RAMSSES - Realisation and Demonstration of Advanced Material Solutions for Sustainable and Efficient Ships

E-LASS seminar #14

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Online

Thin deck panels and high strength steel bulkheads

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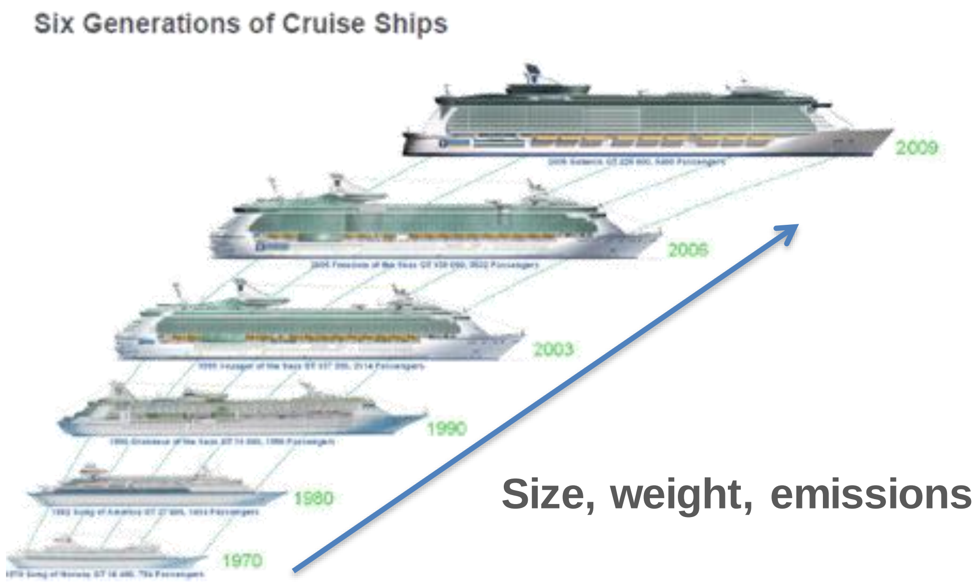
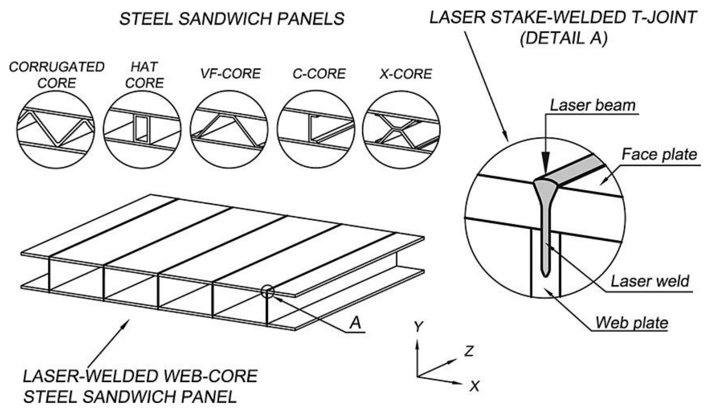
- Ships size, weight, and need of propulsion power is increasing
- Emissions should be reduced
- One solution is reducing weight of the hull
- Classification societies provide boundaries for design of the hull (minimum plate thickness, stress criteria)

