Development of lightweight structures in BESST

Sven-Erik Hellbratt *(Senior Specialist Composite Structures)*
ThyssenKrupp Marine Systems AB

Development of Steel-Composite solutions

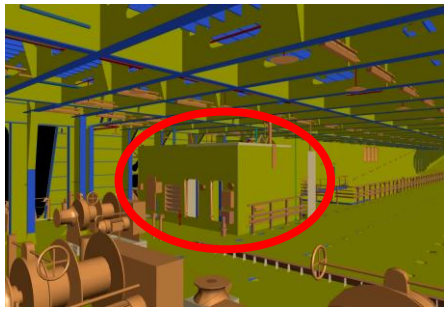
Three Application cases

Application case No 1

"Deck structure above of Deck 11 of Norwegian GEM". (MW)

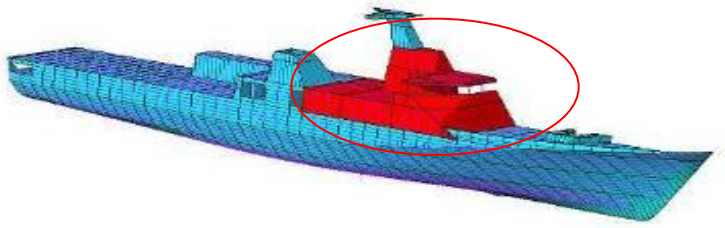
Application case No 2

"Emergency generator housing on a RO-Pax Ferry "(FSG)

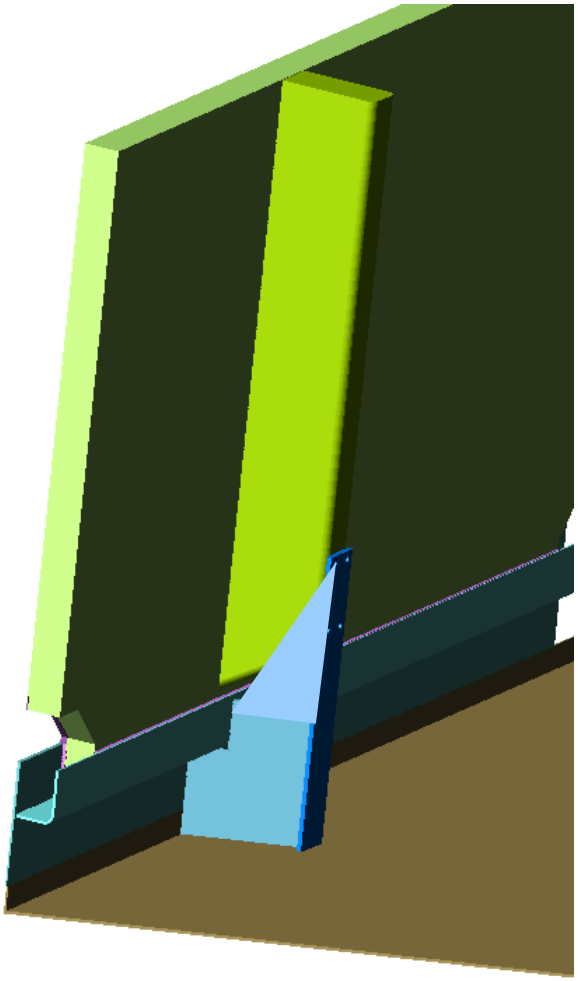


Application case No 3

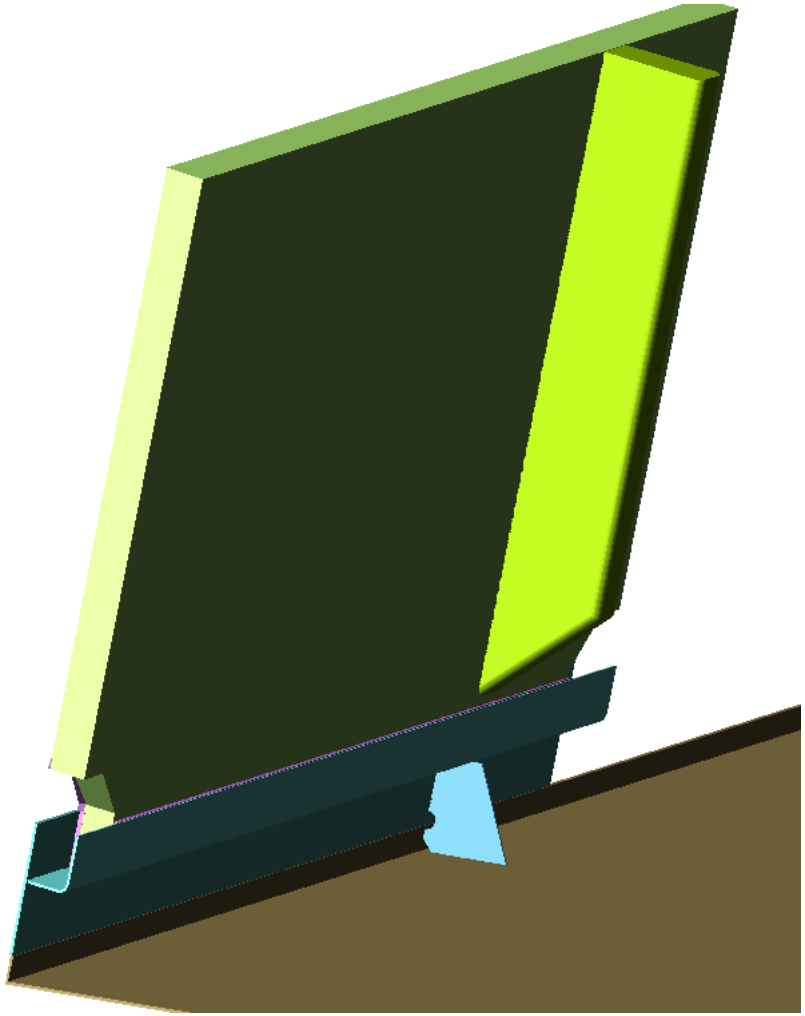
"Integration of Composite Superstructure Module in Steel Shipyard Environment" (DSNS)



