Bottom repairs on single hatch ships or on ships with relatively long hatches

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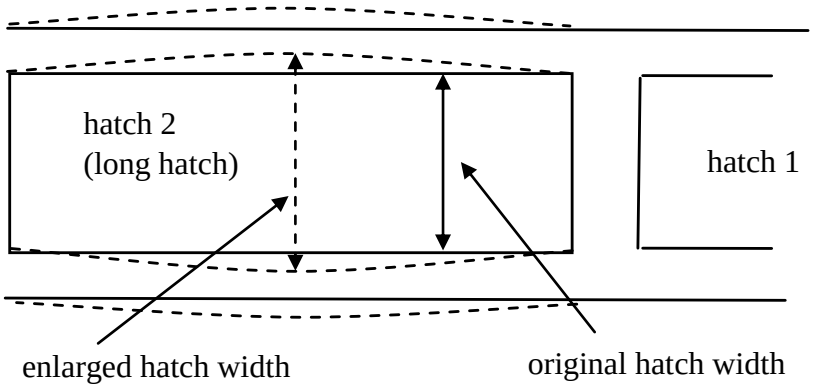
1. Introduction

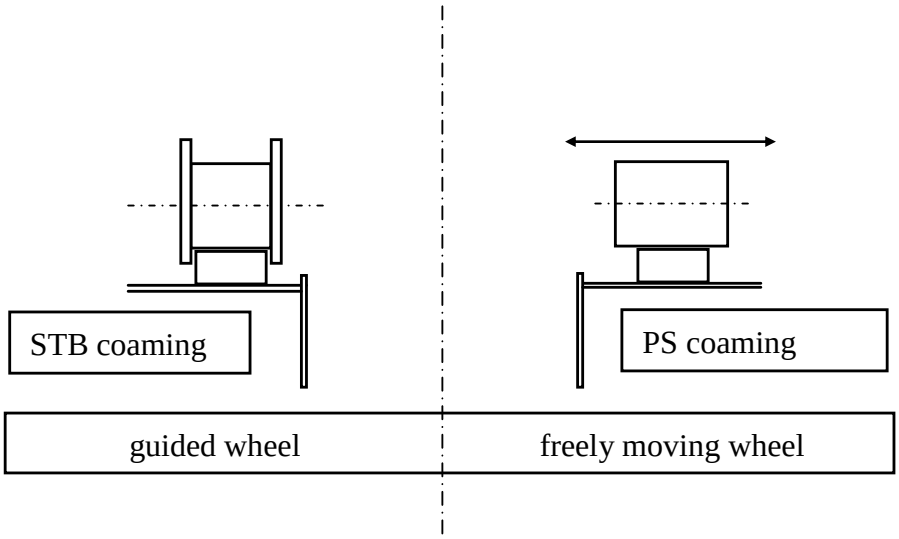
In regard to bottom repairs on ships with one hatch or with relatively long hatches, the ship's transversal structure may deform (gape) to such an extent that the hatch side coamings diverge (they are pulled outwards, so to speak.). Thus, the hatch opening expands the most in the about the middle of its length. We have witnessed gaping of 100 mm and even more.



gaping = enlarged hatch width – original hatch width

Factors which influence such gaping are dependent on the size of the hatch, the height of the coamings and of possible cranes located on the side of the hatch.

To ensure proper function of the hatch covers, the gaping of the longitudinal hatch coamings must be within permissible limits. The reason for the aforesaid is that the hatch cover wheels run on rectangular rails and have only little play on one side of the hatch because of the wheel's guide (does not apply to pontoon covers). Normally, the wheels are guided on one side of the hatch and may move freely on the other.



Independent of the wheel's design, every hatch cover manufacturer specifies a maximum permissible gaping (non-parallelism) of the rails. If this distance is exceeded, the hatch cover may e.g. get jammed during operation or (if worst comes to the worst) plunge into the cargo hold. A further consequence may be that the hatch cover in question does not seal the cargo hold water-tight any longer. It must be noted that the aforesaid applies to each type of hatch cover and influences the sea-worthiness of the ship.

If the ship's transversal structure has deformed beyond its permissible limits, the resulting gaping of the hatch coamings must be rectified. Normally, today, these repairs are performed directly on the hatch coaming. For this, the hatch coaming stays are detached from the deck, and the hatch side coamings are forced inwards hydraulically. The lower end of the hatch

coaming stays has to be renewed (at a height of at least 300 mm) and re-welded to the deck. As one can imagine, this is a costly repair.

The following will go into the causes as well as the possible measures of preventing such gaping.

2. Docking of a ship for bottom repairs

For every ship, the docking plan is part of the delivery documents provided by the new building yard. The docking plan provides information as to where to place the keel and side blocks in order to have the ship's weight (normally without cargo) optimally distributed while taking into account the double bottom's structure. Thus, areas with more weight (e.g. the engine room) are given more support (distance between the blocks is shorter) so that damage to the ship from docking is prevented. Before docking, the dock is set up according to the particular docking plan.

