LÄSS offers more benefits for passenger ship designers

A Swedish-backed project is making tangible progress towards the development of composite materials for use in passenger ship superstructures

The benefits of technology resulting from LÄSS have been evaluated in a study based on the ropax ferry Stena Hollandica

It is well documented that reducing the superstructure weight of displacement ships can result in major improvements to operational efficiency. Increased cargo/passenger loadings, higher speeds, reduced fuel costs, better stability and a lower environmental impact are just some of the many potential benefits.

However, until relatively recently the prescriptive nature of the Solas regulations made it very difficult, if not impossible, to use lightweight materials such as composites for ferries and cruise ships. Things somewhat changed in 2002 when the Solas II-2, Regulation 17 (part F) was adopted. This allowed a functionally based safety design to be used, providing that the same level of safety could be demonstrated, as would be the case if the prescriptive rules had been used.

One of the most significant initiatives towards assessing the benefits of composite materials in the passenger ship sector is the Swedish-based LÄSS project (Lightweight Construction Applications at Sea), which has made a number of significant steps forward so far. More is to come as a result of the decision to extend the project timeframe. One of the key outcomes of the project so far is the Composite Superstructure Concept (CSC), a commercialised construction system which has been developed by three LÄSS members – Kockums AB, Diab AB and Thermal Ceramics – which was officially unveiled at the recent SMM Exhibition in Hamburg, which took place in September this year.

The LÄSS Project was established in 2005 with the aim of rejuvenating the Swedish shipbuilding industry by developing technical solutions for the use of lightweight materials in commercial ships, including both displacement and high speed craft. The consortium behind the project is made up of representatives from the Swedish shipping industry, European materials manufacturers, Swedish universities and research establishments, and classification societies. In total, more than 25 organisations are involved in this project, which is financed by the participating members and

Composite Superstructure Concept : a profile

The Composite Superstructure Concept is a joint venture between the shipyard Kockums AB (a member of the ThyssenKrupp Marine Systems group), structural core manufacturer Diab AB and the fire protection and insulation company Thermal Ceramics, a division of Morgan Crucible.

The Composite Superstructure Concept is one of the first tangible commercial developments that results directly from the LÄSS Project. It is a high strength, lightweight sandwich composite construction system that comprises a structural core, to which glass or carbon fibre skins are bonded securely, using an industrialised resin infusion process. The final stage of the manufacturing process is the application of insulation to the laminate surface to provide the required level of fire protection.

By varying the core and skin thicknesses and properties, a fully integrated superstructure, covering both decks and internal/external bulkheads, can be designed and engineered in such a way that it meets both global and local loading conditions. Compound curves can be readily accommodated, thereby achieving a smoother surface finish.

The foam sandwich composite approach was taken because it offers much higher strength to weight and stiffness characteristics than single skin laminates. A composite sandwich panel operates in much the same way as an I-beam: the core material absorbs the shear forces generated by loads, distributing them over a larger area. The result is a strong structure with no specific weak points. Compared with single skin laminates, foam sandwich composites offer substantial improvements in both flexural rigidity and flexural strength. By increasing the thickness of the core, the improvements are even greater yet the weight increase is negligible.

In depth research shows that the concept is a very viable alternative to existing structures built from steel or aluminium. It allows much higher cargo volumes and/or significant fuel savings as a result of the substantial reduction in weight – more than 50 per cent when compared to a steel superstructure.

Furthermore, the specific reduction in superstructure weight improves hull stability. In addition, the finished structure is not subject to rust or corrosion.

With the major fire testing process now complete, the partners are in a position to open constructive dialogue with interested parties such as naval architects, shipbuilders and classification organisations. It is expected that a fully approved system will be available by the end of 2009 and in service the following year.

The group can guide and advise on any aspect of the structure. This covers the design, engineering, manufacturing methodology, fire protection and certification processes.

Vinnova (the Swedish Governmental Agency for Innovation Systems).

To date, a total of six design solutions have been the subject of exhaustive investigation, including an extensive fire-testing programme. This is important since fire safety is undoubtedly one of the most critical elements in achieving approval of composites for use in commercial ships.

