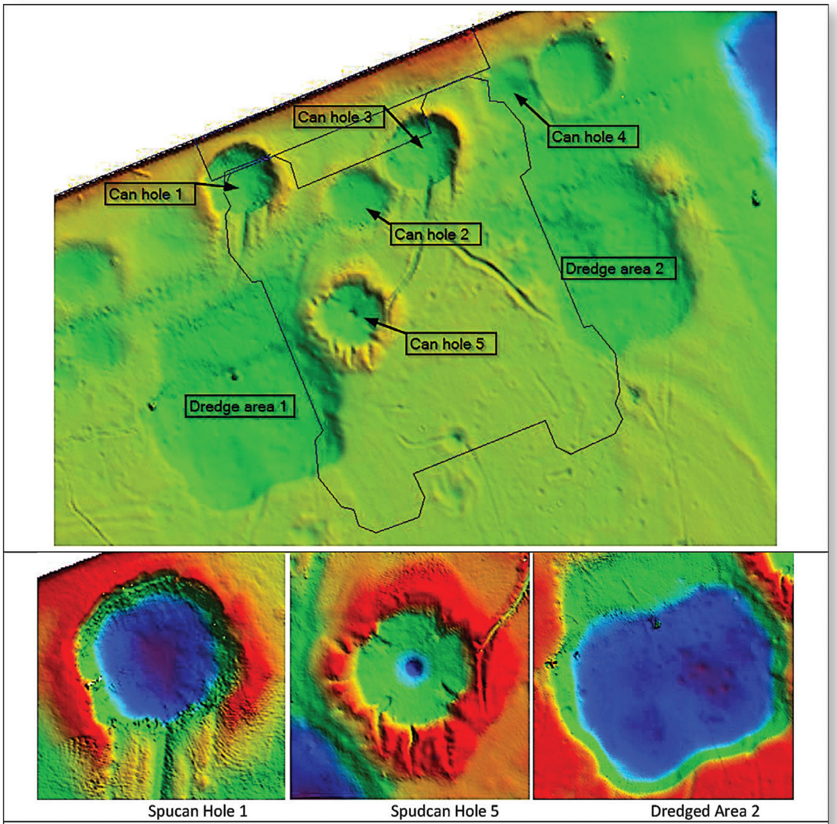

Figure 2: Overview of Stacking Location disturbances with Details of Spud Can Holes1 and 5, and Dredged Area 2

SITE CHARACTERIZATION

Geophysical Survey of Channel Bottom

Originally, it was planned to locate the rig alongside the dock to offer maximum shelter and easily tie the rig to the existing bollards. However, the geophysical survey indicated that the channel bottom adjacent to the dock had been substantially disturbed by the spudcans of numerous jack-up rigs parked over time along the dock (Figure 2).

Spud can holes created an uneven bottom in the area near the edge of the dock to about 200 feet towards the main channel (Figure 3). This continuous jackup rig activities caused the soils within this region to have undergone considerable disturbance to a depth of about 10 to 12 feet below the original mudline.

The nature of the observed bottom conditions at the target location was discussed with the rig owners and various remedial methods were discussed including dredging of the channel bottom and/or filling the spudcan holes with sand. It was concluded that the existing unevenness of the bottom or the creation of stiffer sand filled zones would most likely prevent a firm and level seating of the rig pontoons, if it were to be stacked directly adjacent to the dock (black outline of pontoons in Figure 3). Hence, a revised location just past the disturbed region, away from the dock and towards the main channel was selected, as shown by the red pontoon outline in Figure 3.

Geotechnical Survey

The geotechnical survey consisted in taking standard piston cores (PC), Jumbo Piston Cores (JPC) and gravity (dynamic free-fall) piezocone penetration tests (g-CPT) performed approximately at the four corners of the proposed cold-stacking area. These sampling and testing tools are shown in Figure 4, and were deployed from both a geotechnical vessel (Phase 1) and from a barge, using a crane (Phase 2).

The maximum penetration among the four g-CPTs was about 21 ft below the channel floor, and the maximum JPC recovery depth among the four cores was about 12 ft. Penetrations for the g-CPTs and JPCs varied substantially between the north and south locations due to soil variability.

