MOSAIC

FP7-SST-2012-RTD-1

Materials **O**nboard: **S**teel **A**dvancement and **I**ntegrated **C**omposites

EUROPEAN PROJECT MOSAIC: GENESIS AND EXPECTATIONS

CARLO CAU – CETENA S.P.A.

BORÅS – SWEDEN 8-9 OCTOBER 2013

E-LASS & MESA Workshop

MOSAIC Objectives

- **MOSAIC** main objective is to improve the structural response of the ship, reduce corrosion and **reduce the lightship weight of the structure**, thereby substantially reducing the maintenance and overall operation cost of the vessel.

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WHY MOSAIC

- Main objective will be pursued investigating on the application of two technologies in ships:
  - use of tailored HSLA (High Strength Low Alloyed) steels

  - replacement of parts of the steel structure with composite materials

MOSAIC CONSORTIUM

1. CETENA S.p.A. Centro per gli Studi di Tecnica Navale (CET)
2. National Technical University of Athens (NTUA)
3. The University of Birmingham (UoB)
4. Instituto Superior Técnico (IST)
5. TWI Ltd (TWI)
6. FINCANTIERI – Cantieri Navali Italiani S.p.A. (FC)
7. ALVEUS I.I.c. (AS2CON)
8. LLOYD'S REGISTER EMEA (LR)
9. Asociacion de Investigacion Metalurgica del Noroeste (AIMEN)
10. Estaleiros Navais de Peniche, S. A. (ENP)
11. Danaos Shipping Company Ltd (DAN)

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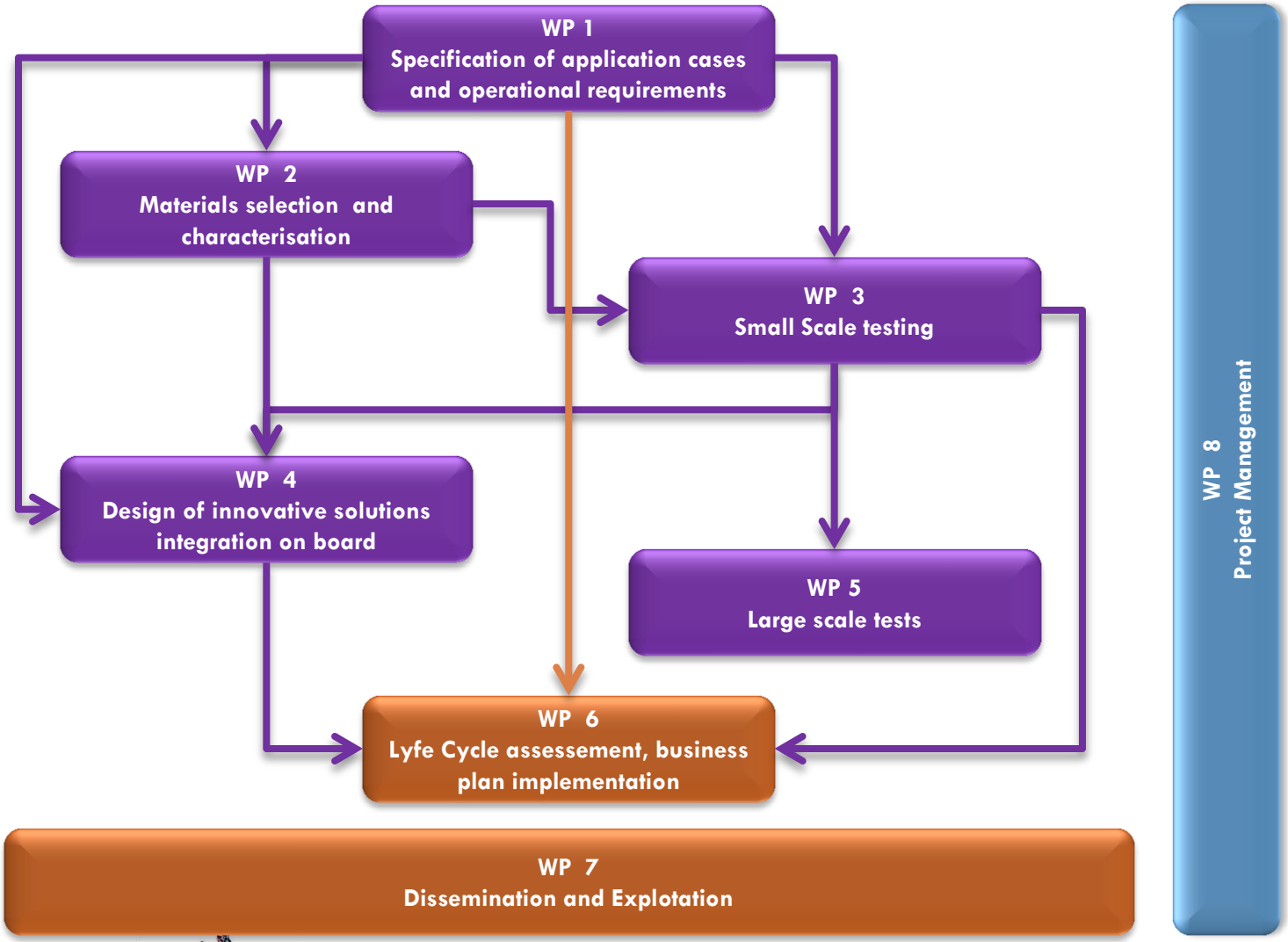
MOSAIC - WORKPLAN