In normal docking conditions, the ship sits on the keel and side blocks. The ship's weight is equally distributed on the blocks. By doing so, possible damage to the ship's structure is avoided.

When a ship with e.g. considerable bottom damage is to be docked, one may assume that the flat bottom area will not sit on all of the blocks due to its damages. Therefore, in such cases, before docking, the ship's bottom is inspected by divers in order to assess the extent of the damage and to determine the location for additional blocks. As soon as the vessel has fallen dry, the ship's condition is to be checked, and possible gaps in-between the blocks and the flat bottom are to be eliminated e.g. by inserting timber wedges.

To avoid larger spaces between blocks and flat bottoms, one may place sand bags on the blocks before docking. This, however, presupposes that the area of damage had been precisely determined by the divers.

Owing to bottom damage and the uneven distribution of weight during docking, additional stress and, thus, deformation in the ship's body (especially in the bottom area) develop, which may substantially differ from that of the undamaged ship.

3. Repair-induced stress on the ship's body

Bottom repairs are carried out according to a work plan (sub-divided into various repair areas) corresponding to the extent of damage. Throughout the entire repair process, local and global stress on the ship's body develops and varies. The individual work steps lead to different kinds of stress during the repair process.

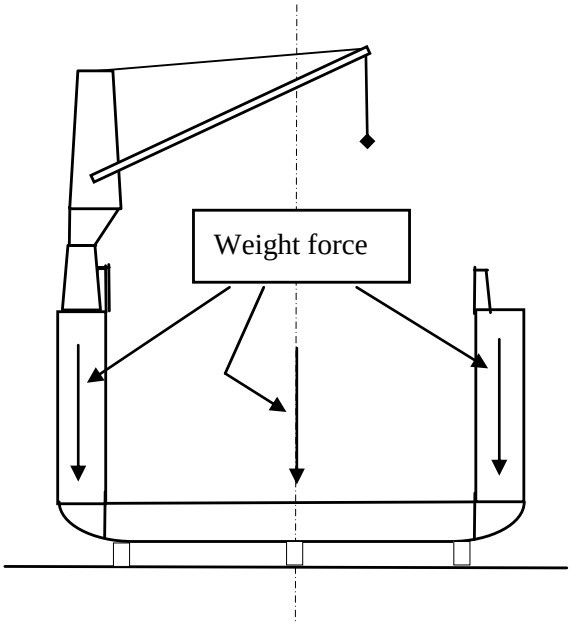
The combination of weight distribution on the blocks, the removal of and the fitting of blocks and the flame-cutting of the damaged and the welding in of the new bottom structures give rise to different kinds of deformation / stress in the entire double bottom area.

3.1 Effects of the removal / replacement of blocks

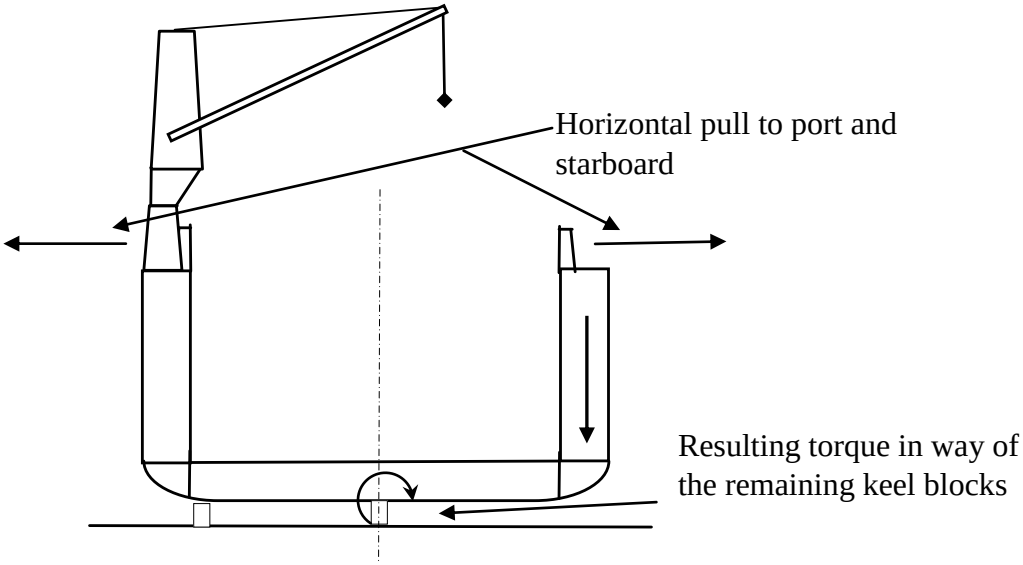
In the course of major bottom repairs, blocks must be removed in way of the intended repair area. Thus, the number of blocks to be removed at one time depend on the size of the section to be repaired next.

