Ship Construction

2nd.Off Course

Content

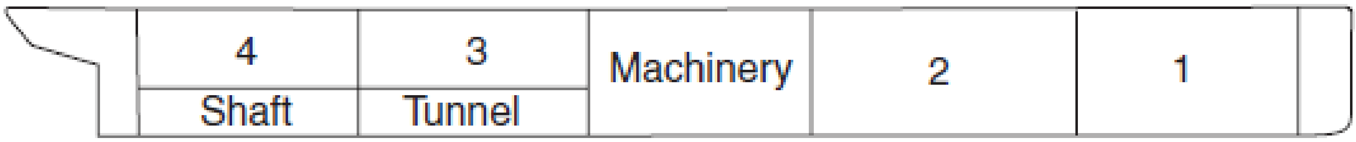
Chapter One

Ship Types

Dry Cargo Ships

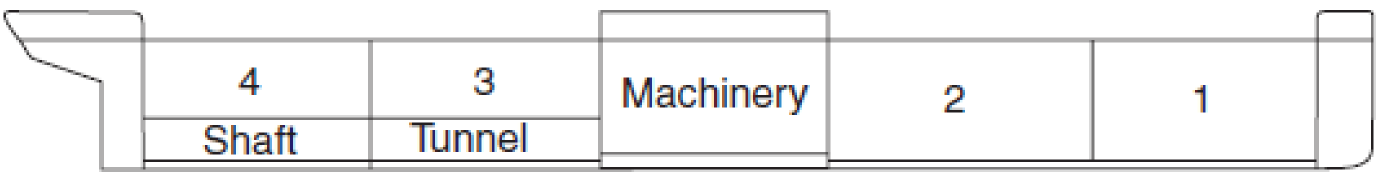
The first steam ships followed in most respects the design of the sailing ship having a flush deck with the machinery openings protected only by low coamings.

FLUSH DECK SHIP



At quite an early stage it was decided to protect the machinery openings with an enclosed bridge structure. Erections forming a forecastle and poop were also introduced at the forward and after end respectively for protection. This resulted in what is popularly known as the 'three island type'.

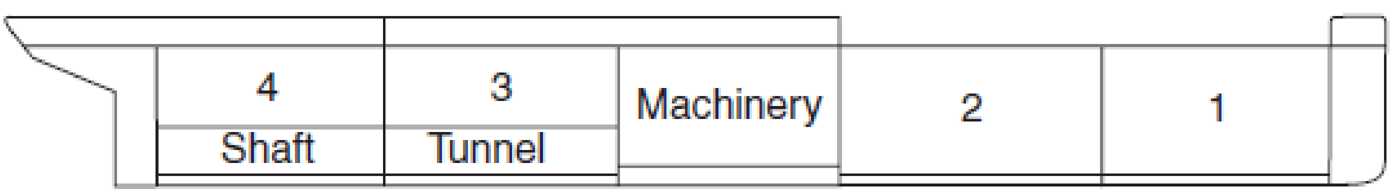
THREE ISLAND TYPE



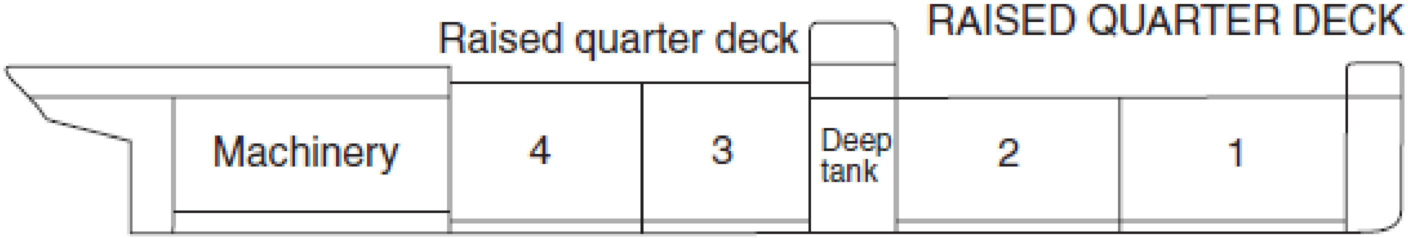
A number of designs at that time also ***combined bridge and poop***, and a few combined bridge and forecastle, so that a single well was formed.

Another form of erection introduced was the ***raised quarter deck***.

COMBINED POOP AND BRIDGE

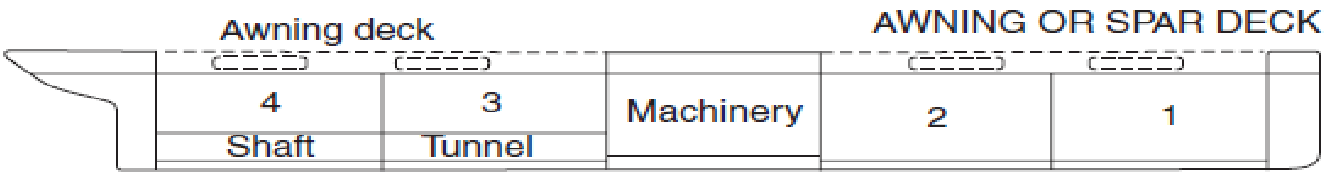


RAISED QUARTER DECK



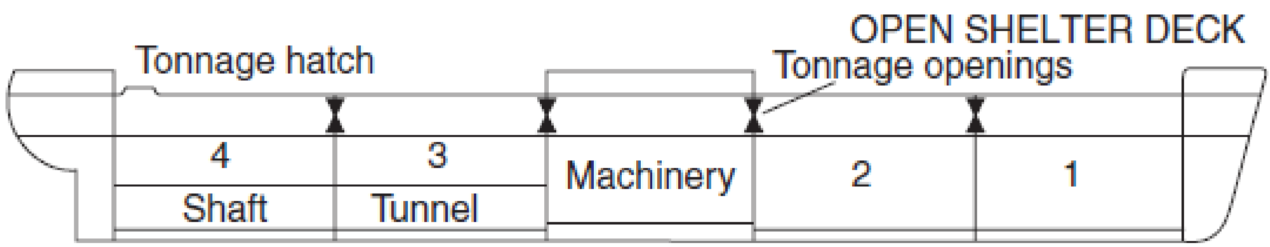
Further departures from the 'three island type' were brought about by the carriage of cargo and cattle on deck, and the designs included a light covering built over the wells for the protection of these cargoes.

This resulted in the awning or spar deck type of ship, the temporarily enclosed spaces being exempt from tonnage measurement since they were not permanently closed spaces.



At a later date what are known as open/closed shelter deck ships were developed.

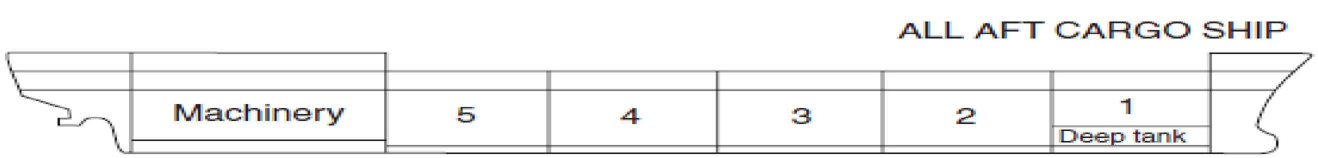
These were full scantling ships having the prescribed openings so that the tween deck was exempt from tonnage measurement when the vessel was operating at a load draft where the freeboard was measured from the second deck.



The all aft cargo ship illustrating the final evolution of the dry cargo ship could represent the sophisticated cargo liners of the mid-1960s.

Cargo handling equipment, which remained relatively unchanged for a long period, has received considerable attention since the 1960s. This was primarily brought about by an awareness of the loss of revenue caused by the long periods of time the vessel may spend in port discharging and loading cargoes.

Conventional cargo ships are now fitted with folding steel hatch covers of one patent type or another or slab covers of steel, which reduce maintenance as well as speed cargo handling. Various new lifting devices, derrick forms and winches have been designed and introduced which simplify as well as increase the rate of loading and discharge.



Bulk Carriers

The **large bulk carrier** originated as an ore carrier on the Great Lakes at the beginning of the 20th century. For the period to the Second World War dedicated bulk carriers were only built for ocean trading, since a large amount of these cargoes could be carried by general cargo tramps with the advantage of their being able to take return cargoes.

A general arrangement of a typical bulk carrier shows a **clear deck** with **machinery aft**. **Large hatches** with **steel covers** are designed to facilitate rapid **loading and discharge** of the cargo.

Since the bulk carrier makes many voyages in **ballast** a large ballast capacity is provided to give adequate **immersion of the propeller**.

The size of this type of ship has also steadily increased and bulk carriers have reached **250 000** tonnes deadweight.

The size of bulk carriers may often be referred by one of the following classes:

'**Handy size**' the smallest bulk carriers of between **10 000** and **30 000** tonnes deadweight.

'**Handy max**' bulk carriers of between **35 000** and **50 000** tonnes deadweight.

'**Panamax**' bulk carriers designed to be of the maximum size that may transit the Panama Canal and generally being just under **80 000** tonnes deadweight.

'**Cape size**' bulk carriers of **80 000** to **150 000** tonnes deadweight which are too large for the Panama Canal and trade from the *Atlantic* around the *Cape of Good Hope*.

Oil Tankers

Until 1990 the form of vessels specifically designed for the carriage of oil cargoes had not undergone a great deal of change since 1880 when the vessel illustrated below was constructed.

The expansion tank and double bottom within the cargo space having been eliminated. The greatest changes in that period were the growth in ship size and nature of the structure.

the average deadweight rising from 1500 tons to about 12 000 tons. Since then the average deadweight increased rapidly to about 20 000 tons in 1953 and about 30 000 tons in 1959.

Today there are afloat tankers ranging from **100 000** tons deadweight to **500 000** tons deadweight.

It should be made clear that the **larger size** of vessel is the **crude oil carrier**, and fuel oil carriers tend to remain within the **smaller** deadweights.

As far as the **general arrangement** is concerned there appears always to have been a trend towards placing the machinery aft.

Moving all the accommodation and bridge **aft** was a later feature and is desirable from the **fire protection** point of view.

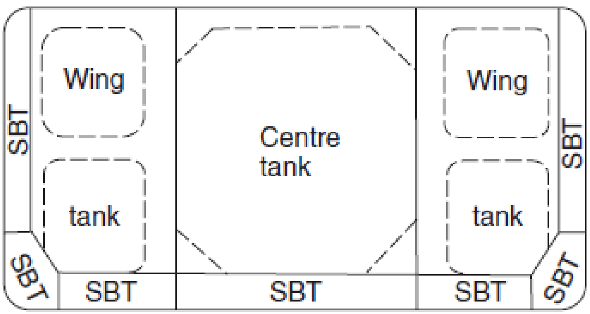
The requirements of the **International Convention for the Prevention of Pollution** from Ships 1973 // MARPOL //

In March 1989 the tanker Exxon Valdez, which complied fully with the then current MARPOL requirements, ran aground and discharged 11 million gallons of crude oil into the pristine waters of Prince William Sound in Alaska.

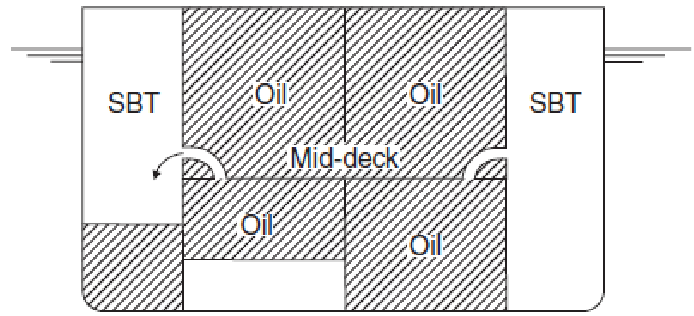
The subsequent public outcry led to the United States Congress passing the Oil Pollution Act **1990** (OPA 90).

This unilateral action by the United States Government made it a requirement that existing **single hull** oil tankers operating in United States waters were to be phased out by an early date, after which all oil tankers were to have a **double hull**

DOUBLE-HULL TANKER



MID-DECK TANKER PRINCIPLE



Classification of Tankers on the basis of Size:

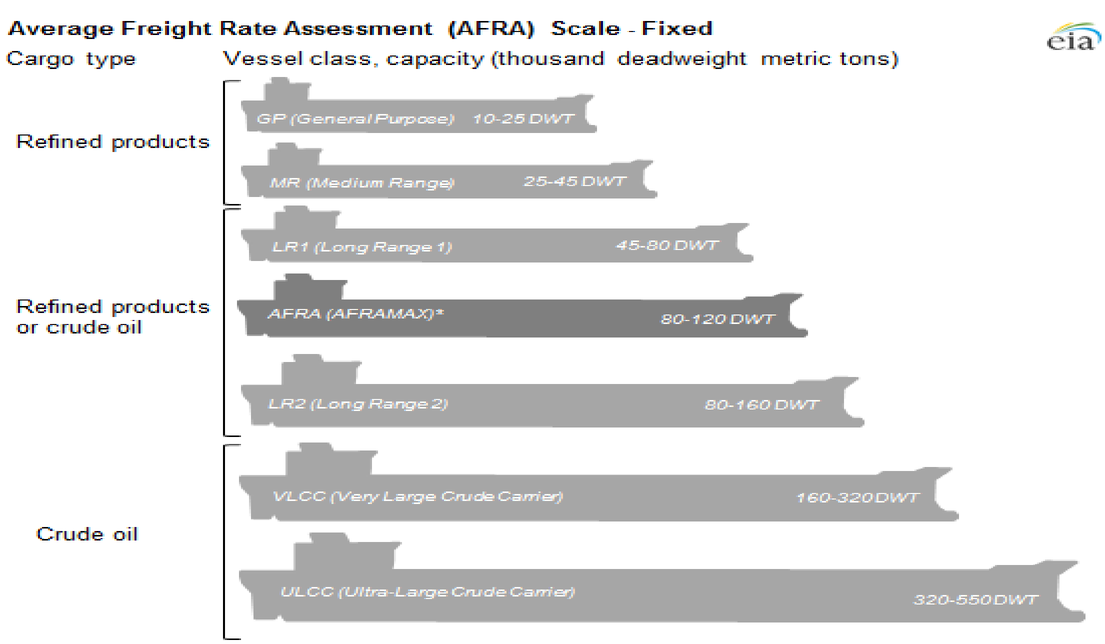
1. **ULCC**: They are known as Ultra Large Crude Carriers and have a cargo hauling capacitance range up to **5, 00,000** tons.

2. **VLCC**: Known as Very Large Crude Carriers, these tankers have a cargo carrying capacitance of **2, 50,000** tons.

3. **Panamax**: The classification of tankers that can pass through the **Panama Canal** is known as the Panamax. The cargo tankers which cannot be classified under this category owing to their size

4. **Aframax**: The Aframax cargo tankers are that type of tanker ships which are mainly used in the Mediterranean, China Sea and the Black Sea. These tankers have a dead weight tonnage (DWT) between **80,000** and **1, 20,000** tones.

5. **Suezmax**: Panamax tankers are named for vessels which can navigate through the Panama Canal. On similar lines, the Suezmax vessels are so called because of their ease in passing through the Suez Canal.



Passenger Ships

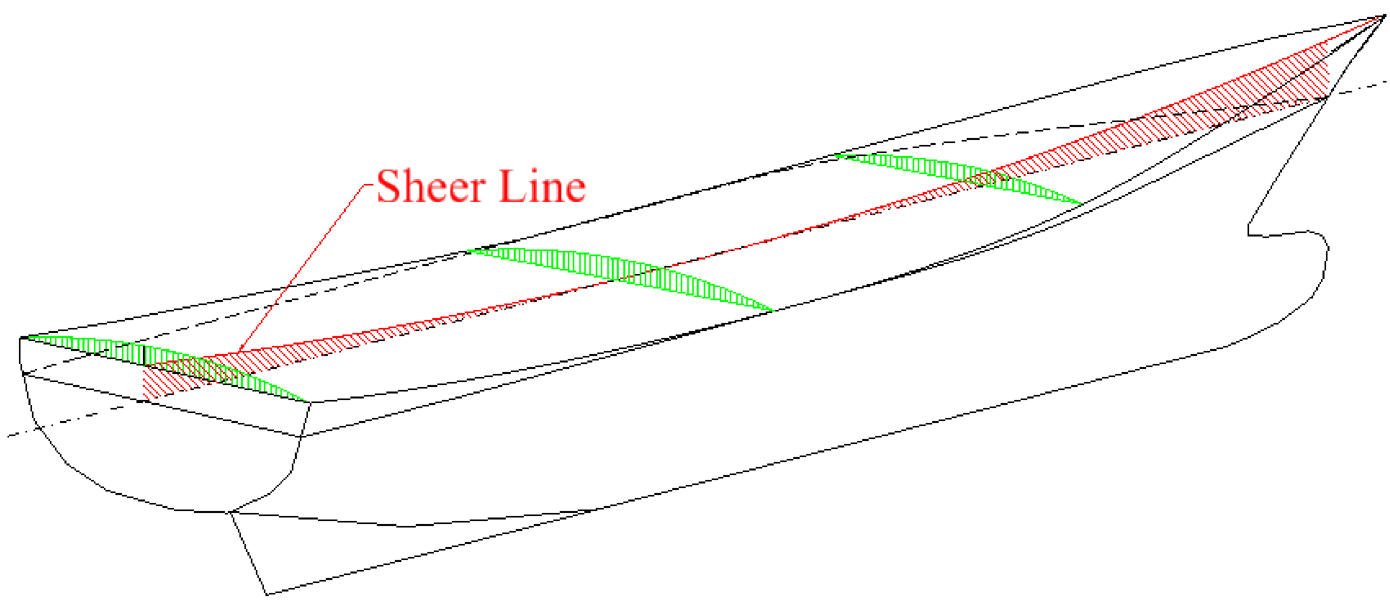
Early passenger ships did not have the tiers of superstructures associated with modern vessels, and they also had a narrower beam in relation to the length. These produced problems of strength and stability, stability being improved by an increase in beam. The introduction of aluminum alloy superstructures has provided increased passenger accommodation on the same draft

Cruise Ship

Ferry ship

Chapter Two

Ship Dimension & Form



After Perpendicular (AP):
A perpendicular drawn to the waterline at the point where the aft side of the rudder post meets the summer load line. Where no rudder post is fitted it is taken as the center line of the rudder stock.

Forward Perpendicular (FP):
A perpendicular drawn to the waterline at the point where the foreside of the stem meets the summer load line.

Length between Perpendiculars (LBP):
The length between the forward and aft perpendiculars measured along the summer load line.

Amidships: A point midway between the after and forward perpendiculars.

Length Overall (LOA): Length of vessel taken over all extremities.

Base Line:
A horizontal line drawn at the top of the keel plate. All vertical dimensions are measured relative to this line.

Beam: Measured at the midship section is the maximum breadth of the ship.

Draft: Measured from the base line to the summer load line at the midship section.

Depth: Measured from the base line to the heel of the upper deck beam at the ship's side amidships.

Freeboard:
The vertical distance measured at the ship's side between the Summer load line (or service draft) and the freeboard /deck line. The freeboard deck is normally the uppermost complete deck exposed to weather and sea which has permanent means of closing all openings, and below which all openings in the ship's side have watertight closings.

Sheer:
Curvature of decks in the longitudinal direction. Measured as the height of deck at side at any point above the height of deck at side amidships.

Camber (or Round of Beam):
Curvature of decks in the transverse direction. Measured as the height of deck at centre above the height of deck at side.

Rise of Floor (or Dead rise):
The rise of the bottom shell plating line above the base line. This rise is measured at the line of moulded beam.

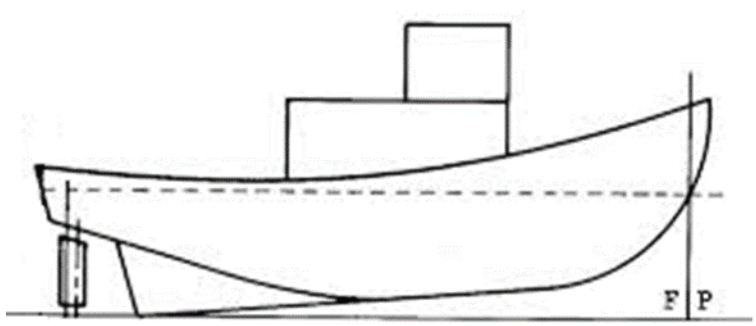
Half Siding of Keel:
The horizontal flat portion of the bottom shell measured to port or starboard of the ship's longitudinal center line. This is a useful dimension to know when dry-docking.

Tumblehome: The inward curvature of the side shell above the summer load line.

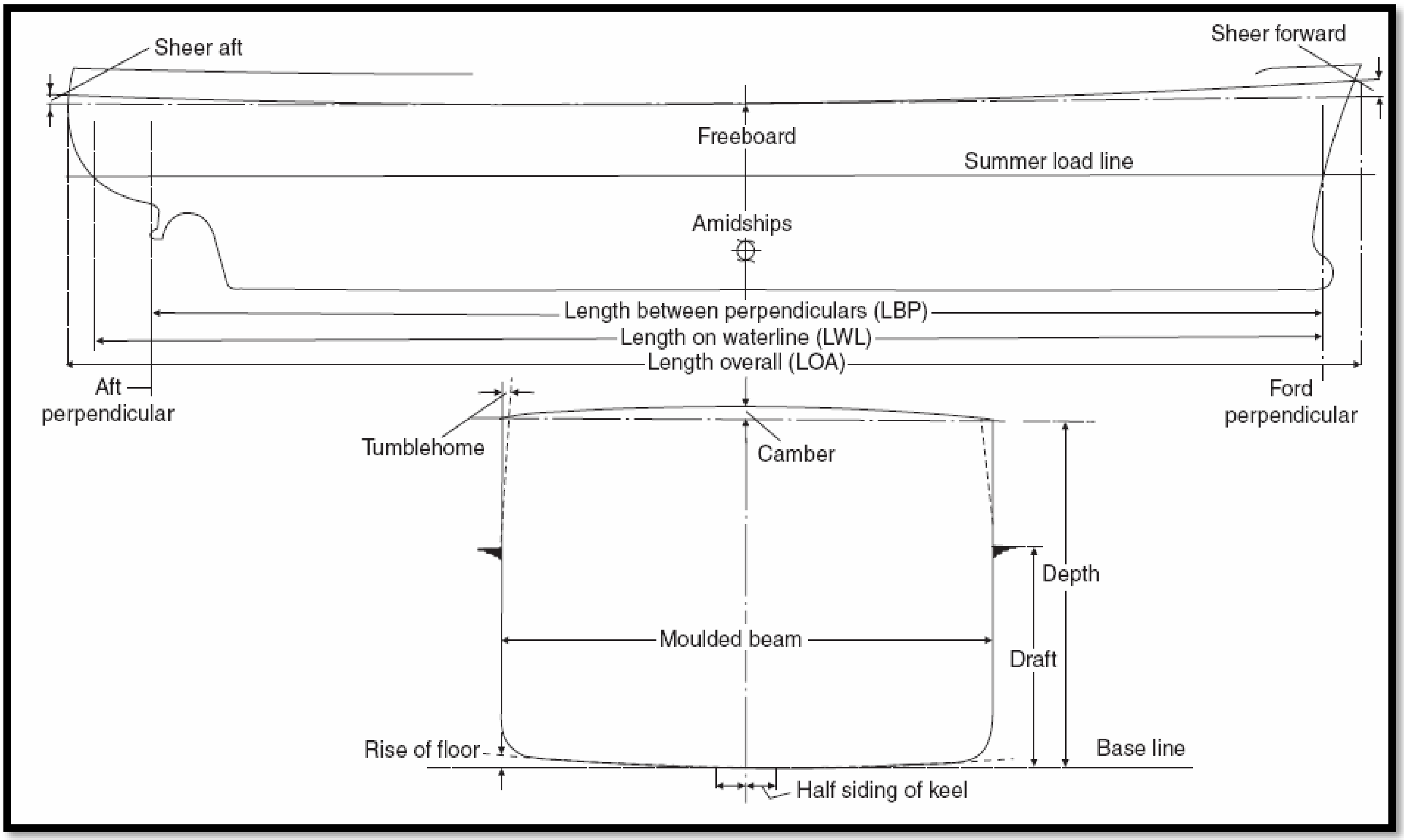
Flare:
The outward curvature of the side shell above the waterline. It promotes dryness and is therefore associated with the fore end of ship.

Stem Rake: Inclination of the stem line from the vertical.

Keel Rake:
Inclination of the keel line from the horizontal. Trawlers and tugs often have keels raked aft to give greater depth aft where the propeller diameter is proportionately larger in this type of vessel. Small craft occasionally have forward rake of keel to bring propellers above the line of keel.



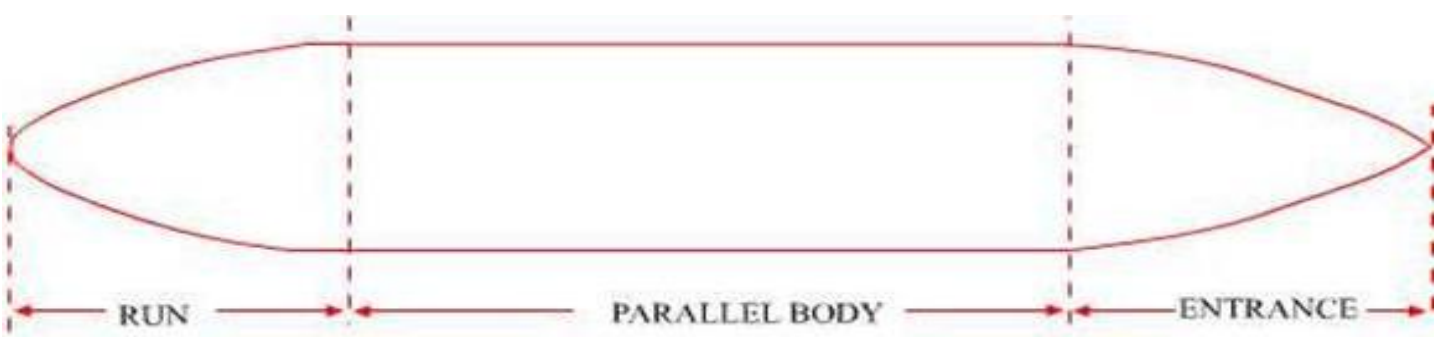
Stem rake



Parallel Middle Body:

The part of a vessel adjacent to the midship section having a uniform or nearly uniform cross-section, usually referred to as the parallel middle body .The **entrance** of a hull is the fore section which parts the water, extending from the shoulder (the area of parallel middle body or greatest breadth) forward

The **run** of a hull is the aft section which reconciles the flow of water, extending from the point of maximum beam (or end of the parallel middle body) to the stern/transom.



Moulded Dimensions:

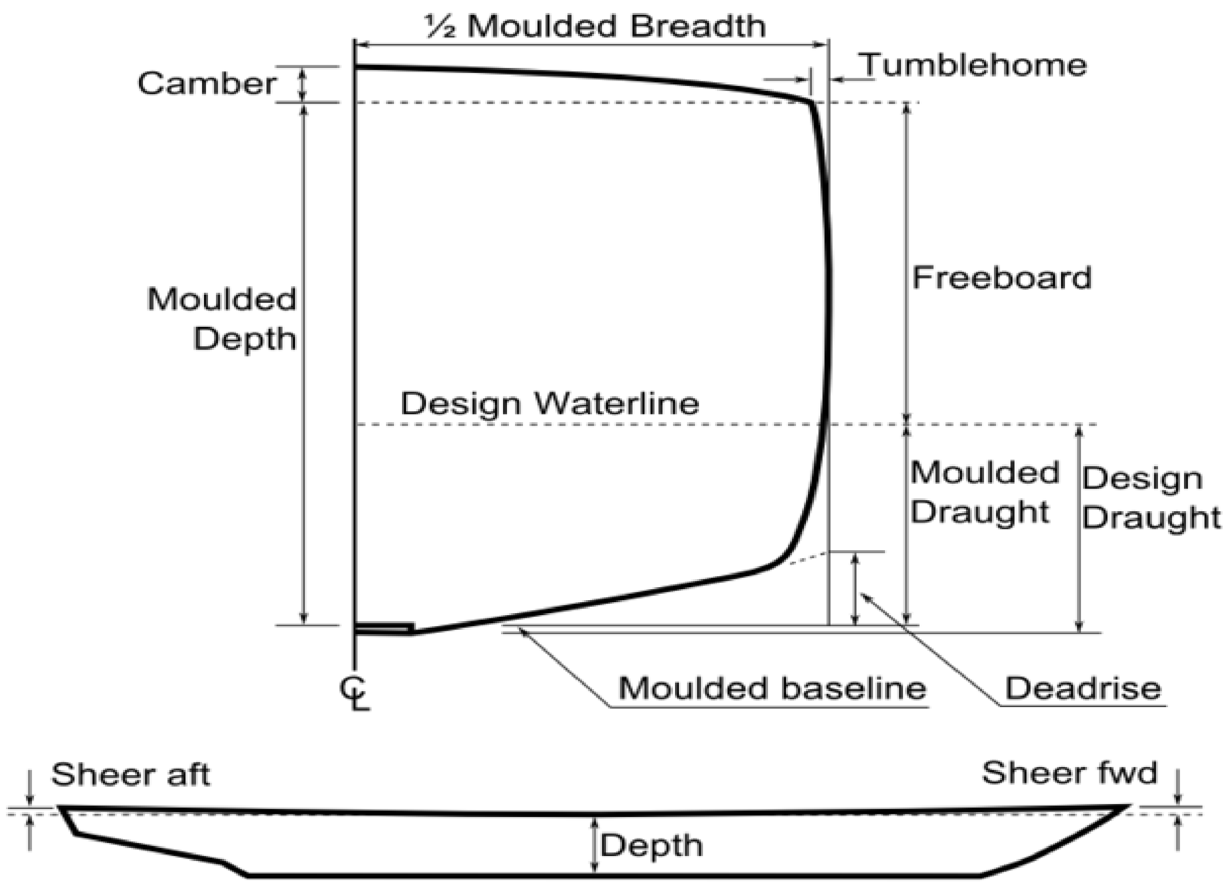
The dimensions of the ship, measured inside the shell and deck plating: horizontally to the outer edges of the frames: vertically from the base line to the level of the tops of the beams at the ship's side.

