DESIGN OF FLOATING DOCKS

by

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1. INTRODUCTION

Access to the underwater parts of ships for cleaning, painting and repairs have always been necessary. Early vessels were beached or careened and by the 17th century graving docks were in use. The earliest form of floating dock was introduced in the late 18th century although true development of the floating docks did not begin until the mid 19th century with the introduction of iron construction and steam power for pumping.

Docks have continued in their popularity since their introduction due to:

1. Self-contained structure not affected by geology of foundations or seismic events such as graving docks and shiplifts. Dock may be placed in deepwater, e.g. fjords, with little problem.

2. Can be heeled or trimmed to match that of a damaged vessel

3. Valuable asset, as it can be sold and towed to a new home with relative ease.

4. Mobility - docks can be moved if a yard decides to reorganise or transferred from one site to another where an operator has a number of yards. Docking operations can be carried out in deep water and then the dock can be moved shallower water at the dockside.

5. Control - Providing there is sufficient water depth, the depth of water within the dock is entirely at the control of the dock and not subject to tidal variations.

6. Reliability - Docks have been used for many years. They do not require large amounts of machinery. For example a large floating dock may need only 6 pumps and in the event of failure an adjacent pump can be used. This contrasts with shiplifts, for example, where the breakdown of any one of a large number of winches would incapacitate the facility.

7. Cost - Docks are undoubtedly cheaper to build than graving docks and are not preceded by large amounts of civil engineering work required by shiplifts, graving docks, and marine railways.

8. Longevity - there are many docks still in operation after 50 or more years, and in some instances up to 90 years. With modern preservation techniques such longevity should increase.
2. MATERIALS

The majority of floating docks are constructed of steel and this continues to be the favoured material. Concrete is sometimes used but as it does not deflect to the extent that steel does it is difficult to measure the longitudinal deflections in the dock that are used to determine the longitudinal bending moment and stresses. Therefore concrete docks, unless small, are required to be operated in accordance with strict pumping plans which is made more problematical by the lack of information on a ship’s weight distribution and keel level giving rise to unforeseen high loads. In addition concrete is difficult to repair unlike steel. Timber docks can sometimes be found in the USA, for example, but sizes are limited. Docks are sometimes constructed with a combination of materials - for example steel sidewalls with concrete pontoons.

3. TYPES OF DOCK

Floating docks have been designed for all size ranges from below 100t to over 100,000t lift capacity, i.e. capable of lifting from the smallest to the largest ships afloat. There are numerous types of docks, the majority of which were invented by such 19th Century engineers as Rennie, Box, Cunningham, Clark, Standfield, etc. These variations were mainly the result of engineers looking at methods of self docking. This was important in the early years when preservation techniques were not reliable and the docks were larger than the available graving docks. This is not such a problem today with modern coatings, impressed cathodic protection and the ability to apply coatings underwater. Although some types of dock are still designed and built today, for example the Cunningham Type or the Clark & Standfield Single Wall Offshore Dock, the main dock types in use today are:
(1) **Box or Caisson Type Dock (non self docking type)**

This type of dock is the simplest, strongest and one of the least costly forms of dock. The dock consists of continuous sidewalls integral with a continuous pontoon and because of its strength it is often preferred for large docks.

(2) **Rennie or Sectional Pontoon Type Dock (self docking type)**

The dock consists of two continuous sidewalls which are bolted to a number of portable pontoons that can be detached and docked on the remainder. These docks generally require more steel than an equivalent box dock to achieve the necessary longitudinal strength and therefore are not often used for large docks. Furthermore, the ability for docks to self dock is not so important with today's preservation systems.

### 4. DIMENSIONS

Dimensions are determined from the main particulars of the ships to be lifted although the maximum particulars may not always be associated with the same vessel:

- Docking displacement (and vertical centre of gravity)
- Maximum length
- Maximum breadth
- Maximum draught
- Blocking length and Docking weight combinations

Dimensions may also be influenced by available water depth, size of dock cranes, extent of outfit, etc. in addition to those necessary to achieve strength, stability and displacement. The current trend is for docks to become wider. This is mainly due to the increasing width of ships - particularly with large multi hull ferries - and more docks now being provided with travelling stages running along the inner sidewalls.

### 5. TRIM, STABILITY AND FREEBOARD

The dock is designed to obtain a defined freeboard to the pontoon deck when lifting the maximum weight of vessel. Typically, the minimum freeboard is 300mm to which must be added the effects of trim due to travelling cranes and also environmental conditions such as waves. In this condition the dock will be carrying the ship, residual ballast (water which cannot be removed from the tanks), compensating ballast (ballast used to control longitudinal bending), weight of moorings, weight of dock and deadweight (e.g. fuel, fresh water, stores etc.)
When at deep sink, the freeboard to the top deck of the sidewall is typically not less than 1000mm but is often much greater, particularly on the larger docks. The tank air pipes are extended into the tanks creating an ‘air cushion’ at deep sink. The length of the air pipe is set so that the amount of ballast water can be pre-set to avoid sinking the dock below the designed freeboard.

Minimum stability occurs during the lifting of a vessel and is not permitted to be less than 1.00 to 1.50m. depending on the design authority. In the raised condition, the stability will be much greater due to the waterplane of the pontoon but consideration should be given to such effects as wind heeling.