The average water depth measured at the time of the site survey in the areas not affected by spud-can holes ranged from 30 to 32 ft, with the water depth some 10 to 15ft deeper at the center of the spucan depressions.

The bathymetry, JPC and g-CPT data results indicate that the seafloor of the channel bottom in the vicinity of the Keppel dock consists of a thin surficial soft clayey layer of about 0.5 to 2ft below mudline. This layer is underlain by a stiff to very stiff clay extending to at least 8 ft below mudline. The two JPCs and two g-CPTs collected nearest to the dock at the originally proposed rig site showed soft clay conditions from the (irregular) seafloor to about 10 or 12 ft depth. The results from the g-CPT tests and the JPC tests at the north and south locations are shown in Figure 5.

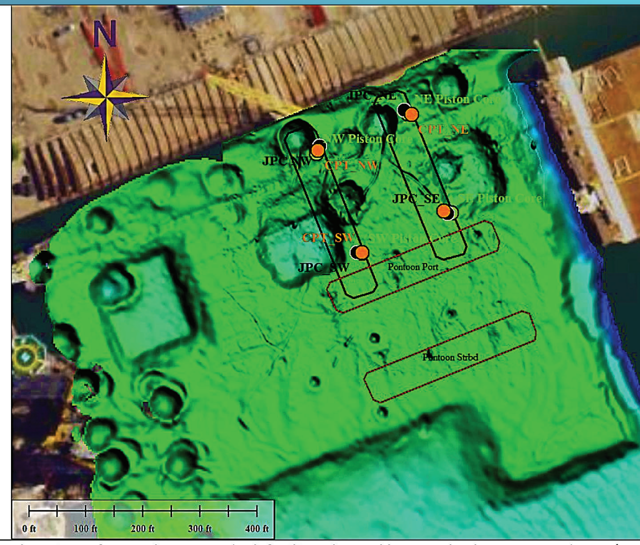

Figure 3. Plan view of Keppel AmFELS dock facility, channel bottom bathymetry, and core/CPT locations. Initial stacking location (black pontoons outlines) and revised location (red-outlined pontoons).

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Continued

PREDICTION OF PONTOON PENETRATION

The penetration analyses were carried out in general accordance with the calculation methods in SNAME (2008). The penetration curves for the rig pontoons at the revised site, using the estimated shear strength profiles shown in Figure 5, are presented in Figure 6.

PREDICTION OF SLIDING RESISTANCE

Based on estimated shear strengths of the upper soft clayey layer, different possible scenarios for sliding for the given loading conditions and assumed soil frictional properties were investigated.

To address the more likely scenario where the seafloor at the stacking site (below the pontoons) is not completely flat, calculations were based on a percentage of contact area.

The approach assumes that at different lowering depths, an increasingly greater percentage of the base surface will be in contact with the uneven bottom and, if it is assumed that this also will be the final penetration, a series of curves can be produced to estimate the corresponding sliding resistances proportional to the contact area.