As soon as one or more supporting blocks is/are removed, the ship's body is no longer supported in this location. Because of the (ship's own) weight, the ship's structure will "sag" several millimetres in this area and will cause stress on the ship's body. Apart from that, the remaining blocks must hold additional weight. To minimise the "sagging", additional provisional supports are to be set up in the area surrounding the repair.

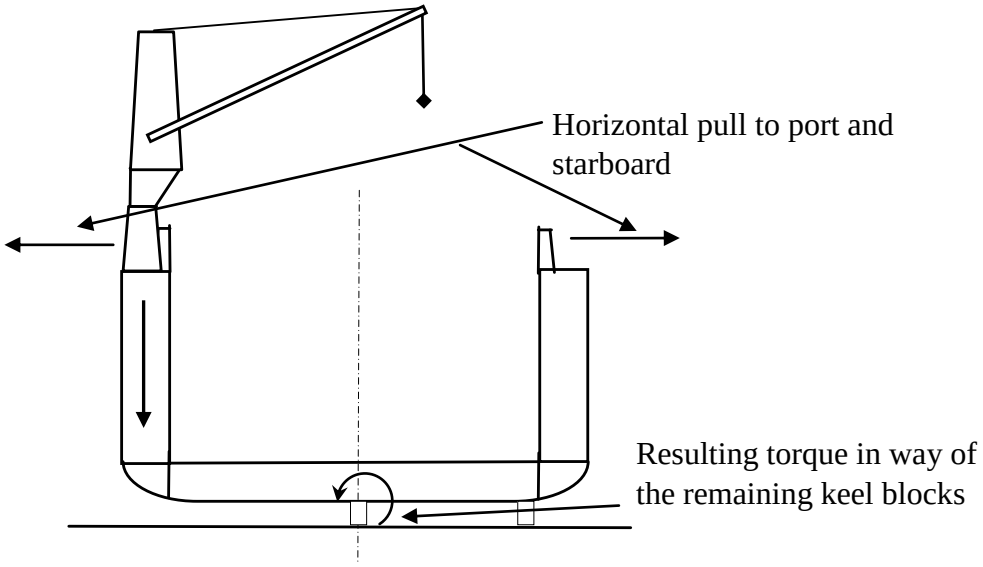
Ship in the dock on blocks



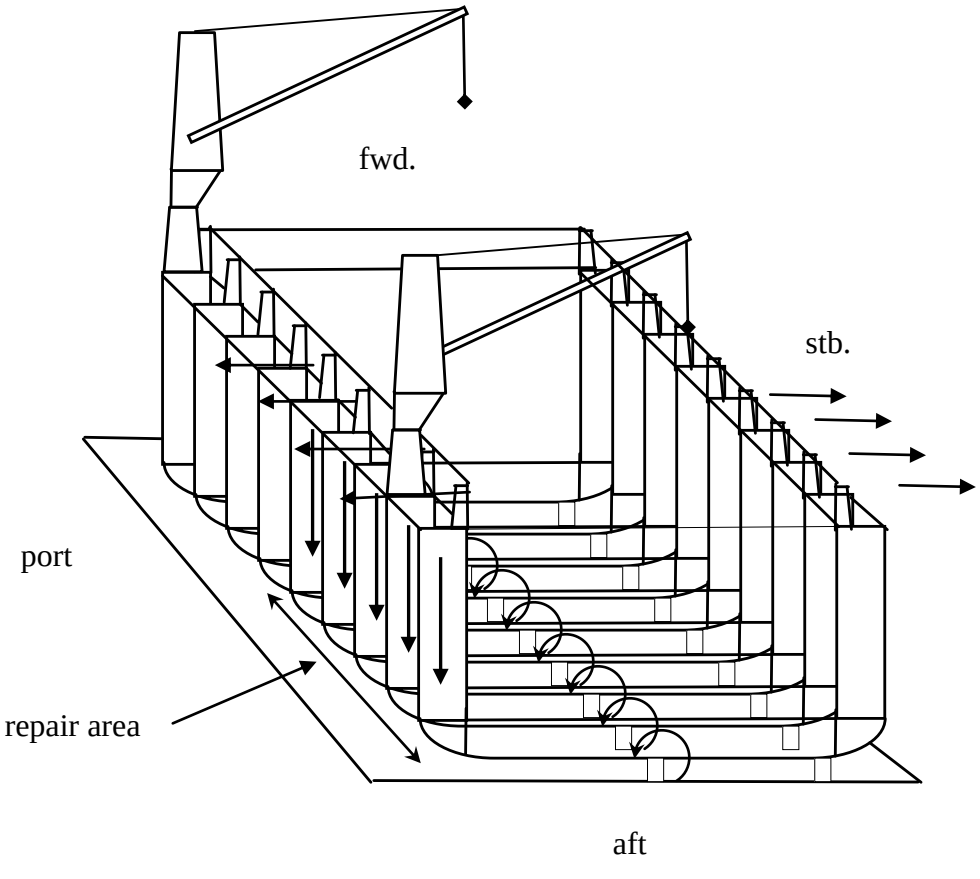
Ship in the dock, blocks removed on one side (starboard)



