Life-Cycle Stability Management for Passenger Ships

Dracos Vassalos, Donald Paterson, Evangelos Boulougouris and Francesco Mauro
Maritime Safety Research Centre, University of Strathclyde
Glasgow, UK

ABSTRACT

Stability has been a primary focus of the maritime industry and of immense interest to the IMO from the outset. Despite several attempts to resolve stability-related issues, the problem of stability remains one that has yet to be resolved. Reasons for this, range from the complexity of the problem itself to misconceptions in its very nature, particularly concerning compromised conditions of the ship in question. More specifically, whilst stability of ships is an extremely interesting scientific problem and a determining factor in ship design, the impact on the operation of passenger ships, a matter of crucial importance from the dual point of view of safety and economics, has hardly ever received the attention it deserves. Currently, intact stability and damage stability share the same stage from a regulatory perspective and, consequently, they have equal impact on design and operation-related decisions, an example of which is the use of combined intact and damage stability GM limit curves (e.g. IACS Rec 110 Rev1). However, in line with goal-based regulations and standards, design and operational decisions should be risk-informed in which case, matters relating to damage stability are of higher concern, simply by virtue of the fact that damage stability is by far the greater risk contributor. In fact, for passenger ships (>500GT), the level of risk associated with intact stability is indiscernible in contrast to that of damage stability. More importantly, in the operational loading conditions of such vessels, damage stability is a more dominant constraint. Hence, such ships are designed based on damage stability considerations alone. However, since life-cycle risk management is still an active research subject, stability management is being addressed somewhat haphazardly by allowing for design GM margins, drawing from experience on the average deterioration of GM over the life-cycle of passenger ships. This is typically 1% to 2% per year on average, which leaves roughly 50% of ships on the wrong side of this averaging process and this, in turn, limits operation substantially with severe economic impact. This paper delves in this direction by drawing on current ship design and operational practice and presents an innovation with application to a large cruise ship to demonstrate how life-cycle damage stability management could be tackled in a structured and cost-effective manner.

KEYWORDS: Damage stability, Passenger ships, Very large cruise vessels, Life Cycle Management, AREST technology.

INTRODUCTION

In current practice, intact and damage stability considerations and ensuing requirements are expressed in the form of limiting GM curves for intact and damage stability, both presented without any due consideration of the risk associated with each condition. This leads to the same emphasis being placed for intact and damage stability requirements and this, in turn, may lead to sub-optimal designs. More specifically, for passenger ships, the risk due to damage stability is orders of magnitude higher than that pertaining to intact stability, Vassalos, et al (2019) and this information is not being reflected through the limiting curves, thus not being properly accounted for in the design process and during operation. Damage stability is assessed for thousands of damage cases and potential scenarios, in three loading conditions which define the vessel draft range (dl, dp, ds) and using the Attained Subdivision Index as a means of statutory compliance. On this basis, the Limiting GM curves are derived following compliance of each draft with the inequality \( A \geq 0.9R \) for passenger ships. This way, risk (for example, Potential Loss of Life – PLL) is calculable and reflects all requisite knowledge. For intact stability, on the other hand, to date, the limiting curve is derived following compliance with the severe wind and rolling criterion for different KGs, indicating the ability of a vessel to withstand the combined effects of beam wind and rolling in a scenario that bears little or no relation to reality and physics. Second generation intact stability criteria address more realistically intact-stability related concerns, including potential problems but risk estimation remains characteristically absent. This being the case, the ensuing results lack risk content and information. Therefore, from a risk-based perspective, any deduction on risk pertaining to intact and damage stability and comparison between the two, could be misleading. In the face of this, ships may be sub-optimally designed. On the other hand, the limiting GM curve linked to intact stability provides implicit information on the payload as a function of draft and KG. This, in turn, allows designers at the early stages of design to make decisions concerning global ship parameters and loading conditions. Accounting for this, it will be of