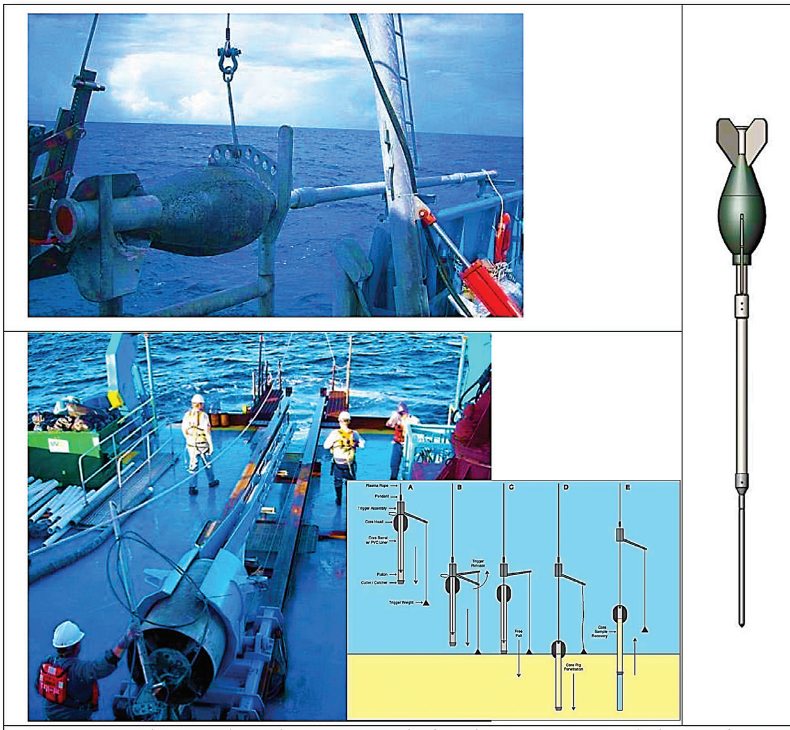


Figure 4: TDI Brooks TDI-Brooks 3-inch piston coring rig (top); Jumbo Piston Coring Rig and Schematic of a PC or JPC operation at the seabed (bottom) ; and g-CPT free-fall CPT rig (right)

CONCLUSIONS AND RECOMMENDATIONS

· Bathymetry data at the proposed stacking location helped identify old spud can footprints and dredged areas that made the initial proposed location adjacent to the dock unsuitable, but also help identify a relatively flat channel bottom some 200 ft away toward the south with average water depth between about 30 ft and 32 ft.

· Simple yet effective and economical geotechnical coring and in situ testing tools were quickly deployed to the site to characterize the properties of the channel bottom sediments.

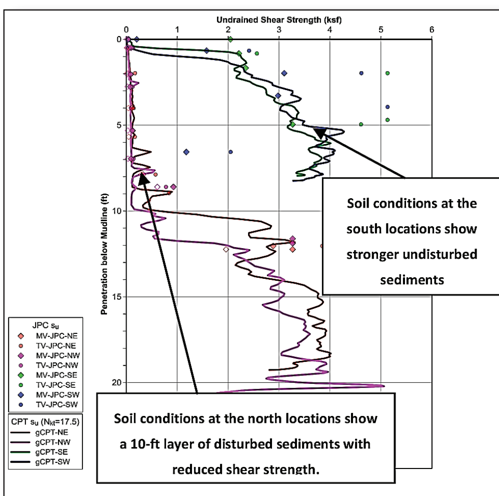


Figure 5. Field Measured Data from JPCs and g-CPTs at south and north locations

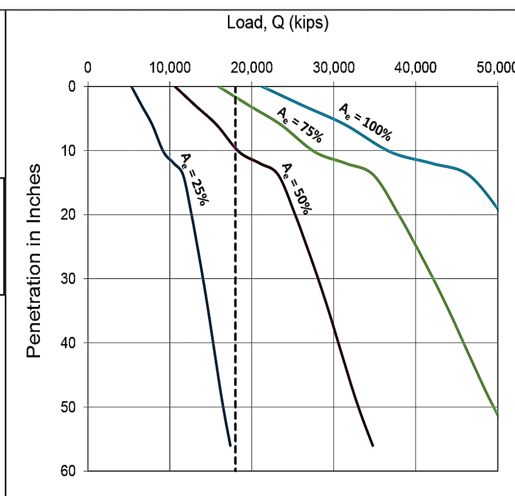


Figure 6. Load vs. Penetration, for different estimated contact areas, Lower Bound Soil Profile

· Based on the field data, the soils from seafloor to 8 ft can be interpreted as stiff over-consolidated clay overlain with a thin (0.5 to 1.7 ft) surficial drape layer of soft clay.

· Upper, lower and best estimate soil strength profiles were developed based on g-CPT and JPC data.