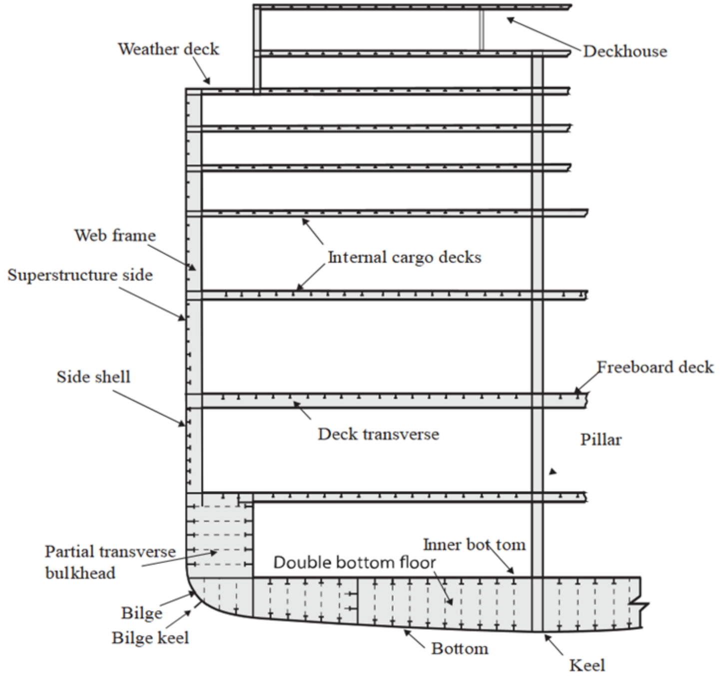


Choises for lowering ship hull weight

- Conventional ship hull is a welded structure made of A or A36 steel (R_e=355 MPa)
- Alternative solutions
  - Alternative materials (composites, aluminum)
    - Challenges: Production costs, fatigue, recycling
  - Alternative structural topology (sandwich structure)
    - Challenges: Connections, corrosion, fatigue
  - <u>Thin plates and high tensile steel (R_e>500 MPa)</u>
    - Challenges: Quality requirements, fatigue

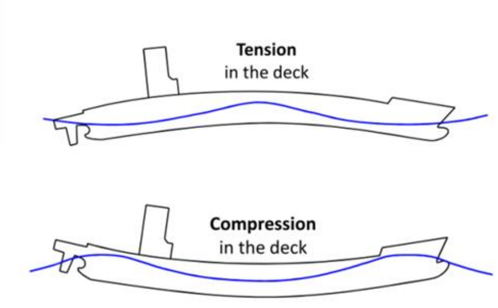


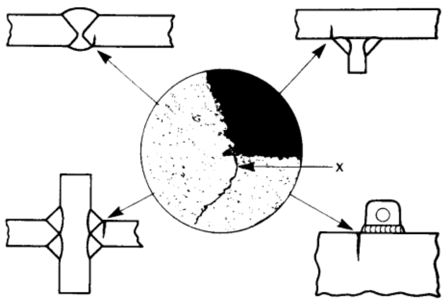
Frank D., Romanoff J., Remes H. 2013 Fatigue strength assessment of laser stake-welded web-core steel sandwich panels, Fatigue & Fracture of Engineering Materials & Structures 36 (8) pp. 724-737

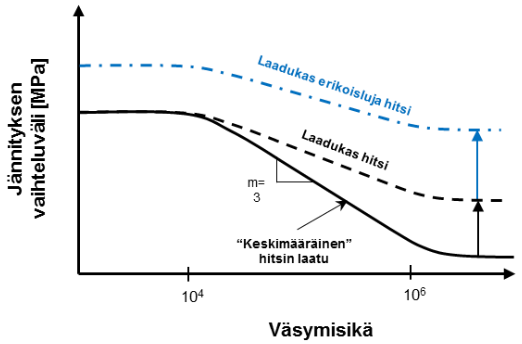


Fatigue of welded structures

- Theory
  - Fatigue means forming of cracks to structure under cyclic loading
    - Nucleation and propagation phase
  - Ship can face 100 million load cycles under ship lifetime
  - Fatigue cracks nucleate at stress concentrations such as weld toe line
  - Fatigue strength is reduced by the initially deformed structure compared to ideally straight shape
- Classification society rules
  - Fatigue criteria (FAT-classes) are defined at standards (DNV-GL)
    - Based on very large data base with high scatter in weld quality
  - For welded joints fatigue strength is the same regardless of the steel static strength
    - Crack-like weld defects are assumed with neglected crack nucleation phase
  - For base material increased fatigue strength is accepted with higher steel static strength
  - Thicknesses below 4.5 mm are not accepted