**6. STRENGTH**

**6.1 Longitudinal**

The required longitudinal strength is mainly dependent on the weight distribution of the ship being lifted and the degree to which water ballast distribution within the dock’s ballast tanks can reduce this. The classification societies define the shape of the weight distribution curve to be used in the longitudinal strength although the actual weight distribution for a particular vessel may require to be investigated where of unusual form.

Small docks are usually designed for level ballasting whilst larger docks normally use differential ballasting to avoid excessive strength requirements. The compensating ballast used in differential ballasting counters the effects of the moments created by the vessel’s weight distribution. This ballasting can be used to create reduced longitudinal moments that not only decrease stresses in the dock but also keel block loads, particularly at the ends.
6.2 Transverse Strength

The loads from the ship are transmitted to the dock's transverse frames via the docking blocks. The transverse frames are supported by the buoyancy of the pontoon with the deficit taken by the sidewalls. The greatest loadings usually occur in way of the heaviest keel block loads, although care must be taken to ensure that there is also sufficient strength in way of the unloaded parts of the dock length.

6.3 Local Strength

There are various areas of local strength from crane loadings to mooring points. However, the principal items are:

**Keel Blocks Loading**: The ship is supported by keel blocks, which have either cast or fabricated steel bases with timber blocks although some modern blocks use rubber instead of timber. These loads are transmitted to the centreline girder which in turn transfers these loads to the transverse frames. The keel block loads are dependent on the weight distribution of the vessel and the spacing of the keel blocks. Whilst minimum standards are defined by the classification societies consideration should be given to the type of vessel’s being docked and the type off repairs which may require block removal giving rise to larger loadings.

**Hydrostatic Loading**: The hydrostatic loadings result from the water pressure acting on the bulkheads and hull of the dock. The hull loadings are offset to some extent by the pressure of the water ballast within the dock. The watertight bulkheads are subject to the different ballast levels and uneven pumping. The watertight bulkheads also require to take differences which may result from the puncture of a compartment or the loss of the sidewall air cushion at deep sink.

7. BALLASTING SYSTEM

Floating docks are normally sunk by free flooding of the ballast compartments whilst pumping up is by means of centrifugal pumps which can number from 2 in small docks to about 9 to 12 in large docks. Pumps vary in size up to about 700mm inlet dia. Pumps are usually situated in the ballast compartments and driven via vertical shafts from electric motors sited on the safety deck. Some docks are provided with dry watertight compartments in the ballast tanks for housing both motor and pump.

Control of the dock during pumping is by means of compartment valves which are normally operated by either:

- Electric motor drives
- Electro-hydraulic operated valves
- Electro-pneumatic operated valves.
The latter are more favourable as the systems can be more easily arranged to automatically close the valves in the event of power failure, thus enabling the dock to fail to a safe condition.

A number of systems are available to monitor the ballast levels. However, those employing pressure measurements to determine water level are particularly useful as the effects of the air cushion can be taken into account enabling the pressure differences on the watertight bulkheads to be monitored at all times.

During the raising or sinking of the dock, the longitudinal bending moments cause the dock to deflect. Two different types of system usually monitor this deflection. Deflection systems are usually optical, pneumatic or hydraulic. The dock operator therefore requires to ensure that the maximum deflection that has been determined as representing the maximum allowable longitudinal bending stresses are not exceeded and ideally, strives to keep the deflection as near to zero as possible. For large docks this may require to be linked to an automatic closedown of the pumps in the event that deflections are exceeded.

In some cases, it is advantageous to introduce air spaces within the pontoon (i.e. dry compartments), which reduce the hydrostatic loadings on the hull and the pumping power requirements. This has to be offset against the increased steel used in way of such compartments.

8. POWER REQUIREMENTS

Electrical power for the dock is usually shore supplied but can also be provided by on board generators. A separate emergency power source is required in the event of loss of shore supply. The emergency supply is usually sufficient to run a limited number of deballasting pumps, control the valve operating gear and operate the fire and washdown pumps and may be provided by an onboard generator or by shore feeder from a separate power source provided by the main feeders.

Where docks are shore supplied, the power is often provided at high tension with onboard transformers stepping down the voltage to typically 440v and 220v. In addition to the power supplies to the dock there are also power supplies to docked ships which often requires a range of voltages and frequencies.

9. FACILITIES

Docks can be provided with a variety of systems and equipment. To some extent this will depend on the shore facilitates but typically these can include:

- Ship Lead in Gear
- Travelling Stages (sometimes fitted with blasting equipment, etc.)
- Low Pressure Air (onboard or shore base compressors)
- High Pressure Air (onboard or shore base compressors)
- Steam (on board boiler)
- Ship’s Oil Fuel transfer and storage
- Travelling Cranes (typically varies from about 1½t SWL on small docks to 50t SWL on large docks)
- Accommodation, Dock and/or Ships Crew (messing, changing rooms, offices etc.)
- Workshops
- Vessel Centring Equipment
- Sliding or Hydraulic operated bilge blocks
- Dock and Ship firefighting systems.
- Oxygen and Acetylene supply system