Ship Stability in Practice

Ross Ballantyne/Stuart Ballantyne, *Sea-Transport Solutions*

ABSTRACT

Designing outside the box but inside the rules – a challenge for any Naval Architect. Modern ship designs are advancing at a faster pace than what the regulators can capture within a code of rules and guidelines.

Ship stability, in particular, is an aspect of naval architecture where a framework of prescriptive rules makes it difficult in practice to achieve an economically and operationally viable solution for unique ship designs.

This paper draws from the experience of an established international marine design firm and brings to attention various issues that are emerging as designs evolve, whilst proposing a way forward for establishing a foundation for practical safe stability assessments in the maritime sector and for future developments on the subject.

1. INTRODUCTION

Ship to Shore. Sea Transport Solutions (STS) CEO, Stuart Ballantyne, fascinated with ship design, left his job at sea as a navigator/deck officer after 7 years and returned to Glasgow to start studying for a career change in Ship Design. It was this foundation of seagoing experience at an early stage where practical, out of the box thinking ship design solutions were established with the Australian Marine Design Firm in 1976. A family based company where employees are a mixture of both Naval Architects and Seafarers, has proven to be a recipe for success with a series of Award Winning designs. This combination of theoretical and practical know-how has provided connections and close working relationships with the maritime regulators for on-going advice and direction for developing and refining the codes of practical ship design. With more and more regulating authorities and their college graduate personnel coming onto the maritime scene, ship stability has always been cause for great debate between designers, operators and authorities. This paper endeavours to briefly highlight the problems, issues, gaps and interactions with ship stability rules in practice.

2. DAMAGE STABILITY LEGISLATION

Queensland, Australia, which is home to over 9,000 commercial vessels and around 260,000 recreational vessels, is a good place to set the scene of the where the maritime industry is globally. For it is here where decisions on ship selection were always bottom line driven. It is also where the STS design firm was established.

The Queensland Maritime regulators at the time were restructuring the Australian Domestic Code into a “Uniform Shipping Laws Code”, which was strongly influenced by unions and the GRT and NRT based code was changed to a length basis, but not fairly. Stability rules were also tightened and this meant that operators of a 36 metre charter vessel had to have extra crew for fewer passengers. The operators came looking for a solution to reduce the crew back to original manning size and increase the passenger numbers, but there was to only be one immediate answer: a catamaran.

Catamarans in those days had a poor reputation for sea handling, so it was in the tank test facilities in Strathclyde where a series of tests with symmetric and partial asymmetric catamaran hulls with bulbous bows was carried out.

Figure 1 - Shangri La 20m Catamaran, hull centrelines toe out, asymmetric hulls with bulbs. Strathclyde Ph D. Student Apostolis Tsanticos standing in photo.

As ex seafarers, the company established a series of minimum tunnel clearances forward and amidships to avoid slamming loads. 20 years later these became compulsory in class rules.

STS also worked with Lloyds Register (LR) as the guinea pig in the establishment of the Special Service Craft (SSC) rules which had been purchased from the Russians. These very sensible rules were first principles based, instead of the old empirical rules, which allowed room to minimise the weight with high tensile steel hulls and aluminium superstructured catamarans and sensibly attack the subdivision requirement rules.

Like most coastal regions, Australia is home to a number of Landing Craft designs which consistently capsize with loss of lives and cargoes as per the below table. A combination of a shallow deck immersion (typically 4-5 degrees in a stern trim configuration) and a bit of movement of deck cargo, a vessel is upside down within 3 to 5 seconds.

