Stability Upgrade of a Typical Philippine Ferry

Dracos Vassalos, Sokratis Stoumpos, Evangelos Boulougouris

Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, Glasgow G4 0LZ, Scotland

ABSTRACT

The waterborne transport in the Philippines has been a sensitive subject amplified by the lack of rules and regulations to restrict ship-owners profit-driven decisions, leading to overloading, with significant impact on ship stability. Most of the Tier-II vessels are using solid ballast to balance trim and increase static stability at the expense of freeboard. To improve matters whilst facilitating the currently adopted process, solutions are required that offer additional buoyancy with increased stability. To this end, a solution is proposed here through the addition of sponsons, providing the required level of intact stability and residual floatability/stability, using a typical Ro-Pax. In this paper, a case study is presented to demonstrate the validity of the proposed solution.

Keywords: *damage stability, freeboard, load line, conversion, sponsons*

1. INTRODUCTION

In the Philippines, it has become common practice to overload passenger ferries with additional people carried, leading to a significantly low freeboard, below the ICLL'66 levels. This increases the risk for the people on-board. In order to keep in operation the vessels concerned without compromising safety severely, an immediate solution is required. One of the obvious solutions identified is the addition of buoyancy by increasing the volume of the hull with sponsons. There are three categories of ships used in the region, namely: old vessels about to be withdrawn from service; the second-hand IMO Tier-II compliant ships (with solid ballast); and the new-built IMO Tier-III compliant vessels (IMO, 2015). This paper focuses on the second category and a case study of the stability upgrade process, using an existing Ro-Pax as a basis, which has already undergone modifications involving the addition of partial decks and other items, aiming at increasing her payload. The extent of modification required to restore vessel floatability and residual stability to satisfactory levels is indicative of the level of risk of these vessels and of the need to take action.

2. CURRENT SITUATION

There are currently approximately 7,000 islands in the Philippines. They are served by ferries providing vital links for trade, communities and tourism. Nearly a billion ferry passenger journeys were conducted in 2013 in South East Asia, according to INTERFERRY. The reason for the concern being raised about domestic ferries is the thousands of lives lost at sea on a yearly basis because of the level of risk inherent in these vessels and the ignorance of people on how unsafe they really are. An overview of the situation is given by the Worldwide Ferry Safety Association reported over the last 14 years, 163 accidents leading to 17,000 fatalities (from which 50% occurred in China, Philippines, Indonesia and Bangladesh) were recorded. This contradicts with IMO's aim to continuously improve the safety of ships and reduce to acceptable levels the risk to people on board. The latter is the main reason why the regulations in this area must come in line with the rest of the international shipping (Adamson, 2015).

2.1 Operational Issues

The major issues of the IMO Tier-II compliant vessels used in this area derives from the wish of ship-owners to increase the capacity of their vessels without considering the limiting criteria set at the design stage. The conversion commences as soon as the vessels are bought in order to increase the passenger carrying capacity with the addition of decks. This results to a change of the longitudinal and vertical distribution of weights and therefore solid ballast (concrete in most cases) is added to adjust the trim and improve the upright static stability. This results in an additional increase of the draught, leading to an increased displacement and resistance but most importantly to a significantly reduced freeboard, impacting the reserved buoyancy and the damage stability of the vessel. The extent of this problem is of such magnitude that demands drastic measures and one such measure is proposed here, as described next.

3. CONCEPT DESCRIPTION

The additional structural parts that are considered for the enhancement of buoyancy and stability are sponsons located at each side of the vessel with a ducktail formation at the aft end. Both modifications will affect buoyancy as well as hydrodynamic properties, which with proper consideration could lead to an increase of the propulsive efficiency and, potentially, to a reduction of fuel consumption or to an increase of service speed. The geometry of these appendages is illustrated in figures 1 and 2. Such a solution will allow the removal of the solid ballast. The resulting hull form has sufficient stability as indicated in the following.

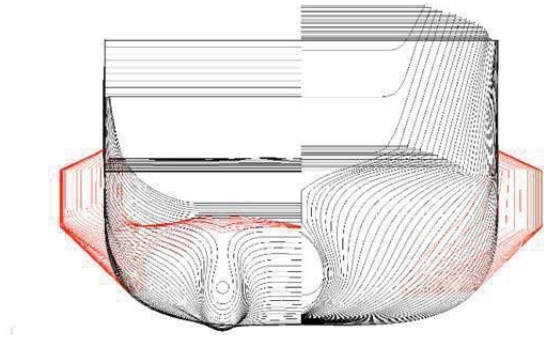


Figure 1 Sponsons with ducktail fitted on the existing hull.