Ship in the dock, blocks removed on one side (port side)



general view of the ship in dock



Comment:

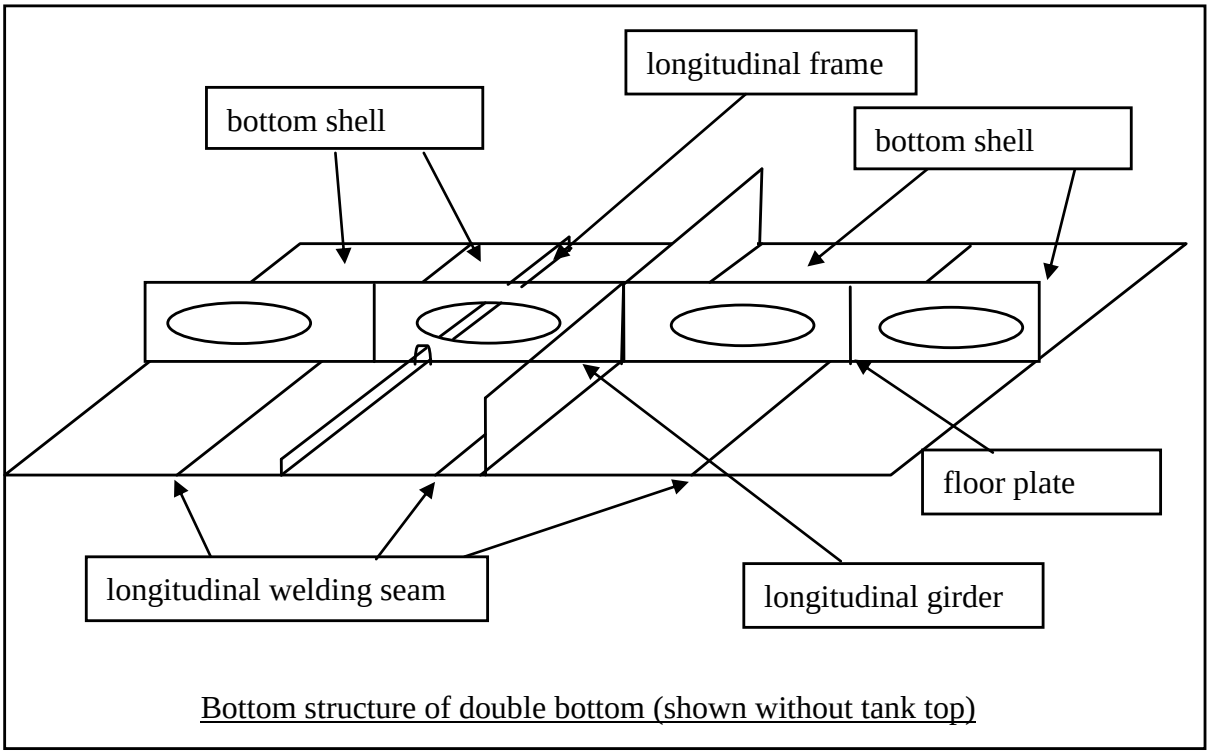
Cranes fitted on one side of the ship increase the weight force on the corresponding side (resulting from the crane's own weight).

If blocks are re-fitted in the area repaired, one must assume that these blocks are neither in the exact same position nor do they hold the same weight (reaction of support) as they did before they were originally removed.

If the ship is un-docked and once again docked during the repair procedure, experience tells us that the ship's position on the blocks has changed. These altered dock conditions will also cause a change the stress on the ship's structure.

3.2 Effects of steel repairs

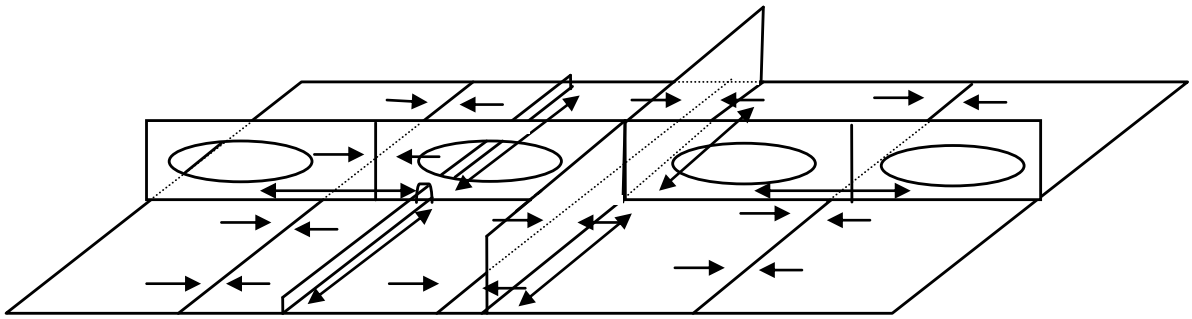
If the damaged plate areas including their longitudinal and transverse frames and stiffeners are cut out, a weakening of the bottom structure ensues. The weakening causes the ship's structure to deform because of the ship's own weight and, thus, causes additional stress on the ship's body. The amount of deformation is usually a few millimetres.