Australia			
•“M.V. Keppel Trader”	16m	1996	Capsized on voyage from Darwin – 1 killed
•“M.V.Tasma”	35m	1991	Capsized on voyage from Cairns to Karumba - no-one killed
•‘M.V. Thuppen	20m	1988	Capsized circa Townsville-Magnetic Island 1 killed,
•‘M.V.Piera’	50m	1992	Ex qld en route to Lihir PNG circa, capsized, Master and Engineer killed, vessel lost
•“M.V.Shellbourne Bay”	20m	1994	Capsized in Thursday Island Harbour (twice !!) Smooth waters, rudder heeling moment causing deck-edge immersion. No-one killed. Trucks on board
•“M.V.Narapi”	25m	1992	Capsized in Horne island – cargo shifted- no subdivision, then sank -not located
•“M.V. Major Dundee”	30m	1993	Truck fell of legs and moved transversly during voyage in partially smooth waters, vessel then had deck edge immersion and promptly capsized, Airlie beach, no-one killed.
•“ M.V. Hinchinbrook Island”	16m	2000	Capsized near Cardwell, Queensland. Partially smooth waters – 1 killed. Manslaughter charges now against owner and surveyor.
PNG			
•“M.V. Sir Garrick”	32m	1982	Capsized Kerema Gulf- master killed
•“M.V. Pakori”	25m	1993	Sank at Kikori through stern flooding - no one killed
Solomon Islands			
•“M.V.Vula”	30m	1987	Capsized killing 20 passengers. The Government then introduced a ban prohibiting landing craft to carry passengers.
•“M.V. Bulamakow	40m	1991	Capsized on a cargo run, crew killed.
Fiji			
M.V. Adi Ywaitui	40m	2006	Capsized killing 1 crew member

Table 1 - Capsized Landing Craft

STS addressed this lack of stability with side buoyancy, whilst at the same time also addressing the Landing Craft’s poor performance in head seas by designing a ship shape high bow, ultimately leading to the development and patent of the “Stern Landing Vessel” (SLV). The SLV, in other words, is a back to front landing craft which there are now 24 in operation and several currently under construction.

Figure 2 - SLV on the beach

Part of the hull design also incorporated a 'V hull' shape which birthed the first "no ballast" bulk carrier the "*MV Deepwater*" in 1990.

Figure 3 – SLV "MV Deepwater"

The company clashed heavily with the Australian Maritime Safety Authority (AMSA) regulators who said these well-deck novel designs were not compliant with the definition of "*Freeboard Deck*" -the uppermost continuous deck. AMSA were insisting on freeing ports from the well deck which is impossible with toxic cargoes such as lead zinc, or any other cargo for that instance. The design of these small bulk carriers was so to withstand total swamping in any loaded condition, however this common sense was only accepted after lengthy discussions and model test experiments. A well deck configuration is far more robust in a heavy seaway.

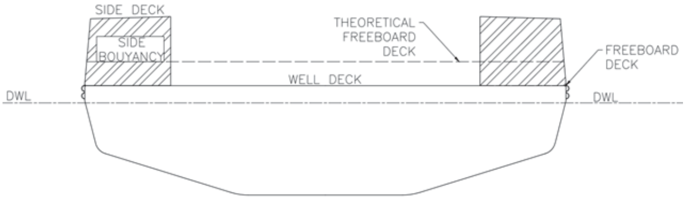

Figure 4 - Well Deck, Flat Deck and 'effective' deck level

3. RESILIENCE

In the case of the small 5300dwt self-discharging bulk carrier, *MV Wunma*, with a well deck configuration, she was abandoned fully loaded in a cyclone in the Gulf of Carpentaria in November 2007. This is the ultimate test for any ship and generally bulk carriers would be overwhelmed in such a situation.

Despite some very bad press at the time, the vessel survived intact, with no loss of life or injuries or pollution and, under her own power, entered the port of Weipa 3 days later. The Australian Government, spent AU$6m on a marine court of enquiry. With no injuries, pollution or damages, this was an enquiry into being nearly pregnant! As a result of this incident and the press coverage of an unsinkable ship, STS secured a contract for a 14,000dwt SLV from the Middle East.

Figure 5 - MV Wunma, with a well deck configuration

4. FORWARD THINKING

The fact that 99% of all clients are after a vessel which makes a profit, ship designers often have to think outside the box. In the case of a client who was after an SLV with a 10 vehicle 65 tonne deck load within a very limited space of time, a second-hand 30 metre length, narrow-beamed, 15 knot small patrol boat with a 3 tonne deck load was purchased and converted.

Figure 6 - LARA V, before *alteration*.

Without touching the vessel's engineering or electrical system, gull wings either side of the vessel were fabricated and attached. With buoyancy of the added shape equal to the weight added including a 5 metre SLV stern section, the vessel ended up carrying the required 65 tonnes as well as gaining another knot in speed.

Figure 7 - LARA V, after alteration.

