Fire safety and FRP composite structures in maritime applications

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Fiber reinforced polymer (FRP) composite consists of a polymer matrix reinforced with e.g. glass or carbon fibers. This forms laminates which can be used together with core material to make up lightweight FRP composite structures, e.g. sandwich panels and stiffeners. Load-bearing structures on large ships are traditionally made of steel but there is great potential in using lightweight FRP for a range of applications, from a single bulkhead or deckhouse to large superstructures, or a whole composite ship. Different construction applications of FRP composite for merchant ships were investigated in the research project LASS, Lightweight construction Applications at Sea [1, 2], which showed that a reduction in structural weight of up to 60 % is achievable. Steel may still be the most cost-efficient material in the construction phase, but life cycle cost assessments showed that use of FRP composite can pay back in short time of operation [1]. Lower fuel consumption per ton-km payload also gives a reduced environmental impact [3]. Furthermore, use of lightweight structures is sometimes the only viable solution to ship stability problems.

In contrast to conventional steel structures on ships, FRP composite sandwich structures are combustible, which causes a fire safety challenge, illustrated in Figure 1. The United Nations agency IMO (International Maritime Organization) provides regulations for ships on international voyages in the Convention SOLAS (Safety of Life at Sea). The prescriptive fire safety regulations in SOLAS do not allow use of combustible materials in structural parts of a ship. However, a reformation of the fire safety chapter in 2002 opened up for alternative solutions and performance-based design of fire safety. Alternative design solutions were now to be accepted if they can be shown to provide a degree of safety that is not less than that achieved by compliance with the prescriptive requirements, i.e. an equivalence principle.

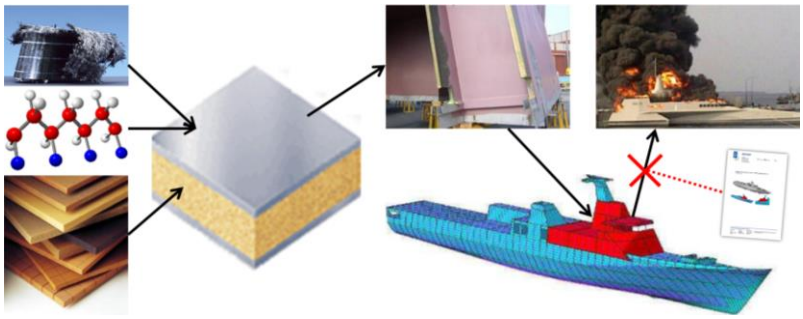

Fig1. A fire safety evaluation is necessary when introducing fiber reinforced polymer composite to ship structures.

The regulation for alternative design and arrangements of fire safety in SOLAS has been the starting point for RISE's involvement in a dozen fire safety evaluations of different FRP composite construction applications (research and commercial), some of which have been published [4,5,6]. From the assessments, five key areas can be identified which are necessary to address when using FRP composite structures: fire growth potential, generation of toxic smoke, fire containment, fire fighting, and structural integrity. Connected to these areas, there are performance requirements in SOLAS and different safety measures proposed to manage the introduced hazards, for example thermal insulation. The experience gathered from the many assessments, together with large interest from industry, has resulted in development of IMO fire safety guidelines for use of FRP composite structures, pending final approval in June 2017.

1. Hertzberg, T. (Ed.). (2009). LASS, Lightweight Construction Applications at Sea. Borås: SP/RISE.
2. Evegren, F., et al. (Eds.). (2011). LASS-C; Lightweight construction of a cruise vessel. Borås: SP/RISE.
3. Hedlund-Åström, A. (2011). LCA and LCC. In F. Evegren, et al. (Eds.), LASS-C; Lightweight construction of a cruise vessel. Borås: SP Technical Research Institute of Sweden.
4. Evegren, F. (2013a). Engineering analysis report – Norwegian Future. Borås: SP/RISE.
5. Hugosson, J. (2011). Preliminary qualitative analysis for alternative design; light weight emergency generator structure on RO-RO ship. Borås: SP/RISE.
6. Evegren, F. (2013b). Engineering analysis report – Eco-Island ferry. Borås: SP/RISE.

Presentation Method (Invited Oral 25 minutes):