The moulded depth:

It is the height above baseline of the intersection of the underside of the deck plate with the ship side.

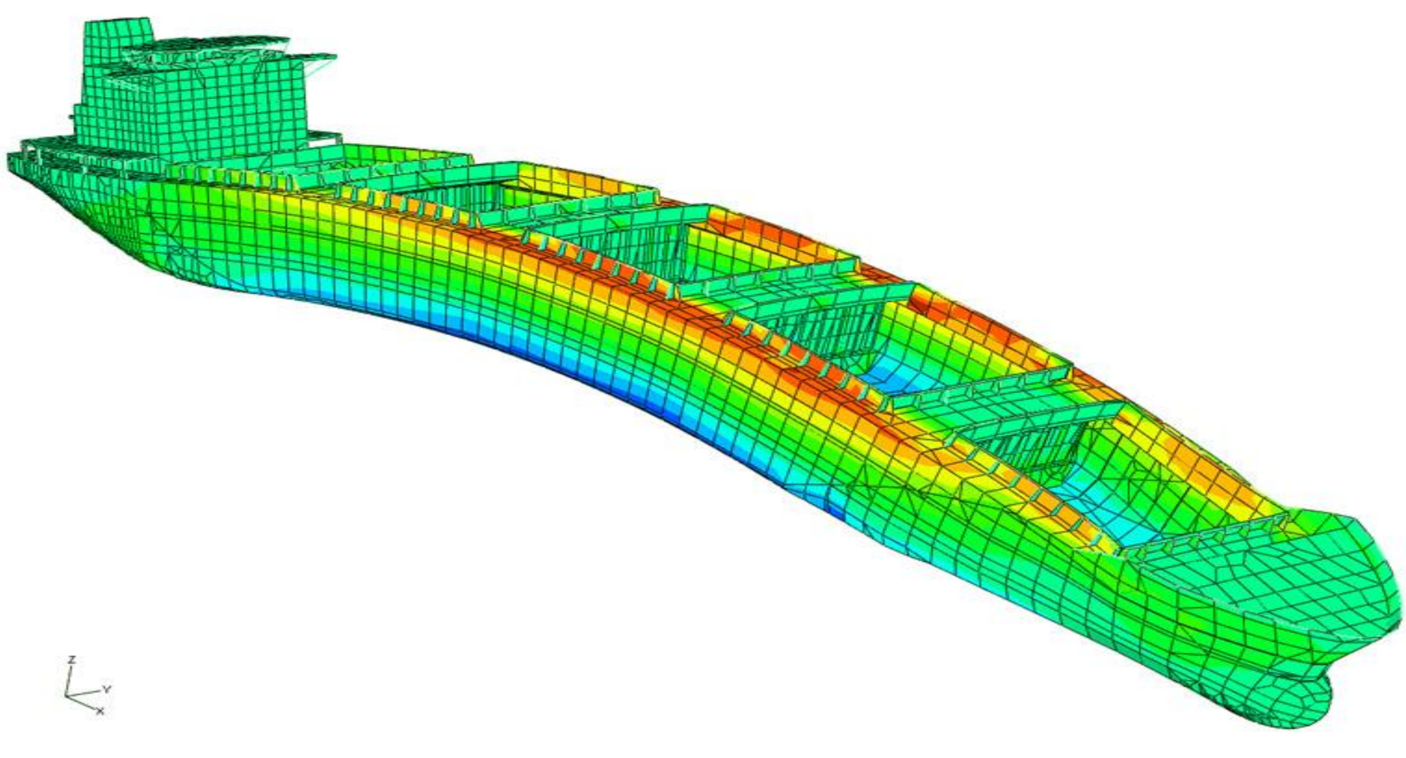
The moulded draught:

It is the vertical distance between the top of the keel to the designed summer load line, usually measured in the midships plane.



Chapter Three

STRESSES IN SHIP STRUCTURES

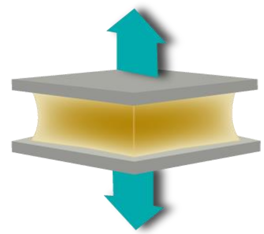


Ship Stresses:

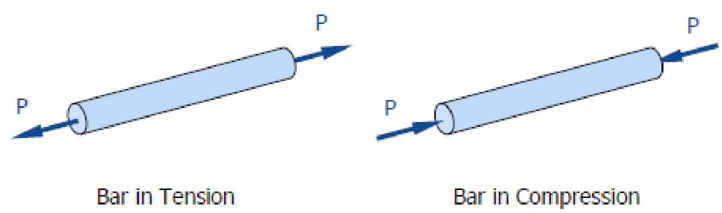
-Stress is load put on a piece of material or on a structure.
-Strain: If the stress is excessive & the material become permanently deformed.

Type of Stress:

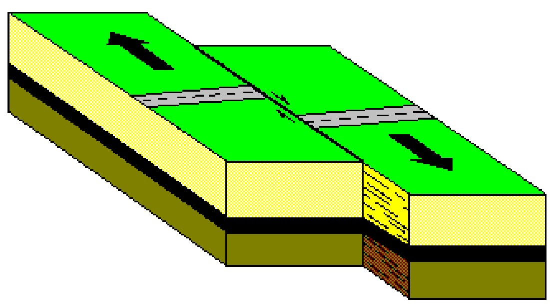
1- **Tensile**: Try to pull the material apart.



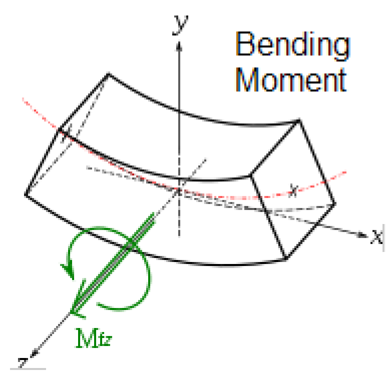
2- **Compressive**: Try to crush/buckle the material

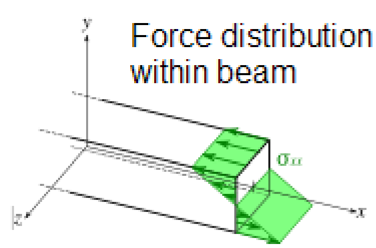


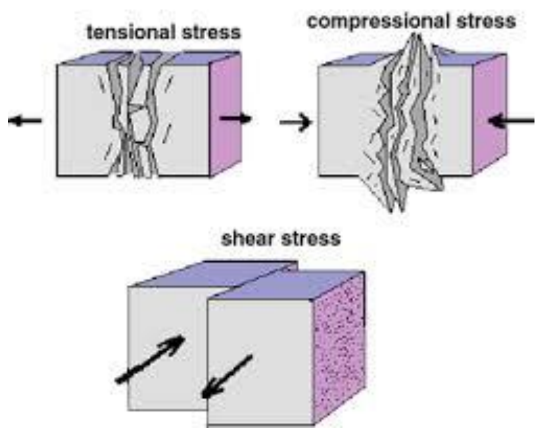
3- **Shearing**: May be described as the effect of forces which try to shear the material across

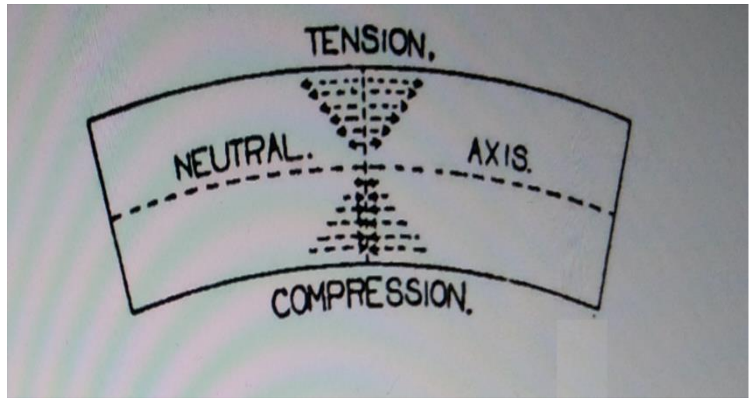


4- **Bending**: Are compound stresses produced by forces when they try to bend a piece of material.









A ship at sea is subjected to a number of forces causing the structure to distort. Initially these may be divided into two categories, as follows:

1. **Static forces** - ship floating at rest in still water. Which are Two forces acting:
   a) Weight of the ship acting vertically down
   b) Buoyancy acting up.

2. **Dynamic forces** - due to the motion of the ship.

The separate structural stresses to which the ships structure is subjected caused by the above forces are as follows:

1. **Principal Structural stresses**- those affecting the whole ship (Hogging and Sagging; Racking; effects of water pressure; and dry-docking.)
2. **Principal Local stresses** - those affecting particular parts of the ship (Panting; Pounding; effects of local weights and vibration)

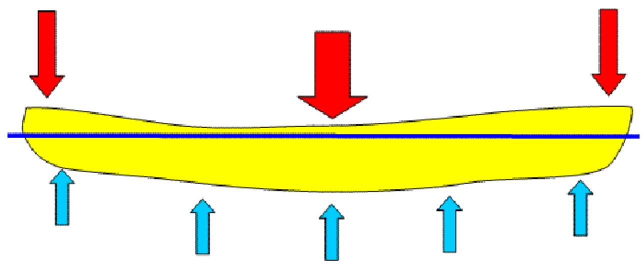
Principal Structural stresses

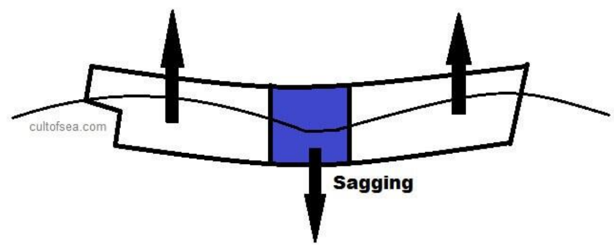
1- Longitudinal Stresses (Hogging and Sagging)

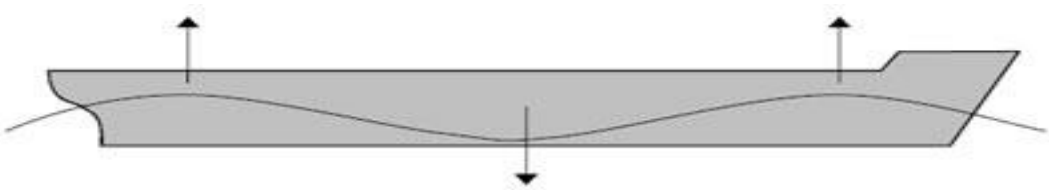
bending stress would occur if the ship were subjected to local loading at the fore end and after ends (e.g. Ship with machinery aft and in light condition with ballasted fore peak tank)

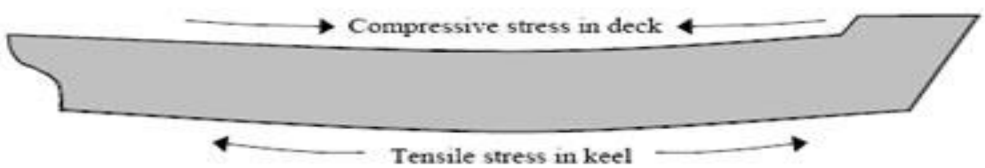
- There is longitudinal bending Stresses which may occur when ship is in a **Seaway** or from her **loading condition** as follows:

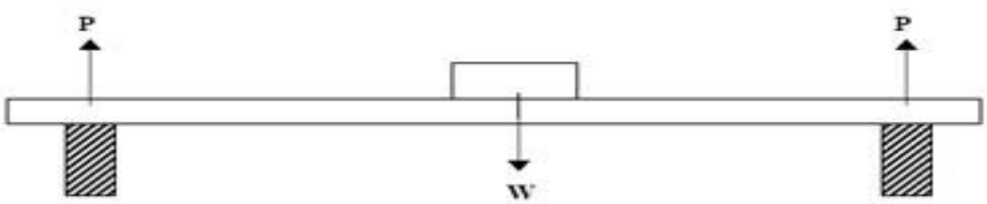
Sagging: when she is being loaded, too much weight amidships and/or by sea wave.





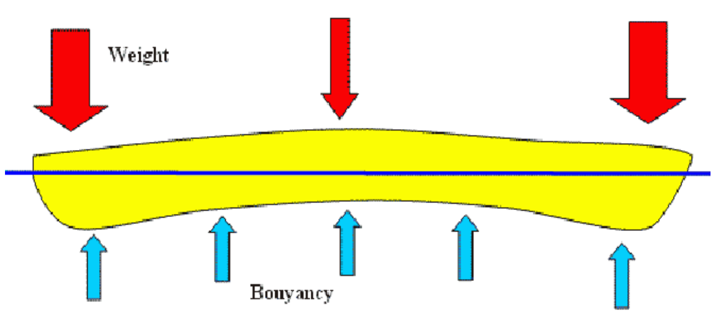


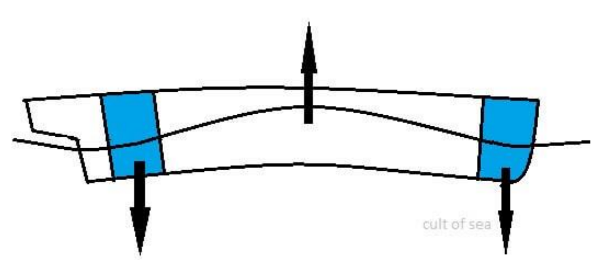


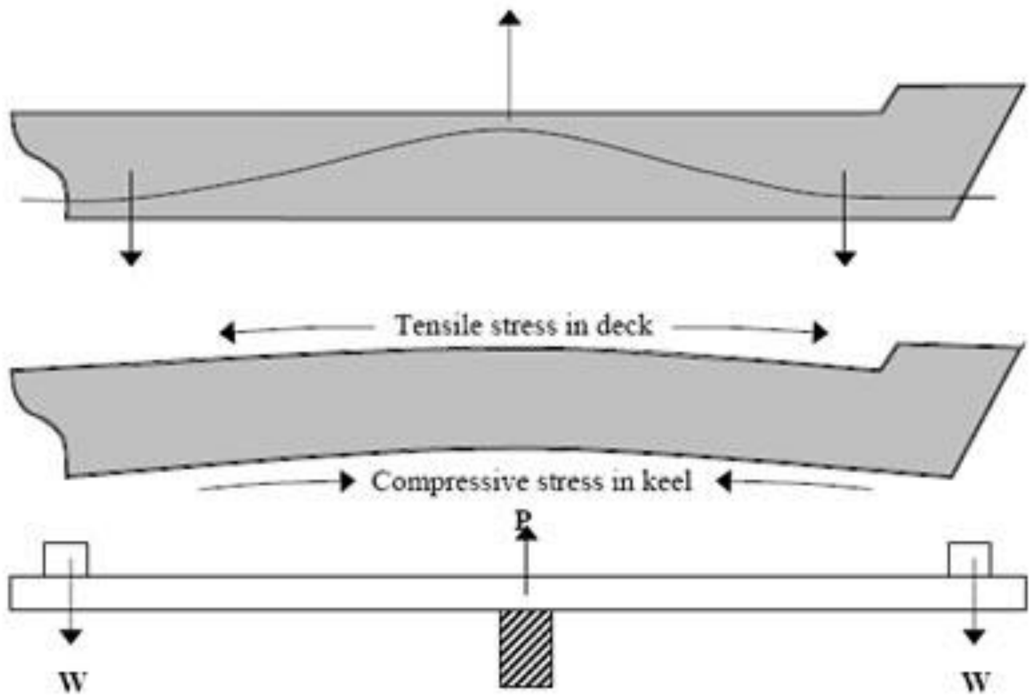


Sagging would occur if the load and buoyancy distribution tended to distort the hull (e.g. ship with machinery amidships in light condition).
This is made worse when the wave crests are at the ends of the ship, with wave length similar to ship length.

Hogging: when she is being loaded, less weight amidships and/or by sea wave.







Hogging would occur if the load and buoyancy distribution tended to distort the hull (e.g. ship with machinery Aft and full forepeak in light condition). This is made worse when the wave crests are at the middle of the ship.

Longitudinal stresses created by Hogging and Sagging can be very severe. These stresses are resisted by all **continuous longitudinal material** especially those parts further from the neutral axis. i.e. Double bottoms center girder, side girders, inner bottom and outer bottom longitudinal, keel and bottom shell, tank top plating. The side shell at the top (the sheer strake) and deck stringer plates. At the decks, longitudinal girders and deck longitudinal also help resist these stresses.

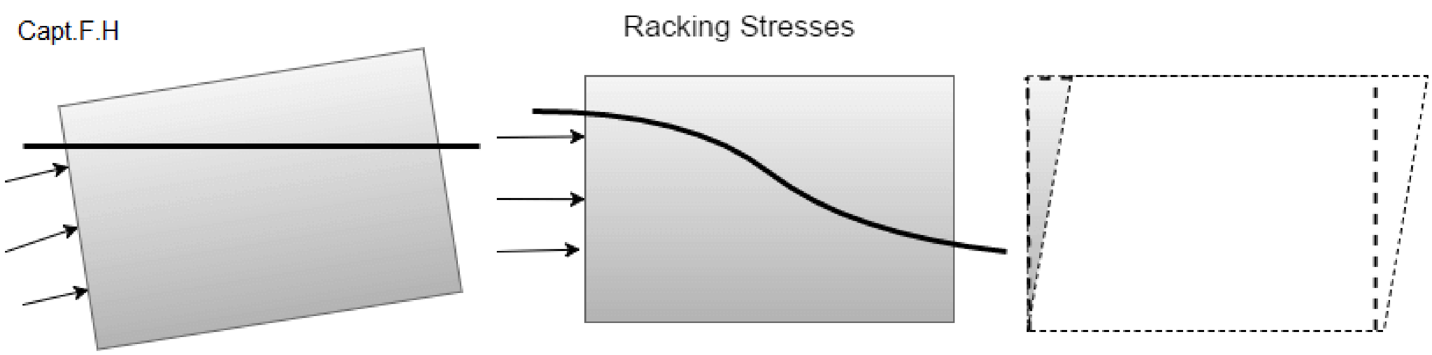
In tankers, longitudinal bulkheads also give greater strength. Special steels for high stress areas are now used, especially in large ships.

2- Racking Stress:

When a ship is rolling in a seaway or is stuck by beam waves, the ship's structure is liable to distort in a transverse direction (Ship is racked by wave action, or by rolling in a seaway)

The stress mainly affects the corners of the ship, i.e. on the tank side brackets and the beam knees, which must be made strong enough to resist it.

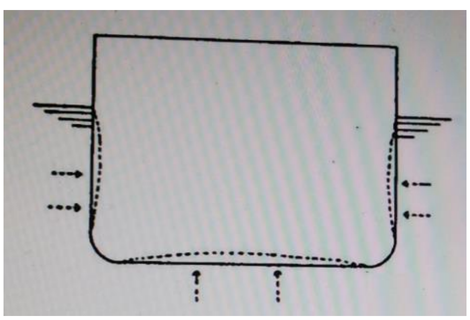
Transverse bulkheads. web frames. frames. or cantilever frames provide very great strength to resist this stress.

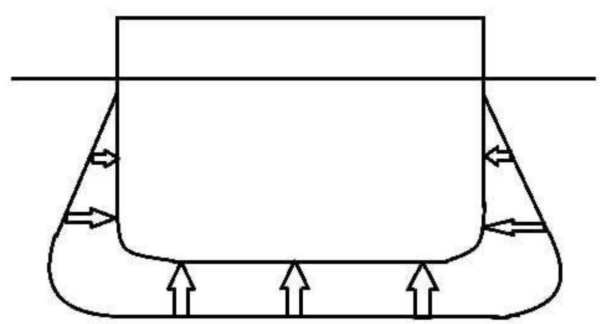


3- Effect of Water pressure:

Acts perpendicular to the shell of the ship, increasing with depth. The effect is to push the ship's bulkheads, floors and girders. It’s tends to **push-in** the sides and bottom of the ship.

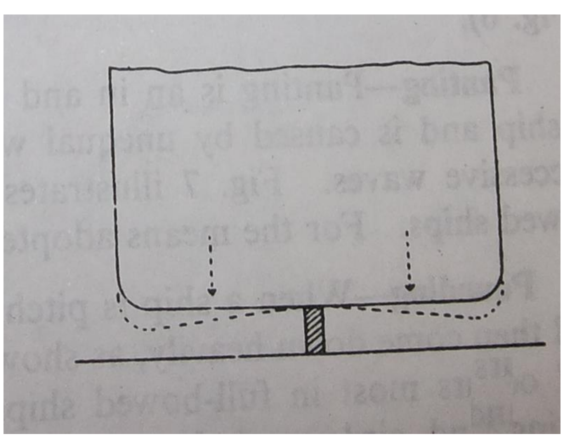
Resisted by bulkhead/frames and floors.

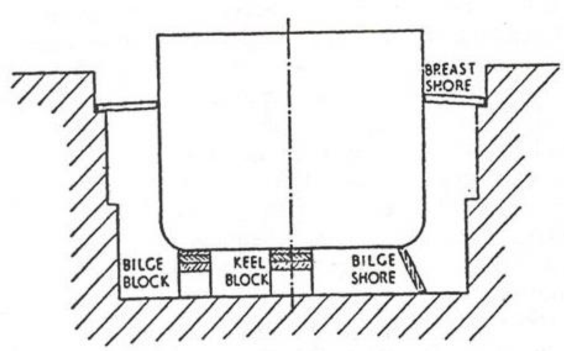




4- Dry Docking:

The tendency of ship structure to sag at the bilges while in dry dock and rest on blocks, the double bottom is usually strong enough to resist this stress.

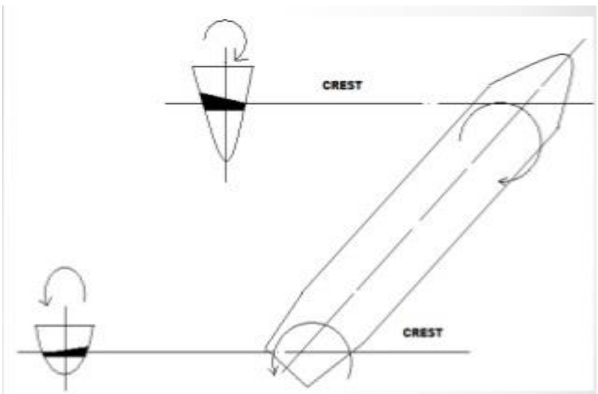


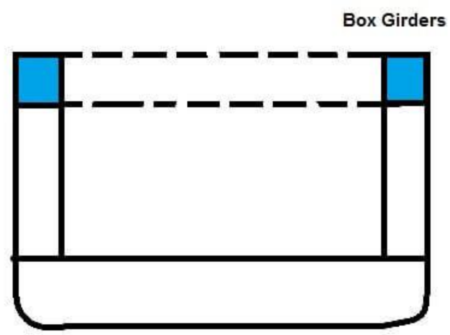


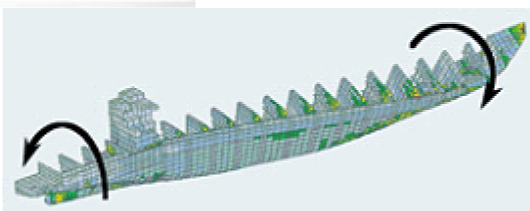
SUPPORT IN DOCK

5- Torsion Stresses:

When anybody is subject to a twisting moment which is commonly referred to as torque, that body is said to be in 'torsion'. A ship heading obliquely (45°) to a wave will be subjected to righting moments of opposite direction at its ends twisting the hull and putting it in 'torsion'. In most ships these torsional moments and stresses are negligible but in ships with extremely wide and long deck openings they are significant. A particular example is the larger container ship where at the topsides a heavy torsion box girder structure including the upper deck is provided to accommodate the torsional stresses.







Principal Local stresses

1- Localized Loading

The movement of a ship in a seaway results in forces being generated which are largely of a local nature. These forces are, however, liable to cause the structure to vibrate and thus transmit stresses to other parts of the structure. Localized heavy weights, e.g. machinery, or localized loading of heavy cargoes, e.g. ore may give rise to localized distortion of the structure.

The ends of superstructures may be major discontinuities in the ship's structure giving rise to localized stresses which may result in cracking.
Deck openings, holes cut in the deck plating, i.e. hatchways, etc., create areas of high local stress due to the lack of continuity created by the opening.

Stresses set up in the vicinity of hawse pipes, windlass, winches etc.

2- Vibration

Vibration from the engines, propellers etc. tend to cause stresses in the after part of the ship. These are resisted by extra stiffening in the double bottom under the machinery spaces and in the region of the stern and after peak.

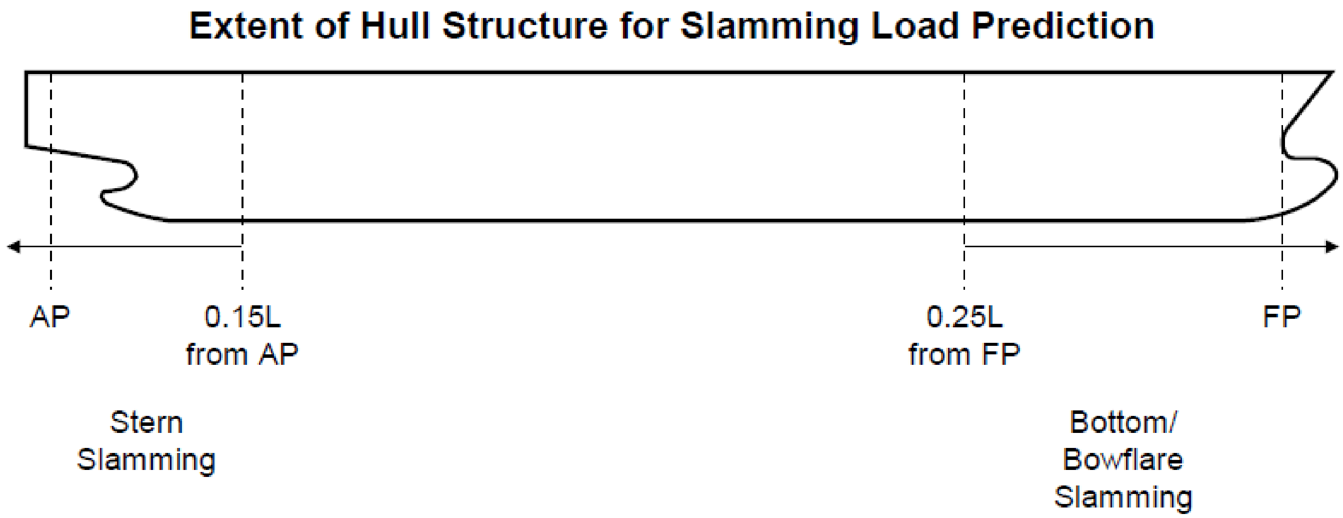
3- Slamming:

In rough seas, the vessel's bow and stern may occasionally emerge from a wave and re-enter the wave with a heavy impact or slam as the hull structure comes in contact with the water.

Typically, there are three types of slamming loads on commercial vessels:

- bottom slamming
- bow slamming
- stern slamming

Pounding: When a ship pitching, her bows often lift clear of the water and come down heavily. It's may cause damage to the bottom plating between the collision B/H and ¼ of the ship's length from stem.

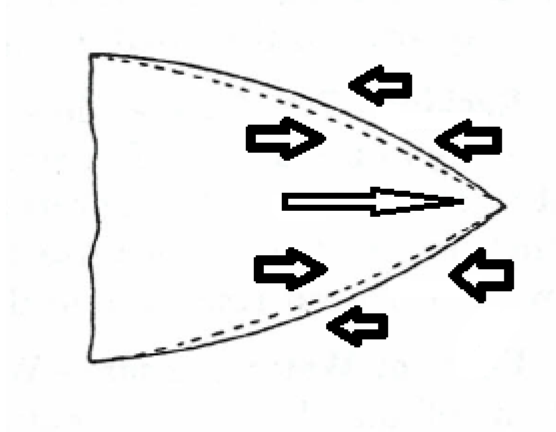


4- Panting:

The movement of waves along a ship causes fluctuations in water pressure on the plating. This tends to create and in-and- out movement of the shell plating. known as panting.

The effect is particularly evident at the bows as the ship pushes its way through the water.

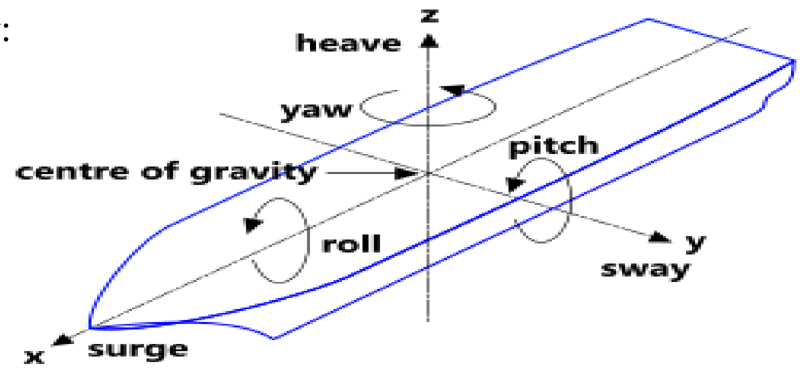
The pitching motion of the ship produces additional variations in water pressure, particularly at the bow and stern, which also cause panting of the plating. Additional stiffening is provided in the form of panting beams and stringers.



Ship movement - the six degrees of freedom

The forces may initially be classified as static and dynamic. Static forces are due to the differences in weight and buoyancy which occur at various points along the length of the ship. Dynamic forces result from the ship's motion in the sea and the action of the wind and waves.

A ship is free to move with six degrees of freedom - three linear and three rotational. These motions are described by the terms shown below:



Corrosion

Natural tendency of all metals is to react with their environment the result is **corrosion**

Metal + damp atmosphere = oxide

- **Corrosion** is the wasting of metals by chemical or electro- chemical reactions with the environment.
- **Erosion** is the destruction of a metal by abrasion, thus it is a mechanical wastage process that exposes bare metal which can then corrode.

