AN OVERVIEW OF SEAGOING FORCES AND SEA FASTENING

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Seagoing Forces

"Seagoing Forces" refer to the loads which cargo is subjected to whilst at sea. The magnitude of these loads is dependent on several variables, relating to both the cargo and the vessel. When combined, using a seagoing forces calculation, the maximum transverse, longitudinal, and vertical (uplift) forces can be used to design a suitable sea fastening arrangement.

To ensure that the seagoing forces are correctly calculated, an engineer should establish accurate values for the following parameters:

1. Centre of Gravity (CoG) of the Cargo
2. Mass of the Cargo
3. Stowage location of the Cargo (relative to the vessel centreline, midships, waterline and vessel deck)
4. Support Arrangement (distance between extreme transverse/longitudinal supports to the CoG)
5. Vessel Particulars
6. Environmental Parameters

Once all the above information is collected, engineering calculations should be conducted in line with the steps detailed in the guidance set by the relevant classification society.

The resultant transverse, longitudinal and vertical loads are products of the vessel motion criteria as defined in the appropriate guidance. These values are specific to the vessel parameters and operating conditions.

Sea fastening

There are a variety of methods that may be used to secure a cargo item to the deck of a vessel for sea transit; however, the most common modes are by way of welded blockers, web lashings /chains, or chocking the items into a bulk stow using timber.

The engineer must identify and assess the seagoing forces which the cargo will experience and determine a suitable sea fastening arrangement using the variety of available methods open to them. Although the governing factor is the capacity of the restraints, this is also typically influenced by the physical parameters of the cargo, and stowage position aboard the vessel. To put it simply, whilst the engineer may prefer one securing method over any other, physical limitations may determine that an alternative must in fact be employed.

The engineer should aim to position welded sea fastenings in way of string points on the deck, hatches or hold bulkheads – i.e., web frames, stiffeners etc. This ensures that the area to which the material is welded has sufficient structural capacity to withstand the forces transferred. Should the interface of the weld be with unstiffened plate or over a stiffer with insufficient weld to the deck plating, it is possible that the plate may yield under the applied loading. Welded Blockers

Welded blockers are widely used in the shipping industry to resist transverse and horizontal motions, and are primarily used for larger, heavier pieces of cargo which are landed directly onto a vessel deck and supported by appropriate dunnage or