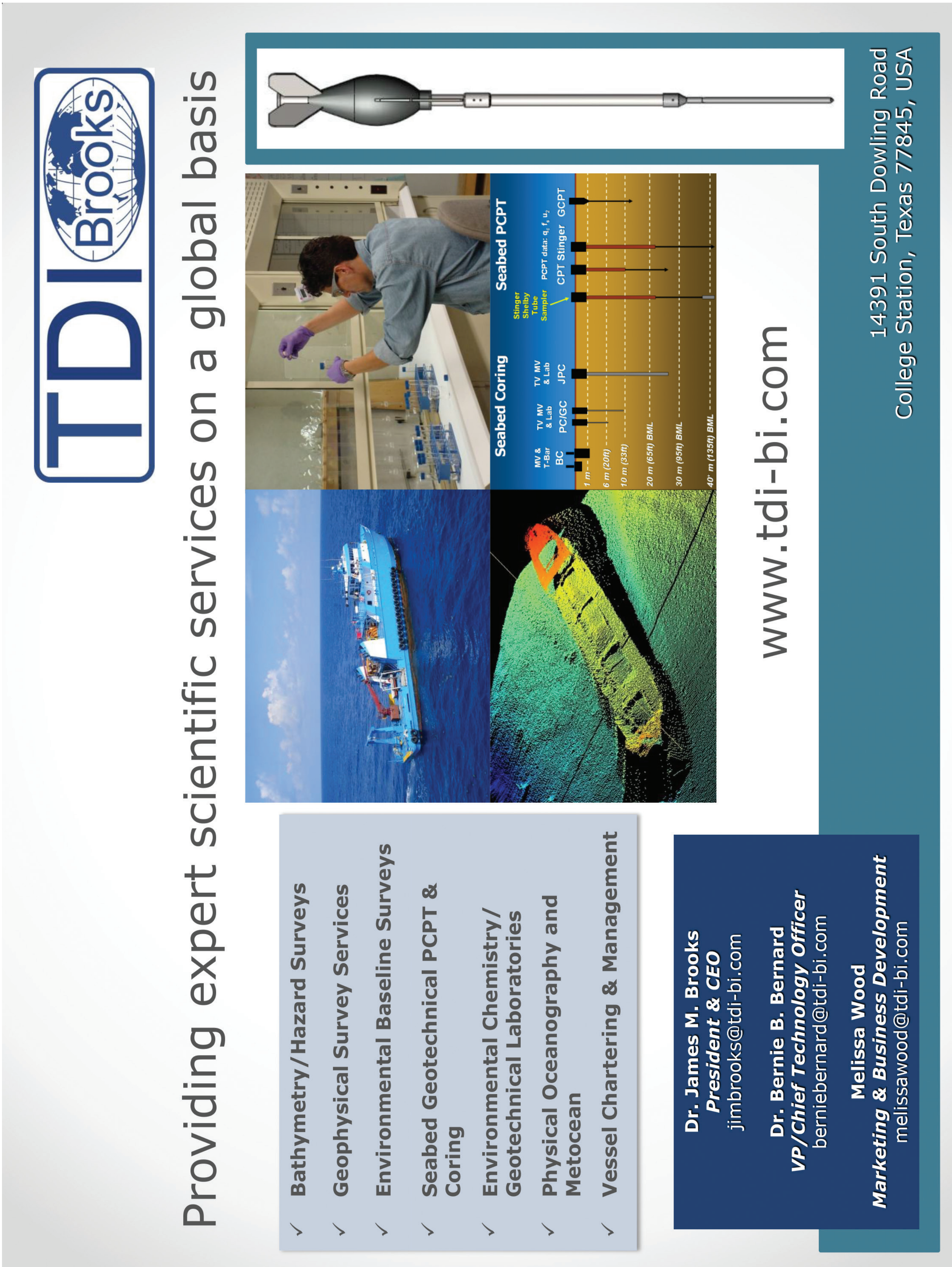
· Pontoons penetrations were predicted to be small, long-term settlements were expected to be negligible.

· Due to the uncertainty in the contact area between pontoons and the channel sediments, it was decided to increase the factor of safety against sliding failure by mooring/anchoring the rig.

1 Jean Audibert, Sr. Geotechnical Consultant, 341 Wildflower Lane, Kerrville, Texas (TX) 78028, USA ;

2 Bernie Bernard, Vice-President/Chief Technology Officer, TDI-Brooks Int'l Inc., 14391 S Dowling Rd., College Station, Texas (TX) 77845, USA ;

3 James Brooks, President, TDI-Brooks Int'l Inc., 14391 S Dowling Rd., College Station, Texas (TX) 77845, USA. ❍



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Dr. James M. Brooks
President & CEO
jimbrooks@tdi-bi.com
Dr. Bernie B. Bernard
VP/Chief Technology Officer
berniebernard@tdi-bi.com
Melissa Wood
Marketing & Business Development
melissawood@tdi-bi.com
14391 South Dowling Road
College Station, Texas 77845, USA