Chemical Corrosion

is the oxidising (or rusting) of iron/steel, by chemical reaction, when exposed to oxygen and moisture primarily it can be prevented by isolating it from the environment.

Ship’s bottom area(completely), boot topping area (intermittently) are immersed in sea water, ideal condition for formation of electro chemical corrosion cell.

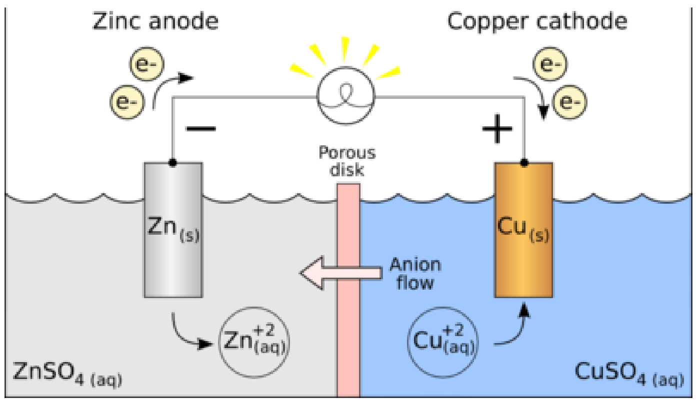
- Thus need a great deal of care to prevent excessive corrosion.

Electro- Chemical Corrosion

is the oxidising (or rusting) of unprotected iron/steel by electro-chemical reaction when submerged in sea-water.

primarily a Corrosion Cell is formed between two metal surfaces (**not necessarily different metals**) in a solution of salt water (***the 'electrolyte'****),* when connected externally.

A current will flow from one metal (*anode*) to the other (*cathode*) as a result of a potential difference between them. This current flow results in metal being removed from the 'anode', whilst the 'cathode' is protected.



Control of Corrosion On Board can be:

1- The application of barrier or protective coating to isolate the steel (or other metal) from the air or from the seawater electrolyte e.g. Paint

2- Using 'cathodic protection' to prevent the steel from forming the anode of a corrosion cell

- sacrificial anodes
- Impressed current systems

sacrificial anodes

This method can be used to protect ship's steel from corrosion when the steel is immersed in water (electrolyte), It prevents the steel from forming the 'anode' of a corrosion cell and operates by providing a reverse current flow to that of the normal corrosion cell.

-Metals or alloys that are less 'noble' than ship's steel is used as anodes (usually aluminum, magnesium or zinc alloys).

-The anode is welded to the hull by their steel cores to give a good electrical connection.

-The life-span of sacrificial anodes is around 2- 4 years depending on paint conditions.

Impressed current systems

Appropriate voltage difference is maintained between the steel hull & fitted 'non- consumable' anodes (who are provided with a DC current rectified from the ships AC supply)

(this can be used only in submerged areas, like the ships underwater hull or in ballast tanks)

Hull Stress Monitoring Systems

The International Maritime Organization (IMO) recommends the fitting of hull stress monitoring systems to facilitate the safe operation of ships carrying dry cargo in bulk. Use of the system will provide the Master and Officers of the ship with real-time information on the motions and global stress the ship experiences while navigating, and during loading and unloading operations.

Hull Stress Monitoring System (HSMS) is a system to provide real-time information to the master and officers of the ship of the motions and global stress the ship experiences while navigating and during loading and unloading operations.

The HSMS is to be considered as an aid to the master. It does not replace his own judgement or responsibility.

Chapter Four

HULL STRUCTURE

Section Used in Shipbuilding:

Plate: The basic material of shipbuilding.

Round Bar: Solid round bars are used for small pillars, handrails…

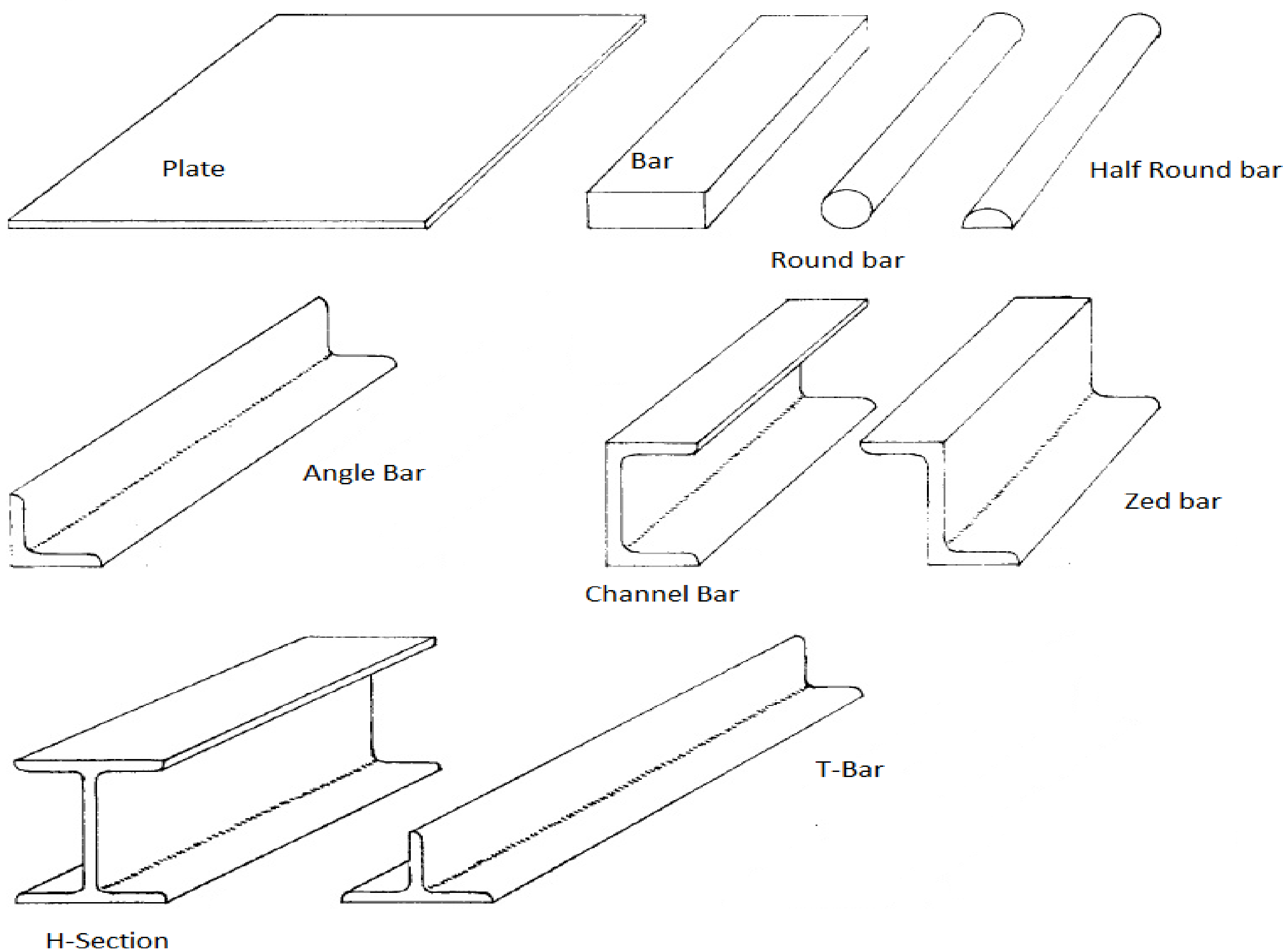
Half Round Bar: sometimes fitted as chaffing pieces, etc.

Angle Bar: Used for connecting parts together or for stiffening plating.

Channel bar: A stronger section than the other bars, usen when the greater strength is required.

H-Section Bar: A very strong section. It's not used generally, but is fitted where special strength is needed.

T-Bar: Used for special purpose, such as beams under deck.

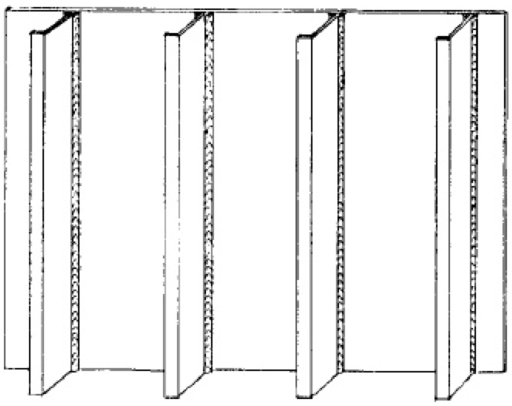


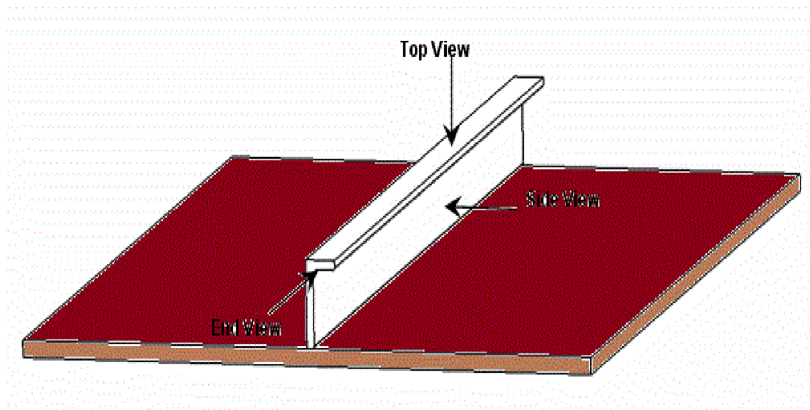
Strengthening of Parts

It is necessary to support plating, etc., against all stresses like distortion, to give greater rigidity and strength to joints, or to make up for lost strength in parts which have been cut away.

Stiffener:

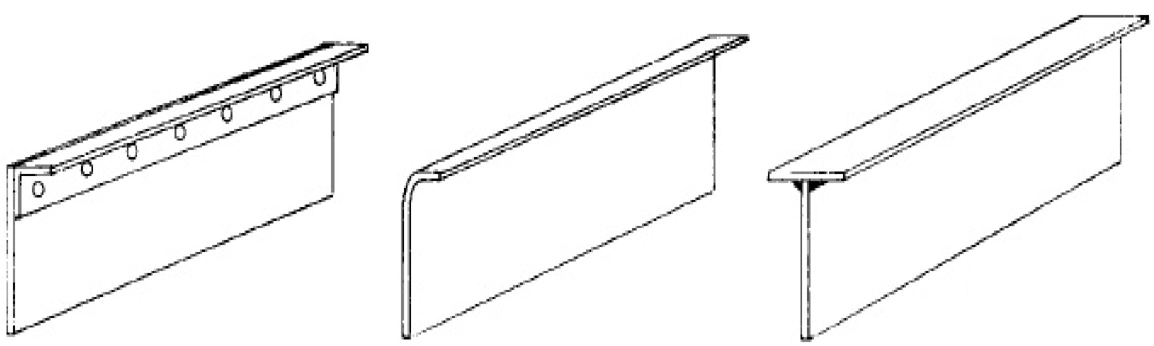
Large area of plating is usually supported by riveted angle or channel, bulb angle or channels, or by equivalent welded section.





Stiffening of Free Edge:

When free edge of plating of plates are under stress, they may tend to buckle and to lose rigidity.



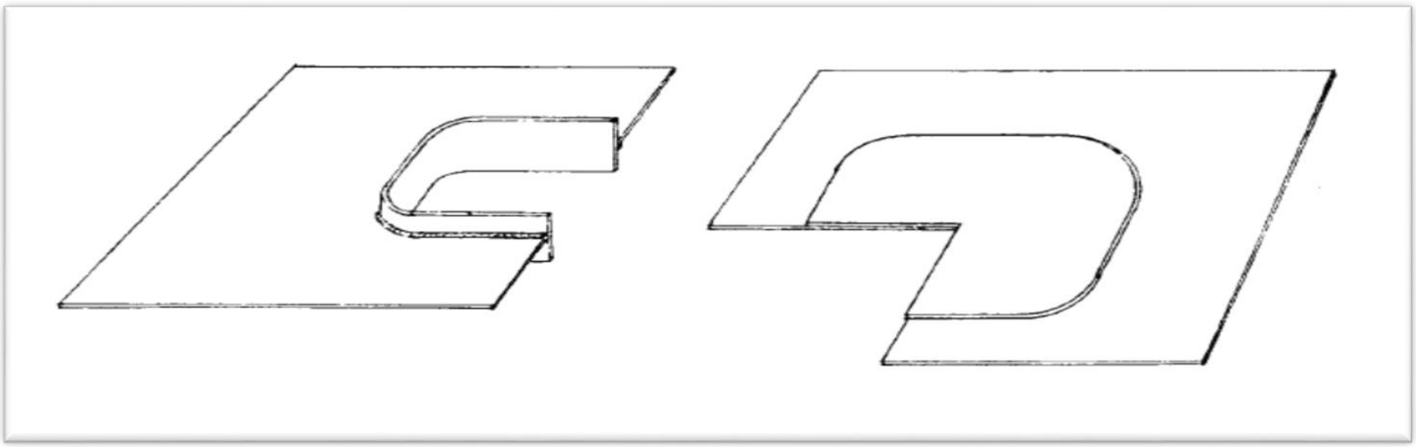
Riveted *Flanged* *Welding*

Reinforcement of Opening:

When opening is cut in plating, the strength may be made up by means of face bars or doubling plates or both.

Face bars are often welded right around the edges of opening, which have rounded comers and are very effective.

Doubling Plates are often fitted at the comers of large openings or sometimes right around the opening. In welded work, thicker plates called 'insert plates', are usually welded-in, instead of doubling plates



shell plating

The shell plating forms the watertight skin of the ship and at the same time, in merchant ship construction, contributes to the longitudinal strength and resists vertical shear forces.
Internal strengthening of the shell plating may be both transverse and longitudinal, and is designed to prevent collapse of the plating under the various loads to which it is subjected.

The bottom and side shell plating consists of a series of flat and curved steel plates generally of greater length than breadth butt welded together.
Stiffening members both longitudinal and transverse are generally welded to the shell by continuous fillet welds.

1. Side shell plating

The side shell is supported by frames which run vertically from the tank margin to the upper deck. These frames, which are spaced about 760 mm apart, are in the form of bulb angles and channels in riveted ships or bulb plates in welded ships.

2. Bottom shell plating

The bottom and side shell plating of a ship form a major part of the longitudinal strength members of the vessel. The most important part of the shell plating is that on the bottom of the ship, since this is the greatest distance from the neutral axis. It is therefore slightly thicker than the side shell plating.

Framing

The bottom shell may be transversely or longitudinally framed, longitudinal framing being preferred for larger ships, and generally required when the ship's length exceeds 120 meters. The side shell framing may also be transversely or longitudinally framed, transverse framing being adopted in many conventional cargo ships, particularly where the maximum bale capacity is required.

Bale capacities

The **bale capacity** of a vessel is a measure of its internal volume of cargo holds. It is the volume formed inside the line of structure within the cargo hold (to the bottom of deck girders/ beams, to the outside edge of shell stringers & frames, and top of deck, double bottom, or ceilings).
No volume allowance is made for spaces between structural members.

Grain capacities

The maximum space available for cargo measured, the measurement being taken to the inside of the shell plating of the ship or to the outside of the frames and to the top of the beam or underside of the deck plating. It is a measurement of capacity for cargo like grain, where the cargo flows to conform to the shape of the ship.

Gross Tonnage

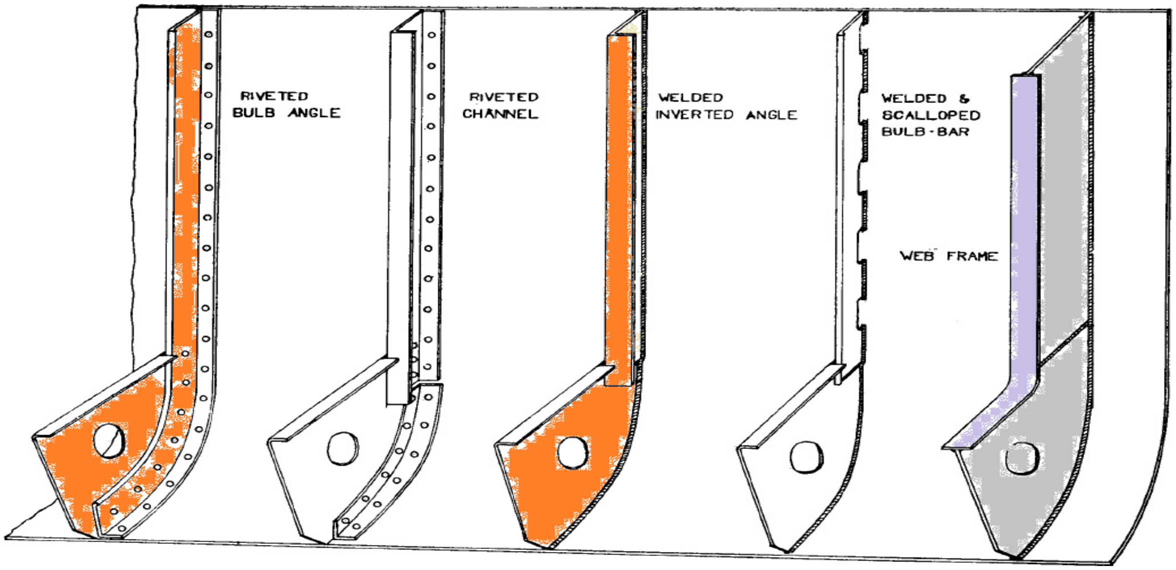
Is a function of the volume of all of a ship's enclosed spaces (from keel to funnel) measured to the outside of the hull framing.

Total volume of all enclosed spaces in cubic meters.

Net Tonnage

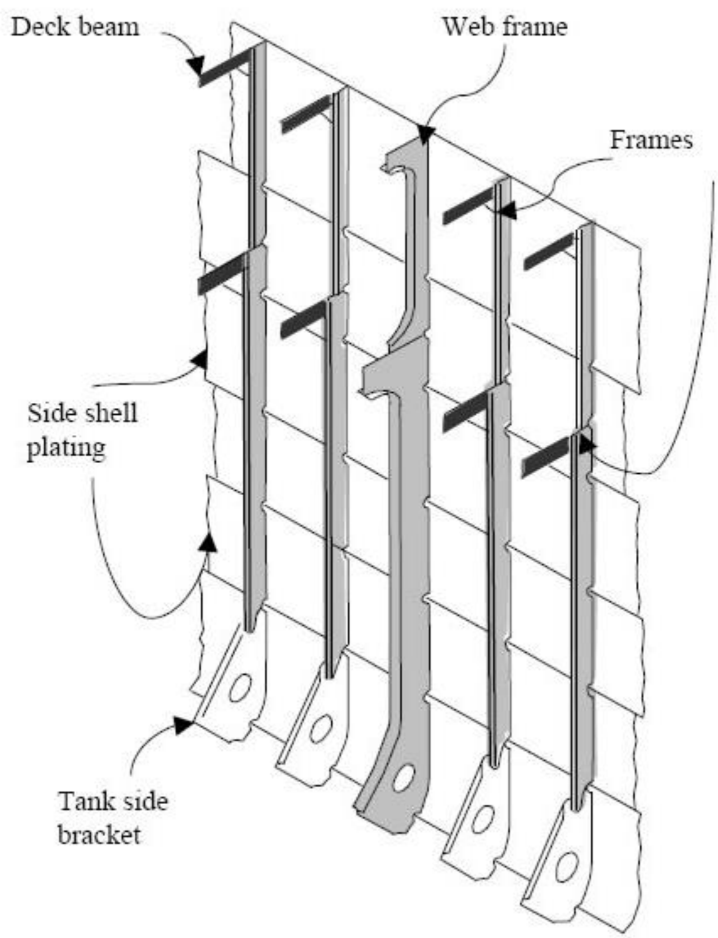
is based on a calculation of the volume of all cargo spaces of the ship. It indicates a vessel's earning space and is a function of the moulded volume of all cargo spaces of the ship.
A commonly defined measurement system is important, since a ship's registration fee, harbor dues, safety and manning rules, and the like may be based on its gross tonnage (GT) or net tonnage (NT).

Frame: On side plating, running vertically (up and down)



Web Frames

Are heavy plate frames, which are not normally used as a system, but are fitted in certain parts of a ship to give local strength. They must be fitted in engine-rooms and at every **fourth frame** space in tween decks abaft the after peak bulkhead.



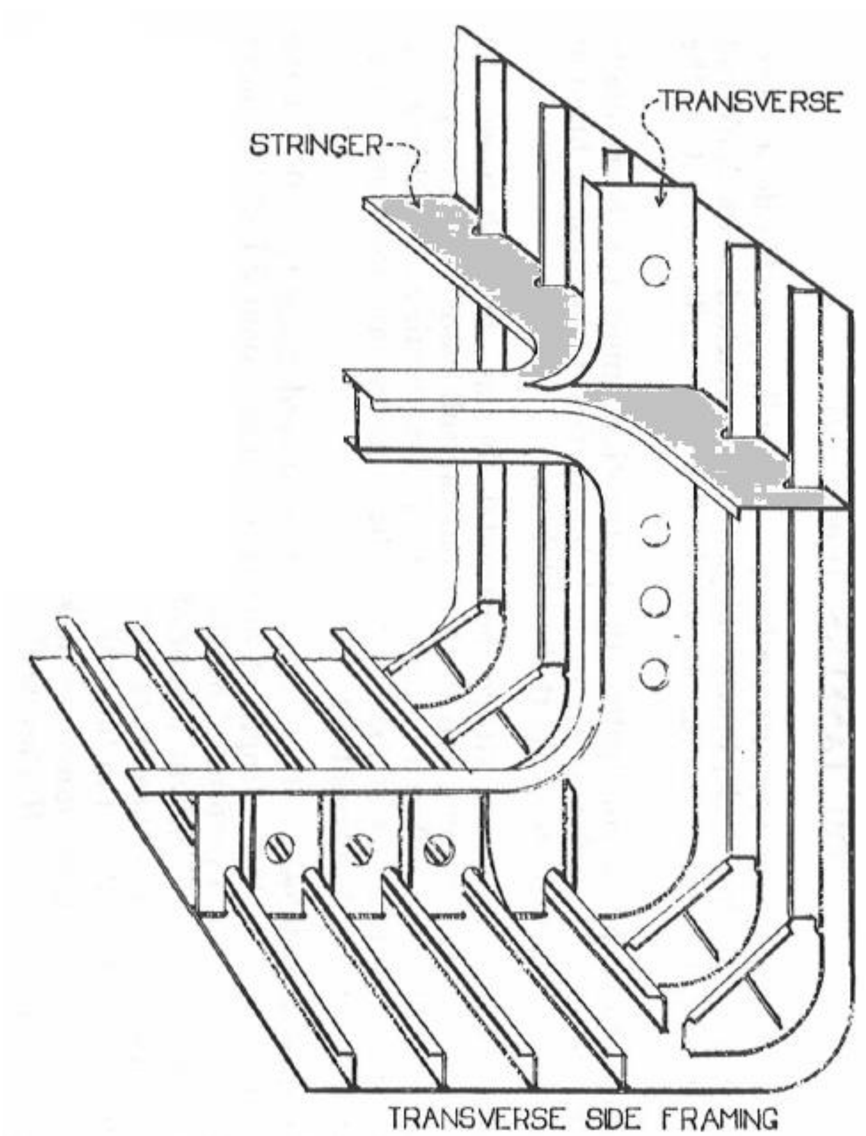
Framing systems

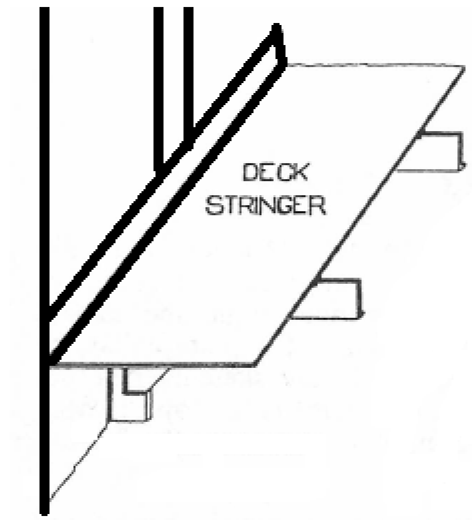
The bottom shell and side plating are framed i.e. stiffened along their length, against the compressing forces of the sea. Two different types of framing are in use, or a combination of the two may be employed. These are known, respectively, as transverse, longitudinal and combined framing, Cargo arrangements may influence the choice of framing systems but, generally, considerations of longitudinal strength are the deciding factor.

SIDE FRAMING

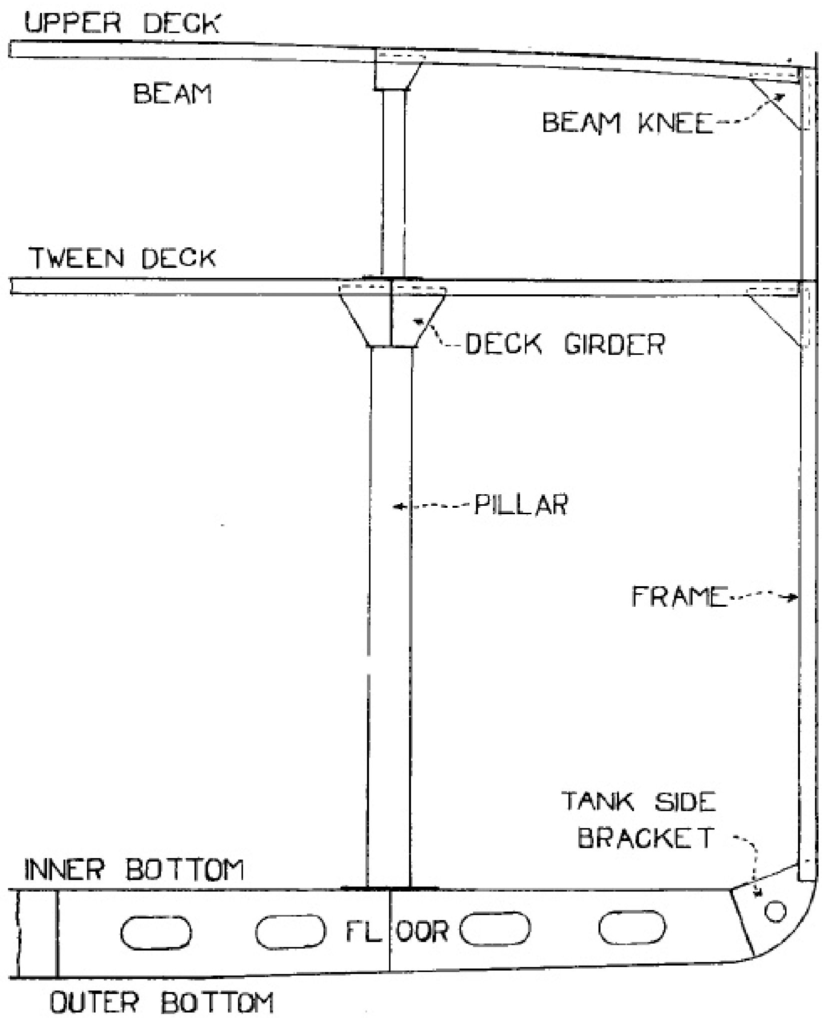
The side shell is supported by frames which run vertically from the tank margin to the upper deck. These frames, which are spaced about 760 mm apart, are in the form of bulb angles and channels in riveted ships or bulb plates in welded ships. The lengths of frames are usually broken at the decks, allowing smaller sections to be used in the 'tween deck spaces where the load and span are reduced.

Stringer: On side plating and longitudinal bulkheads, runs horizontally, forward and aft.





Transverse framing

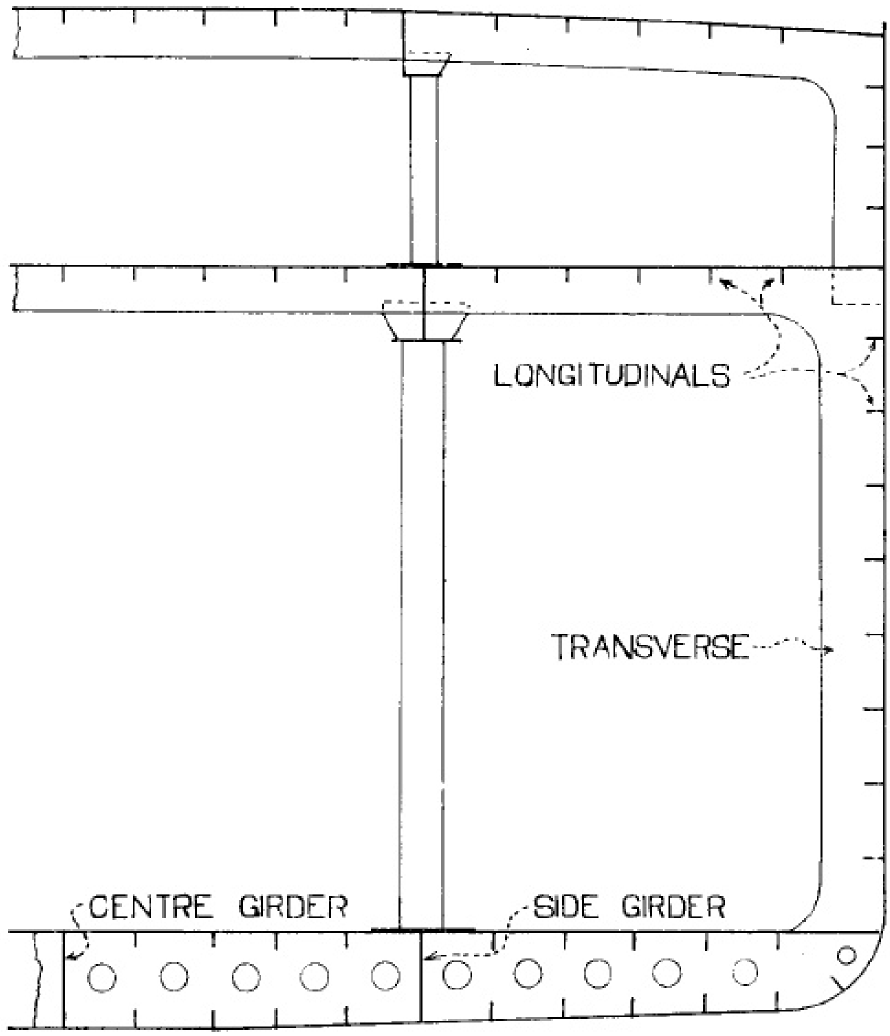


Wooden ships were always built on this system, because closely spaced transverse frames. It was also necessary to use it because sailing ships needed considerable transverse strength to enable them to resist the **racking** stresses set up by the masts and rigging. Longitudinal strength was less important in these ships because they were comparatively small and hogging and sagging stresses were not large.