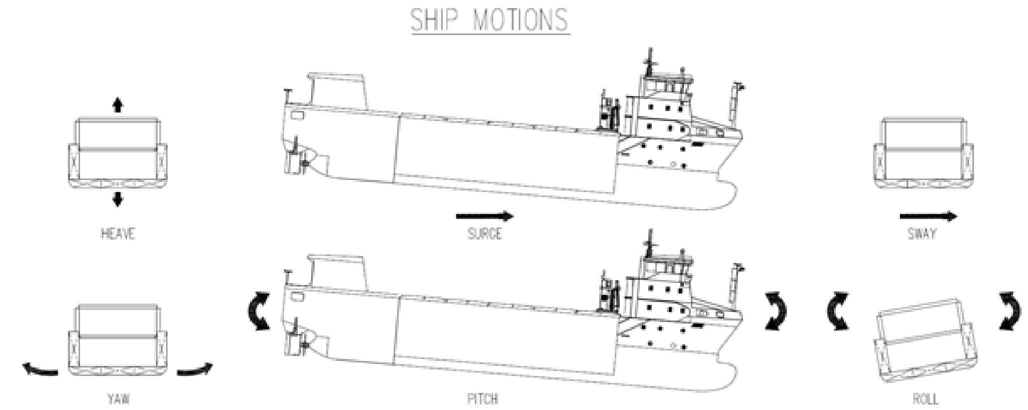

fig. 13/ typical ship motions

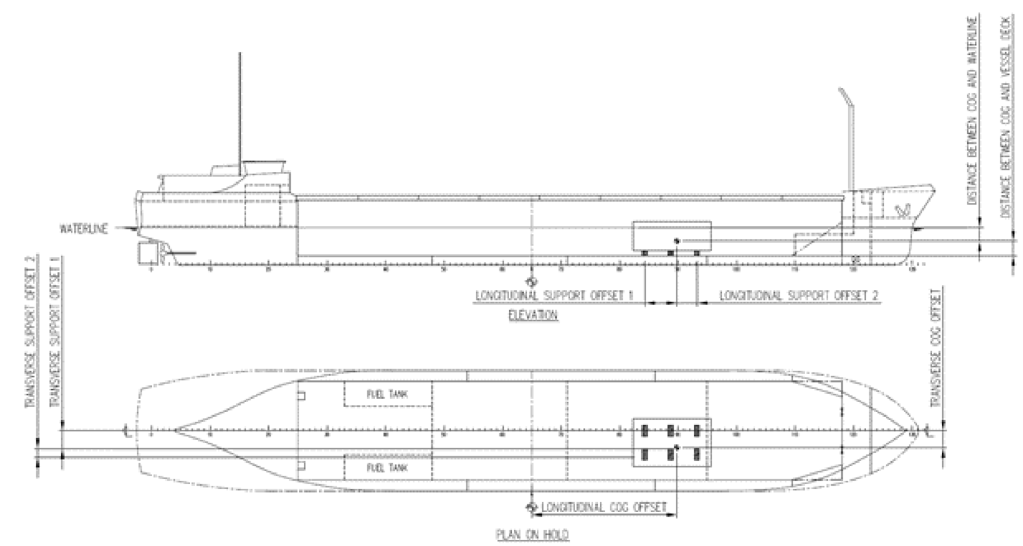

fig. 14/ geometric particulars required for derivation of seagoing forces

Welded Blockers

Welded blockers are widely used in the shipping industry to resist transverse and horizontal motions, and are primarily used for larger, heavier pieces of cargo which are landed directly onto a vessel deck and supported by appropriate dunnage or other load spreading material. They are typically block or "Tee" shaped, designed and positioned in such a way that there is sufficient capacity to withstand the anticipated loading.

The engineer must ensure that there is sufficient height in the blocker to allow for any timber dunnage and that a suitable point of contact is established with the cargo, otherwise, the blocker will simply fix the dunnage and not the mass of the cargo that it is supporting.

In design calculations, the target utilisation for blockers can be brought close to 100% of the safe working stress of the weld, however the utilisation of the welding seams to the deck should be less. It is advisable to ensure that there is some headroom in the utilisation of the materials, as this means that when on-site, if a change of plan is required, there is a level of contingency and the materials may remain suitable for an alternative application. This flexibility protects against any adverse impact of last minute changes on any time sensitive operations.

Welded blockers are relatively simple to install and design, however, the primary drawback is that they provide no restraint for vertical forces.

However, welded blockers can be modified into "welded cleats", whereby incorporating a vertical uplift restraint component. A cleat is a modified blocker which includes a cantilevered section of material at the top of the blocker plate, which is positioned above the cargo (for example, above the flange of a beam on a skid). This cantilever restrains in the vertical direction, while the main body of the blocker will restrain in the horizontal plane.

It is also good practice to ensure that - unless a blocker can be positioned exactly in way of the cargo COG – blockers should be evenly distributed along the direction of restraint to ensure equal loading.

Web Lashings/Chains
Web Lashings and chains operate in the same manner, but typically for differing magnitudes of loading. The cargo must have suitable fixing points, such as lifting pad eyes, beam flange or, structural elements around which the lashing can be wrapped, etc, for this to be a viable method of restraint.

A common drawback of lashings is that as the load path is offset from the centre of effort of the forces, the capacity of the lashing decreases relative to the offset angle. Lashings perform to their rated capacity when in direct tension, however, it is unlikely that this will be the case as offsets must be considered in both horizontal and vertical planes. Therefore, although a lashing angle should be defined in the securing plan, there should be sufficient scope to alter this angle such that in practice, moderate deviations from this angle do not compromise the structural integrity of the lashing arrangement.

The key benefits to using a lashing system are that they are not required to be manufactured to a specific case and are flexible in their positioning. They may also be "doubled" back to increase the SWL (Safe Working Load) capacity by providing two working legs in the direction of the restraint. Another benefit of a lashing system is the ability to provide restraint for out of plane loads. A lashing acting primarily in the transverse direction will have a vertical and longitudinal restraint component – relevant to its angle to both the horizontal and vertical planes.

Timber Chocking
Timber chocking works in a similar fashion to blockers, in that you can restrain in the transverse and longitudinal directions, but not vertically. Whilst blockers are welded to the deck to provided restraint capacity, timber chocking utilises timber sections that are packed tightly between the cargo and hold side, or another cargo item. This securing method is especially useful when cargo is packed extremely tightly in a hold, either due to its size or the stowage plan is particular congested and, if well planned, permits a block stowage securing solution.

Timber must be appropriately sized for the purpose and may require manufacturing, however where standard timber sizes may be used, this can be a relatively cost-effective method of stowing large, box type items. As with welded blocker, this method provides no restraint in uplift, and it is typical that web lashings are passed over the top of the cargo to ensure suitable restraint.