Development of joint system between Steel and FRP sandwich structure

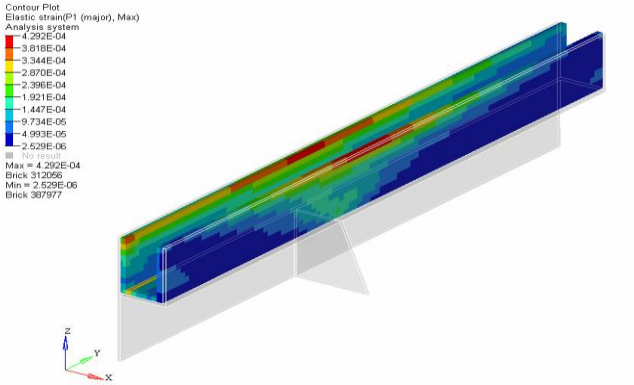


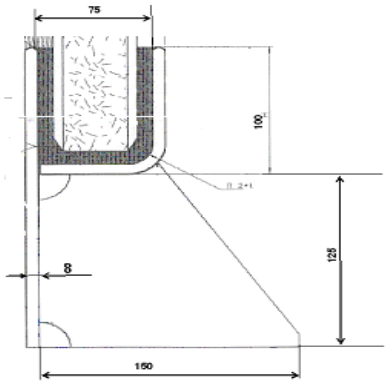
Web connection with fixed ends



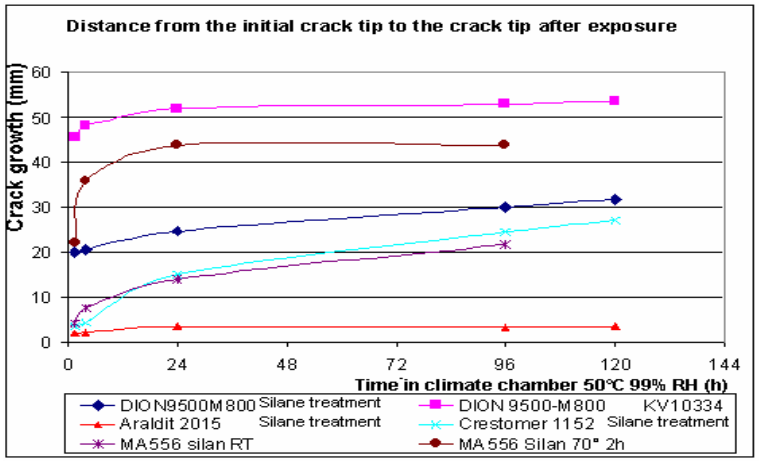
Web connection with sniped ends

Development of joint system between Steel and FRP sandwich structure



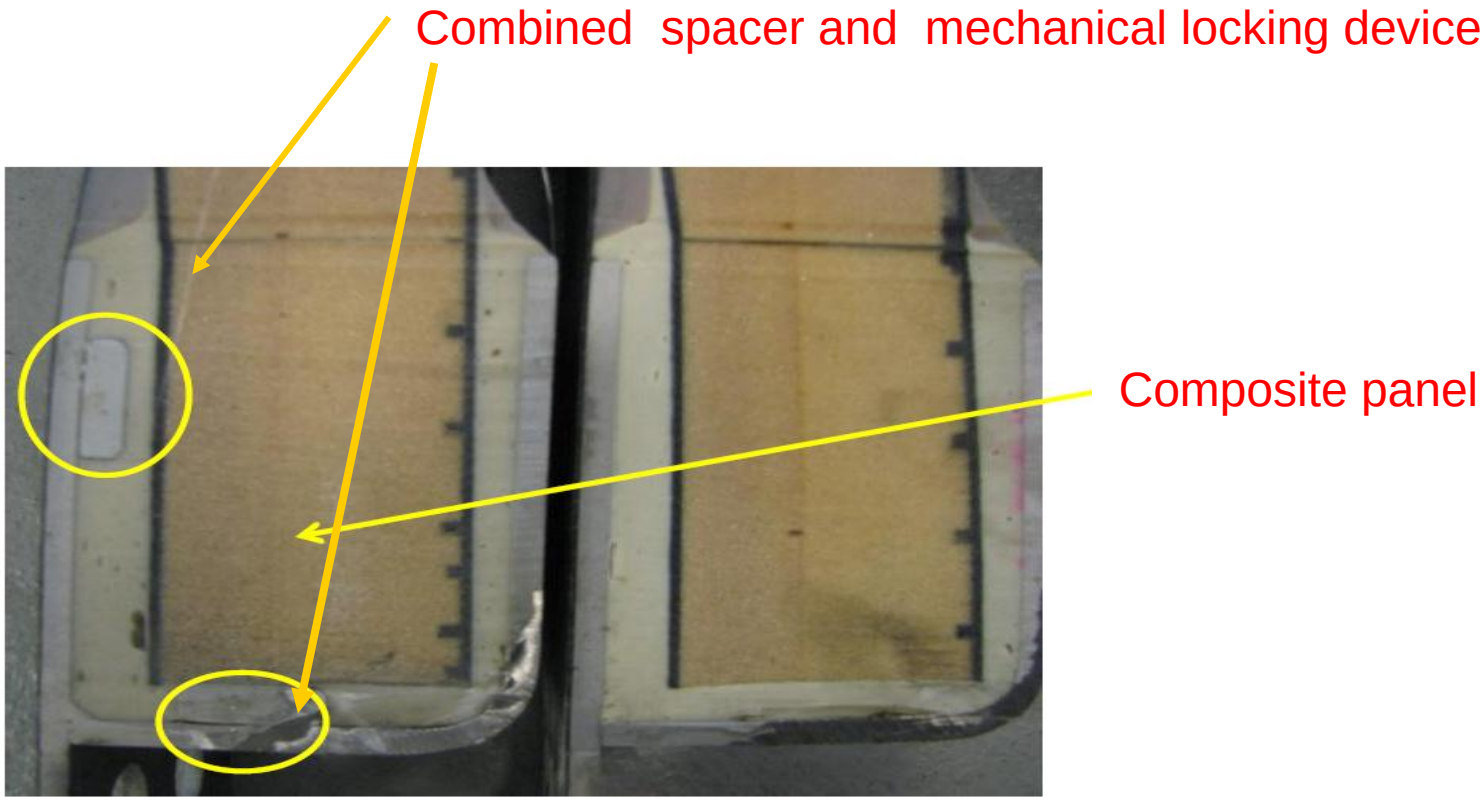


Joint studies



- Temperature impact at welding of a steel/composite joint
- Development of bonding system between steel-composite
- FEM analysis of interface between steel and composite performed
- Ageing testing of the sill system
- Fatigue testing of the sill system