This system is not the most efficient for steel steamships, but it has continued in general use until recently. This was partly because it was cheap to build and served its purpose; and partly because a suitable alternative was not available for many years.

Transverse framing of the shell plating consists of vertical stiffeners, either of bulb plate or deep-flanged web frames, which are attached by brackets to the deck beams and the flooring structure. The scantlings of the frames are to some extent dependent upon their depth and also on the nature of their end connections.
Frame spacing is generally not more than 1000 mm but is always reduced in the pounding region and at the fore and aft ends in the peak tank regions.

Longitudinal framing

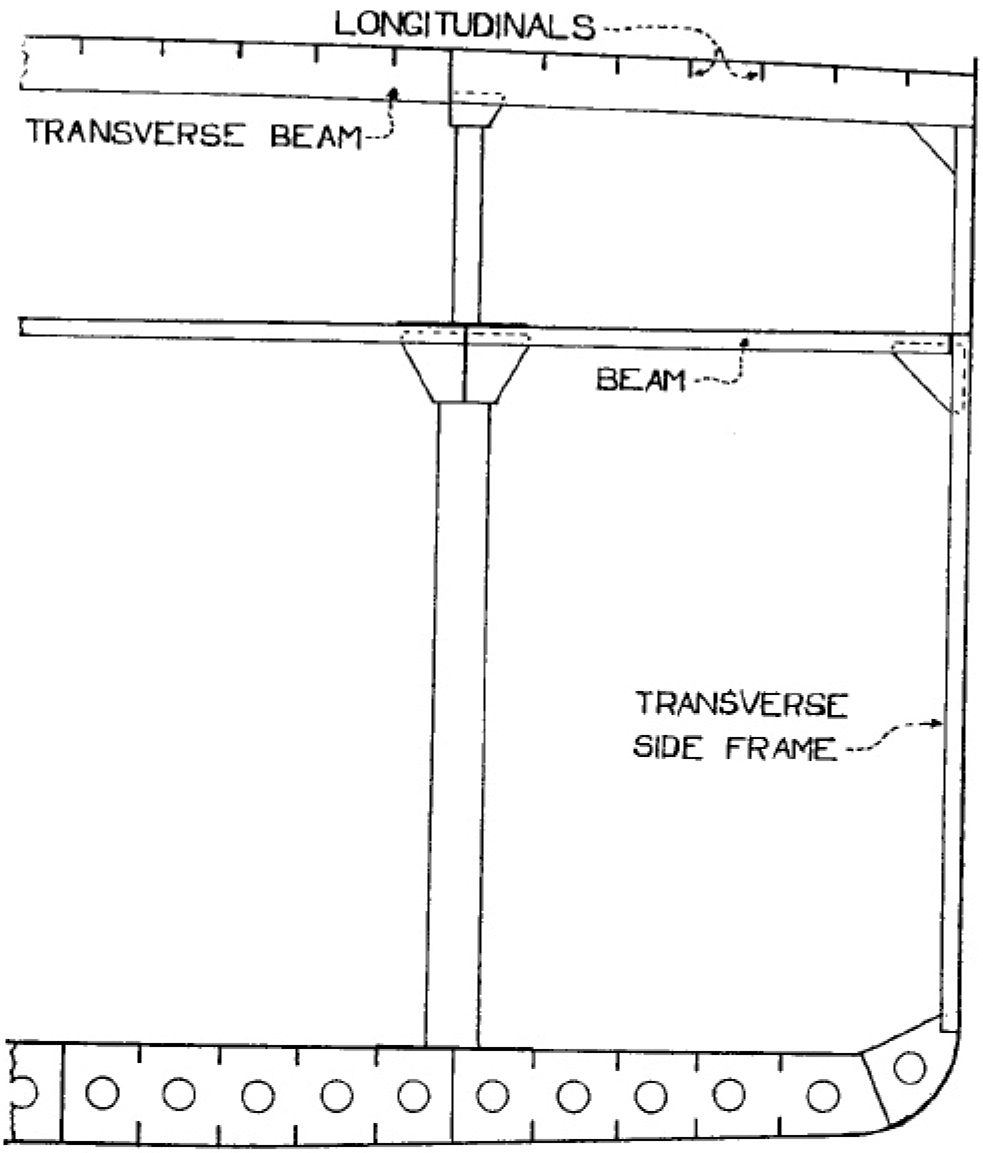


With the coming of steamships, racking stresses became less important, but hogging and sagging stresses became more serious as ships grew longer. It soon became obvious that more longitudinal strength could be achieved by running the frames longitudinally (fore and aft), provided that reasonable transverse strength was maintained.

Longitudinal framing of the side shell employs horizontal offset bulb plates with increased scantlings towards the lower side shell. Transverse webs are used to support the longitudinal frames, their spacing being dependent upon the type of ship and the section modulus of the longitudinal.

Combination System

This was introduced to overcome the disadvantages of the longitudinal system for dry cargo ships. The longitudinal frames are retained in the bottom and under the strength deck, where they give great longitudinal strength; but transverse frames are fitted on the ship's side, where the longitudinal stresses are smaller.
Plate floors and heavy transverse beams are fitted at intervals to give transverse strength and to support the longitudinal.

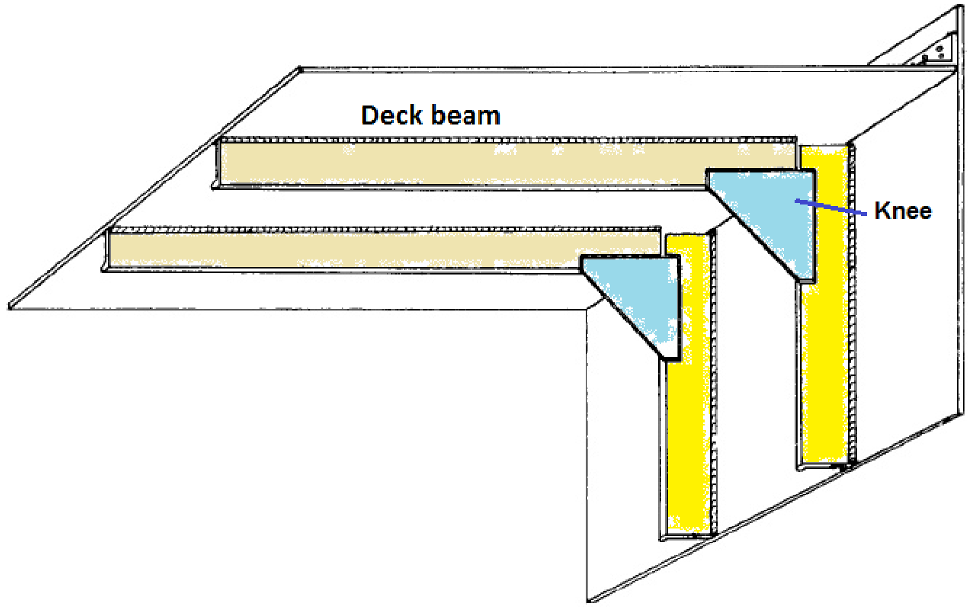


Deck stiffening

The deck plating is supported from below in a manner determined by the framing system of the ship. With longitudinal framing, a series of closely spaced longitudinal are used in addition to deep web transverses.

With transverse framing, transverse deck beams are used at every frame space. Where hatches are fitted to a ship, continuous longitudinal girders are fitted over the length of the ship running alongside the hatches.

Deck beams and transverses



Deck beams are fitted across the width of the ship and are joined to the side frames by brackets known as beam knees'. Continuous longitudinal girders are fitted on the ship which run alongside the hatchways and the beams are bracketed to these girders. In this way the unsupported span is reduced.

Beam Knee:

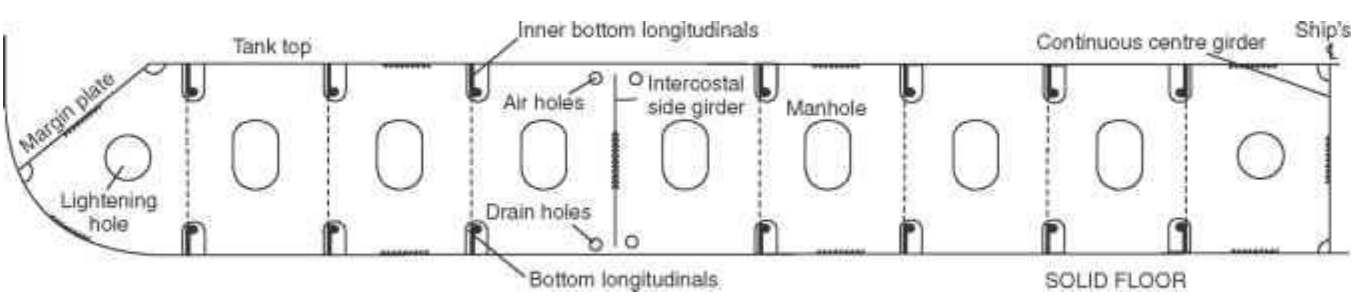
A reinforcement of the end of a deck-beam where it is attached to the side of a vessel to strengthen the whole against the racking effects of rolling at sea.

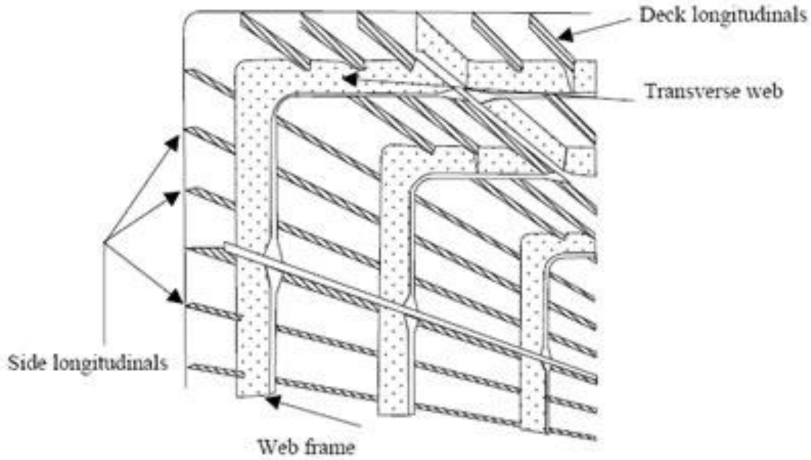
Transverse:

Under decks (deck transverse) and on bottom plating (bottom transverse) but not in Double Bottoms. Runs transversely but much heavier in construction than a beam.

Longitudinal:

Found in longitudinally framed ships, under decks, on side plating, on longitudinal bulkheads, on bottom plating and under the tank too. These members run fore and aft.

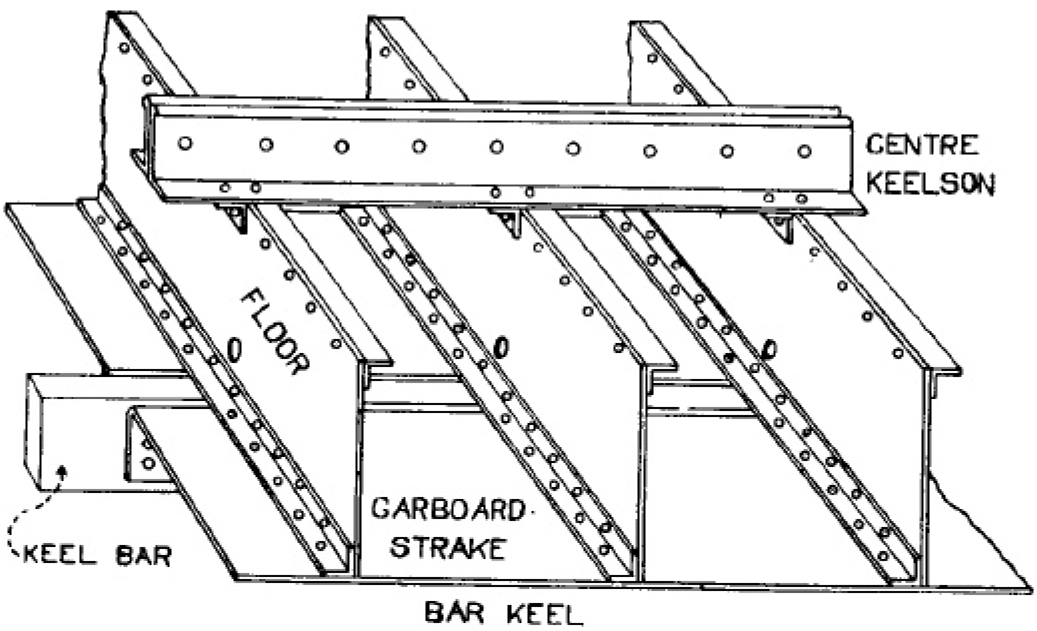




KEELS

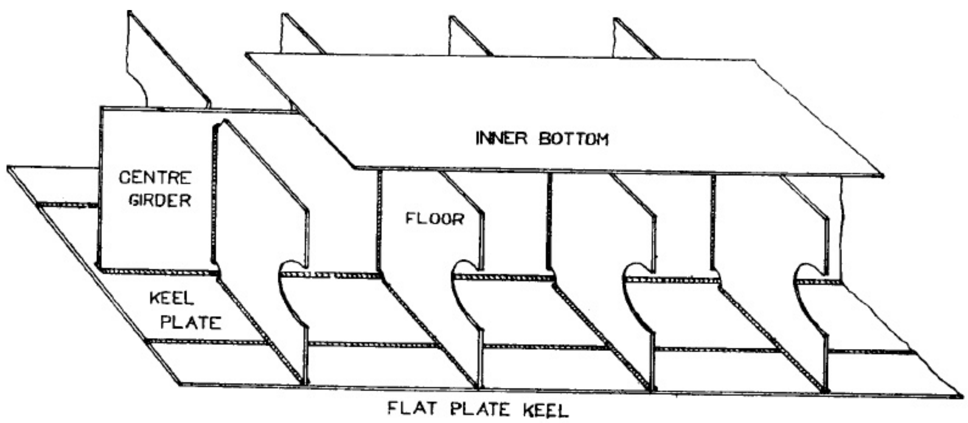
Bar Keel

Bar keels first used in shipbuilding and after changes from wood to iron.
It was found that they did not provide sufficient strength for large vessels, as there was no direct connection between the keel and the floors. They are now only used in certain types of small craft. The depth of the bar is from three to six times its width. It is made in lengths of from 10 to 20 meters



Flat Plate Keel

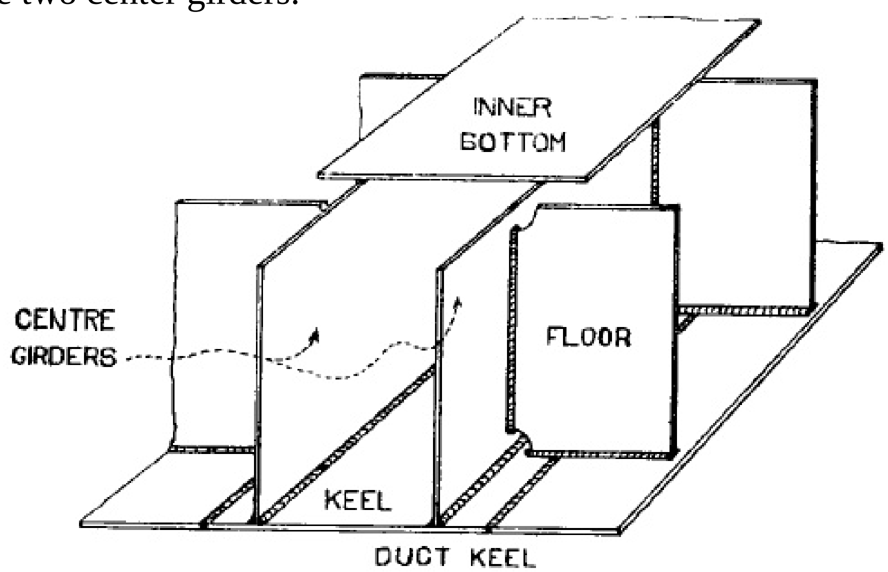
The keel plate may have a width of from 1 to 2 meters. It must be of full thickness for three-fifths of the length amidships, but the thickness may be gradually reduced towards the ends of the ship. The center girder is attached to the keel and inner bottom plating by continuous weld.



Duct Keel

Are a form of flat-plate keel, but have two center girders instead of one. They are often fitted between the collision bulkhead and the forward engine-room bulkhead, to provide a convenient tunnel for pipes from the tanks.

They are not usually fitted abaft the engine-room, because the pipes from the after tanks can be run through the tunnel. Transverse stiffening bars or brackets are often fitted on the keel plate and inner bottom plating between the two center girders.



DOUBLE BOTTOMS CONSTRUCTION

Cellular double bottoms may be transversely framed, with a floor at every frame space, i.e. in line with the frames. If the ship is over 120 meters long, or if is intended for ore or other heavy cargoes, a system of longitudinal framing must be used, with transverse plate floors at intervals. One or more side girders, running fore and aft, are normally fitted between the floors to give extra longitudinal strength.

The outboard boundary of the cellular double bottom is formed by a continuous watertight **'margin plate'**, which is attached to the side frames by 'tank side brackets'.

Girder: Found under decks and on the bottom plating. Girders run forward and aft and are deep and heavy in construction. These are important longitudinal strength members.

Transversely-Framed Double Bottoms

These must have plate floor at every frame space under the engine-room, boilers, bulkheads and in the pounding region. Elsewhere, *plate floors may be not more than 3.05 meters apart, with bracket floors at intermediate frame spaces*.

Vessels of up to 20 meters in breadth must have one intercostal side girder on each side: vessels of greater breadth are to have two such girders on each side. These are to extend as far forward and aft as possible.

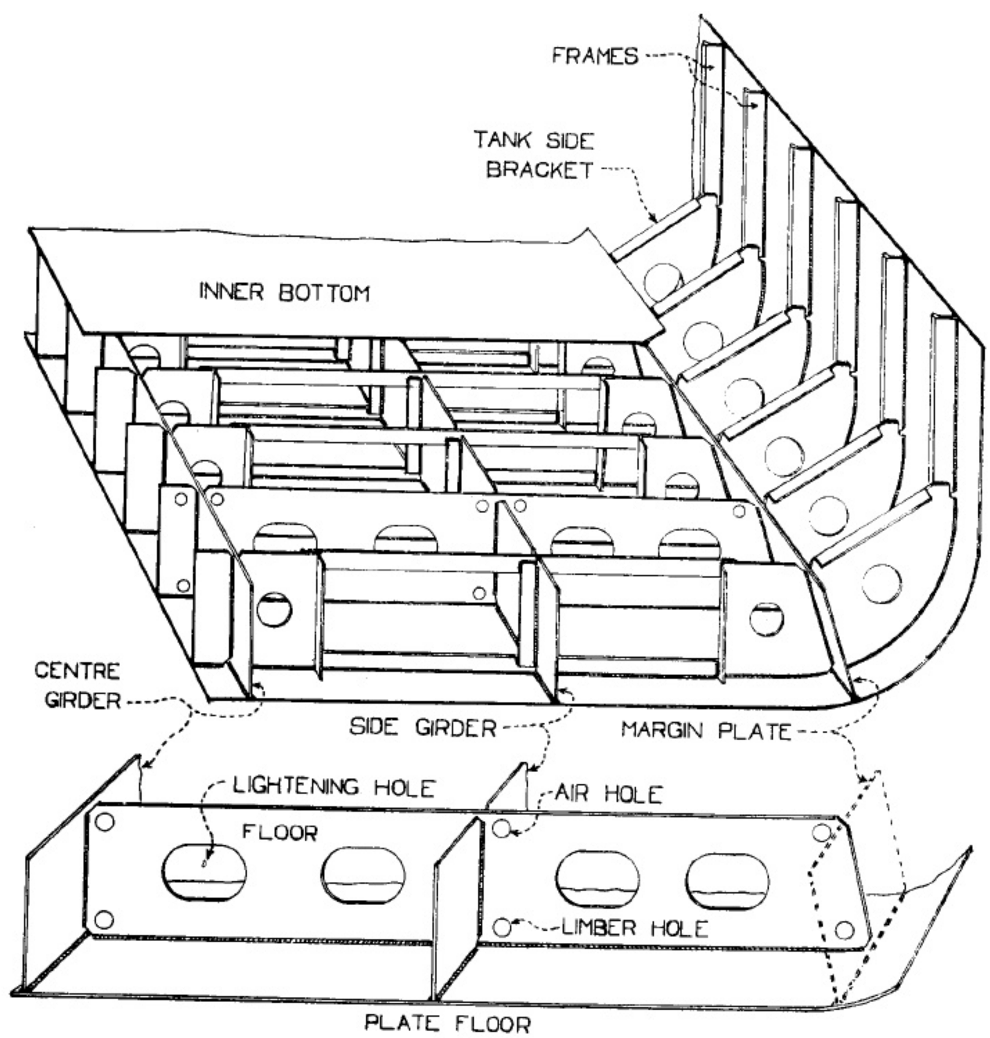


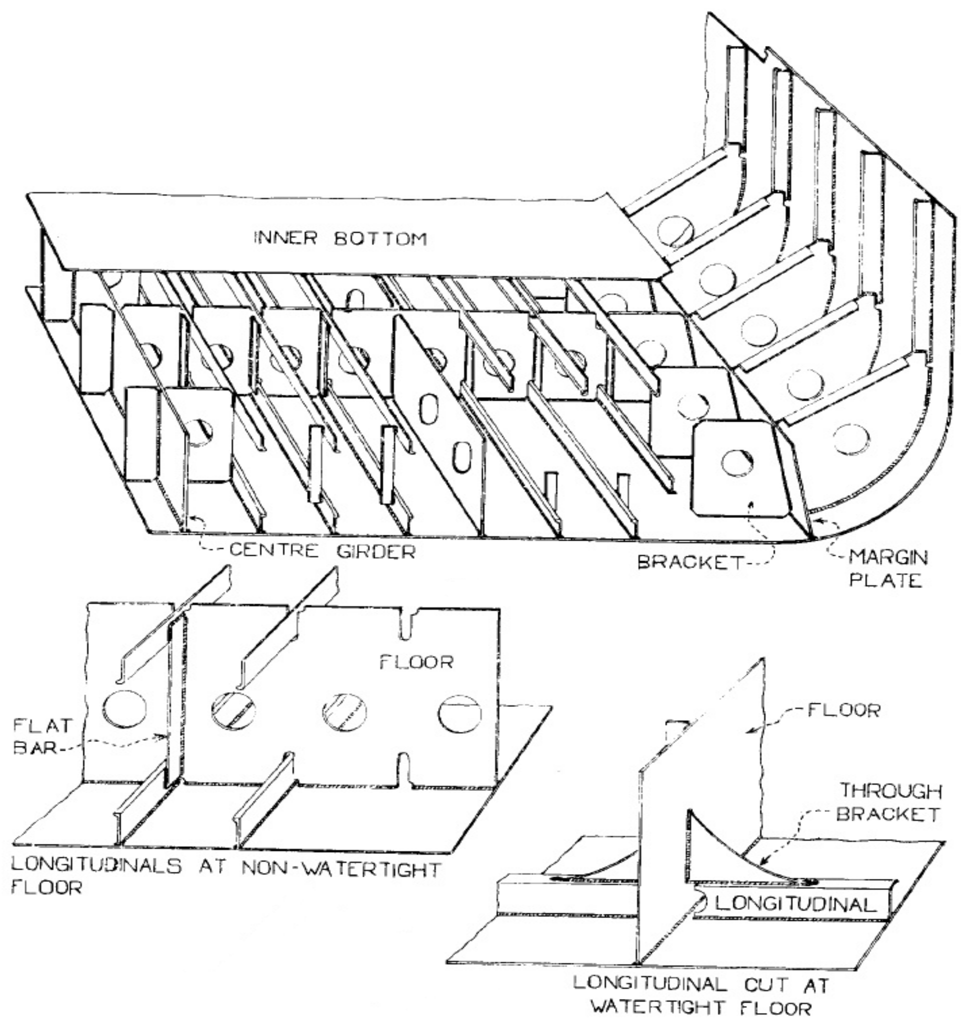
Plate floors consists of a plate, running transversely from the center girder to the margin plate on each side of the ship. These have lightening holes in them unless they are to be watertight. Watertight plate floors must be fitted under or near bulkheads and *if the depth of the center girder exceeds 915 millimeters, they must have vertical stiffeners on them.*

Bracket floors are a form of 'skeleton floor', in which the middle part of the floor plate is omitted and replaced by a 'frame bar' and a 'reverse bar', with a bracket at either end. The brackets are to be flanged on their free edges and their breadth is to be three-quarters of the depth of the center girder.

Longitudinal Framing in double Bottoms

Rules required that Longitudinal Framing shall be fitted in all ships of over 120 meters long. The longitudinal are flat bars, bulb bars, or inverted angles and are supported by plate floors not more than 3.7 meters apart. The longitudinal are attached to these floors by vertical bars, at least 150 millimeters deep, which must extend for the full depth of the floor.

Under engines, boiler bearers, bulkheads and the toes of brackets to deep tank stiffeners, plate floors are required to be fitted at every frame space.



At intermediate frame spaces, between the floors, brackets are fitted from the margin plate to the nearest longitudinal. The center girder must be supported by similar brackets, spaced no more than 1.25 meters apart.

The longitudinal may be cut at watertight floors and attached to them by brackets if the ship is not more than 215 meters long. If the ship is longer than this, the longitudinal must be continuous: in this case, short lengths of longitudinal are passed through close-fitting slots in the floor which are afterwards welded-up to make them watertight.

Great care must be taken in the machinery space to ensure that the main and auxiliary machinery are efficiently supported. Weak supports may cause damage to the machinery, while large unsupported panels of plating may lead to vibration of the structure.

Bilge keel

Most ships are fitted with some form of bilge keel, the prime function of which is to help damp the rolling motion of the vessel. Other relatively minor advantages of the bilge keel are protection for the bilge on grounding, and increased longitudinal strength at the bilge.

Purpose: Bilge keels are intended to resist rolling. Their effects are complex, but may be summarized as follows

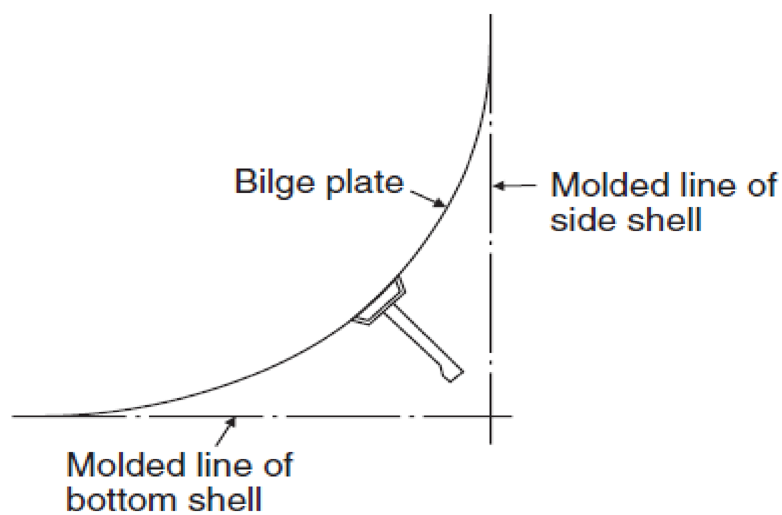
(a) Direct resistance between bilge keel and water has a comparatively weak effect.

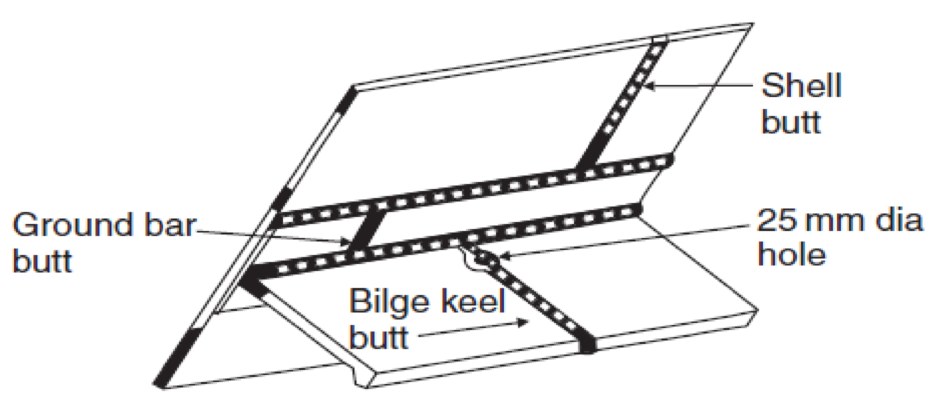
(b) They slightly increase the ship's period of roll.

(c) They upset the transverse streamlines of the ship's hull and thus set up eddy-currents and increase the 'wave-making resistance'.

(d) They increase water pressure over a large area of the ship's hull and this pressure acts in such a direction as to damp the rolling.