Bottom structure of double bottom (shown without tank top)

3.3 Effects from welding procedures

When new transverse structures (floor plates) are fitted by welding, shrinkage stress occurs in the horizontal and vertical welding seams, which contracts the floor plates by a few millimetres (pull). When the bottom shell and bilge plates are welded in, shrinkage stress occurs again in the longitudinal and transverse welding seams, which in turn generates pull to the ship's hull in the transverse direction. In the weld between the floor plates and the bottom shell plates as well as between longitudinal frames / -girders and bottom shell plates, shrinkage stress also occurs primarily in the transverse direction.



direction of shrinkage stress in the welding seams

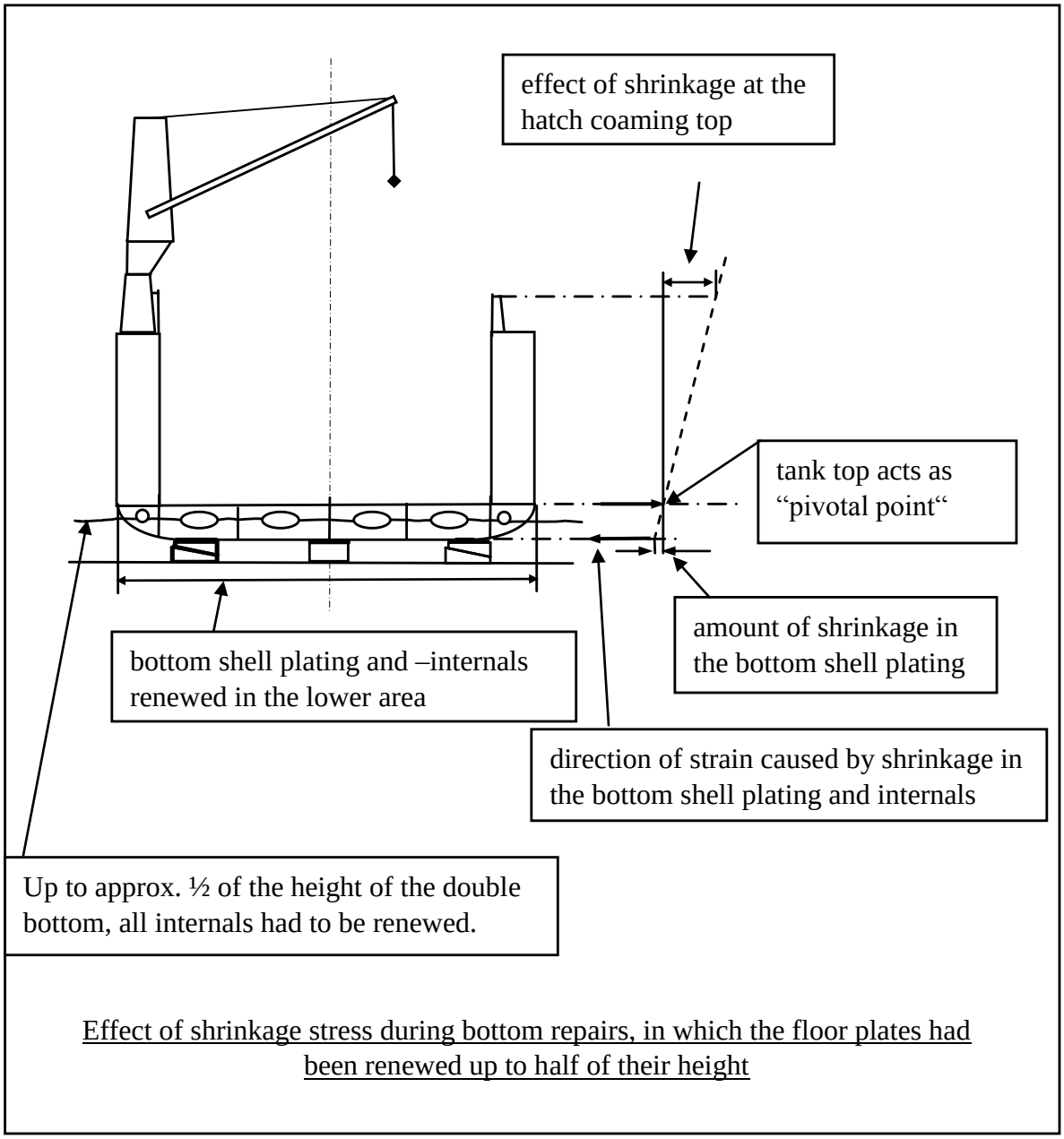
If the gap (clearance) between the steel plates to be welded together is too wide, a lot of welding material and heat must be applied in order to fill the gap and to properly weld the plates together. As a result, considerable shrinkage stress occurs while the welding is cooling off.