“Adhesively bonded steel/composite joint”

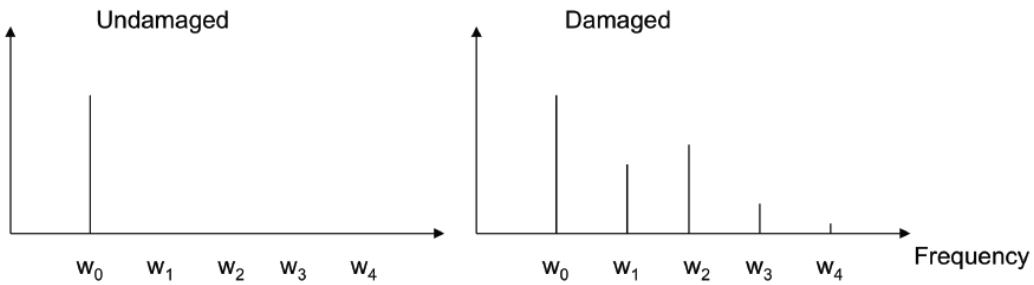


Fatigue testing of the steel/composite joint

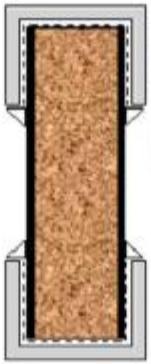
Fatigue failure in the steel after 1.8 million load cycles at 100kN
No damages in the steel/composite interface

Condition Monitoring using Non-linear acoustic technique

Fatigue registration using non-linear acoustic
(WP 17 IT Solutions for Condition Monitoring)
and with traditional strain gauges



When a single frequency is input to the material, the same frequency is measured when the material is undamaged. When the material is damaged higher harmonics are created and can be measured