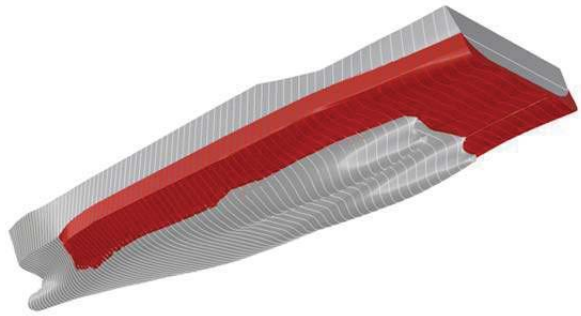


Figure 2 Body plan view of upgraded vessel.

4. REGULATORY FRAMEWORK

4.1 Intact stability

For the present case study the regulations of IMO IS Code 2008 concerning the intact stability of passenger ferry ships (IMO, 2008) is used. Full load departure condition is used.

4.2 Damage stability

Regarding damage stability, an investigation is carried out to assess whether the design will comply with the stability requirements of Regulation 8, Chapter II-1 of SOLAS 1974, SOLAS 88 Amended / II-1 / Reg. 8, for Ships Constructed from 29-4-1990 to 1-10-1994 (IMO, 1988).

The damage case particulars (size) are determined in accordance with the extent of damage in SOLAS 1974. Thus, the worst case 1-compartment damage scenario is considered, involving the engine room and the RoRo deck flooded in full-loaded departure.

5. CASE STUDY

For the calculations performed, a second-hand Ro-Pax ship operating in the Philippines that complies with IMO Tier-II was selected as sample for the comparison before/after the upgrade proposed in this paper.

5.1 Existing ship

This vessel has undergone a number of modifications, as described next:

1) Reinforcements to the freeboard deck to accommodate the new stowage layout and installation/relocation of new fixed cargo securing device;

2) Re-plating of the opening of the upper deck (mid-portion in way of ramp) to accommodate additional passengers. Installation of additional side structures P/S. Installation of additional comfort rooms between frames 15-25 P/S. Cropping out dining tables (inside and outside) and replacement with double bed bunks. Cropping out of seats between frames 90-100 and replacement with double bed bunks;

3) “A Deck” was extended from frame 30 going aft and relocation of inflatable life raft. The conversion of the open space in passenger area was made by installing double bed bunks as well as addition of new cabins on both sides of the vessel. Passenger walkways were created from frame 10-60 P/S along with a passenger ramp (aft) P/S.

4) The navigation bridge deck was extended aftwards from frame 72 to frame 30 and tables and chairs were installed as well as re-installation of lifeboat and davits.

5) Solid ballast was added in the double bottom at the fore end (in Void No. 3 & Void No. 4 to reduce the trim to acceptable levels and reduce the vertical centre of gravity.

5.2 Upgraded ship

The proposed upgrades according to the present proposal are as follows:

1) Removal of the solid ballast from the double bottom.

2) Installation of sponsons. Both the added buoyancy and their structural weight were taken into account

3) Extension of the sponsons to the aft end in order to form a ducktail, helping the adjustment of the trim, the increase of buoyancy and stability.

5.3 Ship particulars

The main vessel’s particulars before and after the proposed changes are illustrated in table 1 below:

Table 1
Ship’s particulars

	Existing Ship	Upgraded Ship
Length (O.A.)	86.90 m	86.90 m
Length (P.P.)	74.00 m	74.00 m
Breadth (mld)	14.00 m	17.18 m
Depth (mld)	10.20/5.50 m	10.20/5.50 m
Draught (designed)	4.35 m	4.02 m
Main engine	3,500 x 2 PS	3,500 x 2 PS

	Existing Ship	Upgraded Ship
Speed (trial max)	15 knots (average)	>15 knots (average)
Passenger Capacity	516 P	516 P
Crew	53 P	53 P
Container Capacity	30 units – 10 ft. van	30 units – 10 ft. van

As seen in table 1, the increase of breadth resulted in draught reduction. The number of passengers is the same for both cases, which is an attractive feature for the ship-owner.

5.4 Lightship calculations of the upgraded ship

The authors examined a number of different sponson sizes before deciding on the configuration presented here. The lightship weight is acquired from the existing stability booklet and the data from the inclined experiment performed following the initial conversion of the sample vessel.

