AN INSIGHT INTO ANCHOR SELECTION

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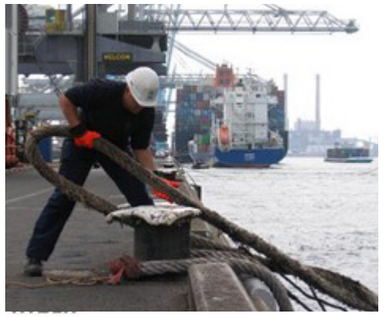
Anchors have a long history, dating back as far as the existence of vessels themselves. Despite this, the subject of anchor selection is often overlooked. This article will explore this topic in more detail, investigating the differing anchor types, their benefits, disadvantages, and common types of usage.

Anchors ensure that a vessel remains steadfast when tethered, whether this is to the seafloor or to a permanent fixture such as a quayside. Although early anchors were often primitive and simple, anchor design has evolved to provide various novel and a full range of innovative, versatile solutions. As engineering advances, so too must anchor design and development – whether it be to anchor a 400m long cargo vessel, a semi-submersible drill rig or a series of offshore wind turbines. Each of these applications require a specific anchor, however, not all anchors can be used for all applications.
There are various considerations when selecting an anchor, however the primary driving factors are:

- Inshore or offshore mooring
- Water depth
- Size and mass of moored vessel

Inshore Mooring

Inshore moorings require the least complex anchors and usually quayside bollards are used. These bollards allow a vessel to moor "alongside" a quay or berth, by connecting the vessel's own mooring wires/ropes to the bollards and then tensioning the lines to provide holding capacity. In most cases, as the weather exposure tends to be less as quaysides are designed to provide sheltered mooring, bollards prove suitable to hold a vessel in place. However, in the case that the mooring bollards do not provide enough capacity, mobile mooring winches can be installed along the quayside and are used in the same manner. This is illustrated in figure 9.



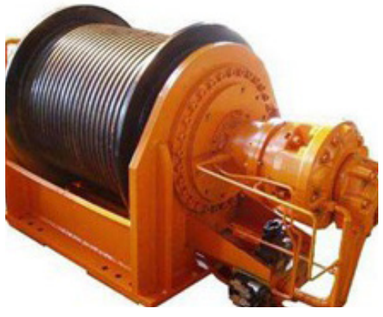


fig. 09/ quayside bollard and mobile mooring winch

Mooring winches are offered in various sizes, with a range of holding capacities and brake loads - a very widely used solution when mooring large vessels alongside a quay or berth.

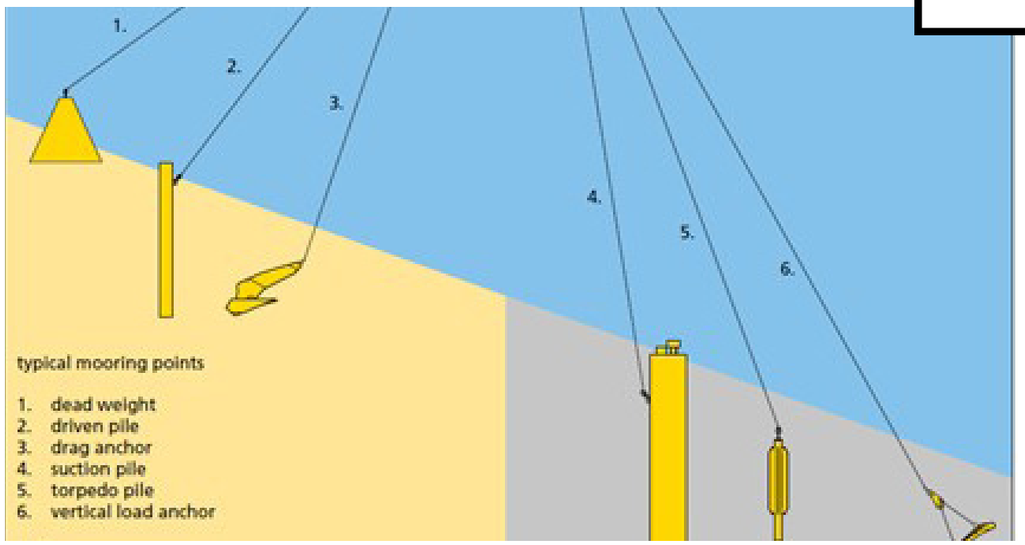


fig. 10/ various offshore anchoring methods

Offshore Mooring

Unlike inshore moorings, offshore applications have more anchoring methods, as shown in figure 10, where the anchor selected is based on the water depth:.