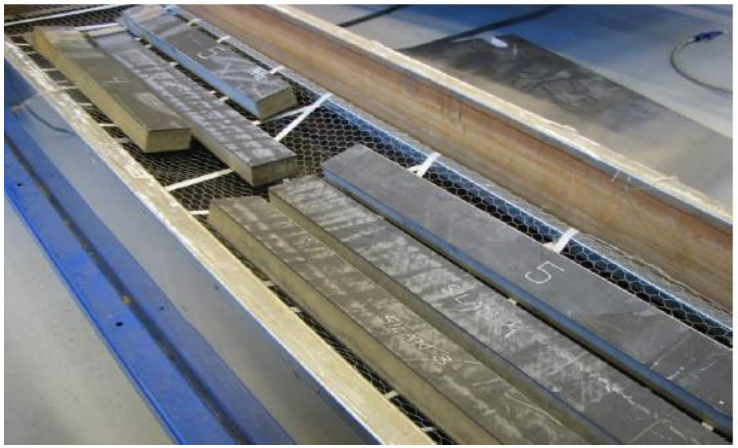
Four point bending

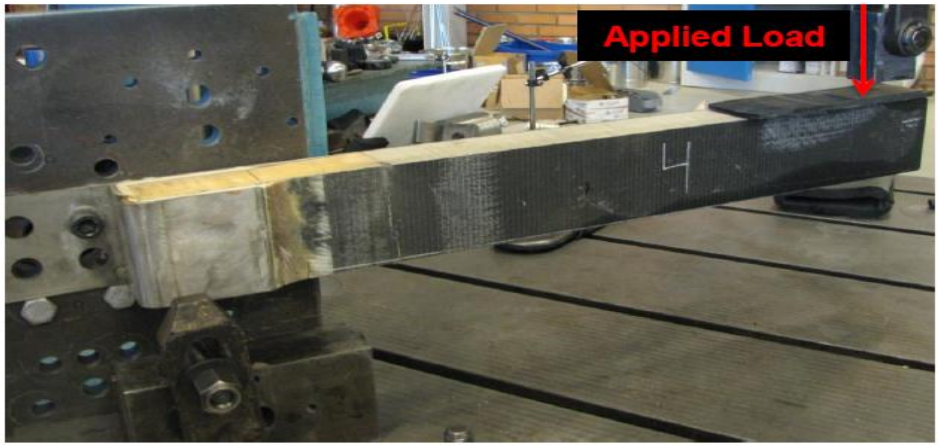
Ageing tests in high humidity

Mechanical testing of adhesive joints

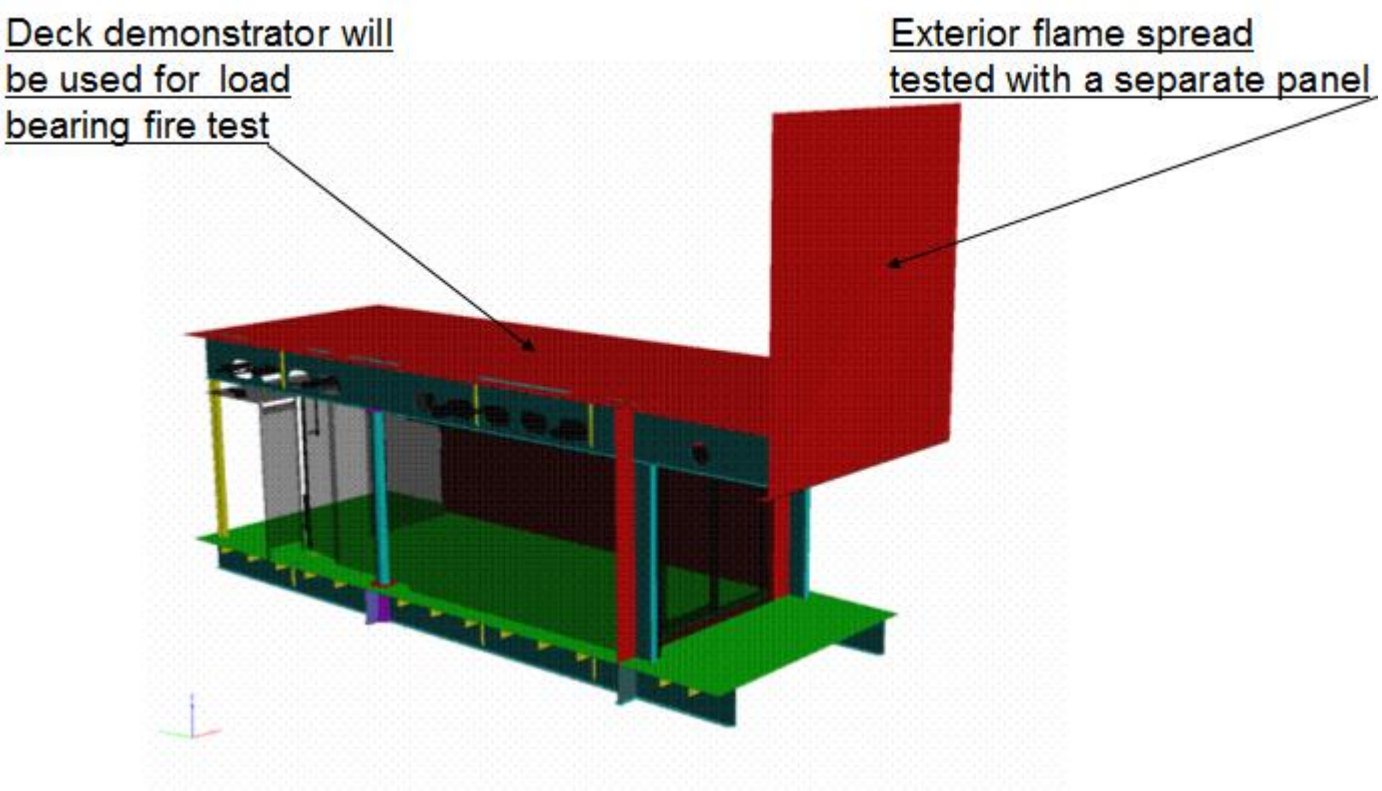
- Test conditions
  - 160 kN hydraulic press
  - Force and displacement from press continuously recorded 5 times/second
  - Load applied at 1100/885 mm distance from support (885 mm for Syl3 specimens)
  - Load is applied at a rate of 10 mm/minute
  - Load is applied as a pushing force onto the edge of the sample
  - Conditioning at high humidity, 50°C for 120 hours, circulating water

Conditioned samples are placed on a net in a box with circulating water underneath the net. A lid is placed on top to increase humidity





Application Case No 1 “Mock-up of a balcony structure of a cruising vessel”



Fire tests, outside fire, Application case No 1

Drencher and external flame spread test

Ignition

Activation(~5 min)

Controlled (~7 min)