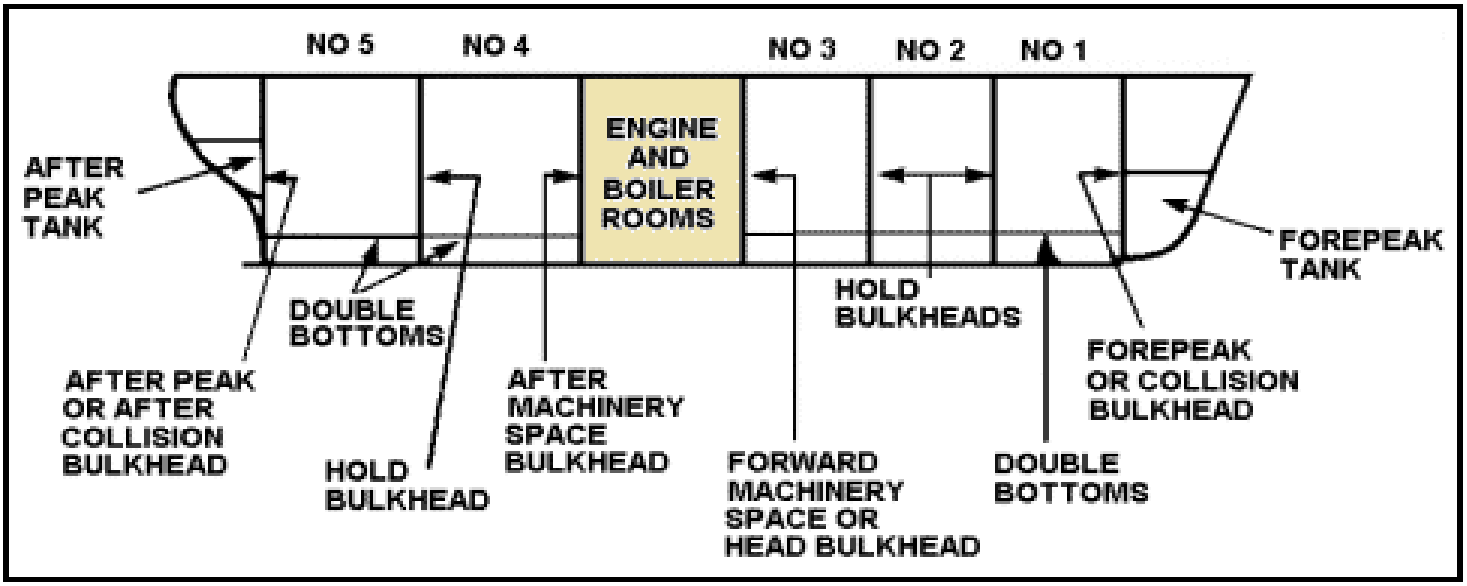
Position: For their protection, bilge keels should always be arranged to lie within the line of the ship's side and that of the bottom of the floors. If they were to project beyond these limits, they would be more liable to damage.



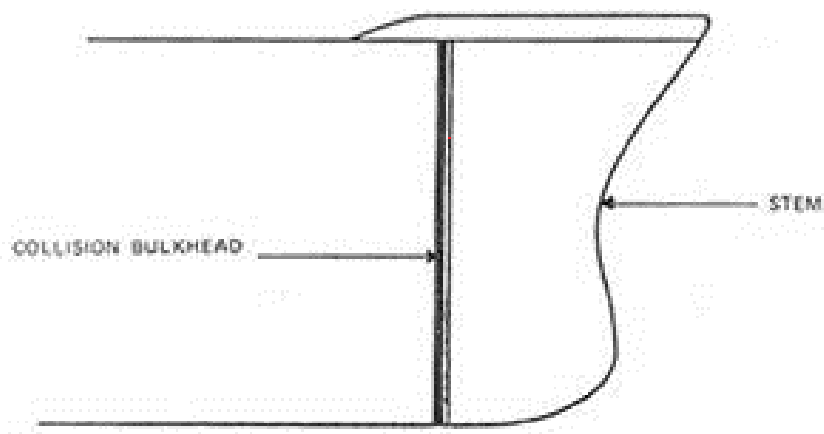


Bulkheads

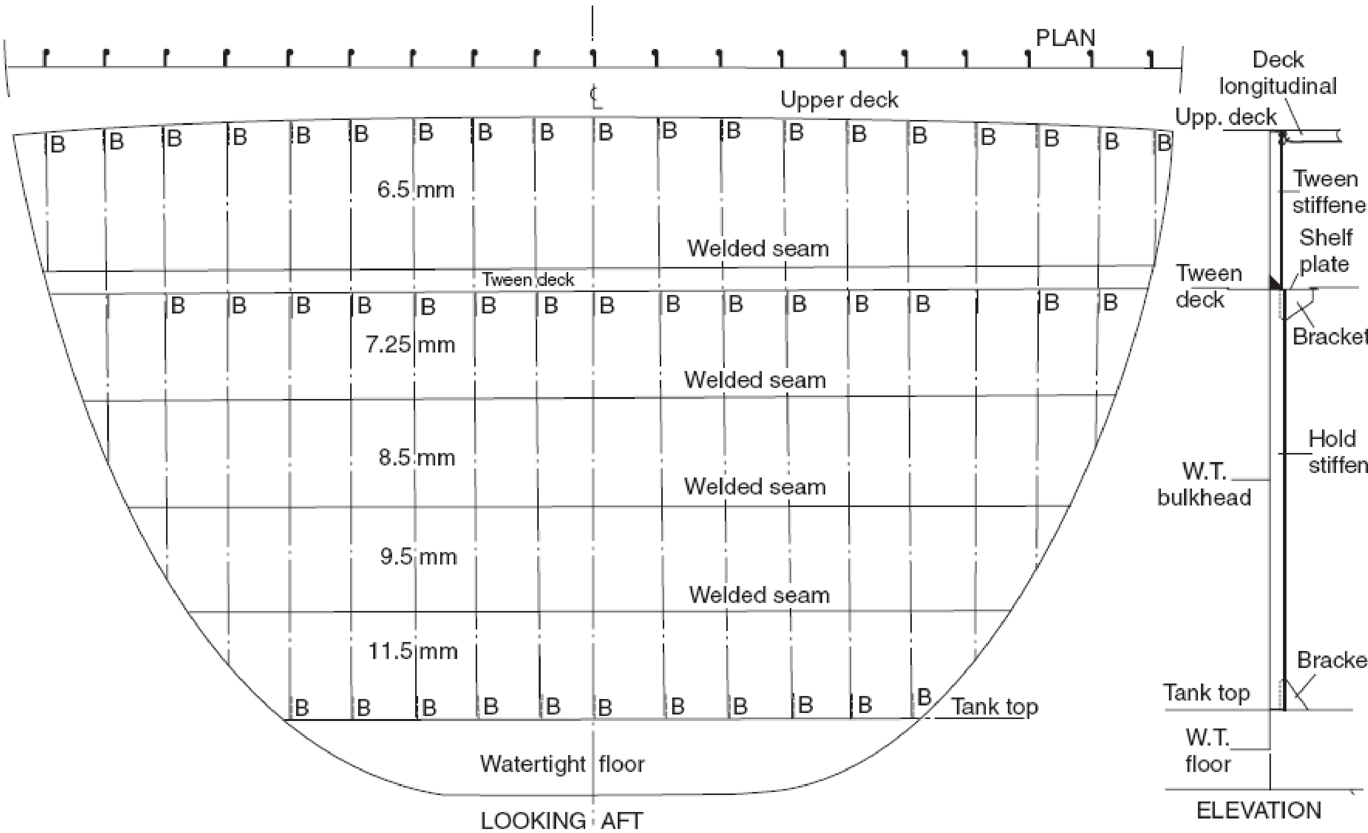
Vertical partitions in a ship arranged transversely or fore and aft are referred to as ‘bulkheads 'Those bulkheads which are of greatest importance are the main hull transverse and longitudinal bulkheads dividing the ship into a number of watertight compartments.



A collision bulkhead must be fitted forward, an aft peak bulkhead must be fitted, and watertight bulkheads must be provided at either end of the machinery space. This implies that for a vessel with machinery amidships the minimum possible number of watertight bulkheads is four.



A minimum number of watertight bulkheads will only be found in smaller cargo ships. As the size increases the classification society will recommend additional bulkheads, partly to provide greater transverse strength, and also to increase the amount of subdivision.



Advantages of Watertight Bulkheads

1- They help in subdividing the ship into number of watertight compartments, thus increasing watertight integrity of the ship.
2- It helps in increasing the transverse strength of the ship which helps in reducing raking.
3- In case of fire bulkheads restrict the spread of the same to other compartments.

Corrugated bulkhead:

Corrugated bulkheads are often used in chemical tankers and product tankers in order to help facilitate cargo tank washing efficiently.

Chapter Five

BOW and STERN

Peak Tanks

Peak tanks are those found at the forwards and aft extremities of the ship, that is, forward of the collision bulkhead and aft of the after peak bulkhead.

The construction within these tanks differs from that of the rest of the ship, the reason being that the stresses suffered in these parts is considerably different.

There are two types of Peak Tanks:

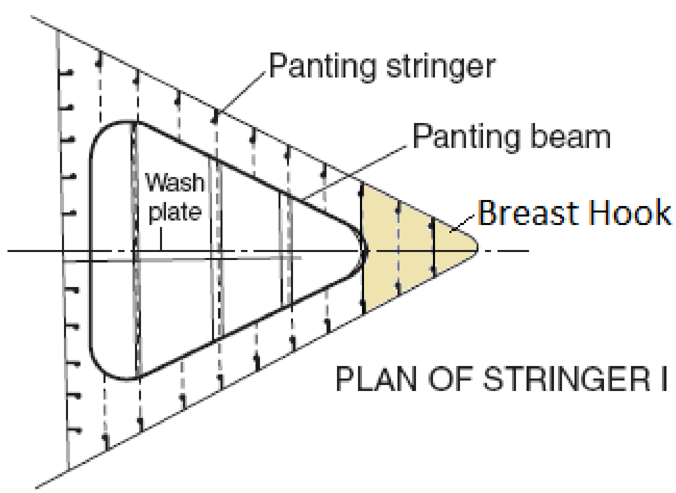
1. Fore Peak Tank

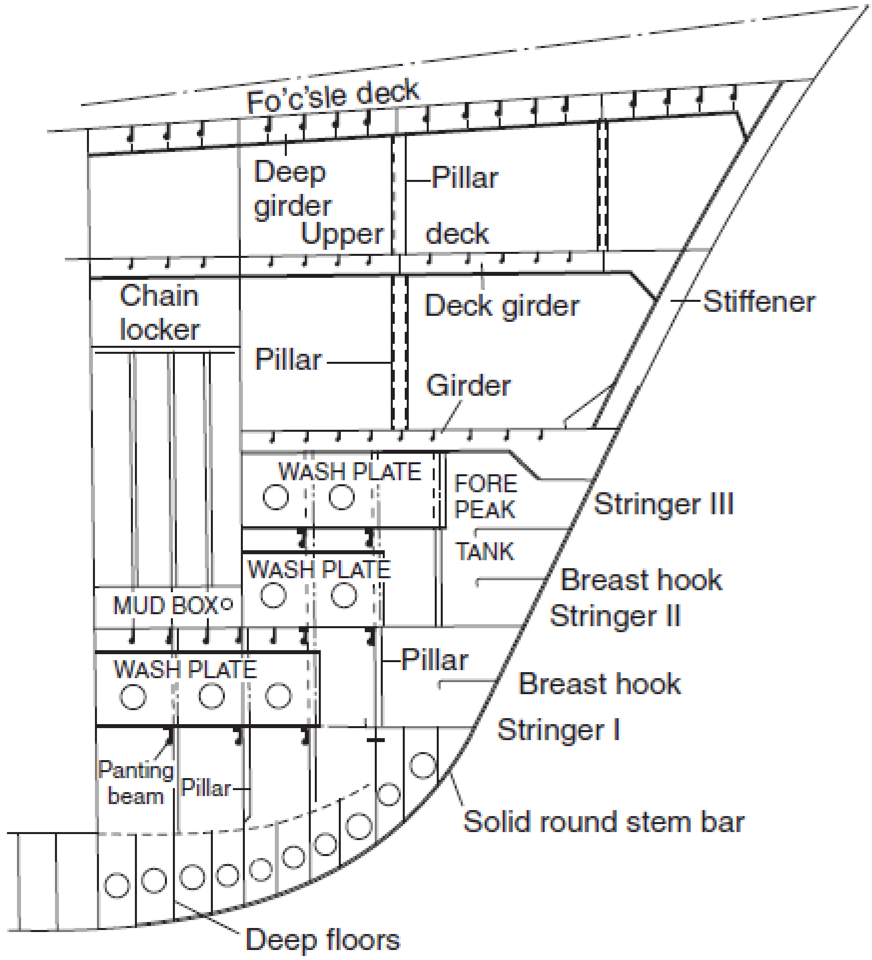
2. After Peak Tank

The Fore Peak Tank

Above the floors, a wash plate (not watertight) divides the tank longitudinally into two. If the collision bulkhead is corrugated, then no further strengthening is provided for the bulkhead itself, otherwise, suitable stiffening is to be found on the bulkhead, the collision bulkhead forms the after boundary of the Fore Peak Tank.

Strengthening against painting is the most outstanding feature of the Fore Peak Tank. This takes the form of **Panting beams** and **stringers**, the panting stringers are essentially triangular plates bordering the tank horizontally at two or three levels These stringers are further reinforce by panting beams as in the figure **Breast hooks** (smaller horizontal triangular plates) are fitted between and at each level of panting stringer These provide additional strengthening in the vicinity of the stem.



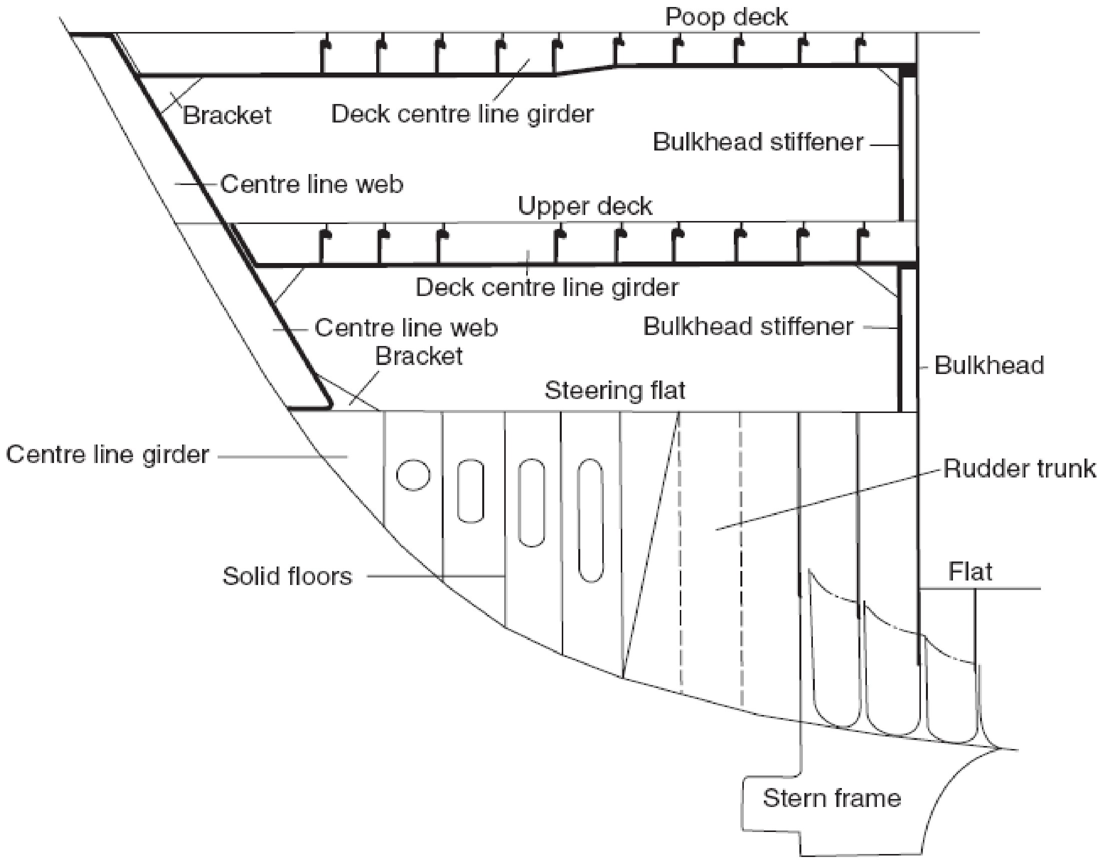


The After Peak Tank

This compartment extends from the after peak bulkhead to the stern frame and aft end of the ship. In this tank also, solid floors are fitted at every frame space as additional strength is required here

There are floors fitted abaft of the higher than the stern frame to support the part of the stern which overhangs the rudder and propeller. At the head of the rudder of the rudder post an extra-strong floor is fitted called the Transom Floor. This floor is designed to support the overhanging mass and framework of the stern.

The entire tank is divided longitudinally into two by a wash-plate with lightening holes which runs vertically forwards and aft on the centerline.



Bulbous bow

The bulbous bow is fitted in an attempt to reduce the ships resistance. Arrangements vary from a casting plated into the forward end to a fully radiuses plated structure, or in some cases a cylindrical shape plated into the forward end. The effectiveness of the arrangement is the subject of much discussion but improved buoyancy forward is provided which will reduce the pitching of the ship.

After End arrangements

Two main types of stern construction have been used to date - the cruiser stern and the transom stern.

The upper part of the stern of a ship extends abaft the rudder post, and there must be a special arrangement of framing to support it.

This framing is mainly carried by the 'Transom', which consists of a deep, heavy floor, securely attached to the rudder post, in association with transverse frame and beam. These are known as the 'Transom Floor', 'Transom Frame' and 'Transom Beam', respectively.

The transom floor must have the same depth as the floors in the cellular double bottom, but must be slightly thicker.

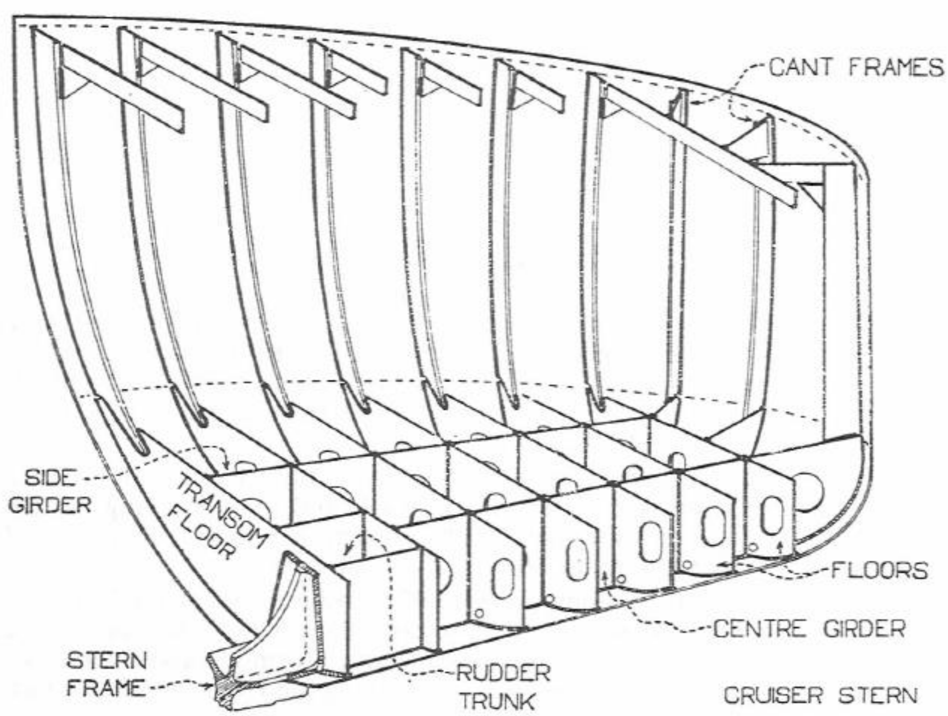
1- Ordinary Sterns (Cruiser Sterns)

At one time they were used almost exclusively in merchant ships, but they have now been superseded by the Cruiser Stern, or Transom Stern, and are virtually obsolete for large vessels.

Ordinary sterns had a system of **'Cant Framing'**, which radiated out from the transom in much the same way as the spokes of a wheel. The cant frames were attached to the transom floor by brackets; whilst the fore ends of the cant beams were lugged to the transom beam.

Cruiser Sterns**:** Have a system of ordinary transverse framing which is supported by an intercostal girder at the center line. This girder has to be doubled, just abaft the transom floor, to allow the rudder stock to pass. A number of **'can't frames'** are fitted abaft the aftermost transverse frame.

Where extra strength is required, web frames may be required and also extra longitudinal girders to support them.



In practice the structure is arranged in two main forms:

(a) cant frames in conjunction with cant beams.

(b) horizontal frames in conjunction with either cant beams or transverse beams.

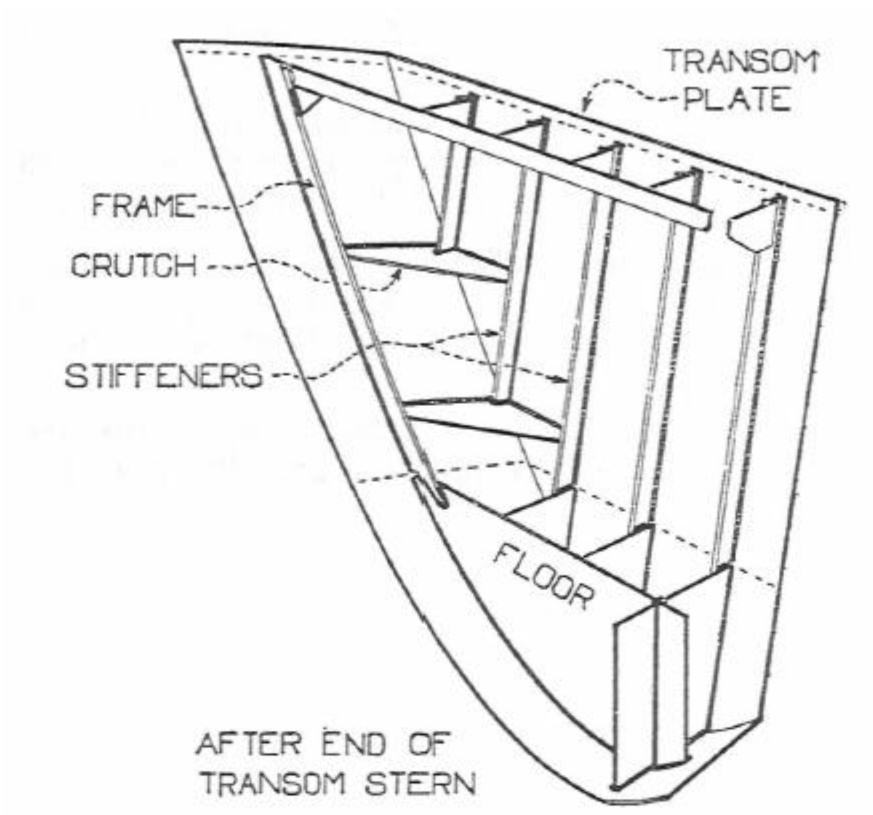
A cant frame is one which is set at an angle to the centerline of the ship. Such frames are fitted 610 mm apart, thus dividing the perimeter of the cruiser stern into small panels. At the top, these frames are bracketed to cant beams which also lie at an angle to the centerline. The forward ends of the cant beams are connected to a deep beam extending right across the ship. At the lower ends, the cant frames are connected to a solid floor

2- Transom Stern

This is similar to a cruiser stern, except that the **cant framing** at the after end is omitted and is replaced by a flat plate, called a '**transom**'.

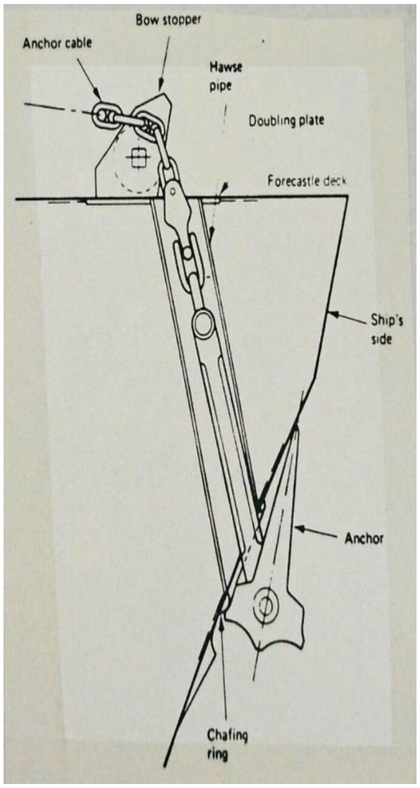
Deep solid - plate floors are also a feature of the transom stem construction, together with a centerline girder.

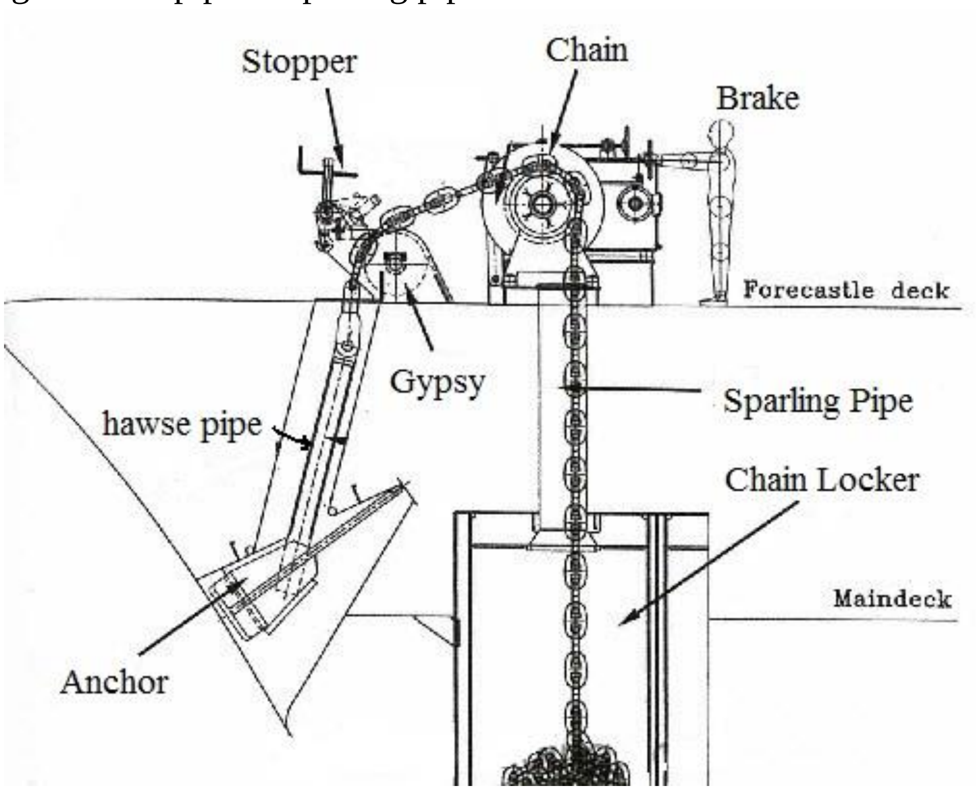
The flat plate of the transom stem construction, however, allows use of vertical stiffeners around the sell plating. The vertical stiffeners are bracketed to the floor and to the deck beams which run transversely across the stem. A deep horizontal stringer can provide additional stiffening to the shell plating if required. A deep center girder runs beneath each of the decks at the stem and is bracketed to the deep web at the centerline of the after shell plating. This web is likewise bracketed to the various floors in the stem and finally to the solid - plate floor construction below.



Anchor and cable arrangements

A typical arrangement for raising, lowering and stowing the anchors of a ship is shown below. The anchor is attached to a heavy chain cable which is led through the **hawse pipe** over the windlass and down through a chain pipe or sparling pipe into the chain locker.





The forecastle deck houses the windlass or windlasses which raise and lower the anchor and cable.

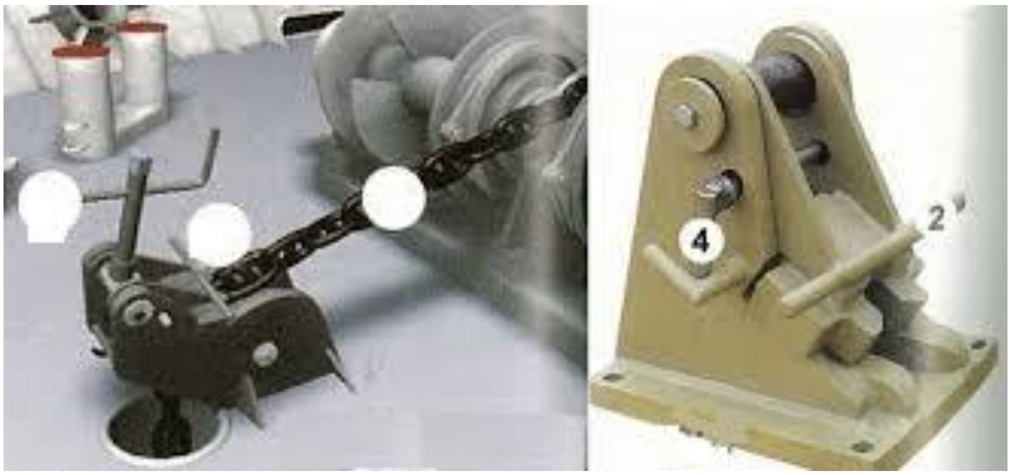
The anchor cable passes through the shell via the **hawse pipe** on to the forecastle deck. It travels over the cable stopper and on to the windlass cable lifter drum. From the cable lifter it drops vertically down into the chain locker below.

Hawse pipe

The hawse pipe is fitted to enable a smooth run of the anchor cable to the windlass and to maintain the watertight integrity of the forecastle. It should be of ample size to pass the cable without snagging when raising or lowering the anchor. Construction is usually of thick plating which is attached to a doubling plate at the forecastle deck and a reinforced strake of plating at the side shell. A rubbing or chafing ring is also fitted at the outside shell. A sliding plate cover is shaped to fit over the cable and close the opening when the ship is at sea.

Cable stopper

The chain, cable or bow stopper is fitted on the forecastle deck in line with the run of the anchor cable. It is used to hold the anchor cable in place while the ship is riding at anchor or the anchor is fully housed. In this way the windlass is freed and isolated from any shocks or vibrations from the cable. The chain topper is not designed to stop the moving cable, but only hold it in place.