4. Effects of stress on the ship's structure:

The previously mentioned sources of stress, particularly the shrinkage stress resulting from welding in the double bottom area, can cause contraction, reducing the ship's width in the bottom area. The resulting pull has its effect to the centre line of the ship. The fixed-point or, respectively, the "pivotal point" lies at the height of the tank top. Thus, the top of the hatch coaming moves outwards (gapes), i.e. diametrically to the direction of the force in the double

bottom structure. This is the source of the problems with the hatch covers mentioned at the beginning of this essay.

The width of the gaping is dependent on the distance between the tank top and the top of the hatch coaming.



Effect of shrinkage stress during bottom repairs, in which the floor plates had been renewed up to half of their height

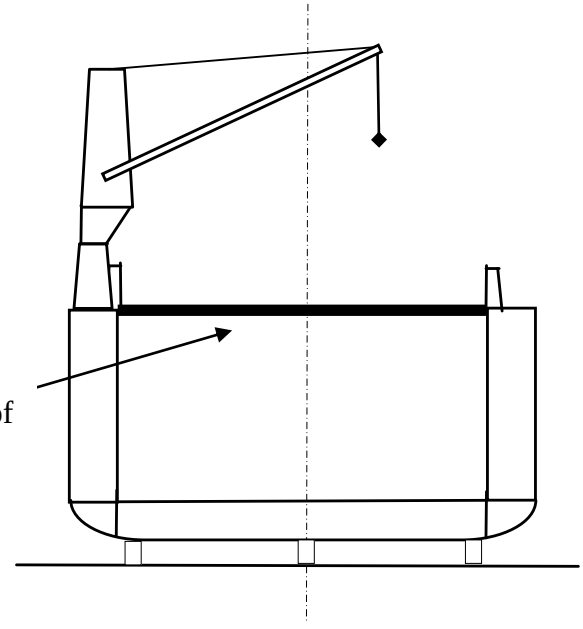
5. Measures to avoid or reduce the gaping/deformation of the longitudinal hatch coamings

By performing certain measures (described more in detail in the following) or, as the case may be, the combination of those measures, deformation/gaping of the longitudinal hatch coamings can be minimised or even avoided.

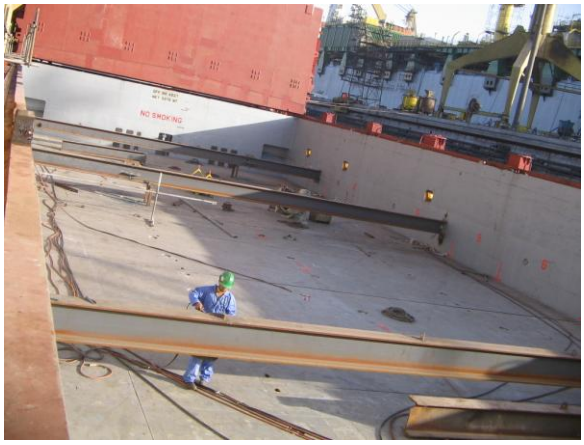
5.1 Fitting of strong beams in the hatch opening in way of the main or tween deck

The fitting of horizontal strong beams (3 to 6 pieces – dependent on the length of the hatch) in transverse direction of the hatch opening in way of the main or tween deck restricts the movement of the hatch opening and, thus, reduces the deformation/gaping of the longitudinal hatch coaming. The dimensioning of the strong beams must be chosen in such a way that permanent deformation (resulting from welding stress) in the double bottom structure/repair area is largely avoided.

Upon completion of the repairs, it makes sense to check the elongation of the strong beams. The elongation sheds light on the amount of pull which has resulted from the shrinkage stress. Before removal of the strong beams, the longitudinal bulkhead (bulkhead between cargo hold and side tank) is to be straightened by well-directed flame heating just above the tank top.