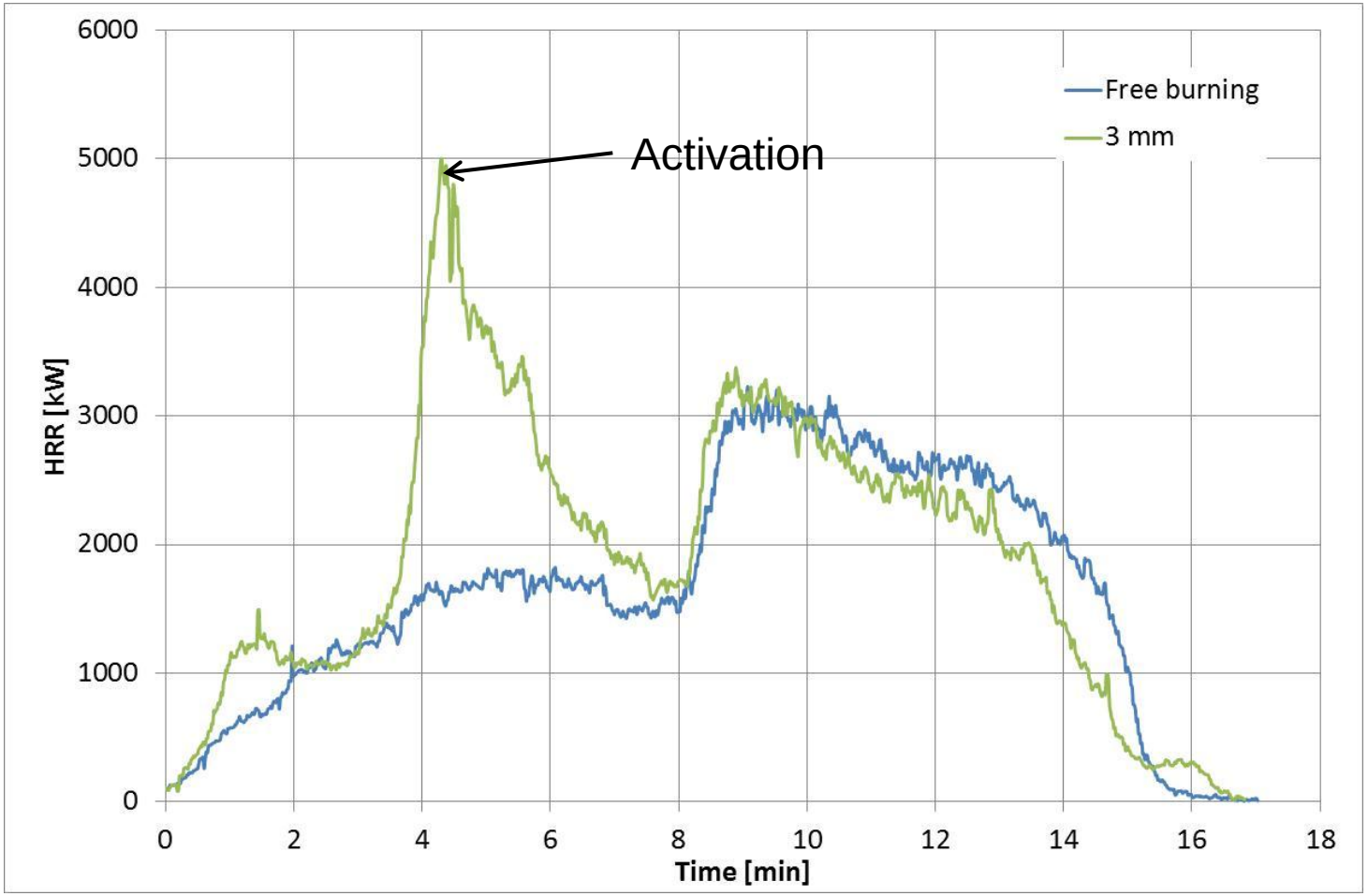
Fire tests, outside fire, Application case No 1

Water application system

Test	Design discharge density (mm/min)	Design flow rate (L/min)*	Total water flow rate (L/min)**	Collected flow rate (L/min)	Actual measured discharge density (mm/min)***	Percentage of water reaching the vertical surface (%)
3	2	48	60	31.8	1.32	66%
1	3	72	90	34.7	1.45	48%
5	3	72	90	42.5	1.77	59%
2	4	96	120	57.3	2.39	60%

