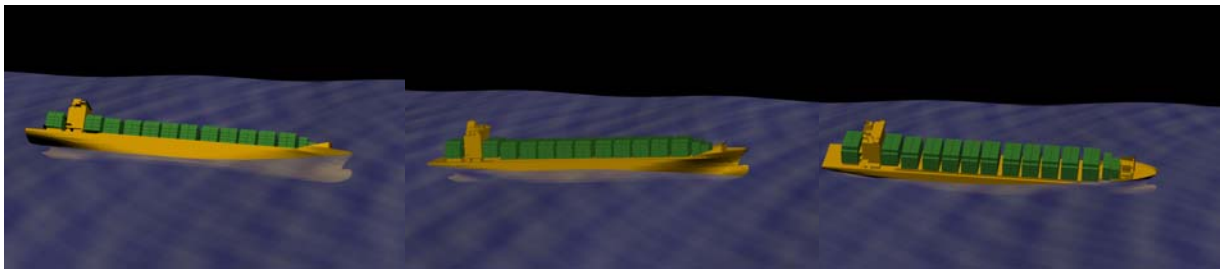
Head-sea parametric rolling of container ships



Computer generated simulation of parametric roll

Parametric roll

The term parametric roll is used to describe the phenomenon of large unstable roll motion suddenly occurring in head or stern seas. Due to its violent nature, the large accelerations associated with the onset of parametric roll cause concern for the safety of container ships. Possible consequences include loss of containers, machinery failure, structural damage, and even capsize.

Parametric roll is a "threshold" phenomenon. This means that a combination of environmental, operational and design parameters needs to occur before it is encountered. These are:

- the ship would be travelling with a small heading angle to the predominant wave direction (head or stern seas)
- wavelength would be comparable to ship length
- wave height would be large
- the ship's roll damping characteristic would be low.

If unfavourable tuning occurs between wave encounter period and natural, or twice natural, roll period of the vessel, then parametric roll motion can be experienced.

Why are container ships vulnerable?

Hull forms with pronounced bow flare, flat transom stern and wall-sided midship section are most vulnerable to parametric roll. Such features contribute to the variation of the ship's stability characteristics due to the constant change of the underwater hull geometry as waves travel past the ship.

Is it new?

Although this phenomenon has been studied in the past it has only come to prominence on container ships relatively recently. Until the 1990s, it was considered critical only for small ships of marginal stability, like fishing vessels.

Lloyd's Register's involvement

Lloyd's Register supports initiatives made to introduce guidance on avoidance of parametric roll. At present the IMO sub-committee on stability and load lines and on fishing vessel safety (IMO SLF) is tasked with addressing this issue.

Does the maritime industry fully understand parametric roll?

While a great deal is understood about parametric roll, it should be remembered that, based on present knowledge, it is not possible to quantify precisely the probability of a vessel experiencing parametric rolling. This is because the factors influencing the phenomenon have been identified in a qualitative manner. Specific encounter thresholds and magnitude of resulting motion in complex head or stern seas are still uncertain.

This is acknowledged by IMO SLF which has stated that the time needed for the development of fully matured performance-based criteria to avoid parametric roll could be at least five years.

Possible long-term solutions

Effective solutions to this problem need to focus on avoiding the likelihood of it occurring. The way to achieve this is generally agreed to be by modifying the ship at the design stage, either by:

- modification to the hull form, or
- improvement of the vessel's roll damping characteristics.

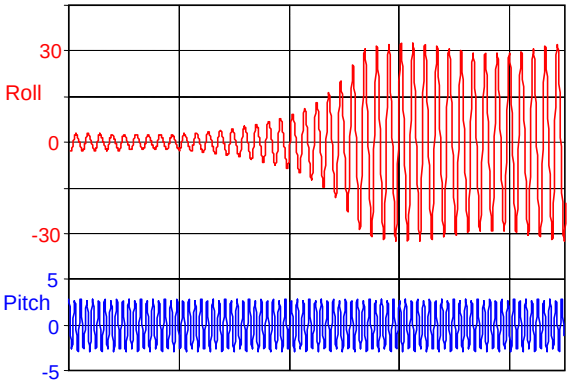
Modifications to the hull-form would be aimed at reducing the effect of large bow flare and flat stern lines, so the vessel has a better volume distribution along its length. This ensures the maintenance of satisfactory stability during the passage of a wave along the ship.

Elements that may contribute to improving the vessel's roll damping characteristics include:

- passive or active anti roll tanks
- fin stabilisers
- large bilge keels.

While these methods of prevention show good promise, choice of a particular option must be based on the individual ship owner's preference. The preferred choice will impact on the vessel's performance in terms of speed, stability and container carrying capacity.

Lloyd's Register



Time simulation of parametric roll

Reducing the consequences

Without a reliable method to reduce the likelihood of parametric roll, owners and designers striving to reduce the consequences of extreme motion encountered during parametric rolling need to address two main aspects:

- container securing system
- machinery systems.

Parametric roll is an extreme condition for container securing since it combines the effect of large roll and pitch amplitudes. This scenario imposes significant loads on container securing systems. While in theory the container securing system could be designed for such extreme motions the result would be a significant reduction in the number of containers that could be carried on deck. So essentially there is a trade off between increased container security and the associated cost.

Such extreme roll angles exceed those usually adopted during machinery design. Indeed, it would be very difficult to bench test a large marine diesel engine at these angles. Possible consequences on machinery operation of the ship heeling to very large angles include loss of cooling water suction, exposure of lubricating oil sumps and, for resiliently mounted engines, problems with connection of services – and hence shut-down of the main engine.

Should we raise the standard for container securing?

In response to concerns voiced in the industry, Lloyd's Register has investigated its container securing requirements. The conclusion is that although the number of containers lost is increasing, the proportion lost, as a percentage of the total containers moved by sea, is still small.

Evidence gathered from a number of sources indicates that compliance with an approved stowage plan based on Lloyd's Register's Container Securing requirements is a significant factor in reducing container damage on ships.

The review also concluded that a formulation could be developed, taking into account some of the factors that contribute to parametric roll. In this way container securing systems on ships more vulnerable to parametric rolling could be designed to a slightly increased standard.

Conclusions

- Parametric roll is a relatively rare phenomenon occurring in head seas which is characterised by rapidly developed large unstable rolling motion.
- Risk control options exist in both design and operation of container ships that can effectively reduce the likelihood of occurrence of parametric roll.
- Reducing the likelihood of its occurrence is considered a more effective approach than mitigating the consequences of parametric roll.
- Compliance with Lloyd's Register current requirements for container securing systems reduces the risk of container losses during parametric roll.
- The way forward is further investigation into the phenomenon so that safe operation is always assured.

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