Mudmat Role in Offshore Drilling Operations

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ABSTRACT
Drilling for petroleum beneath the sea has increased tremendously in the last fifty years. Now a days offshore activities take place in water more than half of the nations on the earth. Offshore drilling is a mechanical process where a wellbore is drilled below the seabed. It is typically carried out in order to explore for and subsequently extract petroleum. Drill ships, offshore platforms and subsea equipment are the drilling units to extract petroleum. In drilling process some of drilling units needs to be placed or landed on the top of the sea bed, in this case direct landing or placing on seabed cause problems for drilling operation. To avoid this case mudmats are used to place in-between drilling equipment and seabed. Without mudmat drilling equipment operation is difficult, there will be problems due to lateral loads on structures and seabed soil properties. Mudmat can be defined as the structure used to prevent offshore structures from sinking into soft unconsolidated soil on the seabed. In the present study key role of mudmat in drilling operation and mudmat design considerations are discussed.

Keywords----- Drilling; mudmat; seabed; subsea equipment.

I. INTRODUCTION

Offshore drilling is a mechanical process where a wellbore is drilled below the seabed. Offshore drilling is performed at mid sea location. There are many different types of facilities from which offshore drilling operations take place. Combined drilling and production facilities either bottom founded or floating platforms, and deep-water mobile offshore drilling units (MODU) including semi-submersibles or drill ships. These are capable of operating in water depths up to 3,000 meters. In shallower waters the mobile units are anchored to the seabed. For each and every drilling unit has its own structural components to perform drilling operation. Out of these Jacket platform and subsea equipment has additional structural component which is called Mudmat. In general drilling units which are placed or landing on seabed has to be fitted with mudmat structure where the legs are landing on seabed. Mudmat transfers the drilling unit load to seafloor. Mudmats are generally fitted to the seabed touching structures, those are Jacket structures and subsea equipment. Mudmats are connected to these structure at fabrication point then the structure is transported to drilling point along with mudmats.

II. MUDMAT OVER VIEW & USAGE

Mudmat is the temporary seafloor support for jackets and subsea equipment. The function of mudmat is to provide adequate area for load distribution to the soil. Mudmats are designed to support the weight of structures plus additional loads imposed by the environmental conditions. Commonly used mudmats, consist of a top plate and a number of perpendicular vertical stiffeners that function as load-bearing beams. The fundamental aspect need to be consider in the design of mudmat is the vertical resistance of soil provided by the bearing capacity of the soil, resistance of the structure against sliding and over turning. Another aspect rarely being considered is the settlement of the mudmat. Settlement of the mudmat can be predicted by comparison of applied pressure and the ultimate bearing capacity of the mudmat. Mudmats are the most reliable for on-bottom stability of drilling units.

The first step in design sequence requires geometrical engineer explore soil conditions at proposed location. By drilling and sampling a boring geometrical data are determined for the critical zone generally located to a 40 to 50 feet below the seafloor. The mudmat should be designed based on bearing capacity of the seafloor soils as determined by the geometrical engineer. The bearing capacity of seafloor can be predicted by using the formula,

\[ Q = (f \times a \times L) + (q_u \times A) \]

\( f \) = skin friction factor of soil
\( a \) = perimeter area of foundation
\( L \) = Penetration depth of foundation
\( q_u \) = bearing strength of soil
\( A \) = bearing foot print area of soil

Often the bearing capacity of the soil is unknown, and in some instances the line of demarcation between the soil and the sea water is much undefined. Under these circumstances, the Jacket files, subsea equipment may sink into the sea floor and become lost. In addition, any attempt to increase the bearing capacity of the soil typically involves increasing either the perimeter area of the foundation or the bearing footprint area of the foundation,
or both. However, for poorly consolidated soils, the resulting foundation may be too large to pass through the moon pool of a drilling rig or too heavy to be lifted by the standard equipment on the drilling rig.

i) Mudmat for Jacket structures:
Various types of structures have been employed in offshore extraction operations. Typically, the structures consist of a horizontal working platform or equipment deck which is supported above the water's surface by a substructure, commonly referred to as an offshore jacket. Offshore jackets are most often fabricated onshore, towed or transported by barge to the drilling site, and lowered to the proper position on the sea floor. Generally, an offshore jacket is comprised of at least three substantially vertical legs that are interconnected by framing or cross-bracing members to form a triangular or rectangular base, wherein a leg is disposed at each corner of the base. In its upright position, the jacket rest on the sea floor with the bottom of the legs resting on the sea floor or slightly penetrating into the soil. The jacket is secured to the sea floor with piles which are either driven through the legs or driven through sleeves attached to the legs.