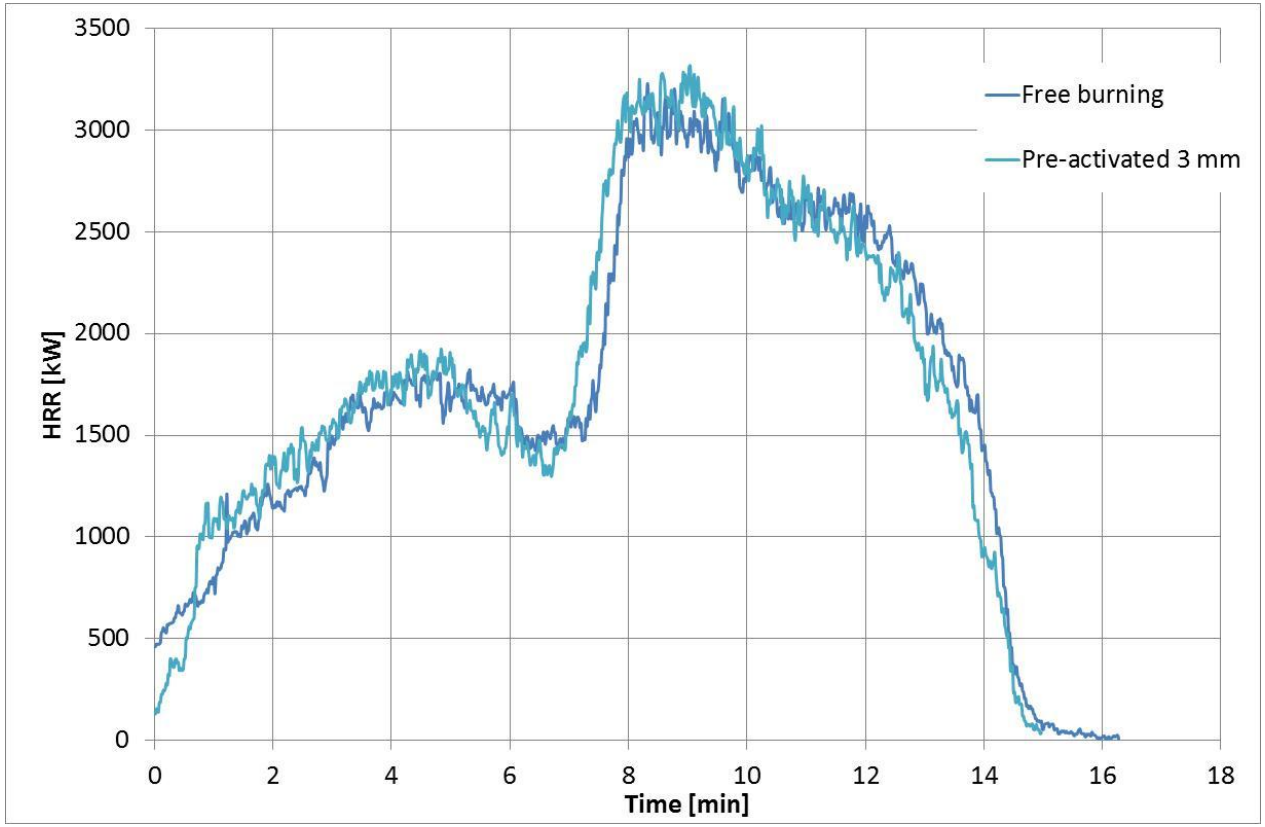
Fasade tests

Results – Comparison 3 mm/min of water vs. non-combustible



Fasade tests

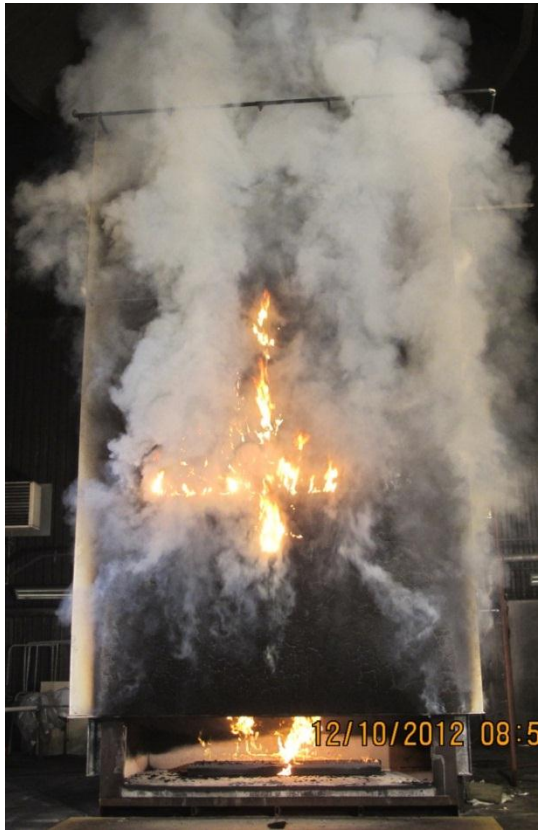
Results – Comparison pre-activated drencher vs. non-combustible