strong beams

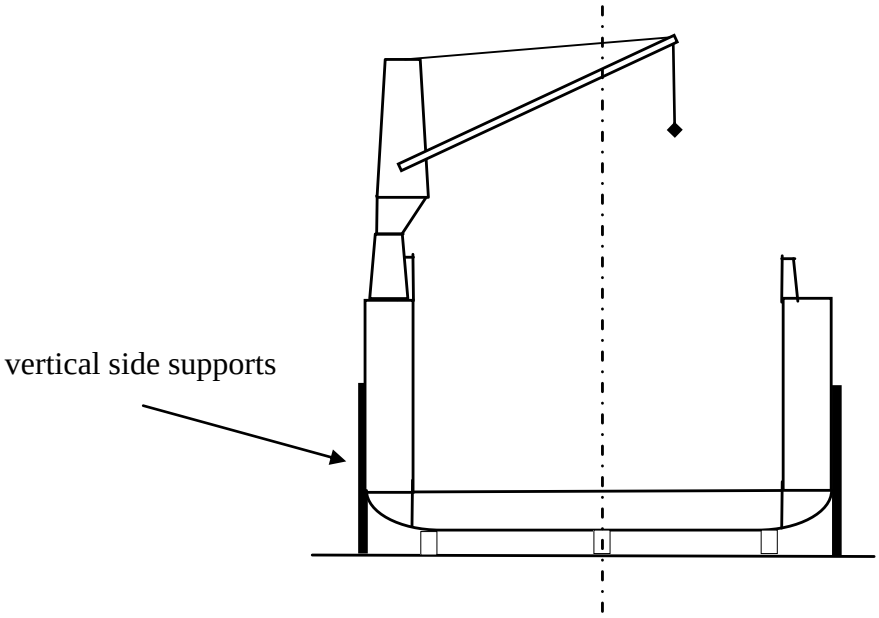



Pontoon-type tween deck covers may also be used as strong beams.

If, in the case of bottom repairs, the tank top must also be partly renewed, in addition to the strong beams, stiffeners should be fitted diagonally (forming an X-shape) into the cargo hold.

5.2 Supports on the sides of the ship and/or stern and/or bow areas

Vertical side supports serve to pick up the extra load resulting from the removal of the side- and/or keel blocks and to prevent the "side boxes" (either with or without cranes) from sagging due to their own weight. These supports must be dimensioned according to the scope of repair and the size of the ship.



side supports

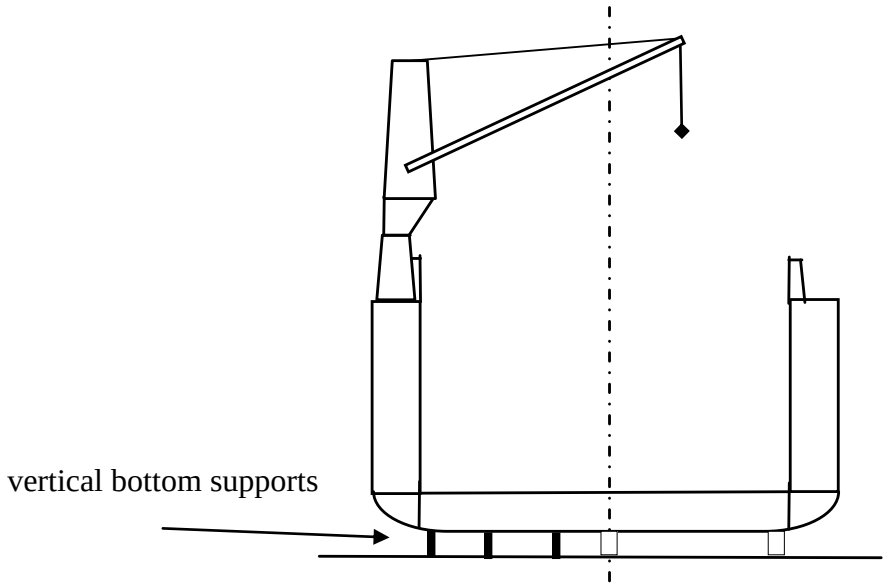
side supports

bow support

stern support

5.3 Support in the bottom area when removing / fitting keel and/or side blocks

The area to be repaired at one time should not be too large. Instead, it would be better to work simultaneously on several smaller areas that are not located next to each other so that the bottom structure is not unnecessarily weakened. If a great number of blocks in the bottom area are to be removed at once, provisional bottom supports should be fitted.



provisional supports in the repair area

provisional supports in the repair area

5.4 Observance of welding preparation according to the ship's building standard (e.g. gap between the individual plates to be welded)

Gaps between the plates to be welded are to be kept as small as possible or as small as necessary. If a gap is too large, a lot of weld material and, thus, a lot of heat is introduced into the structural element, which, in turn, will cause significant shrinkage stress while cooling down.

Unfortunately, accuracy is not always observed while performing hull repairs. Due to convenience, plates are often cut in situ by hand, which may lead to the consequence that the standard gap width is not observed.

5.5 Observance of welding sequences

Depending on the scope of the repair, a schedule of welding sequences (here, the welding methods, the preheat temperature, the number and direction of welding layers are defined) should be made.

Quote:
The schedule of welding sequences (compilation of the welding sequences on a structural element) provides for the practical connection between the construction requirements (according to drawings), on the one hand, and the welding documentation (WPS) of the individual seams, on the other hand. The welding sequence for a structural element is determined within the schedule of welding sequences. For each welding seam, a WPS can be created, or, as the case may be, an existing WPS can be adopted. For each welding seam, information about the method of testing, scope of inspection and further technical comments (weld run sequence, direction of weld) may be listed within said table.

5.6 Ship's mass distribution on blocks

Through the irregular mass distribution on blocks before, during and after repairs, stress occurs in the entire double bottom area, which together with welding stress results in a deforming force, which effect culminates in way of the longitudinal hatch coamings (gaping).