The *Lara V* alteration of course caused concern with the regulators at the time who insisted this could not be done. The vessel however was compliant in all aspects of ship design but not all stability criteria at the time, with one example, the requirement to have the GZ_{max} occur after 20° heeling angle. With this new trimaran hull configuration, this obsolete rule could not be met. The regulators could not see the 'intent' of the rules and although the stability criteria on face value had not passed 100%, the vessel's significant increase in stability safety was surprisingly not an easy argument, but ultimately an argument that was won. Basically it was taking the exceptionally low GM and raising it considerably with the aid of a trimaran shape that was really the core solution. The commercial risk was taken by our design office and had a happy ending technically, operationally and commercially.

5. GRT ISSUES

When addressing the problems of the South Pacific nations, numerous capsizes were occurring predominantly with vessels that were under 500GRT. It was conclusive that the bottom dollar ship selection of vessels below 500GRT was to escape from an "IMO convention vessel benchmark", at which point the extra expense it incurs. The unfortunate part of this is that the resultant sub 500GRT vessels are only 40-45m in waterline length and the predominant trade winds generate a wave height and frequency only suitable for a minimum 60m L_{WL} vessel, instead these small waterline vessels fall into the troughs of the oncoming waves. Survivors of these tragedies such as the, Rabaul Queen, reported that "three large waves overcame the vessel" prior to capsize. The local regulators then finger-pointed to passenger overloading, where in fact the water on deck captured within the bulwarks is believed to be the major offending contribution to the capsize and loss of 142 lives. Marine operators have continued to push for the 500GRT benchmark to be replaced with 60m L_{WL} without success.

The Dutch Naval Architect, Ernst Vossnack, also concluded that the pursuit of a lower GRT by eliminating forecastle and aftercastle buoyancy was the primary reason for the capsize of small Mediterranean 999GRT and 1499grt vessels in heavy weather, where their dynamic stability reserves were overwhelmed by the harsh reality of big waves.

This issue of GRT should be seriously addressed with the IMO to avoid further loss of life with naval architects creating ships that are fundamentally unseaworthy. It appears IMO are no longer interested in Safety of Life at Sea and have for the last decade, in this author's opinion, had a myopic view on environmental issues and very little or no interest in the ongoing capsizes of landing craft and the demise of sub paragraph GRT vessels.

6. ASSESSING UNCONVENTIONAL SHIPS

Addressing the major problems of worldwide transhipping (restrictions of a 2m wave height and 20 knot wind speeds and transportable moisture limits (TML)), the Floating Harbour Transhipper (FHT) was developed. This innovation incorporates exports of bulk commodities from remote small shallow draft harbours with shallow draft SLV's to an FHT which has a wet dock to offload these small feeder barges.

Two interlinked vessels, one loading, one discharging creates its own problems, but stability in the end was not one of them. The 'ship within a ship' concept was beyond standard ship stability criteria, so a series of model test basin experiments were required to evaluate safety of the vessels at sea, which for now, have satisfied the local marine regulators.

Model test facilities are a great tool for assessing ship safety and stability, but unfortunately access to these resources are not always available in a timely manner or at bargain prices. Computational fluid dynamics (CFD) software is becoming more powerful, so perhaps one day the regulatory bodies may embrace the results of these tools with greater confidence, thereby allowing for a greater quantity of unique vessel designs to be designed, assessed and built.

Figure 8 - Floating Harbour Transhipper (FHT)

7. CONCLUDING REMARKS

So how does a Design Office focus on out-of-the-box practical solutions deal with stability regulations during the design phase: problems, issues, gaps, interactions, recommendations?

As a ship design company that have expanded into owning and operating ports and vessels, we prefer to find experienced ex mariners with current seagoing qualifications in amongst the regulators. This is getting more difficult and with this difficulty comes frustration, as the pure academic regulator will hide not only in the prescriptiveness of the regulations as opposed to the intent, but sometimes his or her own misguided interpretation of the regulations.

We would encourage the regulators to employ seafarers who do not only have deepsea experience, but rather more importantly have sea time on smaller, modern coastal vessels.

Innovation has a long way to go with commercial vessels and there is a strong future for the industry if we do not constrain the thinking.

Ross Ballantyne/ Stuart Ballantyne