Fire tests, outside fire, new treatment of fibre and resin systems

LEO – No drencher activation

Fully developed

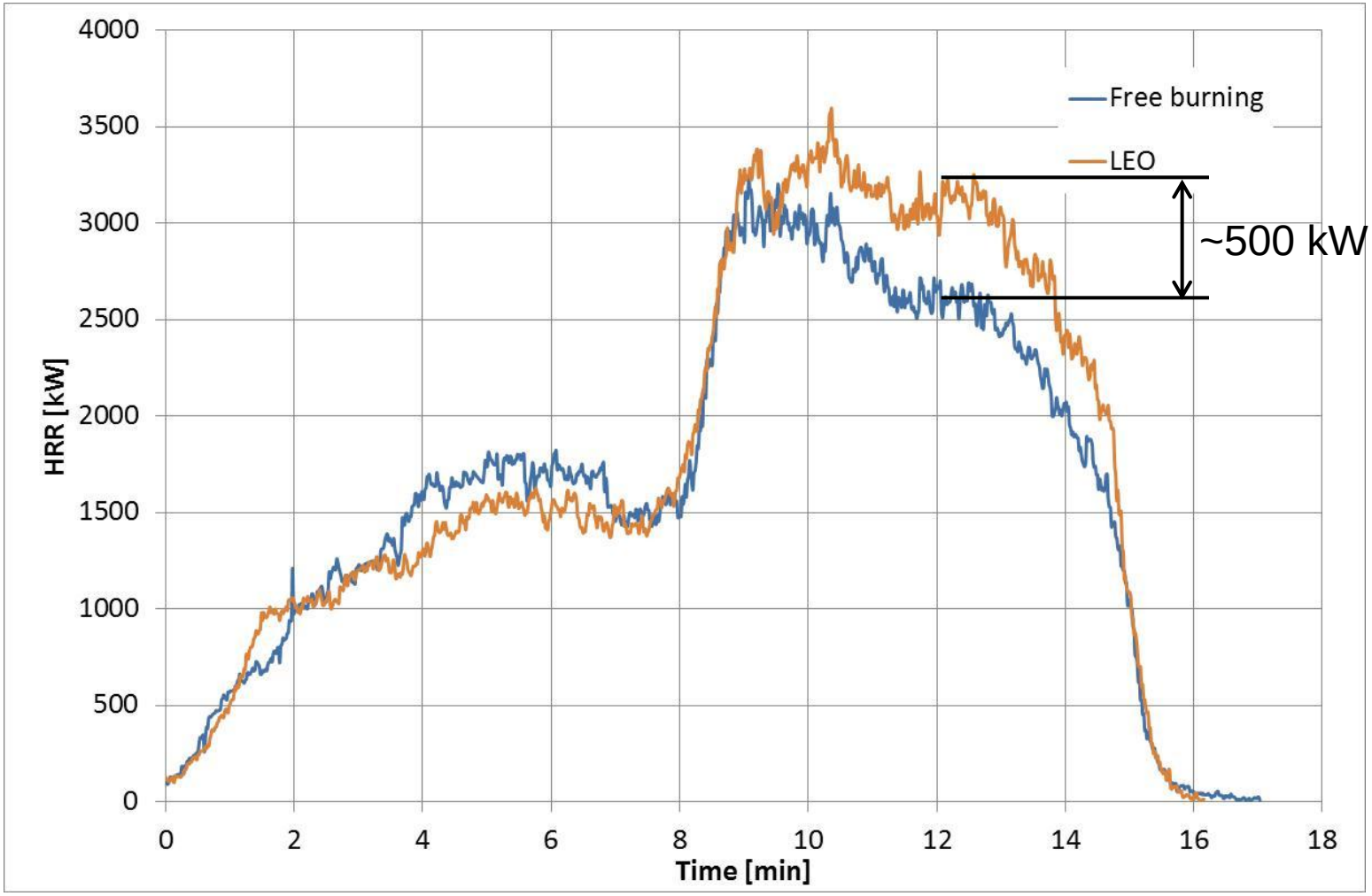


Fuel pan burn-out

Self-extinguished

Outside fire-Fasade tests

Results – Comparison LEO vs. non-combustible

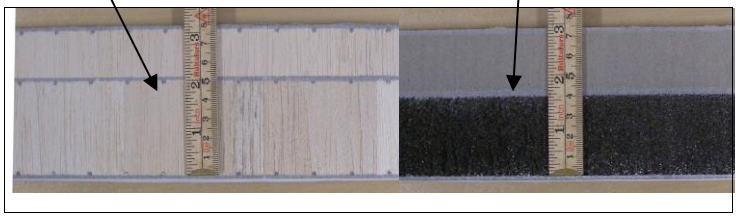


Outside Fire , New Structural concept

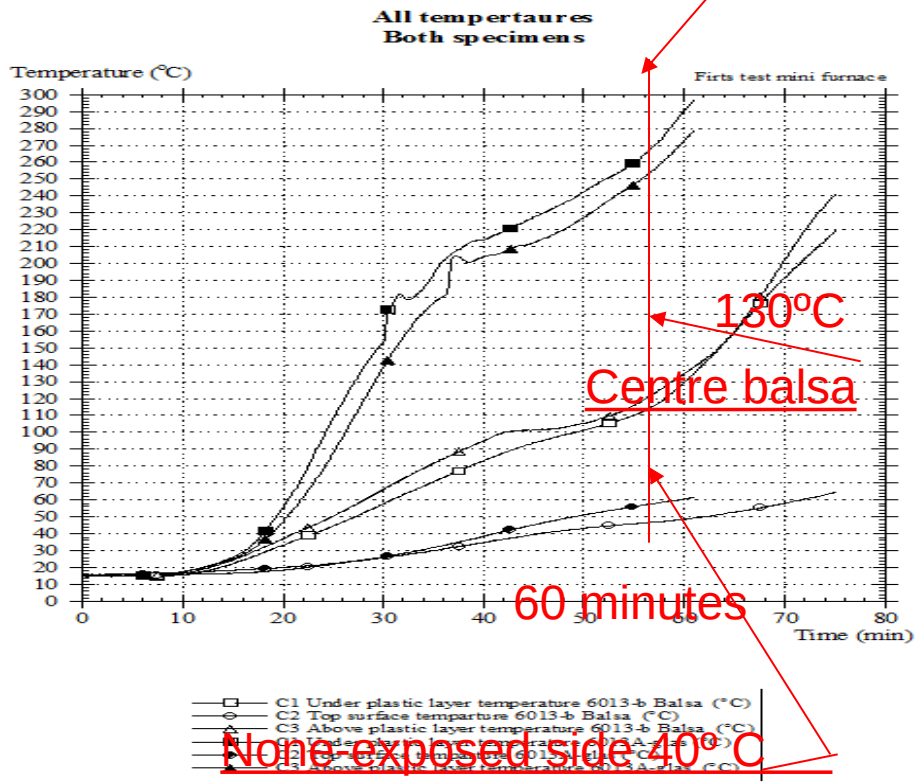
Fire test of two types of triple sandwich for outside fire (FRD 60)