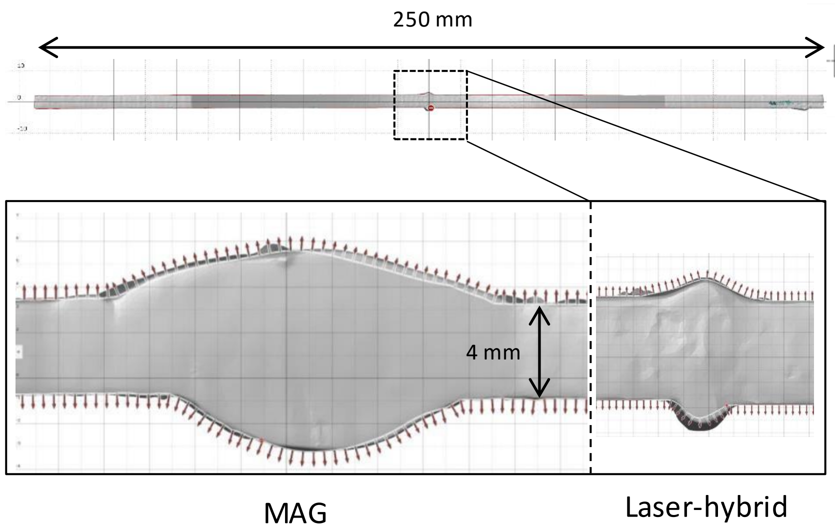


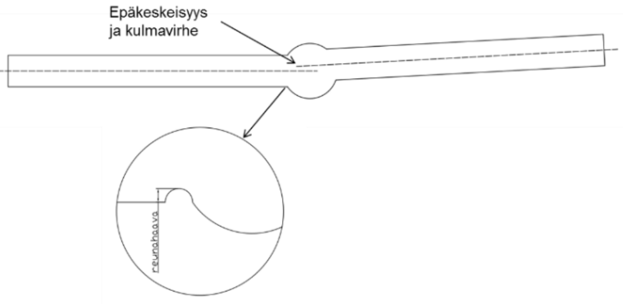




Thin plates (4 mm)

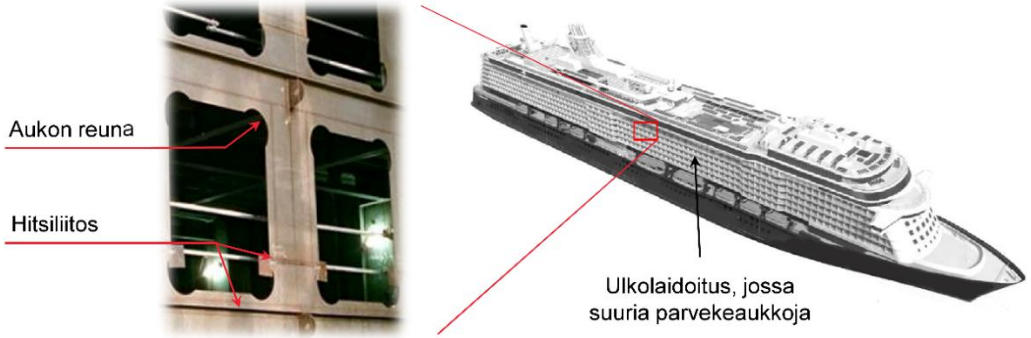
- Weight saving potential at areas with low loading such as deck plates close to ship hull neutral axis
- Fatigue strength is sensitive to weld defects:
  - Undercut
  - Axial misalignment
  - Angular misalignment
- Classification societies do not allow use of thicknesses below 4.5 mm
- Fatigue design recommendations (IIW) do not apply to thicknesses below 5 mm
- However, good fatigue strength is observed for high quality welded joints (4 mm plates, laser-hybrid)

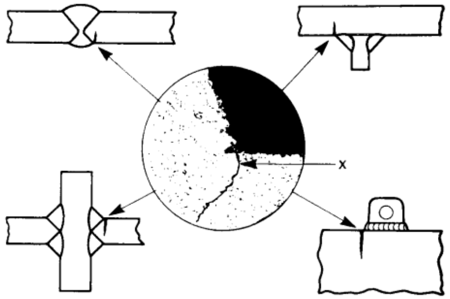




High tensile steel (R_e > 500 MPa)