Windlass

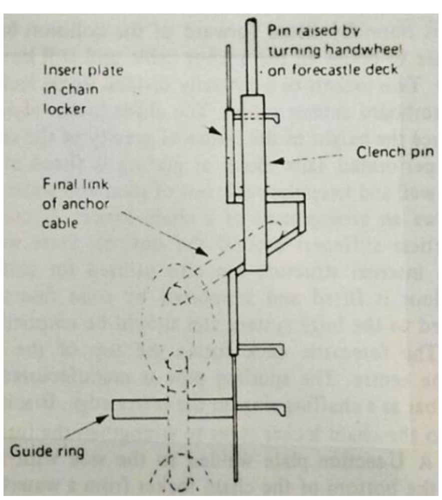
The windlass is the lifting device for the anchor cables or chains and is also used for mooring and winching duties. Various drums or barrels can be 'clutched in' to perform the different duties. For raising the anchor, the cable lifting drum is engaged.

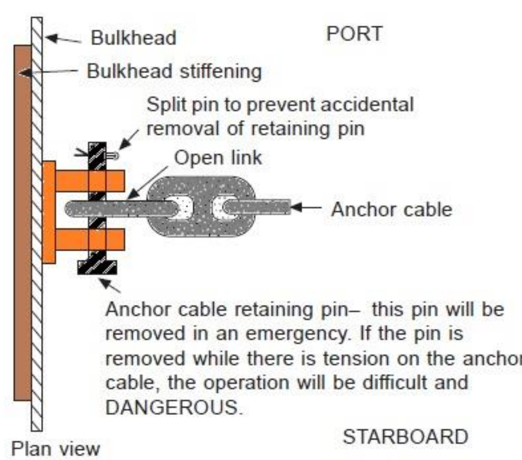
Chain locker

The chain locker is normally fitted forward of the collision bulkhead. It is of dimensions adequate to house all the anchor cable and still leave a considerable empty space above. Two lockers or a centrally divided single locker will be fitted for the port and starboard anchor cables. The chain locker should be as low as practicable to reduce the height of the center of gravity of the considerable mass of the cables. A perforated false floor or grating is fitted at the bottom to provide a drainage well and keep the cable out of mud and water.

Clench cable assembly (Bitter End)

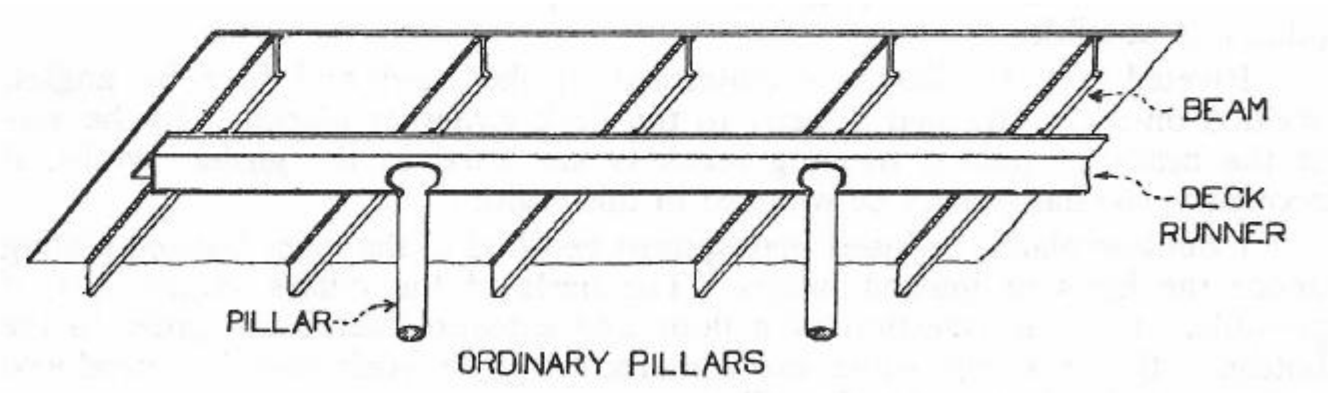
The final link of the anchor cable is secured to the ship's structure by clench pin. On most modem ships this pin is positioned on the outside of the chain locker and can be released easily and quickly. A situation may arise where the safety of the ship does not allow time to raise the anchor. By releasing the clench pin all the cable can quickly pass out of the chain locker, leaving the ship free to proceed out of danger.





SYSTEMS OF PILLARING

Pillars are intended to support the deck above them and to tie the beams to the bottom, or deck below. They are usually fitted two or more beam spaces apart, so it is necessary to fit a deck girder, running fore and aft under the beams, to support the intermediate beams.



Bulwarks

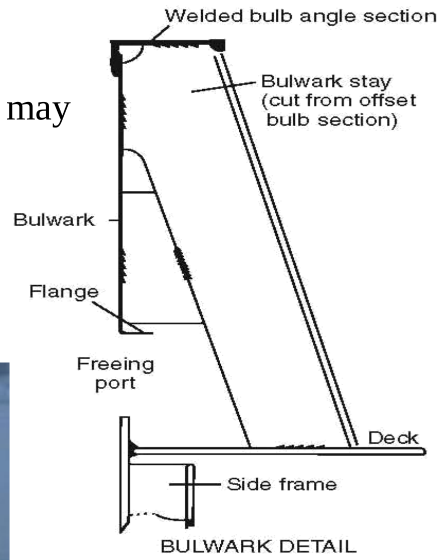
fitted on weather decks are provided as protection for personnel and are not intended as a major structural feature. They are therefore of light scantlings, and their connections to the adjacent structures are of some importance if high stresses in the bulwarks are to be avoided.

Bulwarks should be at least 1m high on the exposed freeboard and superstructure decks, but a reduced height may be permitted if this interferes with the working of the ship.

Bulwarks and guard rails are fitted for the safety of the crew and play no part in the structural strength of the vessel. They are usually 1 meter in height. plated bulwarks are to be stiffened by a strong rail section and supported by stays from the deck.

The plating of bulwarks is to be doubled or of increased thickness in way of mooring pipes, eye plates, etc.

Freeing ports



Are cut in bulwarks forming wells on decks in order that water may quickly drain away. The required area of freeing ports is in accordance with the Load Line Rules.

Chapter Six

HATCHWAY

HATCHWAYS

The resistance to longitudinal stress is much reduced in the way of hatches, on account of the large amount of material which must be cut out of the deck. Stress concentrations cause a tendency for the deck to fracture at the hatch corners. There is also a loss of resistance to loads of water or cargo on the deck, due to the beams being cut at the hatch coaming.

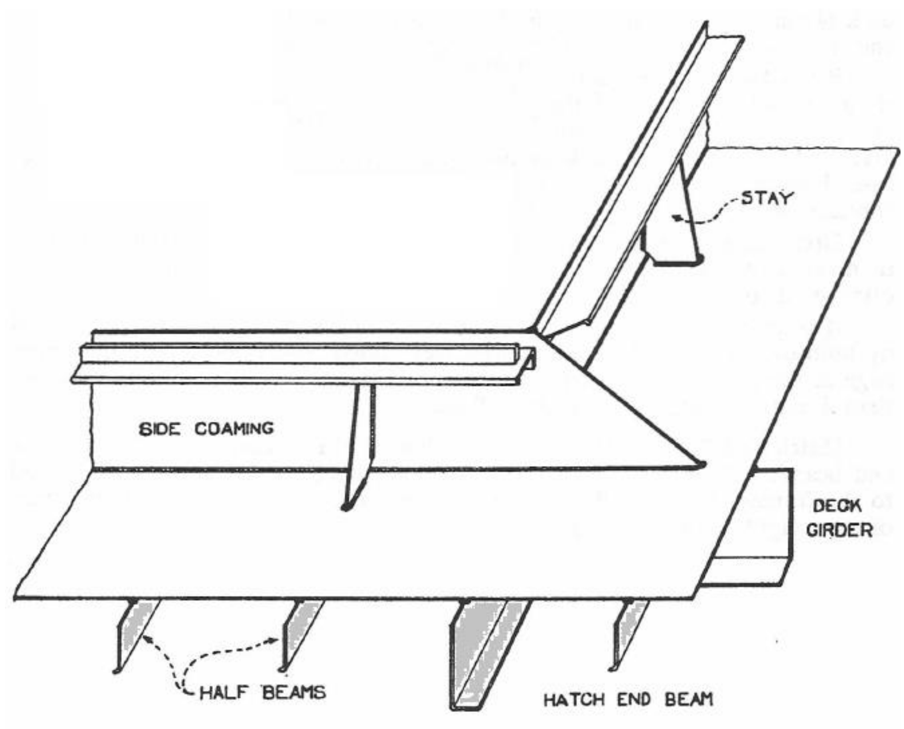
These weaknesses must be compensated for or they might be dangerous. To give the necessary strength the deck plating must be strengthened or doubled, and the coamings and their connections must be sufficiently strong and rigid.

Hatch coamings

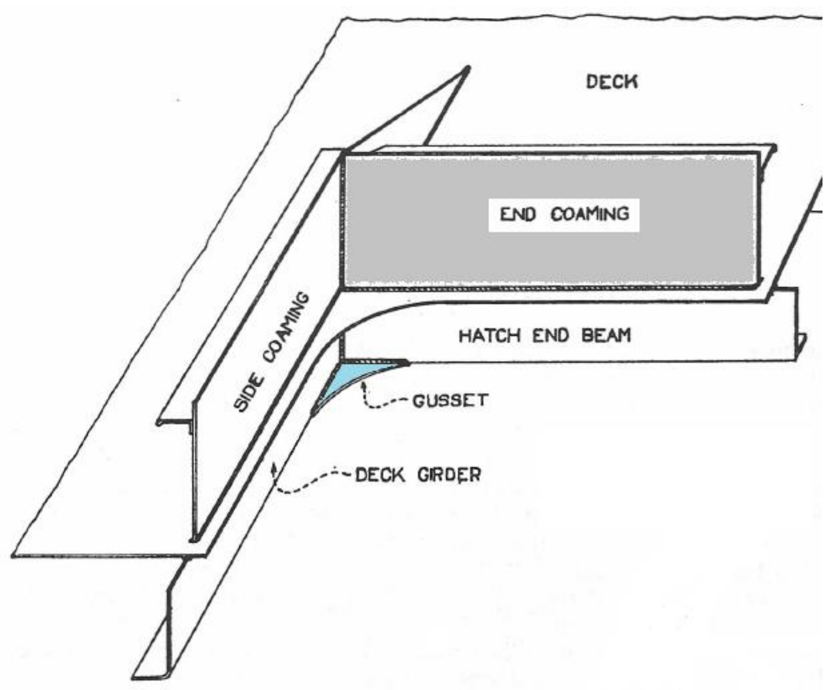
The edges of all hatch openings are framed by hatch coamings. On the weather deck the coaming must be at a minimum height of 600 mm according to the load line regulations. This is to reduce the risk of water entry to the holds.

The weather deck coaming must be a minimum of 9 mm thick, and where the height is in excess of 600 mm it must be stiffened by a horizontal stiffener and vertical brackets must be fitted not more than 3 m apart.

The side coaming plates, as an extension of the longitudinal girder, are of greater thickness than the end coaming plates and are extended beyond the hatch opening in the form of brackets These brackets also serve to support the platforms used for the hatch operating equipment, Smaller vertical brackets arc fitted around the remainder of the coaming structure to stiffen it

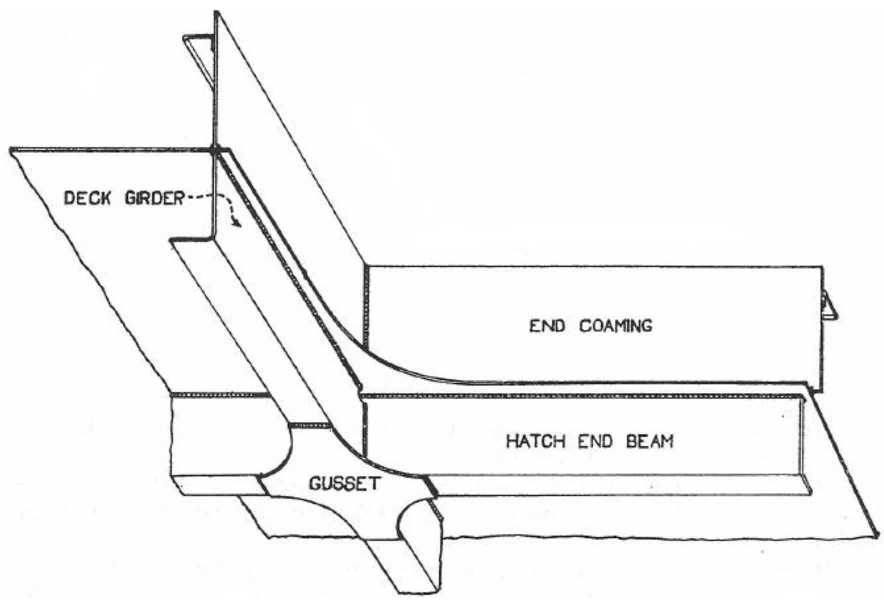


The hatches may be closed by wood boards which are supported by the portable hatch beams.



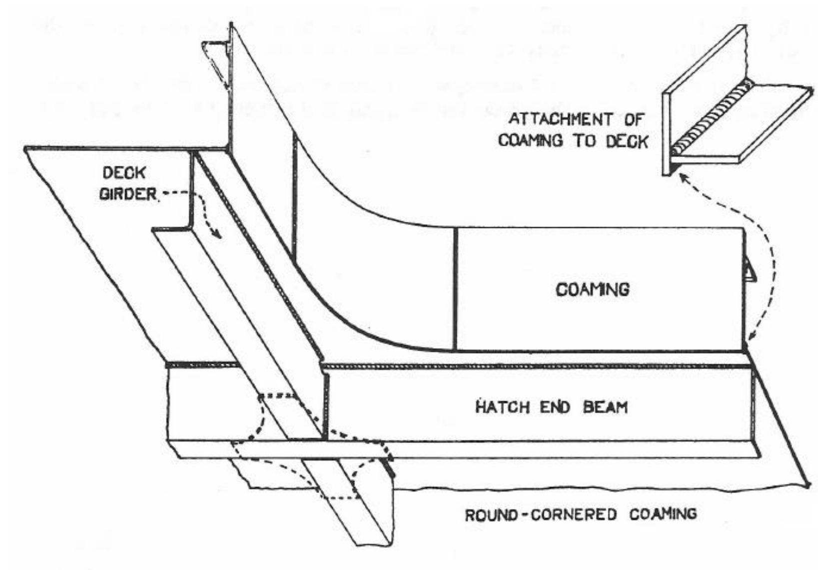
The beams may be fitted in guides attached to the coamings and lifted out to clear the hatch, of fitted with rollers allowing them to be pushed to the hatch ends. The covers are made weather tight by means of tarpaulins (Traditionally used), at least two tarpaulins being fitted on weather deck hatches.

Hatch End Beams The beam at each end of a hatchway is called a 'hatch end beam'. These are usually made stronger than normal and are connected to the frames by heavy, flanged beam knees, because they carry at least part of the weight of the coaming.



Half Beams

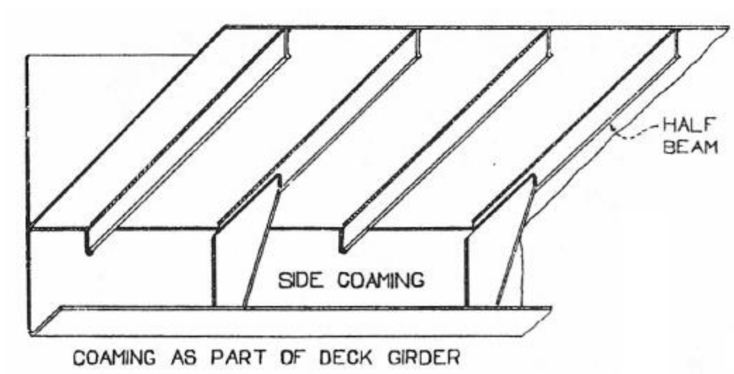
Transverse beams in the way of the side coamings are cut at the latter and are called 'half beams'.

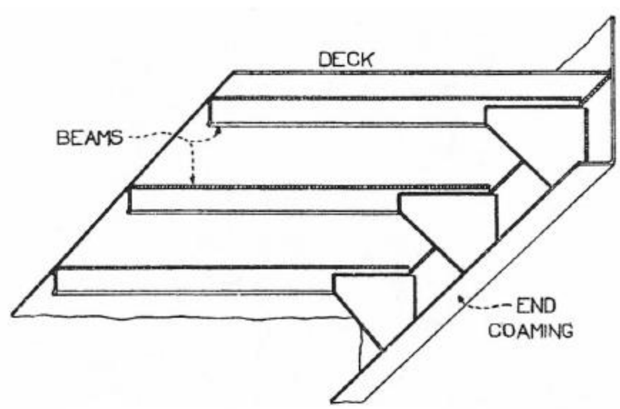


If the side coamings form part of the deck girder, the half beams are attached to them by welded bars and by brackets at alternate beams; as for deck girders.

If the side coaming does not form part of the deck girder, the connection is by direct welding; unless the deck girder is at some distance from the coaming, when brackets may be fitted between the two.

Longitudinal Beams at Coamiogs-If longitudinal beams are fitted under the deck, they are cut at the hatch and coaming and attached to it by brackets.

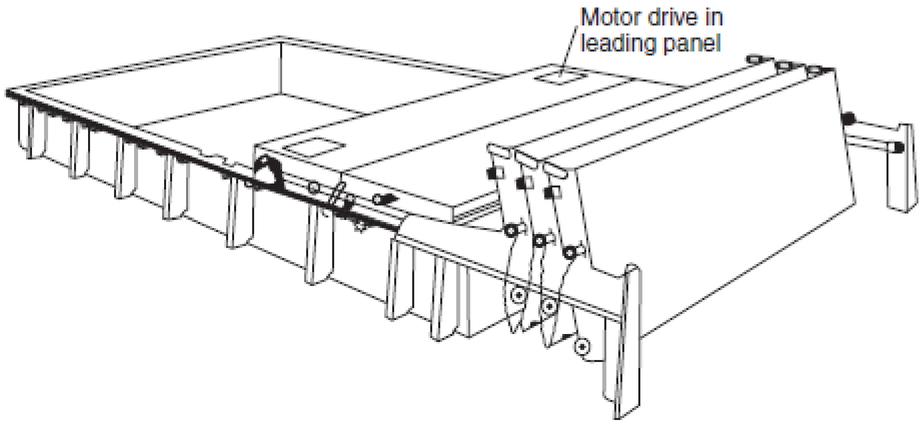




Modem ships are fitted with steel hatch covers. There are many types available, the principal ones being fore and aft **single pull**, **folding**, **piggy-back**, **pontoon**, and **side rolling:**

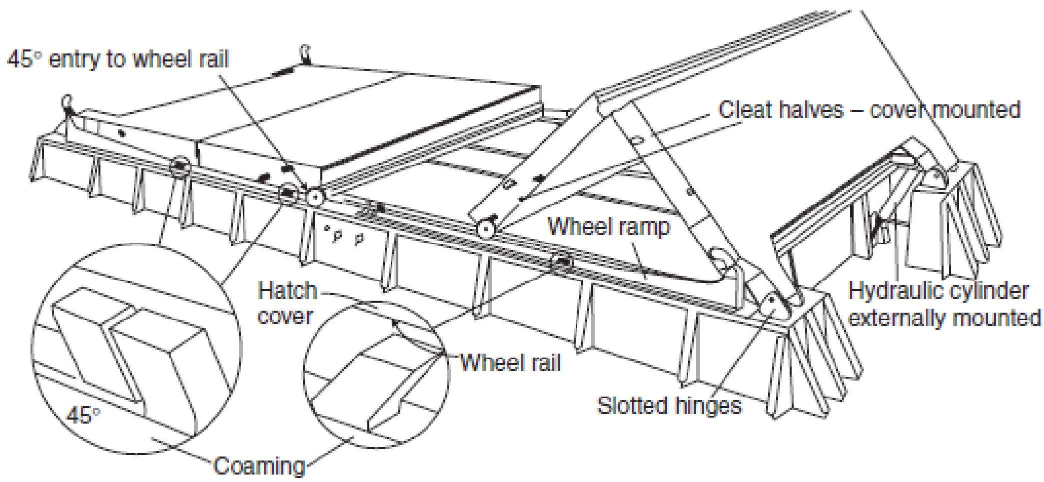
Single pull covers

may be opened or closed by built-in electric motors in the leading cover panel (first out of stowage) that drive chain wheels, one on each outboard side of the panel. Each panel wheel is permanently engaged on a fixed chain located along each hatch side coaming. In operation the leading panel pushes the others into stowage and pulls them into the closed position. Alternatively, single pull covers are opened or closed by hydraulic or electric motors situated on the hatch end coaming at the ship's center line, driving endless chains running along the full length of the hatch side coaming port and starboard and connected to the leading panel. Vertical stowage of panels is at one end of the hatch and covers may have a nesting characteristic if space is at a premium; also, on large hatches opening may be to both ends with vertical stowage at each end.



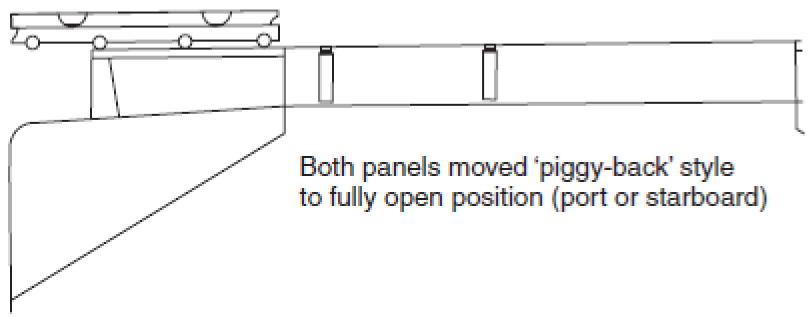
Folding covers

may be of direct pull type where suitable lifting gear is carried onboard or can be opened or closed by externally mounted hydraulic cylinders actuating the leading panels.



Piggyback

covers permit horizontal stowage of panels, avoiding fouling of lifting devices particularly in way of very large openings such as on bulk carriers and container ships, where the hatch need only be partially open for working. The covers consist of a dumb panel that is raised by high lift cylinders and a motorized panel that is rolled underneath the dumb panel. Both panels can then be moved 'piggy-back' style to the fully opened hatch position port or starboard or partially opened position fore and aft.



Pontoon covers

are commonly used on container ships, being lifted by the ships' or shore cranes with the container spreader. They are closed weather tight in a similar manner to the other patent covers.

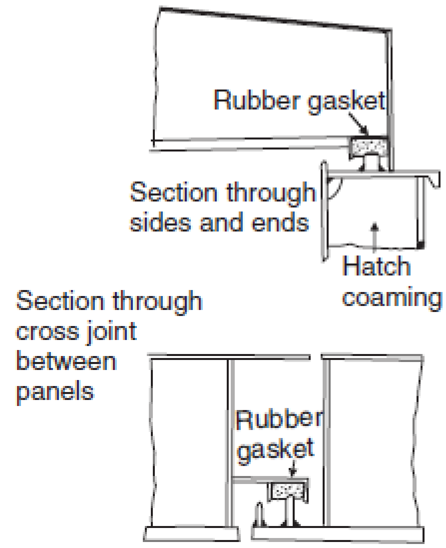
Side rolling

are very common on large bulk carriers and can operate on similar principles to the single pull cover except that they remain in the horizontal stowed position when the hatch is open. Various other forms of cover are marketed, and tween deck steel covers are available to be fitted flush with the deck, which is essential nowadays when stowing cargoes in the tweens.

To obtain weather tightness the patent covers have mating boundaries fitted with rubber gaskets; likewise, at the hatch coamings, gaskets are fitted and hand or automatically operated cleats are provided to close the covers. The gasket and cleat arrangements will vary with the type of cover.

Securing Arrangement

The covers interlock at their ends and are fitted with packing to ensure that when the covers are wedged down, a watertight cover is provided. Such covers do not require tarpaulins. At the hatch sides the covers are held down by cleats which may be manual as shown in figures or hydraulically operated.

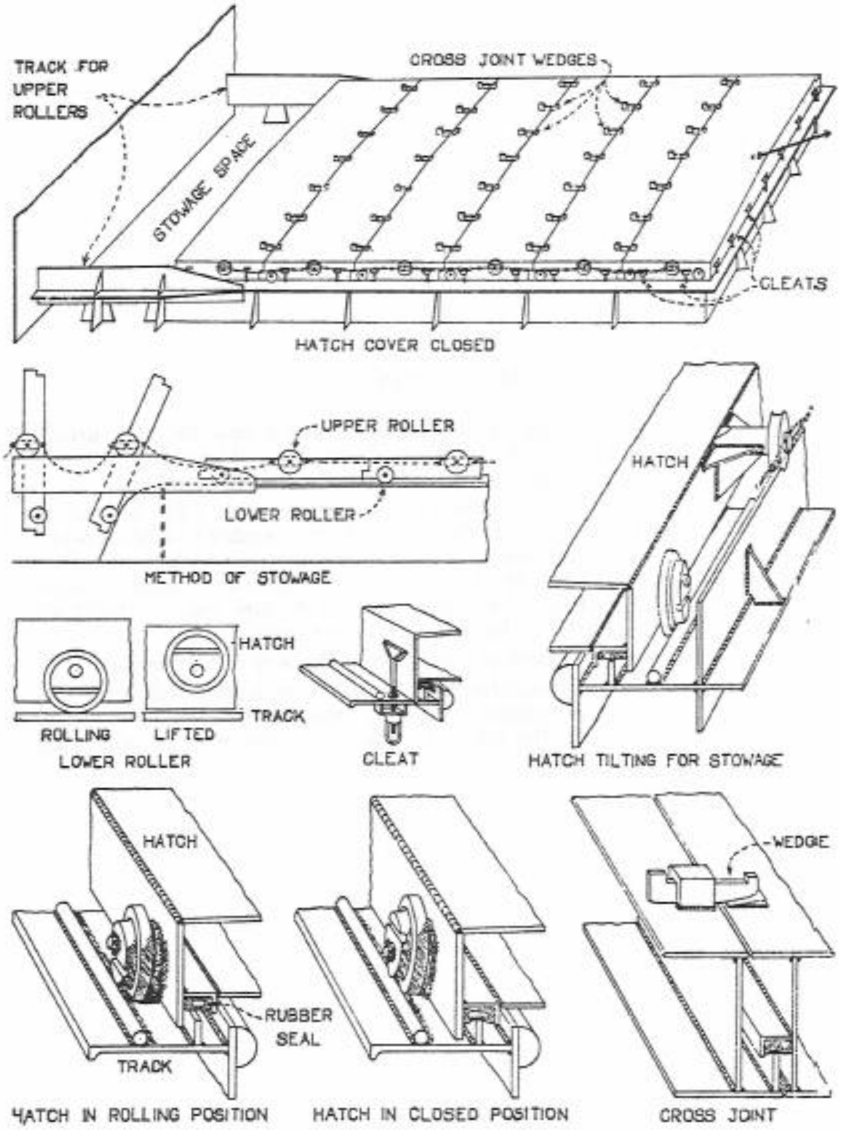


Steel Hatch Covers

These have many advantages and are much used in modem ships. They must have cleats about 2 metres apart, with a minimum of 2 cleats per panel. At hatch ends, one cleat is to be adjacent to the hatch comer. Cross joint wedges should be about 1·5 metres apart: or special arrangements should be made in lieu of them.

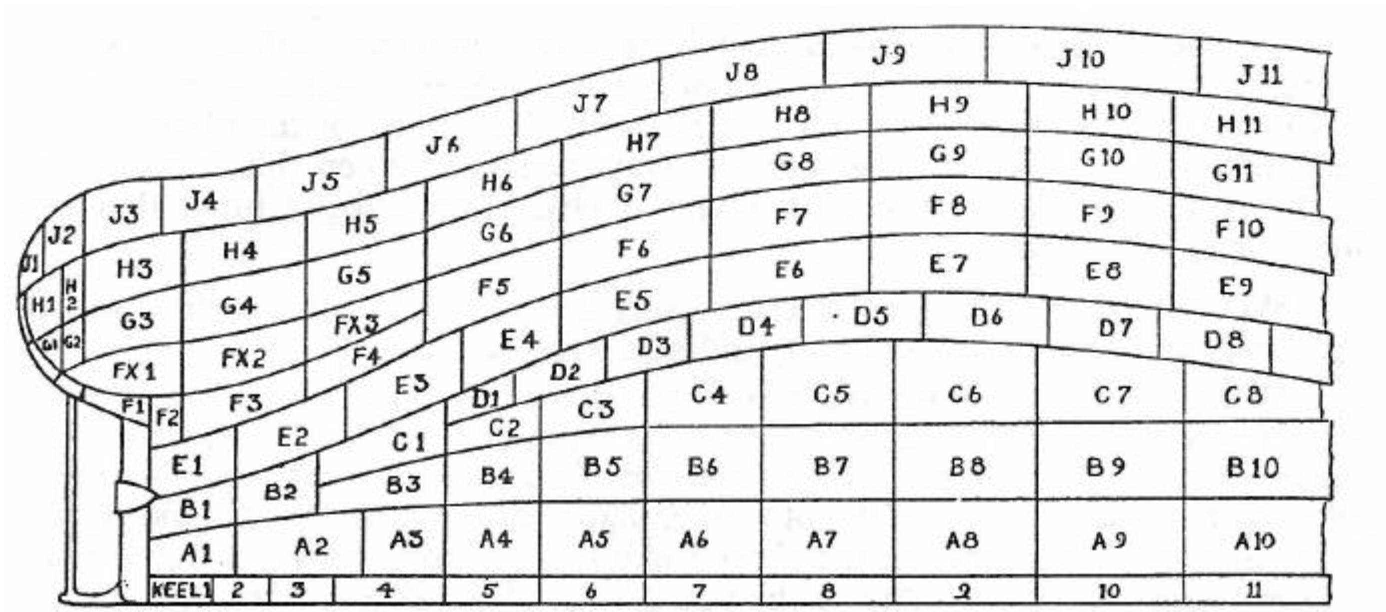
MacGregor hatch covers, as shown in the sketch, are a very strong and efficient type and do not require separate beams. The lower rollers are mounted on an eccentric bush which enables them to be raised or lowered.

This enables the hatch covers to be raised for rolling and stowage, or lowered so that they can be secured and made watertight. The upper rollers engage on a special vertical plate at the end of the track and tilt the hatch into a vertical position for stowage. These upper rollers are joined by lengths of chain or wire so that they can be pulled along the track. The hatches are made watertight by rubber jointing, as shown: being pulled down by cleats and cross-joint wedges.