Triple sandwich with Balsa core (passed)

Triple sandwich with PVC core, Glass core (failed)



Centre Foam Glass 280º C



130ºC

Centre balsa

60 minutes

None exposed side 40º C

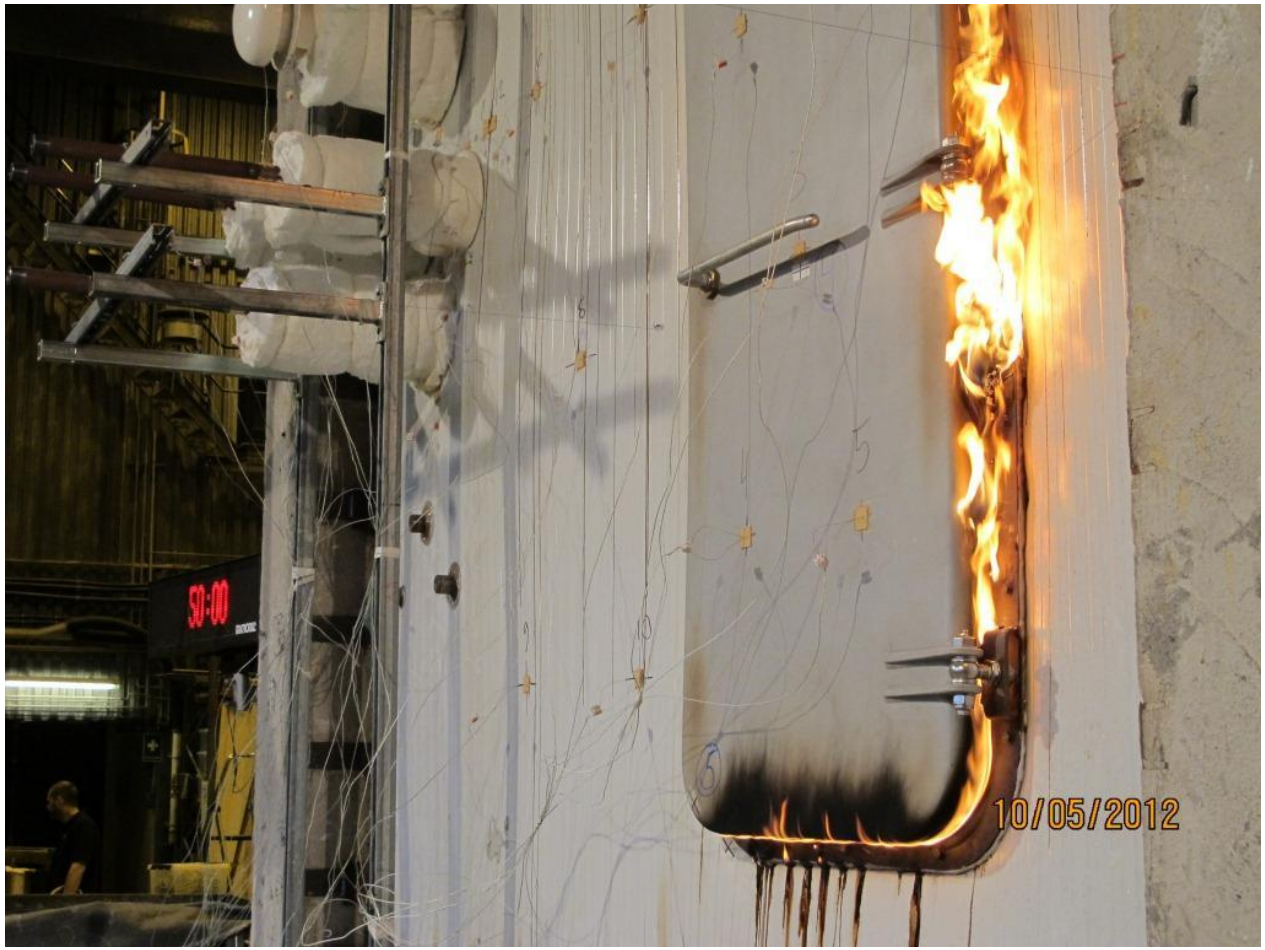
Fire test Application case No 3




Several ideas and solution for outfitting and penetrations were realised and tested.


Successful fire test on developed solutions

Fire test Application case No 2



Fire test on metal sandwich structure from building industry equipped with pipe penetrations and an approved A-60 door

The A60 approved door may have failed due to ignition of the rubber seal caused by the low heat transfer of the sandwich structure

Steel / composite joint that can be used in traditional steel shipyards conditions in full scale production

Lessons Learned from BESST and Ro-pax project

- Realistic fire tests which have been performed must convince Administrations with low or none experience of light weight structures if they are well informed in advance of a project (Administrations must be on the train from start of a new project!)
- Continues work to establish Classification Rules is a kea-factor for success
- Ship owners that can see the benefits of lower fuel costs, greening profile and lower life cycle costs with lightweight structures must put pressure on IMO to establish Classification Rules
- Methodology of Risk based Analysis when combustible materials according to Rule 17 shall be used must be harmonized and known by the Administrations!!