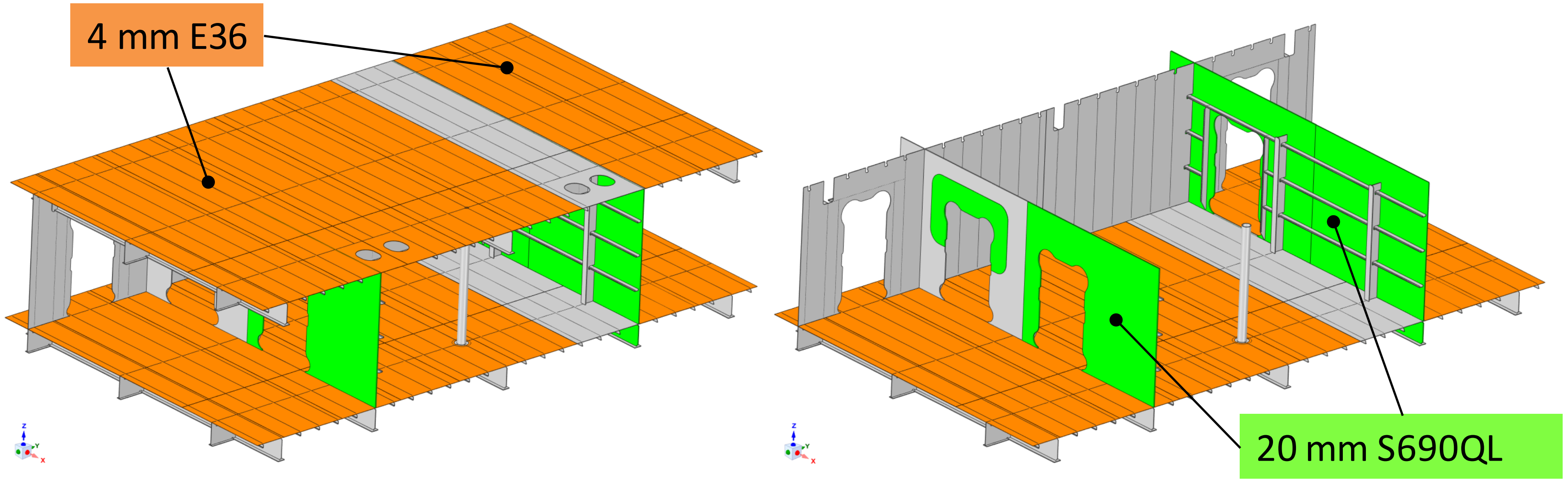
- Weight saving potential at areas with high loading and structural discontinuities
  - Longitudinal bulkheads with large openings
  - Uppermost decks
- Challenges of welded connections:
  - Fatigue strength sensitive to crack-like undercuts
  - Pre-heating
- Classification societies do not allow higher fatigue strength for high tensile steel
  - Crack-like defects assumed
- However, in fatigue tests high tensile steel is found to have increased fatigue strength with high quality welding