Large-scale furnace trials have been carried out at the Swedish facility of SP Fire Technology. Actual tests have included 60-minute deck, 60-minute bulkhead, and room corner test, also tests of door and window sections and a large-scale test on a fibre reinforced plastic (FRP) sandwich structure, including cabins and corridor. These all demonstrated that an FRP structure that featured a lightweight fire insulation layer could be used for both decks and bulkheads, and would meet the aims of Solas regulations. Further tests also showed that the fire regulations could be met even when penetrations were made through the bulkheads and decks.

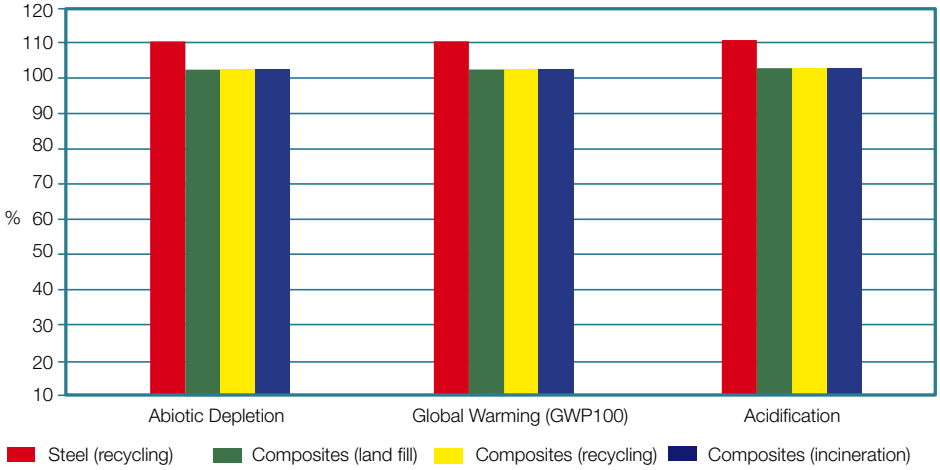
A detailed quantitative fire risk analysis was also performed on a variety of different fire scenarios to demonstrate that the systems met safety requirements.

Two lightweight solutions for a ropax ferry and a freighter have been developed, and these involve replacement of the steel superstructure with one made from lightweight sandwich composite materials. A detailed ropax ferry study has been carried out, based on the 188m long *Stena Hollandica*.

The basic design philosophy adopted involved keeping the original spacing between stiffeners. However, all plates, longitudinals, transversals and girders would be replaced by equivalent glass reinforced plastic (GRP) components. Other elements of the design philosophy included:

- the foam sandwich superstructure panels were designed to be produced by a vacuum resin infusion process
- the weight-optimised superstructure would be subordinated in favour of yield ability
- the translation of global loads in the superstructure would be restricted
- the existing hull structure would be used for load translation
- the superstructure would not carry any global loads
- design would be according to DNV rules.

This CSC deck section shows the fire insulation in place



Detailed lifecycle analysis studies showed a better outcome than steel or aluminium, with an environmental impact of 10 per cent per tonne/km

The results of this study showed that the sandwich composite alternative, including the fire protection layer, was more than 60 per cent lighter than the original superstructure. Fire protection is intended to provide a full '60 minute fire integrity and insulation' level (A60 equivalent) for the whole superstructure, there being no contribution from the combustible elements of the composite structure during the first 60 minutes of a fully developed fire.

Furthermore, a lifecycle cost (LCC) analysis revealed that the additional initial cost of the composite approach could be recovered in less than two years and the revenue increases, assuming a 25 year service life, could amount to more than US$65 million at current prices. This figure could be further augmented by the fact that maintenance costs for the superstructure would be substantially reduced as result of the virtually 'maintenance-free' nature of sandwich composites.

It may come as a surprise to some that the composite alternative was also the more environment friendly option. Detailed life cycle analysis (LCA) studies showed a better outcome than steel or aluminium with an environmental impact of 10 per cent per tonne/km.

The LÄSS project is set to continue with a new study that involves the replacement of three decks on a 300m cruise ship with a sandwich composite solution. Both DNV and Germanischer Lloyd will be involved in this study.

As a result of this and other LÄSS studies, it is hoped that a set of standard procedures and regulations for lightweight solutions will be in place by the end of 2009. **PST**

CSC components are seen here being fire tested

This article was written by Johan Edvardsson, Kockums AB; Lars-Magnus Efraimsson, Diab AB; & Allan Beeston, Thermal Ceramics Ltd