TRACK FOR UPPER ROLLERS
CROSS JOINT WEDGES
STOWAGE SPACE
CLEATS
HATCH COVER CLOSED
UPPER ROLLER
LOWER ROLLER
METHOD OF STOWAGE
HATCH
HATCH
TRACK
ROLLING
LIFTED
LOWER ROLLER
CLEAT
HATCH TILTING FOR STOWAGE
HATCH
RUBBER SEAL
TRACK
WEDGE
HATCH IN ROLLING POSITION
HATCH IN CLOSED POSITION
CROSS JOINT

Chapter Seven

SHIP'S PLAN



SHELL AND DECK PLATING

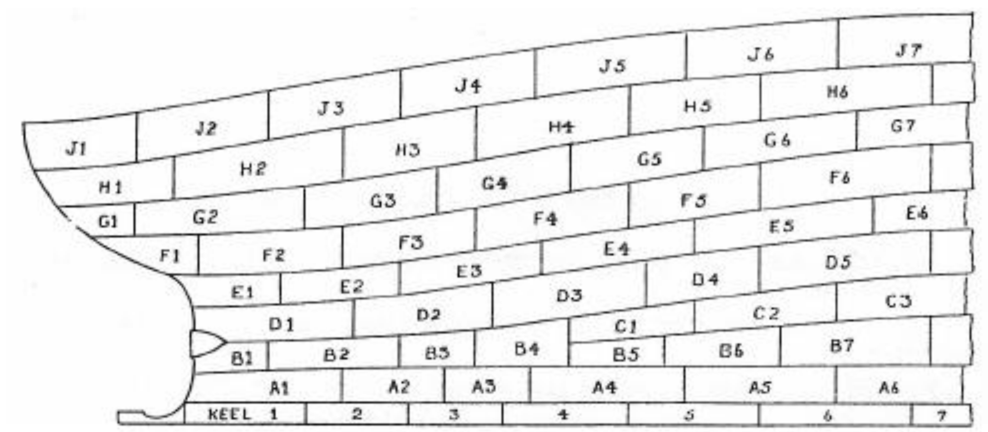
Stresses on Plating-The obvious purpose of plating is to keep out water and to tie together the ship's framework. It also plays an important part in resisting longitudinal bending stresses, so it needs to be stronger amidships than at the ends, particularly at the deck and bottom.

Shell Expansion and Deck Plans

These are plans which show all the plates in the hull, drawn to scale. They also show many other details, including frames, floors, deck edges, stringers, etc. The partial plans shown in the plate, opposite, are simplified and are merely intended to illustrate the fitting of shell and deck plating.

Identifying Plating

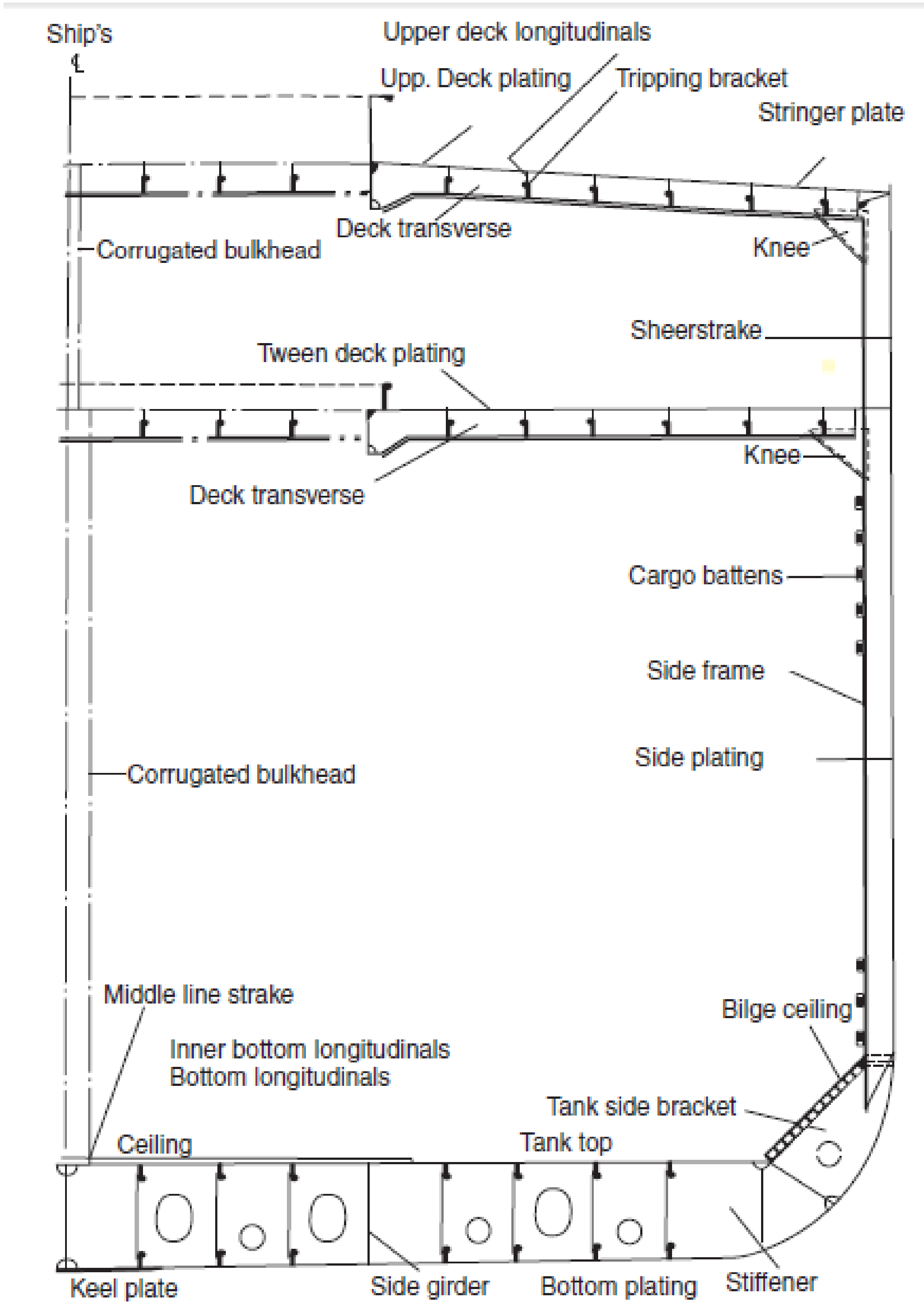
Strakes of shell plating are distinguished by letters from the keel outwards, the garboard strake being strake 'A'. The plates in each strake is usually numbered from aft to forward. For example, plate D5 would be the fifth plate from aft in the fourth strake from the keel.
Strakes of deck plating are lettered from the center line, outboard; whilst deck plates are numbered from aft to forward.



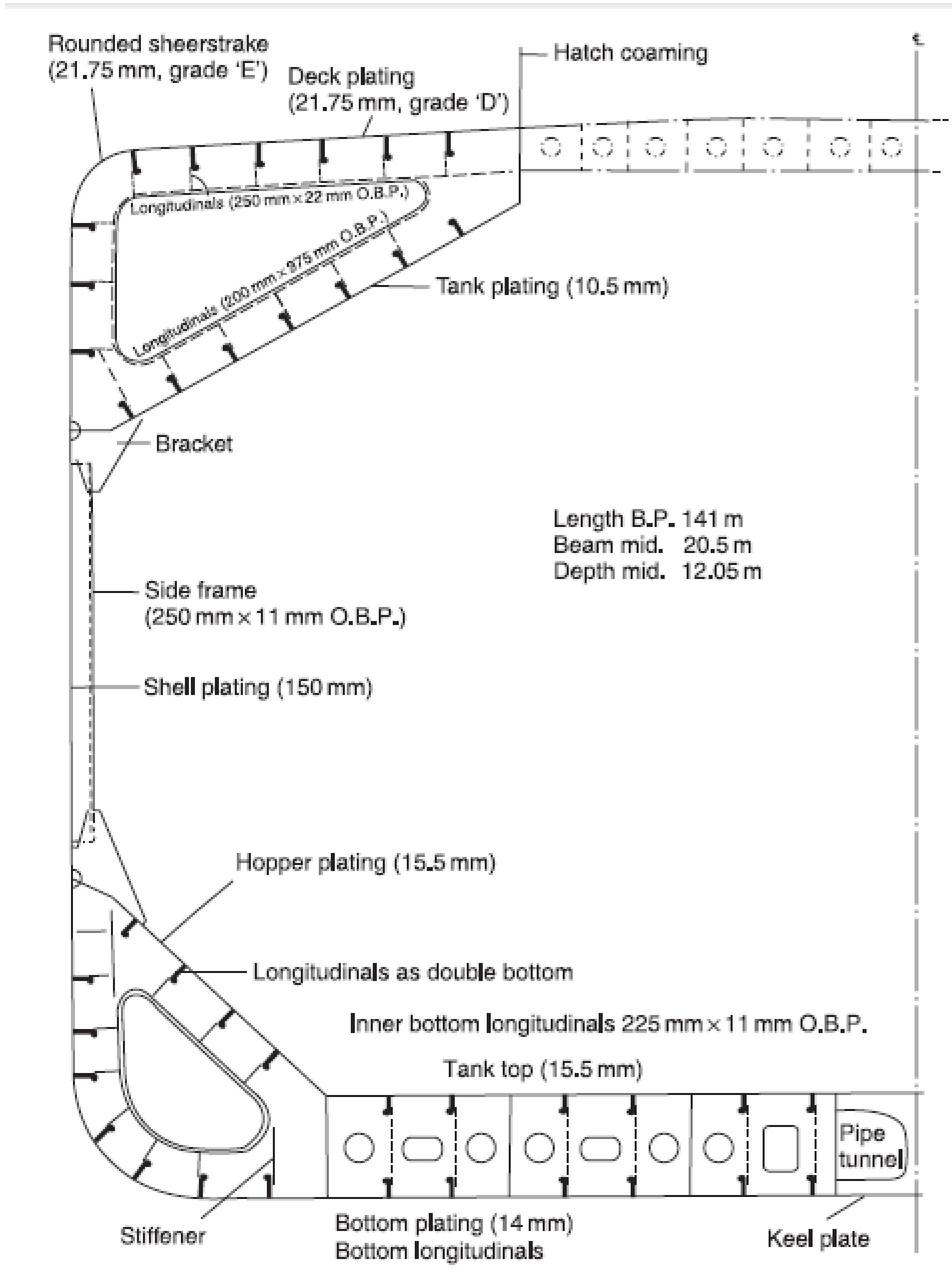
midship cross section

With the knowledge of past Chapters now check the midship cross section of following ship's type and check their construction and difference:

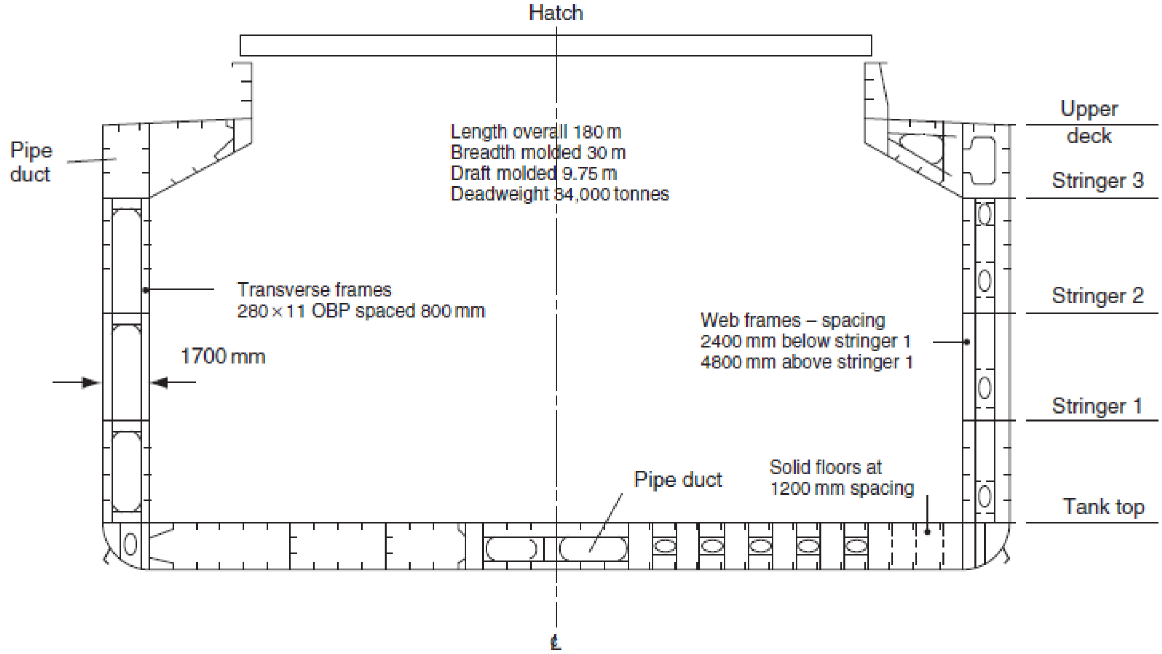
General Cargo Ship



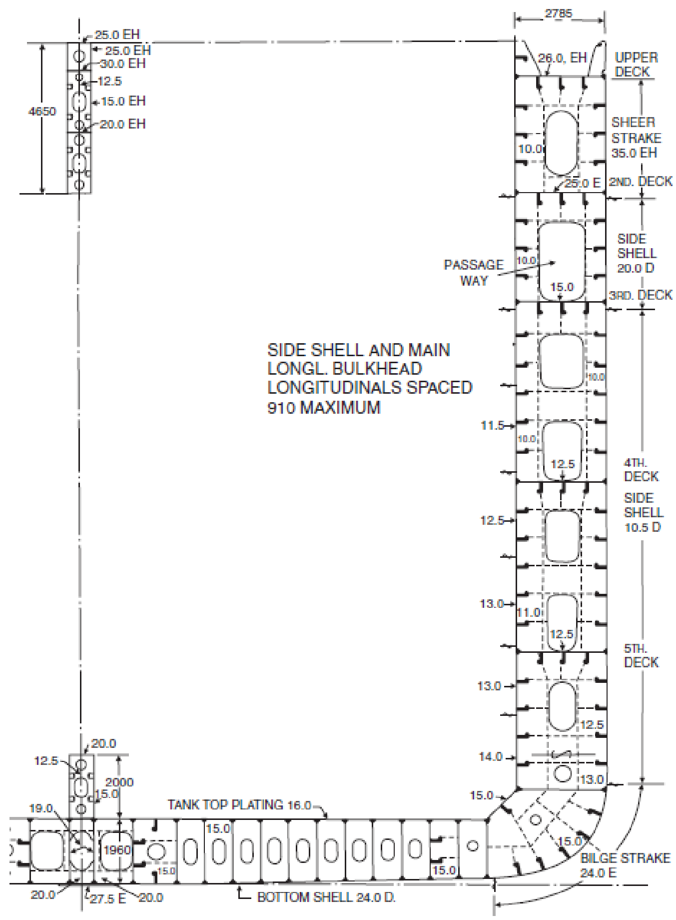
Single Skin Bulk Carrier



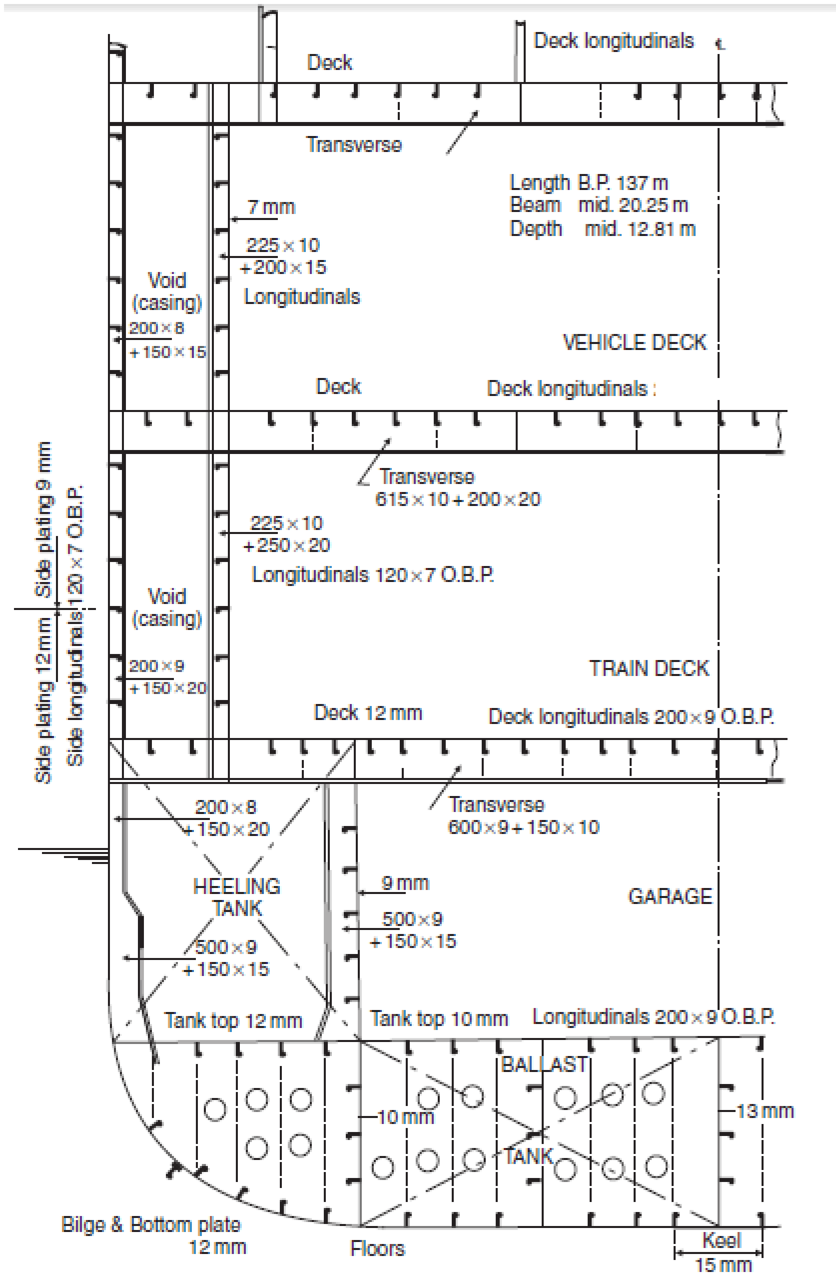
Double Skin Bulk Carrier



Container Ship

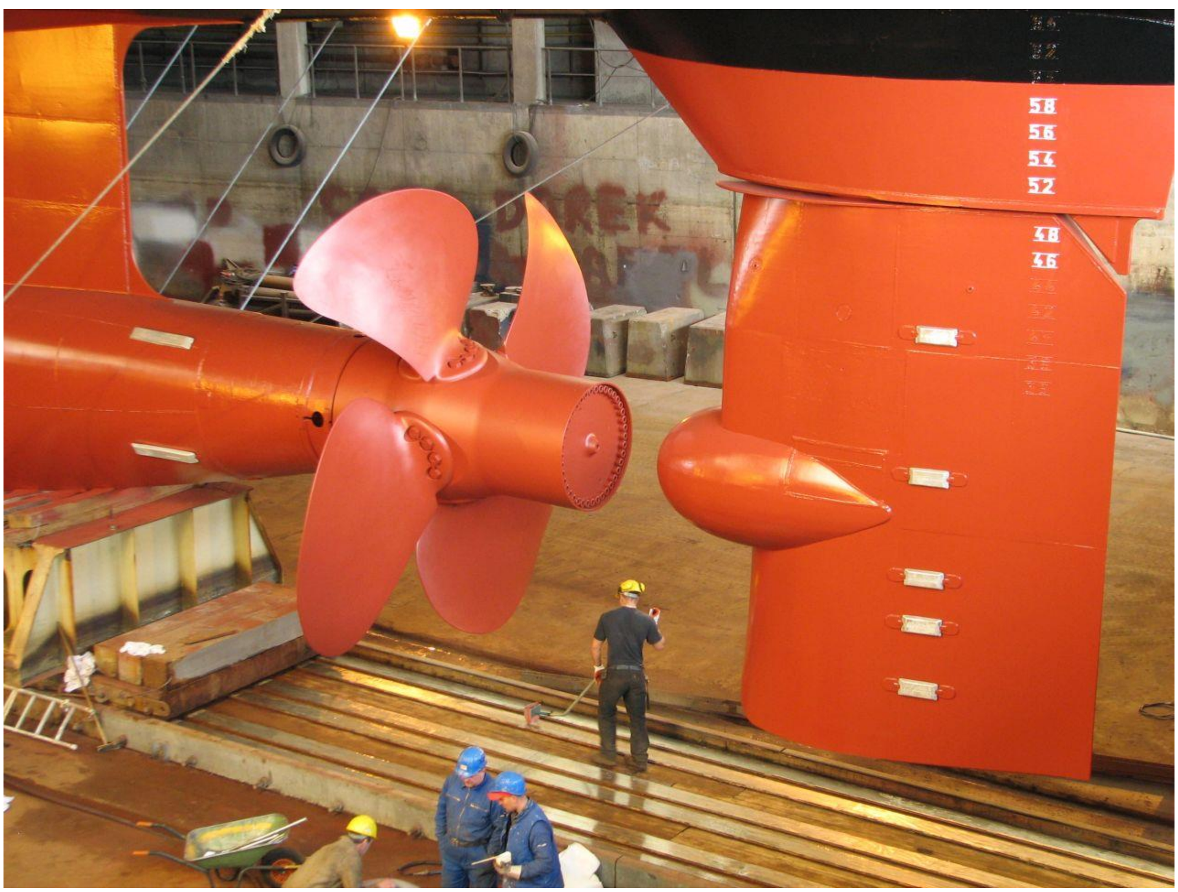


Ro-Ro Ship


Deck
Deck longitudinals
Transverse
Length B.P. 137 m
Beam mid. 20.25 m
Depth mid. 12.81 m
7 mm
225 × 10
+200 × 15
Longitudinals
Void
(casing)
200 × 8
+150 × 15
VEHICLE DECK
Deck
Deck longitudinals
Transverse
615 × 10 + 200 × 20
225 × 10
+250 × 20
Longitudinals 120 × 7 O.B.P.
Side plating 9 mm
Side longitudinals 120 × 7 O.B.P.
Side plating 12 mm
Void
(casing)
200 × 9
+150 × 20
TRAIN DECK
Deck 12 mm
Deck longitudinals 200 × 9 O.B.P.
200 × 8
+150 × 20
Transverse
600 × 9 + 150 × 10
HEELING
TANK
9 mm
500 × 9
+150 × 15
GARAGE
500 × 9
+150 × 15
Tank top 12 mm
Tank top 10 mm
Longitudinals 200 × 9 O.B.P.
BALLAST
TANK
10 mm
13 mm
Bilge & Bottom plate
12 mm
Floors
Keel
15 mm

Chapter Eight

RUDDER and PROPELLER

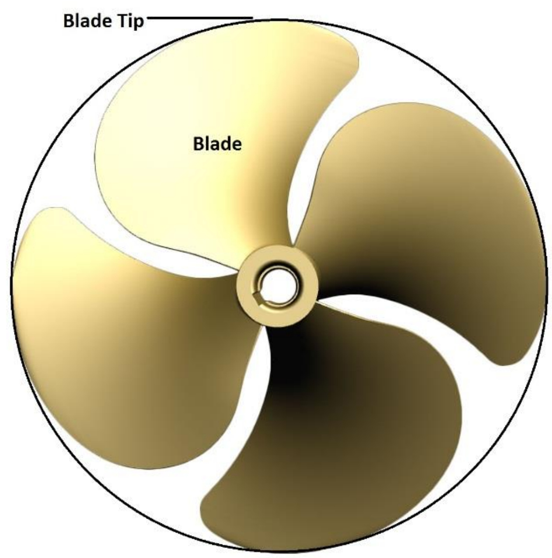


PROPELLERS

A propeller is a rotating fan like structure which is used to propel the ship by using the power generated and transmitted by the main engine of the ship.
The transmitted power is converted from rotational motion to generate a thrust.
They help the vessel to move forward or backward and there are many different types of propellers which are used based on requirements.

The efficiency of a propeller takes an important place in the design-process of the propeller because its efficiency and the ship's fuel consumption are directly related.

PROPELLER TERMINOLOGY:



RPM: Revelation per minute

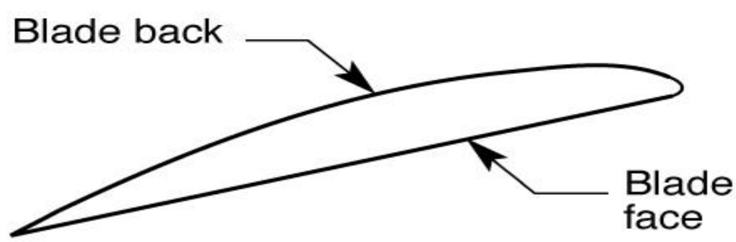
Blade Tip

Maximum reach of the blade from the center of the hub.

Blade Back
Suction side. Forward side of the blade (surface facing the bow).

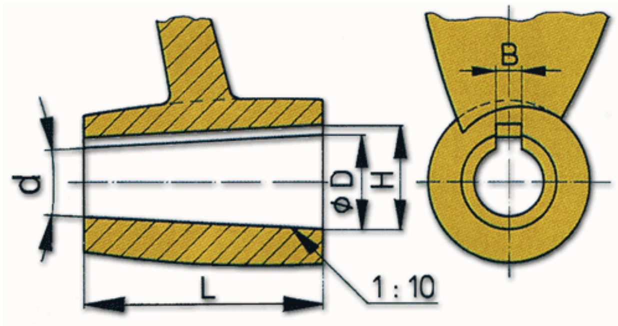
Blade Face
Pressure Side, Pitch Side. Aft side of the blade (surface facing the stern).

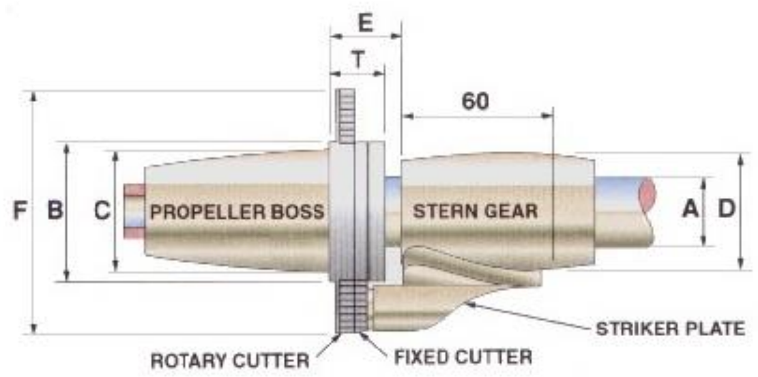
Blade Number
Equal to the number of blades on the propeller.



BOSS:

The thick, central portion of a fixedpitch propeller hub. Also called *blade boss*. Solid cylinder located at the center of the propeller. Bored to accommodate the shaft.

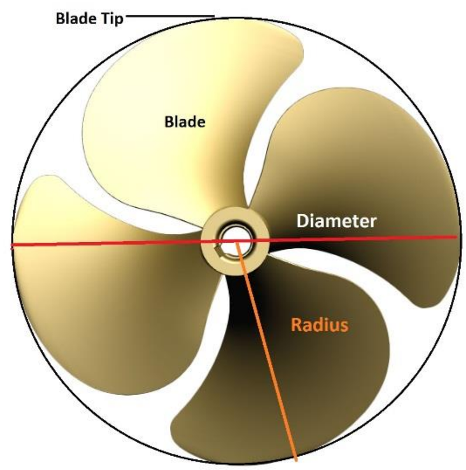




Diameter

Diameter is two times the distance from the center of the hub to the tip of the blade.

It can also be looked at as the distance across the circle that the propeller would make when rotating.

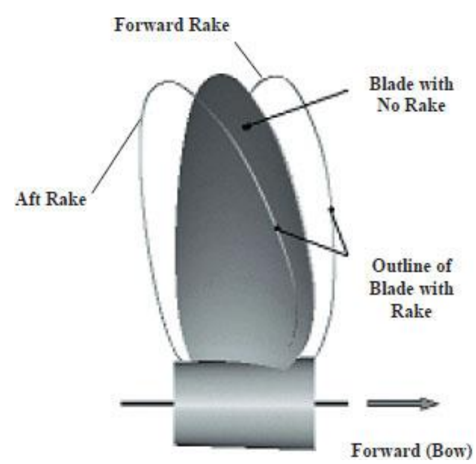


Radius:

The distance from the axis of rotation to the blade tip. The radius multiplied by two is equal to the diameter.

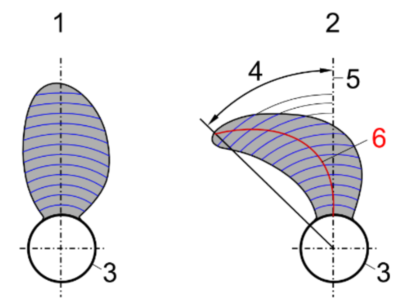
Rake

Rake is the degree that the blades slant forward or backwards in relation to the hub. Rake can affect the flow of water through the propeller



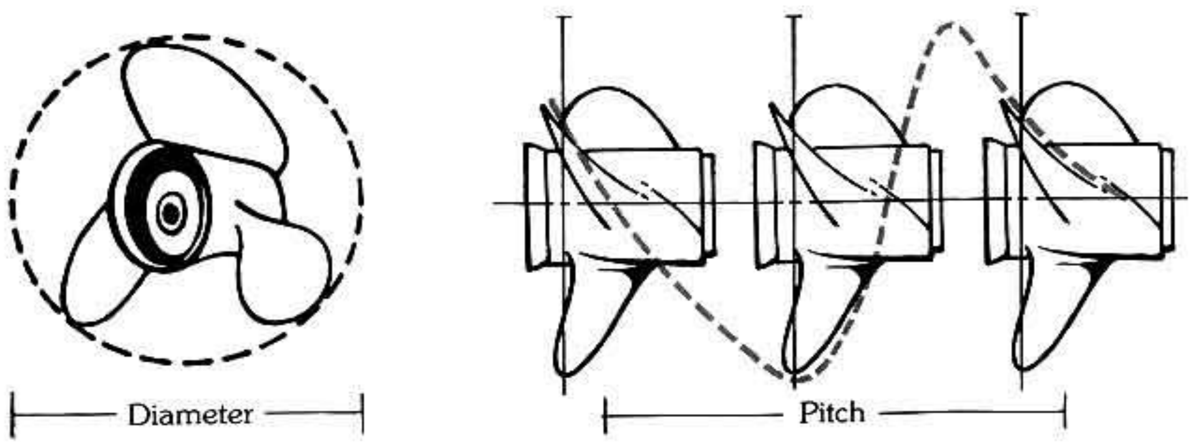
Skew

The transverse sweeping of a blade such that viewing the blades from fore or aft shows an asymmetrical shape.