Alternative Sea fastening
Other than the above, another common sea fastening mode is the fixing used for shipping containers – referred to as "dovetails". These fixing points are secured to the vessel deck and allow for a container to be placed directly on top, with the dovetail featuring a locking mechanism which interacts with the container fixing to hold the cargo securely. These fixings can also be used for flat rack containers for OOG cargo:

Other Considerations
There are a multitude of additional factors which must be considered when securing and locating cargo on a vessel. Of these, the ability of the vessel structure to absorb the imposed loading may typically be considered the most crucial. The deck of a vessel hold has strong points along its length and width which are the preferred locations for securing any lashings/blockers and positioning any cargo supports.

Considering the underside of a vessel deck as a series of interlocking frames which are bounded by the the bottom plating of the vessel and the hold floor, as shown in figure 17, it becomes apparent that the intermediate, unsupported plates are weak points and any excessive force applied here could puncture or fracture the deck plate, causing damage to the vessel, or result in in the overall failure of the seafastening arrangement. In some situations, the specified loading capacity of the deck as found in the vessel specification is sufficient justification for the loads imposed by a specific seafastening arrangement, however, in more specific cases, a deck strength check must be performed to determine the structural capacity of the underdeck structure.

fig. 15/ typical welded "Tee" blocker (top) and typical welded "Cleat" blocker (bottom)

90% of the world's goods are transported by sea. With this much movement, and given the adverse weather regularly met offshore, something as simple as tying cargo down when on a vessel is of paramount importance. Without making these considerations and correct execution of the above aspects, vessels risk cargo shift, damage or worse.

fig. 16/ example of combined lashing and timber choking sea fastening arrangement

However, if the right securing method is chosen for a specific spectrum of seagoing forces, your cargo will remain secure and safe throughout its voyage.

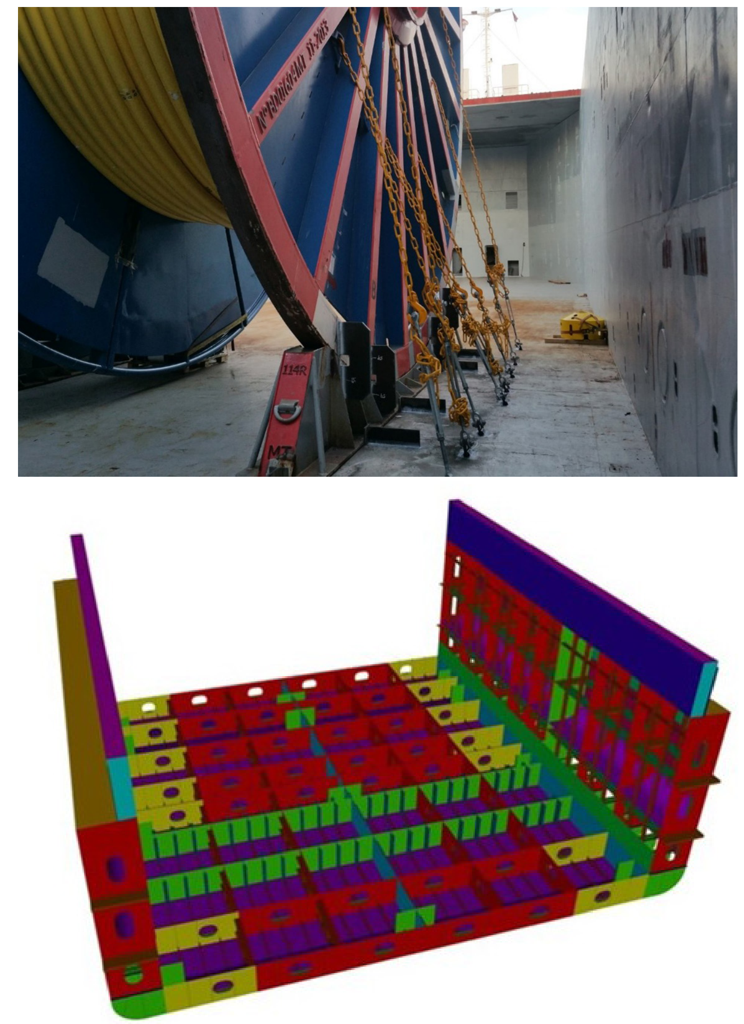

fig. 17/ reel sea fastening (top) and structural model showing arrangement of strong points below a vessel's tank top (bottom)