Table 2
Lightship calculations

	Mass (t)	LCG (m)	LCG MOM (tm)	VCG (m)	VCG MOM (tm)
Lightship	1805.72	-5.89	-10632.1	7.16	12936.2
Permanent Ballast Void No.3	-53.00	19.37	-1026.61	2.08	-110.24
Permanent Ballast Void No.4	-38.31	14.98	-573.88	0.74	-28.35
Sponsons	76	-12.72	-966.72	3.67	278.92
Total	1881.72	-6.164	-11599	7.023	13215

5.5 Stability analysis

The initial ship hullform was modelled in Maxsurf© (Bentley, 2014) and the resulting hydrostatics properties were compared with the original, showing only minor differences. Following this, the geometry of the sponsons was attended to and the resulting hull form was analysed.

The results indicate that the intact stability of the vessel following the installation of sponsons is improved. However, due to the removal of the permanent ballast from the forward part of the vessel, the trim increases. On the other hand, the damage stability of the vessel is significantly improved with the volume acquired from the sponsons contributing to the buoyancy, especially at the aft end. The increased waterplane area leads to an increase of the metacentric height, resulting to compliance with all the required stability regulations. The data for intact and damage stability at the full load condition are shown in table 3.

Table 3
Intact full load condition calculations

	Existing Ship	Upgraded Ship
Draught amidships, m	4.348	4.021
Displacement, t	2739	2723
Volume (displaced) m^3	2671.87	2656.95
Trim (+ve by stern), m	0.434	0.592
LCB from amidsh.(+ve aft), m	3.492	4.462
LCF from amidsh.(+ve aft), m	7.282	8.468
KG fluid m	6.207	6.293
GMt corrected m	0.939	4.372
Immersion (TPc) tonne/cm	9.060	10.769

As seen in table 3, the displacement for the upgraded ship is reduced as the weight of the sponsons is smaller than the weight of the solid ballast removed. The trim shows a minor increase but the draught amidships reduces. Noticeable changes are the increase of the TPC and the shift of LCF and LCB towards the aft end. There is, obviously, a marked improvement in GM.

In table 4 below the respective results are presented for damage of the engine room at full load condition according to Regulation 8, Chapter II-1 of SOLAS 1974, SOLAS 88 Amended / II-1 / Reg. 8, for Ships Constructed from 29-4-1990 to 1-10-1994 (IMO, 1988):

Table 4
Damage full load calculations

	Existing Ship	Upgraded Ship
Draught Amidships, m	5.264	4.712
Displacement, t	2739	2723
Volume (displaced), m^3	2671.888	2656.948
Trim (+ve by stern), m	0.688	0.627
LCB from amidsh.(+ve aft), m	3.501	4.463
LCF from amidsh.(+ve aft), m	5.852	7.752
KG fluid, m	6.207	6.293
GMt corrected, m	0.768	3.662
Immersion (TPc), tonne/cm	7.533	8.870

In the intact stability calculations performed, both designs comply with the regulations. However, the damage stability of the existing vessel fails to comply with the SOLAS requirements. The results from the upgraded vessel are promising seen on table 5 below albeit an extensive modification. A major impact on the margin line and deck line can be observed.

Table 5
Damage freeboard

Key points	Existing ship	Upgraded ship
	Freeboard, m	Freeboard, m
Margin Line (freeboard pos = -24.03 m)	0.013	0.584
Deck Edge (freeboard pos = -24.03 m)	0.089	0.66
DF point Vent. Head 1	5.698	6.235
DF point Vent. Head 2	5.698	6.235

Table 5 presents a comparison of the damage stability results for both vessels. It is clear that the upgraded vessel meets the criteria whilst the existing fails to comply with. This is also apparent comparing figures 3 and 4.

Figure 3: GZ curve existing ship

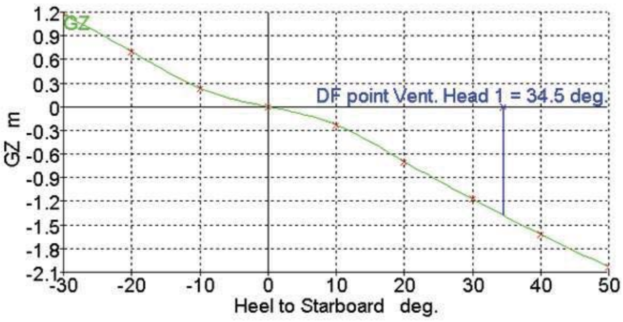
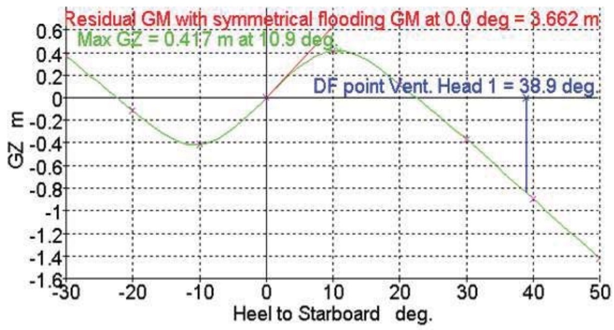


Figure 4: GZ curve upgraded ship



The results demonstrate that the existing ship loses stability in the scenario considered, which involves one-compartment damage. In a real scenario the existing ship will capsize almost instantly following one-compartment damage.