![Mudmat for Jacket structure](image1)

If the jacket leg extensions and lowest horizontal bracing do not provide adequate temporary support, mudmats must be provided and should be designed bases on bearing capacity of the seafloor soil as determined by the geometrical engineer. So offshore jacket structures must be temporarily supported by the mudmats near sea floor soils before driving of the foundation legs. Along with mudmats the foundation elements that bear on the seafloor soil include the jacket leg extensions lowest level of horizontal bracing. All these foundation elements must be designed to support the weight of the jacket plus additional environmental loads. Almost all steel jackets are built with mudmats as mean of temporary support. This means mudmats are most reliable for on-bottom stability prior to jacket installation. Mudmat has large surface area, distributes the weight of the jacket over the top soil layers of the ocean floor. The mudmats also provides the foundations for the jacket until completion of the pile grounded operation. The elements of the mudmats are limited and they become functionally useless after completion of the pile grounding operation.

ii) Mudmat for subsea equipment:
Subsea equipment refer to the technology, and methods employed in marine biology, undersea geology, offshore oil and gas developments, underwater mining, and offshore wind power industries. Subsea mudmat are used to provide additional support for the equipment on sea floor when the sea bed is soft. A mudmat foundation for supporting an item of subsea equipment on the sea floor comprises a mudmat on which the item of subsea equipment may be supported and a plurality of legs which are pivot ably connected to and depend downwardly from the mudmat. The legs are free to pivot outwardly relative to the mudmat upon insertion of the legs into the sea floor to thereby increase the load bearing capacity of the mudmat. Subsea mudmats are used to support,
- Pipe Line End Terminations (PLET)
- Pipe Line End Manifolds (PLEM)
- SLED systems
- Subsea Umbilical Termination Assembly (SUTA)
- Offshore manifolds.

![Mudmat for Umbilical Termination Assembly](image2)

iii) Mudmat on land:
A mudmat is also used on wet floor on earth land to avoid lateral sliding and penetration in to tye soil of land for moving vehicles. Figure3 gives the clear picture of mudmat on land.

![Mudmat for vehicle on wet landfloor](image3)

iv) Loads on mudmat:
There is always gravity (self-weight of structre) load is acting on mudmat, along with this there are extra load due to environmental conditions and waves. Presence of gravity load and environmental actions, the mudmats are subjected to combined vertical and horizontal, moment and torsion loadings. The bearing capacity of the foundation is further reduced in combination with horizontal loading and moments, and can be further reduced when torsion moment is applied. There fore the vertical effects, moment and...
torsion to be consider along with vertical loading when calculating the mudmat capacity. In offshore foundations torsion is always considerable.

Main forces on mudmats:
- Vertical force – V
- Horizontal force – H
- Torsion – T

The horizontal and torque can be replaced by equivalent horizontal force ($H_{eq}$). Then the final design loads on mudmats are vertical and equivalent horizontal loads.

$$H_{eq}=\frac{2T}{L_{eff}}+\sqrt{H^2 + \left(\frac{2T}{L_{eff}}\right)^2}$$

Where $L_{eff}$ is the length of effective area

III. MATERIAL AND STRENGTH

Material used in mudmat design are steel, wood, fiberglass (PVC, GRP) in general. Depending on the loads and type of structure material needs to decide. At the starting stage wood material is used to prepare the mudmats, later steel is comes into picture. Latest concept for mudmat design says the use of fiberglass material. This latest modification has impact on time and economy point of view.

i) Steel mudmats

Conventional steel mudmats are typically fabricated from large stiffened plates which are welded to a frame work of beams attached to the structure base. Steel corrode when it is immersed in electrolyte such as sea water. The rate of corrosion can be suppressed by attaching sacrificial anodes. Connecting a metal of higher potential to a metallic structure creates an electrochemical cell in which the metal with lower potential becomes a cathode and is protected, this technique is called cathode protection. Corrosion is the major problem if the mudmat is made up of steel to overcome this problem fiberglass cathodes are introduced.

ii) Fiberglass mudmats

Light weight, less expensive, easily transported, assembled and attached to offshore structures. Being formed of such plates are corrosion resistance, eliminating the need of cathode protection. PVC&GRP plates are lighter in weight than the wood and steel, such that they have less impact on Buoyancy and weight of structure to which they are attaching.

Advantages of mudmats made with PVC&GRP:
- High flexural strength
- High flexural stiffness
- Reduced number of support beams
- Reduction in fabrication costs
- Reduction in anodes
- Light weight
- Easy installation

iii) Horizontal Sliding resistance

The horizontal sliding resistance of mudmat comes from the shear strength of soil at the base of the mudmat, the following equation represents the sliding strength of the mudmat at seafloor clay profile.

$$Q_1 = S_u \times A_c$$

$Q_1$ - Ultimate lateral resistance
$S_u$ - intact shear strength at the base of mudmat
$A_c$ - Area of mudmat

IV. CONCLUSION

Mudmats are playing vital role in offshore drillings operations, mainly for steel jacket structures and subsea equipment as mentioned in above sections. Without mudmat it is difficult to place the structure above the seabed. Mudmat provides the sufficient surface area for load distribution over the seafloor for offshore structures and maintains the lateral stability against environmental effects. Mudmats are playing significance role in offshore drilling operations.

REFERENCES