6. Summary

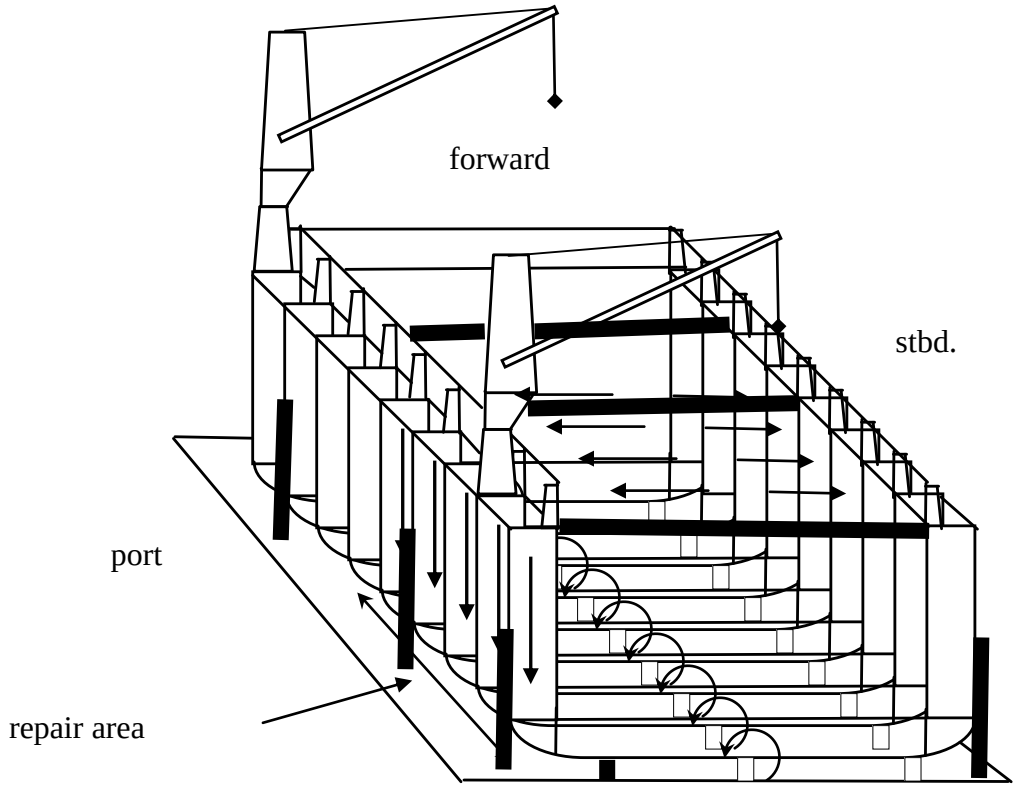
To solve the gaping problem of the hatch coamings, horizontal strong beams are to be welded (in a transverse direction) into the hatch opening. The number of such depends on the length of the hatch; however, the minimum requirement is 3-4 strong beams at the height of the main- or tween deck. The dimensions of the strong beams should be chosen in such a way that permanent deformation (resulting from welding stress) in the double bottom area is avoided to a large extent.

In the past, these strong beams were checked for their elongation. The results then shed light onto the magnitude of force caused by welding stress.
At that time, before the strong beams were removed, the longitudinal bulkheads (bulkheads between the cargo hold and side tank) were straightened by well-directed flame heating just above the tank top.

This method of flame straightening has been buried in oblivion in German shipyards as this workmanship no longer exists. In foreign shipyards, this method was and is widely unknown.

When performing extensive bottom repairs, not only transverse strong beams (possibly diagonal stiffeners, as well) are fitted into the hatch opening, but side supports are also fitted to the ship from the outside.

overall view in the dock



In way of the aft crane, the side blocks are removed locally (port side).
anti-clockwise torque force resulting in way of the keel blocks
vertical force resulting in way of the “side boxes”
horizontal force resulting in port and starboard direction

Practice shows that bottom repairs of today must very often be carried out under time pressure. The truly necessary and time-consuming technical repair preparation (measurements, drawings, welding documentation, welding seam preparation, schedule of welding sequences etc.) of the steel areas to be repaired have been replaced with on-site ad-hoc repairs. As a result, inaccuracy is pre-programmed. In particular, the lack of adequate fitting accuracy requires an increase in the application of heat from welding work, and thus, causes additional shrinkage stress.

The consequence is that the effects of the aforesaid on the hatch coamings (gaping) can not be completely prevented; however, such can be minimised by using the appropriate supports to the ship’s hull.

According to experience, the gaping of the hatch coamings is nowadays remedied directly on the hatch coamings. Here, the hatch coaming stays are detached from the deck, and the hatch coaming is forced inwards. The lower sections of the hatch coaming supports (approx. 300 mm) are renewed and re-welded. This method is, irrespective of the size of the ship, a considerable cost factor.

cutting of the hatch coaming stays

positioning the hatch coaming stays

fitting a new section in-between the stays