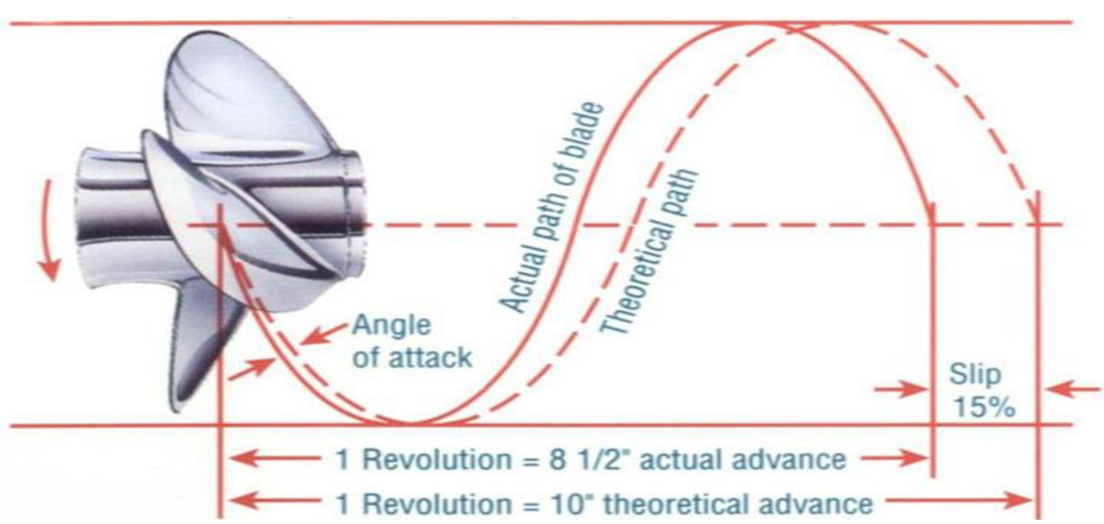
Pitch

Is defined as the distance a propeller would move in one revolution.



Slip

It is the difference between actual and theoretical travel of the propeller blades through water. A properly match propeller will actually move forward about 80 to 90 perfect of the theoretical pitch.



Propellers are being classified on the basis of several factors. The classification of different types of propellers is shown below:

A) Classification by **Number of Blades** Attached:
Propeller blades may vary from 3 blade propeller to 4 blade propeller and sometimes even 5 blade propeller. However, the most commonly used are 3 blades and 4 blade propellers.

3 blade propeller:
A 3 blade propeller has following characteristics:

- The manufacturing cost is lower than other types.
- Are normally made up of aluminum alloy.
- Gives a good high speed performance.
- The acceleration is better than other types.
- Low speed handling is not much efficient.

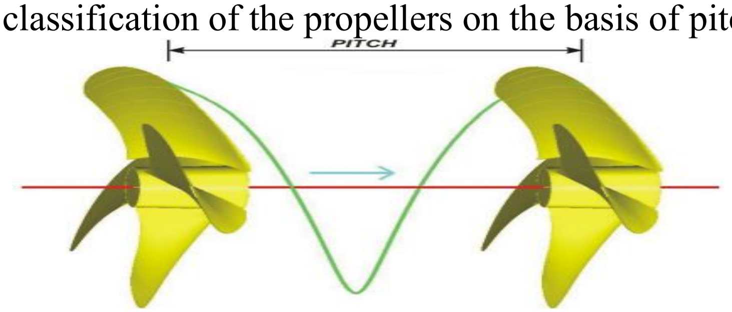
4 blade propeller:

- The manufacturing cost is higher than 3 blade propellers.
- 4 blade propellers are normally made up of stainless steel alloys.
- Have better strength and durability.
- Gives a good low speed handling and performance.
- Has a better holding power in rough seas.
- 4 blade propeller provides a better fuel economy than all the other types.

5 blade propeller:

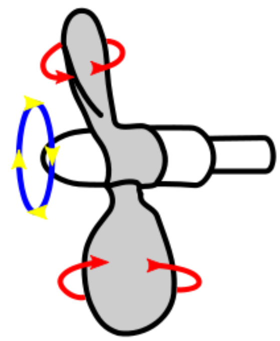
- Manufacturing cost is higher of all.
- Vibration is minimal from all the other types.
- 5 blade propellers have better holding power in rough seas.

B) Classification by **pitch** of the blade**:**
Pitch of a propeller can be defined as the displacement that a propeller makes for every full revolution of 360˚. The classification of the propellers on the basis of pitch is as follows.



Fixed Pitch Propeller:
The blades in fixed pitch propeller are permanently attached to the hub. The fixed pitch type propellers are casted and the position of the blades and hence the position of the pitch is permanently fixed and cannot be changed during the operation.
Fixed pitch propellers are robust and reliable as the system doesn't incorporate any mechanical and hydraulic connection

Controllable Pitch Propeller:
In Controlled Pitch type propeller, it is possible to alter the pitch by rotating the blade about its vertical axis by means of mechanical and hydraulic arrangement. This helps in driving the propulsion machinery at constant load with no reversing mechanism required as the pitch can be altered to match the required operating condition.
Thus the maneuverability improves and the engine efficiency also increases.



Propellers are to be **examined** visually on the occasion of each propeller shaft or tube shaft survey.

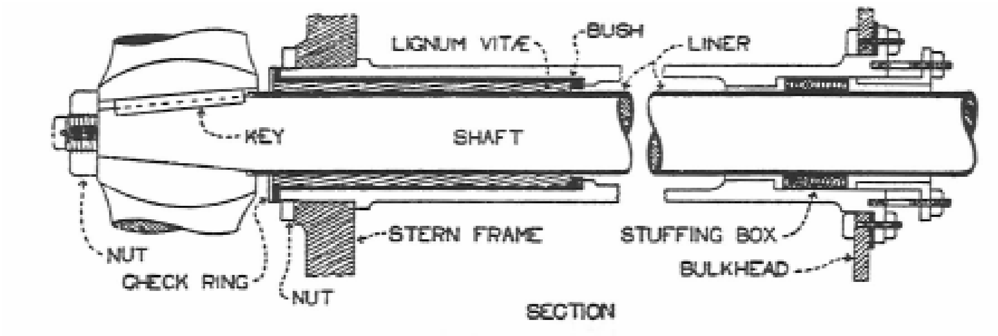
Damages, such as cracks, deformation, cavitation effects, etc. are to be reported and repaired at the Surveyor's discretion. Controllable pitch propellers are to be checked for oil leakage. The function of controllable pitch propellers has to be tested. The maintenance according to fabricator's instructions has to be checked

STERN TUBES

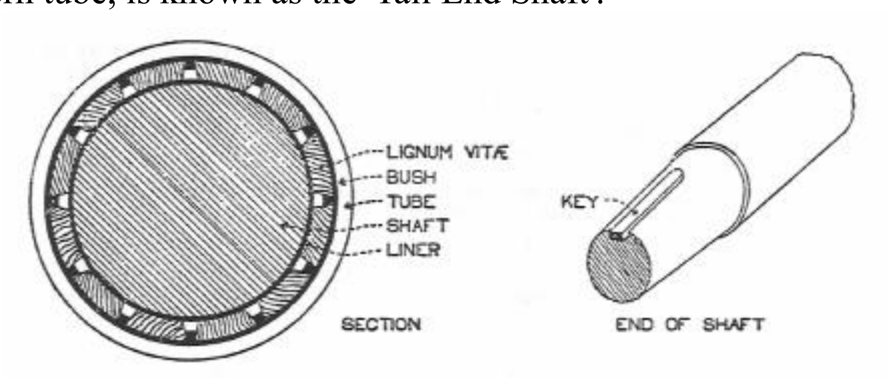
The purposes of the stern tube are to support the shaft and to make a watertight joint where the shaft enters the hull.

At the fore end of the tube there is a flange which is bolted to the after peak bulkhead. At its after end the tube has a small flange cast on it and abaft this it is threaded to take a large nut. When it is in position, the flange bears against the fore side of the stern frame and the nut on the after side.

Construction
The tube itself is usually made of steel. Inside this again is a brass bush which has grooves in it, running fore and aft. Strips of lignum vitae are fitted into these grooves to act as a bearing for the shaft.

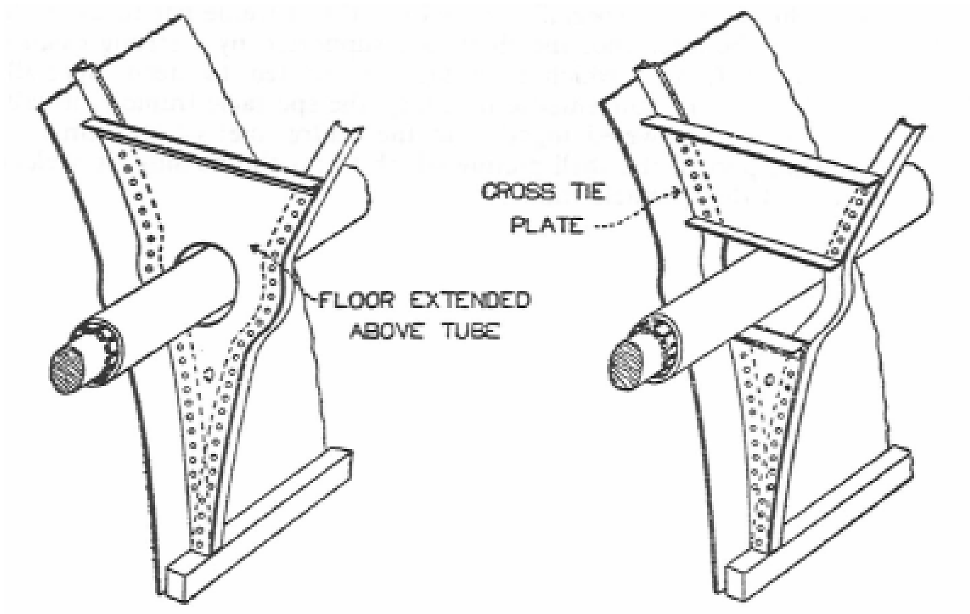


The strips are kept in place by means of a ring known as the 'check ring'.
which is bolted on to the after end of the tube.
Small spaces are left between the lignum vitae strips and through these the water can enter to lubricate and cool the shaft. In order to prevent this water from getting into the hull of the ship, a stuffing box is fitted at the fore end of the stern tube. The aftermost length of shafting, which revolves in the stern tube, is known as the 'Tail End Shaft'.



It usually has a brass liner shrunk on to it. In some ships the stern tube is bushed with white metal instead of lignum vitae and oil is used for lubrication. In this case special glands are used to prevent the escape of oil.

Strengthening Around Stern Tube is usually considerable vibration in the vicinity of the stern tube, and arrangements must be made to strengthen the ship against this.
The floors must extend above the tube. If this is impossible, deep 'cross tie plates', flanged on their upper and lower edges, must be fitted above the tube.
The plating of the after peak bulkhead must be thickened or doubled around the tube. The shell plating must also be thickened in this vicinity.



Rudder

The rudder is the most important part of the ship. If the rudder becomes defective, the ship can no longer operate, even though the condition of the hull and machinery is satisfactory. Similar to the propeller, the rudder is normally immersed under water, therefore, details of its condition can be observed only during a bottom inspection when the ship is docked. Inspection of the rudder also includes inspection of deformation, checking for cracks and the condition of rudder bearing wear down.

Rudders originally consisted of a single plate, with supporting arms, riveted on either side of it. This type has now been superseded, in larger ships by double plate rudders, which are normally streamlined and are often **balanced**, or **semi-balanced**. They may be hinged on pintles and gudgeons, or they may turn about an axle which passes down through the rudder.

The stock, which turns the rudder, passes vertically upwards to the steering-gear through a gland at the shell plating, or a watertight rudder trunk. It is usually connected to the rudder by a bolted coupling, which can be disconnected so that the rudder can be lifted for maintenance without disturbing the stock.
Note that the centers of the pin ties, or axle, must be in the same line as the center of the stock, to enable the rudder to turn.

The weight of the rudder may be taken by a bearing pintle, or by a bearing at the rudder head, or by a combination of both.

The framework of double Plate Rudders may be a casting, or it may be built up of welded plates, with plating on either side. Most modem rudders are of this type and are usually streamlined. 'They may be unbalanced, with their whole area abaft the rudder stock: or balanced, with part of their area forward of the stock.
Streamlining reduces the 'drag' caused by a rudder and may also improve the ship's steering, particularly in the case of balanced rudders.

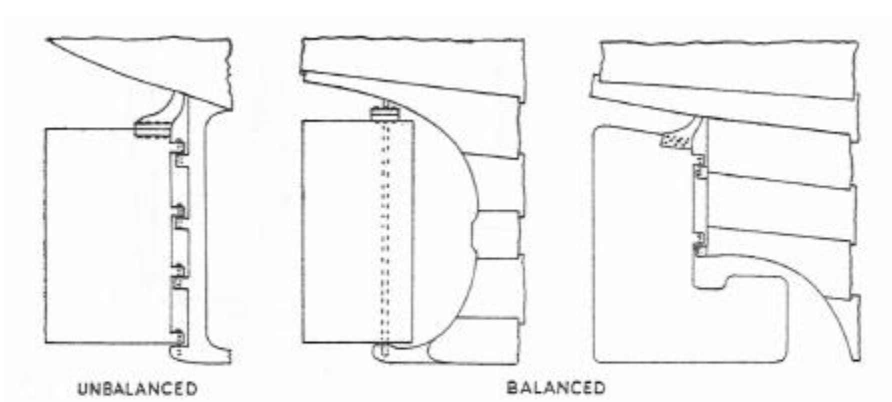
The rudder frame may be of forged or cast steel, or it may be built of web plates welded together. The plating is usually welded to the frame. Slot welds, or continuous butt welds are commonly used for this purpose. When plate frames are used.
The inside surface of the rudder is coated with bitumastic, or some similar 'Preservative, and the space within it is now often filled with foam plastic. There must be some means of draining the rudder.

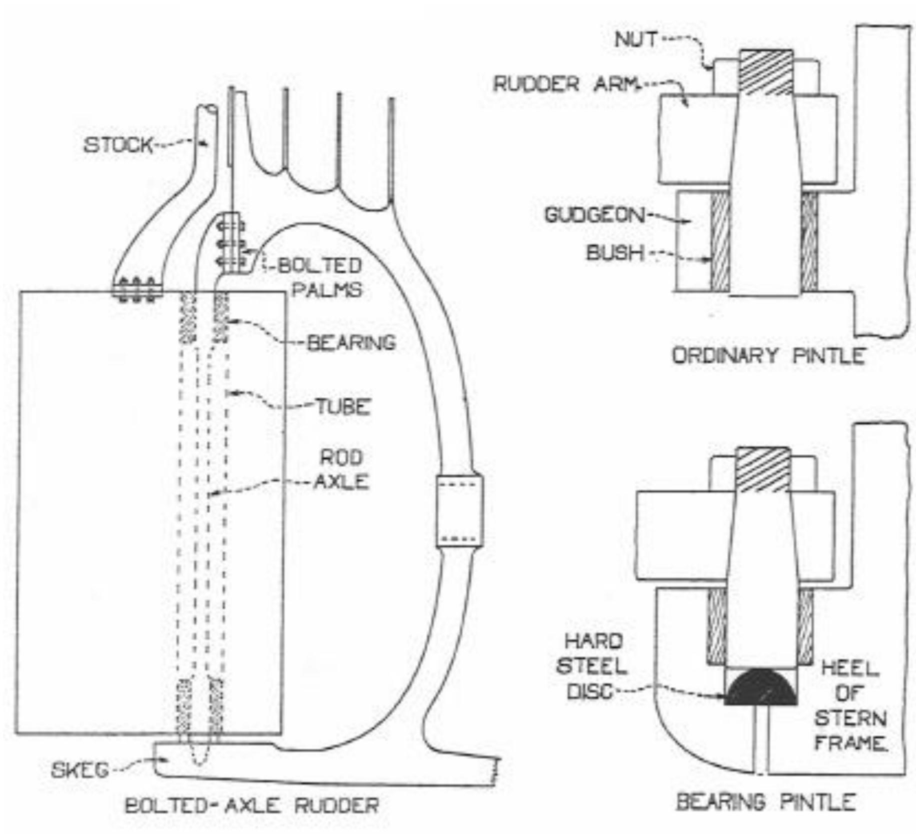
Balanced Rudders

Water pressure tries to force the blade of an unbalanced rudder amidships and thus puts considerable stress on the rudder stock and steering-gear. If part of the blade is extended forward of the stock, the pressures on this tends to counterbalance that on the after part, so that there will be less stress on the steering gear. Unfortunately, the ratio between the pressures varies with the rudder angle, so that it is not usually possible to balance a rudder for all angles.

Semi-balanced rudders

Are those in which the area forward of the stock is too small to give a full balancing effect. They are often found in twin screw ships.




STOCK
BOLTED PALMS
BEARING
TUBE
ROD AXLE
SKEG
BOLTED-AXLE RUDDER
NUT
RUDDER ARM
GUDGEON
BUSH
ORDINARY PINTLE
HARD STEEL DISC
HEEL OF STERN FRAME
BEARING PINTLE

Chapter Nine

Load Lines Rule

International Convention on Load Lines of Ships 1966.

The first International Convention on Load Lines, adopted in 1930, was based on the principle of reserve buoyancy, although it was recognized then that the freeboard should also ensure adequate stability and avoid excessive stress on the ship's hull as a result of overloading.

In the 1966 Load Lines convention, adopted by IMO, provisions are made determining the freeboard of ships by subdivision and damage stability calculations.

Minimum free boards are assigned so that a vessel remain seaworthy when loaded and to provide reserve buoyancy so that:

1. The vessel will not be in danger of foundering in heavy seas
2. In the event of major damage, the vessel will still remain afloat or will sink slowly enough so as to enable the crew to get clear

Load line Zones

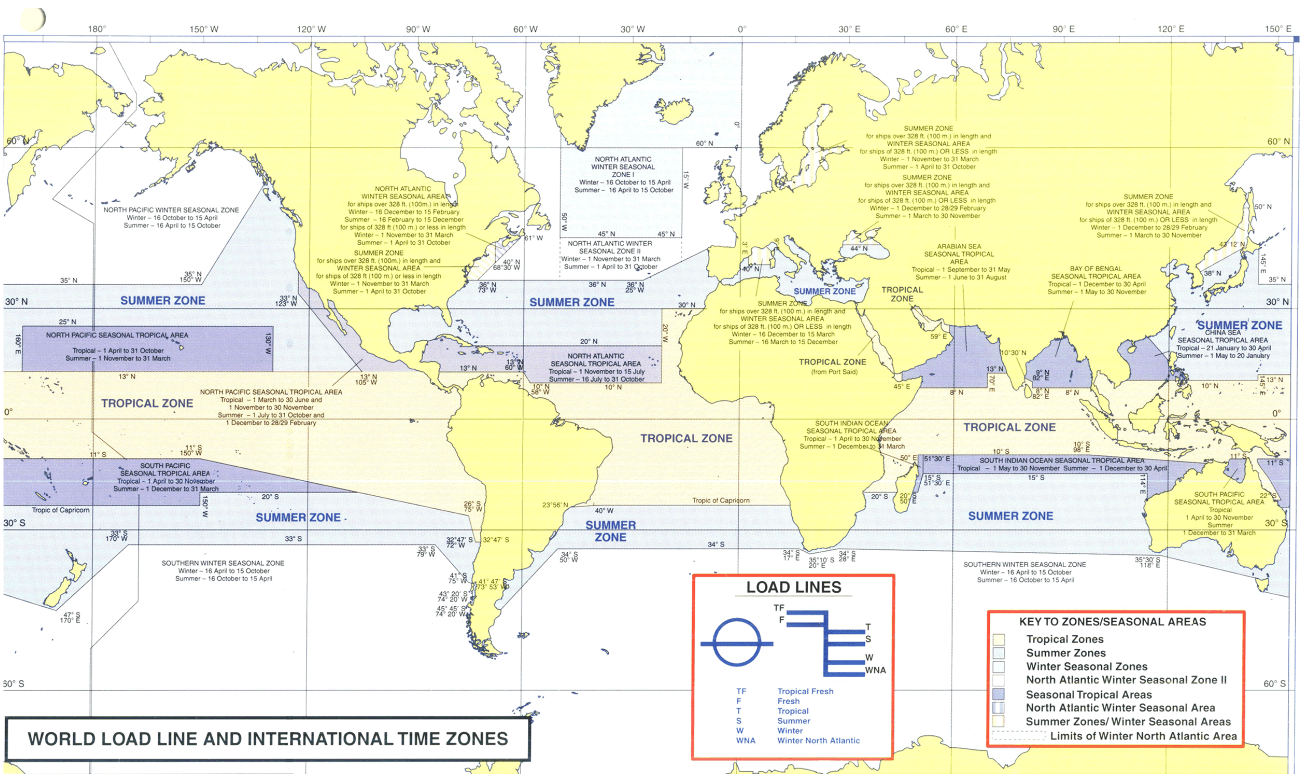
The seasonal zones, areas and periods that determine the appropriate load line in a particular sea area at a given time of year are by way of the chart.

The ***Tropical***, ***Summer*** and ***Winter*** freeboard zones are based upon the following weather criteria:

Summer Zones – Regions where not more than 10% of wind speeds exceed force 8 Beaufort (34 knots).

Tropical Zones – Regions where not more than 1% of wind speeds exceed force 8 Beaufort (34 knots) and not more than one tropical storm in a ten-year period occurs in an area of 5º latitude/longitude square in any one separate calendar month.

Winter Zones – Are all other regions.



- Load line symbol shall be marked on both side amidships.
- Location of mark are calculated/verified by class & reflected in relevant certificate.
- SLL is primary line than other marks which are derived. It depends on ship’s type, length, number of superstructures, amount of sheer, bow height etc.

Associated Definitions/Terms

<u>MOULDED DEPTH:</u> the vertical distance measured from top of keel to top of freeboard deck beam at side.

<u>FREEBOARD:</u> vertical distance amidships, between the upper edge of the <u>Deck Line</u> and upper edge of the related load line.

<u>FREEBOARD DECK:</u> normally the uppermost continuous deck exposed to weather & sea which has permanent means of closing all openings in the weather part, and below which all openings in the sides of the ship are fitted with permanent means of watertight closing.

The **deck line** is a horizontal line 300 millimeters in length and 25 millimeters in breadth. It shall be marked amidships on each side of the ship, and its upper edge shall normally pass through the point where the continuation outwards of the upper surface of the freeboard deck intersects the outer surface of the shell. The location of the reference point and the identification of the freeboard deck shall in all cases be indicated on the International Load Line Certificate.

ASSIGNED FREEBOARD: A term for the final summer and other freeboards as calculated, marked and entered in the load line certificate by the Certifying Authority.

CONDITIONS OF ASSIGNMENT OF FREEBOARD FOR ALL SHIPS

These are certain requirements which must be met to ensure water tightness of openings and the ability of the ship to rapidly free itself of water on its decks :

The **structural strength** of the ship must be sufficient for the freeboard assigned to her.
Her **stability** in all probable loading conditions must be sufficient for the freeboard assigned to her, having regard to the intended service of the ship (stability criteria)
Bulkheads, at exposed ends of enclosed superstructure are to be of efficient construction, with openings capable of being closed.
Hatchways are to have coamings of sufficient height, strength & means of closing them watertight.
Machinery space openings are to be efficiently framed & enclosed by a steel casing of substantial strength. Doors & covers are to close openings weather tight.
Manholes in exposed position on the freeboard or superstructure deck are to be fitted with a substantial cover to secure them watertight.
Ventilators are to have means of closing & securing weather tight.
Air pipes are to have means of closing them weather tight.
Cargo ports & similar openings are to be fitted with doors, designed to ensure water tightness & structural integrity of the shell.
Scuppers, Inlet & discharges which pass through the hull are to be fitted with automatic non-return valves.

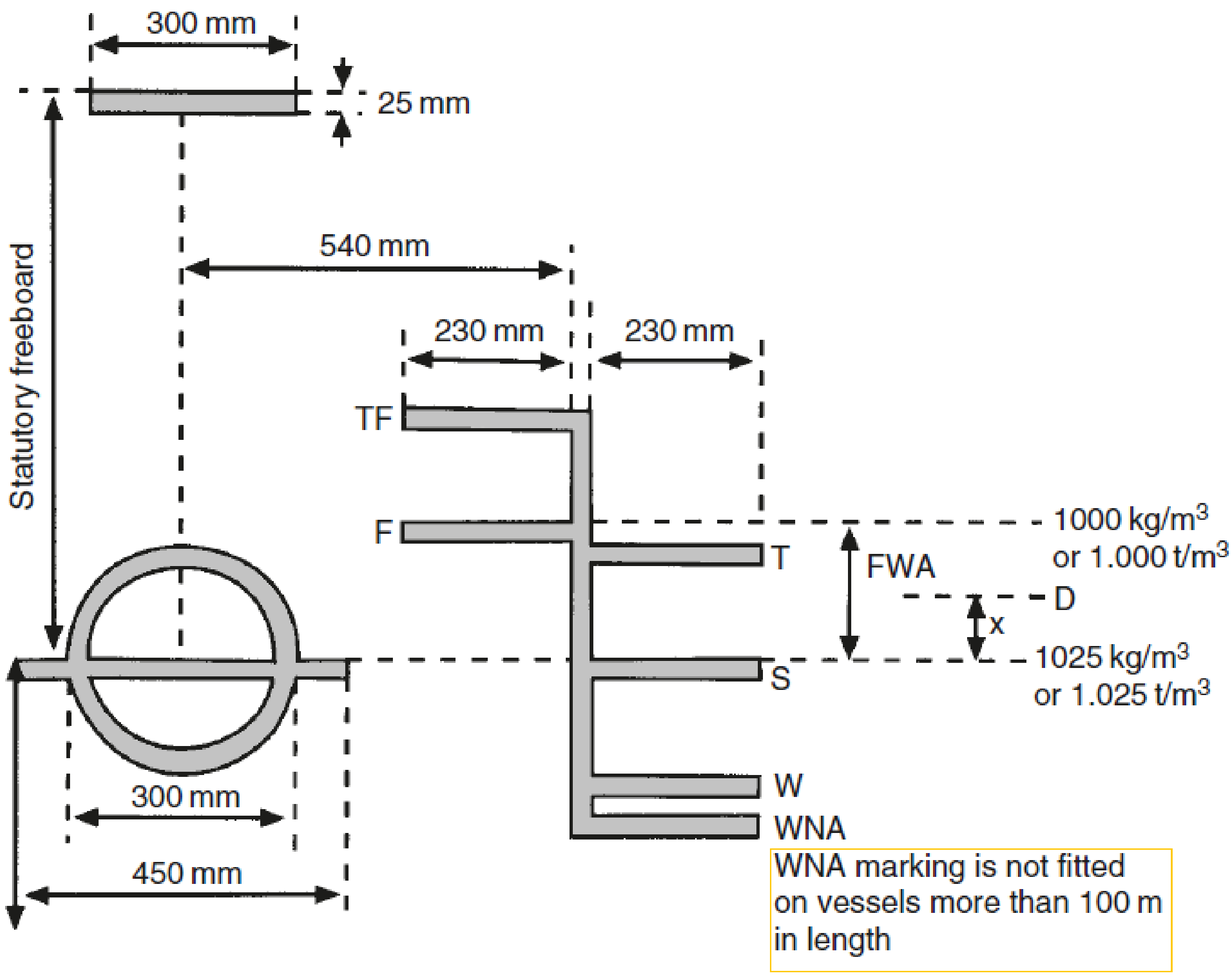
Port holes below the freeboard deck & in an enclosed superstructure are to be fitted with a hinged dead light, which can be closed & secured watertight.
Accommodation, deck houses are to be of efficient construction with safe access.
Exposed ports of the freeboard deck & super structure deck are to be fitted with efficient guard rails or guard wires & stanchions or bulwarks.
Gangway, under deck passage & all means of access are to be designed, constructed & fitted with life lines, access ladders, and guard rails so as to provide effective protection for the crew.

Freeing ports: where bulwarks on any exposed decks form wells they must be provided with efficient means for rapidly freeing the decks of water. The lower edges of freeing ports should be as near the deck as practicable. Two-thirds of the freeing port area is required to be provided in the half of the well nearest the lowest point of the sheer curve, where the deck has sheer. Openings in the bulwarks are protected by bars spaced approximately 230mm apart. If shutters are fitted, these should be prevented from jamming.
Protection of Crew: Efficient guard-rails or bulwarks of minimum height 1 meter are to be fitted on all exposed parts of freeboard and superstructure decks. A lower rail may be permitted by the Administration. The maximum vertical spacing between deck and lower rail is 230 mm, and between other rails is 380mm. Satisfactory means should be provided for protection of crew in getting to and from their quarters and other parts used in the working of the ship.

Side Scuttles: Below the freeboard deck or within the enclosed superstructures side scuttles should be fitted with efficient hinged, water-tight, inside deadlights. No side scuttle should be fitted with its sill below a line drawn parallel to the freeboard deck at side and having its lowest point 2.5 per cent of the ship's breadth above the summer water-line or 500mm whichever is the greater distance.

The purpose of a load line is to ensure that a ship has sufficient freeboard and thus sufficient reserve buoyancy.

This symbol, also called an international load line or Plimsoll line, indicates the maximum safe draft, and therefore the minimum freeboard for the vessel in various operating conditions.



Prepared by Captain Farshad Haeri