In contrast to the existing ship, the upgraded vessel has a range of positive stability of about 20 degrees. This meets the minimum requirements of damage stability set by SOLAS, namely angle at equilibrium post damage area under the GZ curve as well as residual GM as seen in Tables 5, 6 and 7.

Table 6
Residual freeboard criteria

Criteria	Value	Units	Actual	Status
Heel angle at equilibrium for unsymmetrical flooding - Equil based	7.0	deg	0.0	Pass
Margin line immersion - Equil based	0.000	m	0.584	Pass

Table 7
Damage stability criteria

Criteria	Value	Units	Actual	Status
Range of residual positive stability	15.0	deg	22.4	Pass
Area under residual GZ curve	0.8594	m.deg	5.7613	Pass
Maximum residual GZ (method 2 - manual calc.)	0.100	m	0.417	Pass
Maximum GZ (intermediate stages)	0.050	m	0.417	Pass
Range of positive stability (intermediate stages)	7.0	deg	22.4	Pass
Residual GM with symmetrical flooding	0.050	m	3.662	Pass

6. CONCLUDING REMARKS

From the results presented in this paper the following conclusions may be drawn:

The condition of the existing fleet as represented by the sample ship examined herein is unacceptable, as the vessel has no stability in case of damage. The present study shows that a medium cost conversion could provide a basic level of safety. Similar solutions have been used in Europe to upgrade existing ships in the late 80s and 90s.

Regarding the intact stability of the existing ship, it is clear that the conversion process leading to increased capacity focuses on satisfying stability and freeboard requirements for intact ships and as such it meets pertinent requirements. This is encouraging, as the process adopted, meets the requirements laid down by the Philippine Administration.

For the damage stability, equally interesting and worth noting is that freeboard requirements are also satisfied for the converted ship, even though the Philippines Merchant Marine Rules and Regulations (PMMRR) are not explicit enough when it comes to damaged ships. However, the ship has no damage stability whatsoever and this is the heart of the whole problem.

On the contrary, for the upgraded ship following the addition of sponsons the vessel intact stability has been further enhanced, meeting the requisite criteria with considerable margin.

Regarding damage stability, the addition of sponsons and ducktail bring the required effect on damage stability, perhaps with some further adjustment on the trim still required, which will be easily achieved with a more in-depth study following due optimization process. The size of the sponsons is indicative of the degree of non-compliance and the perilous situation resulting from the conversion process of the RoRo tonnage imported in Philippines and then converted to increase carrying capacity.

The key problem leading to this situation is lack of damage stability regulations in PMMRR, which should be attended to with immediate effect to apply to all existing and any newly imported or constructed ships.

Sponsons are not a panacea. They provide the additional buoyancy required for the sought out increase in payload whilst providing the platform to meet damage stability requirements as apply in international regulations. Should this solution proved to be infeasible due to financial or other reasons there are alternative solutions that could be considered. However, leaving the current fleet in the situation that it currently is, is not an option that should be accommodated any longer.

7. REFERENCES

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8. APPENDIX I

NOMENCLATURE

Units	The metric system is used
Shell plating	The shell plate thickness used in the calculations
Keel	The thickness of the keel plate
Draught	The draught T used in the calculations is measured from the baseline at Lpp/2.
Base Line	The base line of the ship is the upper side of the keel plate
DISP	Tabulated displacements are measured on the outside of the shell plating
AP	Aft Perpendicular
FP	Forward Perpendicular
Lpp	Length between perpendiculars
KMT	Transverse metacentric height at zero angle of heel measured from the baseline
LCB	Longitudinal position of centre of buoyancy measured from midship
LCF	Longitudinal position of centre of floatation measured from midship
TPC	Tonnes Per Centimetre. i.e., weight which when added or subtracted will change the draught by one centimetre.
MCT	Longitudinal moment required to change trim by one centimetre
T	Draught amidships, measured from the upper side of the keel plate at Lpp/2.
T_{aft}	Moulded draught measured at AP
T_{fwd}	Moulded draught measured at FP
TRIM	TRIM aft is positive when t_{aft} is larger than t_{fwd} i.e. the ship has an aft trim; TRIM is negative when t_{fwd} is larger than t_{aft} i.e. the ship has a forward trim.