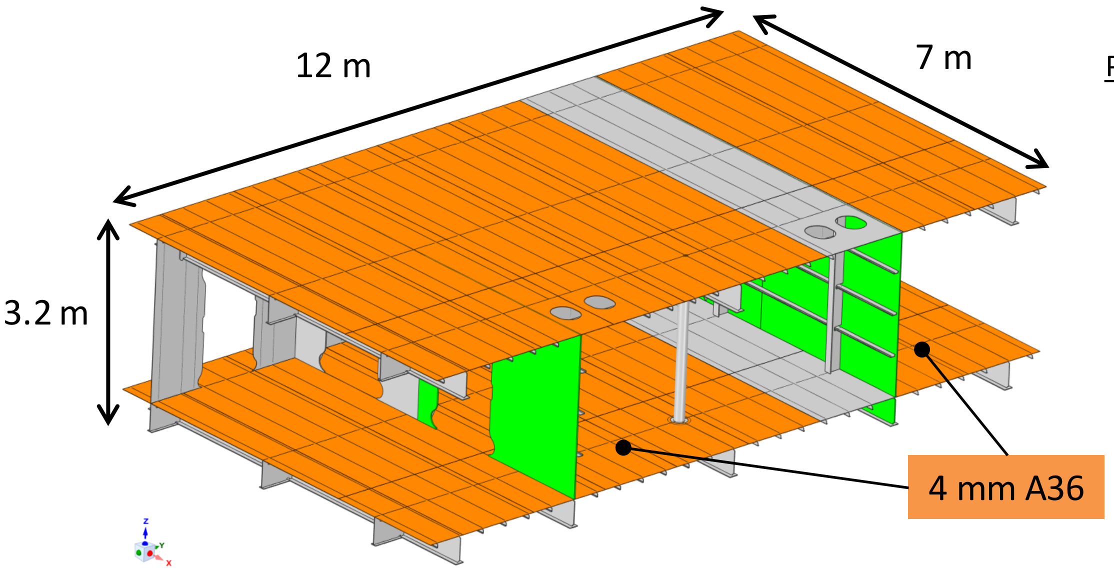


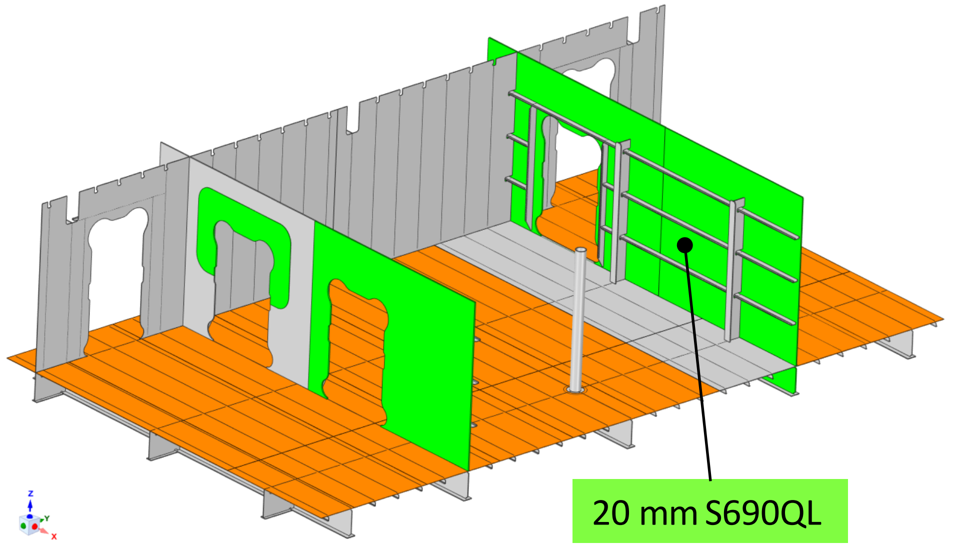


RAMSSES WP20 demonstrator

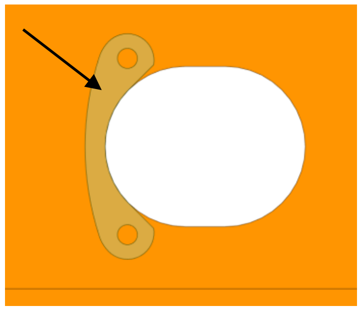
- Real-scale block of cruise ship is built using 4-mm thick deck plate and high tensile steel (R_e=700 MPa) bulkheads
- Laser-hybrid welding is used for deck panels
- MAG and sub-merged arc welding is used for bulkheads
- From finished demonstrator, fatigue test specimens are cut
  - Fatigue strength of real-scale structures using real shipyard production will be investigated



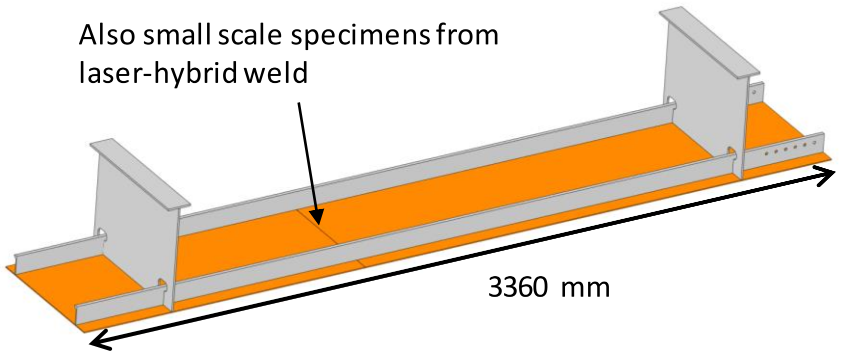




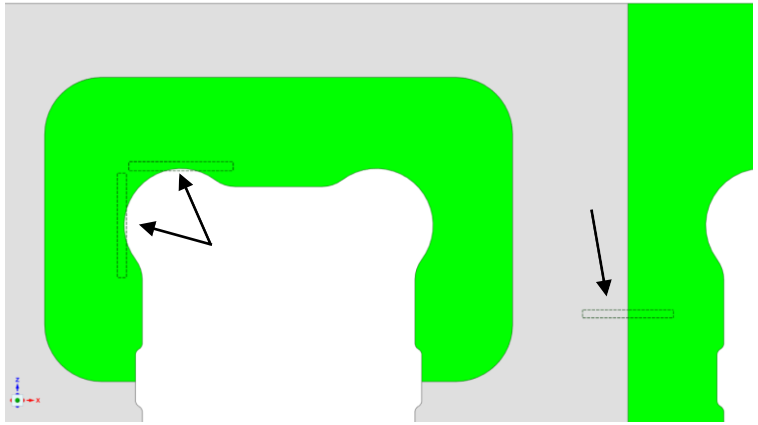
Plasma cut edge specimen from deck



Laser-hybrid welded deck butt-joint specimen



Plasma cut edge specimen and A36 to HTS butt-joint from HTS bulkhead



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European Commission

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