Deadweight Anchors

Of the above, deadweight anchors are the simplest solution, and are still regularly and widely used. The working principle of a deadweight anchor is in the name; they rely on sheer weight to provide anchoring capacity, usually being a concrete or metal block, which is dropped to the seafloor, enabling vessels to then hook up. An example is provided in figure 11.

The main benefits of this anchor are twofold: versatility and cost effectiveness. As the mass of the anchor provides the holding capacity, they may be deployed on any seafloor condition, where other anchor types require a certain seabed profile or seabed material. Secondly, the cost of such an anchor may be far less than other alternatives, as they require no complex engineering, manufacture, or testing. In short, they are easy to design and fabricate.

However, deadweight anchors do have some limitations, particularly their holding capacity efficiency. Some modern-day anchors may provide holding capacity nearing 50 times that of the actual anchored mass, whereas a dead weight anchor's capacity is relatively close to the mass of the anchor itself (in direct tension and negating buoyancy). As such, these anchors tend to be reserved for light applications, in relatively calm conditions, for example, near shore mooring of small crafts or vessels.

fig. 11/ deadweight anchor just before it is dropped to he seafloor

Drag Embedment Anchors

Drag embedment anchors are some of the most versatile and best performing anchors available today. They rely on being "dragged" along the seabed by an anchor

fig. 12/ two piece drag embedment anchor

handling vessel, which coupled with their design, forces the anchor to submerge itself in the seabed. The deeper the anchor is laid; the more holding capacity is provided.

There are various shapes and designs available for a drag embedment anchor, however recent developments have resulted in a two-piece system, comprising of a "fluke" and a "shank" where the fluke can be set to different angles to suit different seabed characteristics. These high holding capacity anchors can provide up to ~50 times their own weight in holding capacity (in the right conditions) and are considered very easy to handle and install.

An example is shown in figure 12.

Drag embedment anchors are widely used in the offshore industry, primarily for drill rigs, production platforms and FPSO's due to their high holding capacity. They are limited to deployable water depth however, as the deeper the water becomes, the longer the catenary is, and as such the weight of the anchor line itself increases. They require a relatively shallow catenary to ensure little to no uplift is subject on the anchor, as this can result in dislodging. As well as a shallow catenary, engineers will routinely design a drag embedment mooring line to allow for a length of grounded line in front of the anchor, to assist in reducing uplift. This adds to the line length and as the line length increases so too does the footprint of the anchor spread and the weight of the mooring line, which must be taken up by the vessel fairleads which may become over utilised.

Pile Anchors

As illustrated in figure 10, there are various types of pile anchor, namely: driven pile, gravity pile and suction pile. All these types use the same working principle and share common characteristics; they are all also capable of withstanding horizontal and vertical loads and are designed to resist vertical loading primarily. The benefits of pile anchors are that the mooring spread footprint may be reduced in size, in comparison to a drag embedment spread, as the normal angle between the seabed and the mooring line can be increased. In some spreads, such as those which utilise taut leg mooring, 90-degree mooring lines can be laid - it is these characteristics which make pile anchors popular in ultra-deep-water applications.

The theory behind pile anchors is that the mass is submerged into the seabed and the depth of submersion provides the holding capacity, coupled with some clever engineering in the case of the suction pile. The installation of gravity piles relies on the mass of the anchor being dropped from the back of a vessel and the kinetic energy gained as the anchor falls through the water column will provide enough impact force to drive the anchor into the seabed.

In comparison, driven pile anchors are lowered to the seafloor via a crane, as illustrated in figure 13, and the initial impact will result in some embedment of the anchor. However, the installation workpiece includes a large "hammer" which will then drive the pile further into the seabed until the desired embedment depth is achieved.

Finally, suction piles are the most complex of the available pile anchors and have an interesting working principle which relies on creating a vacuum within the anchor to provide the holding power. The suction pile anchor relies on its hollow shape to ensure holding capacity – the pile can be described as a hollow, capped cylinder where the underside remains open. The restraint is provided by dropping the large "can," as shown in figure 14, to the seafloor where >~60% of the mass will submerge under its own weight (in optimal cases). A remote operated vehicle (ROV) is then used to activate a valve on the topside of the can to discharge the trapped water between the seabed and the capped end of the can, which creates a vacuum.

As this brief insight into anchoring illustrates, modern engineering has made it possible to moor in ever increasingly difficult locations, water depths and environments with a solution for any application.

fig. 13/ drive pile anchor lifted by crane

fig. 14/ suction pile anchor