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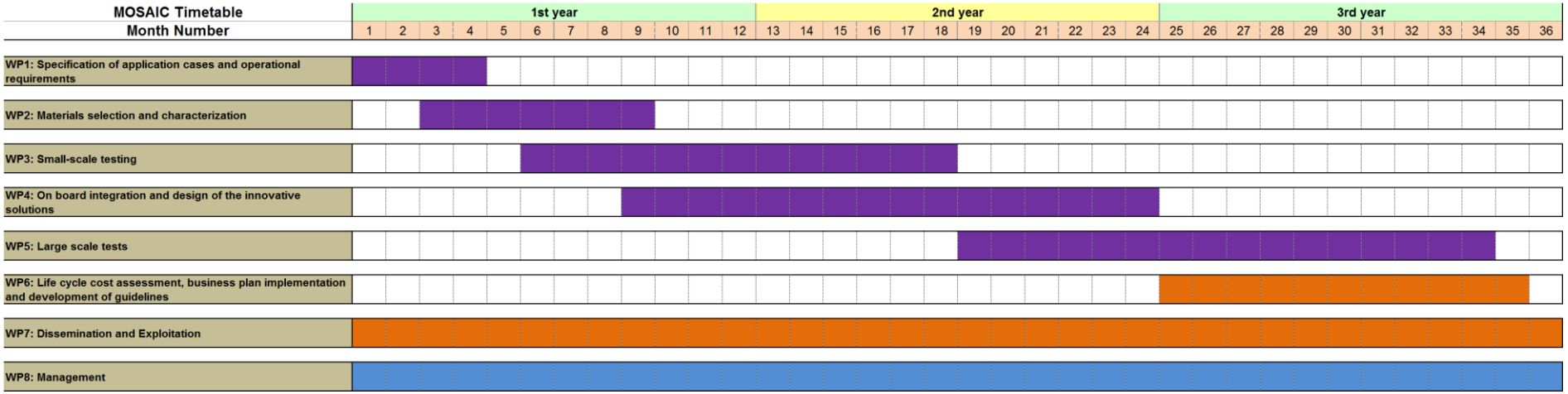
MOSAIC Timetable



MOSAIC

Grant Agreement

- Signed on 31st July 2012
- Entry into force : 31st July 2012
- Start of project: **1st September 2012**
- Duration: 36 months
- Maximum EU contribution: **EUR 2,859,690**
- Two reporting periods:
  - P1 (1st Sep 2012 –28th Feb 2014)
  - P2 (1st Mar 2014 – 31st Aug 2015)

MOSAIC – Project Structure

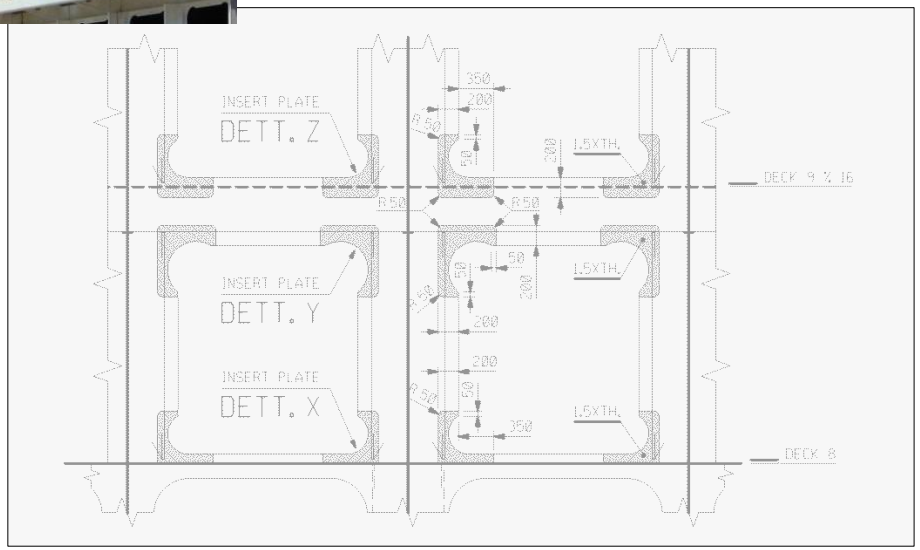
- MOSAIC project is broken down into eight separate work packages (WP),
  - WP1. Specification of application cases and operational requirements (FC)
  - WP2. Materials selection and characterization (UoB)
  - WP3. Small-scale testing (NTUA)
  - WP4. On board integration and design of the innovative solutions (CET)
  - WP5. Large-scale tests (TWI)
  - WP6. Life cycle cost assessment, business plan implementation and development of guidelines (AS2CON)
  - WP7. Dissemination and Exploitation (IST)
  - WP8. Project Management (CET)

Results at Project Month 06

- Definition of case studies for the application of HSLA steels on particular critical structural
  - 14 possible critical cases identified.
  - The selection was made on the basis of the following criteria:
    - In line with the business area of the partners.
    - Solution of existing problems
    - Wide range of applicability.
    - High number of performance factors
    - **Applicability of Friction Stir Welding technology**
    - Compatibility with thicknesses tested in the project
- Definition of case studies for the application of composite materials on structural elements
  - Identified 16 possible case studies and highlighted the acceptability SOLAS
  - The selection was conducted on the basis of performance criteria (weight, fatigue behaviour, safety, aerodynamics, hydrodynamics) as well as cost and production technologies.

Selected Case Study HSLA

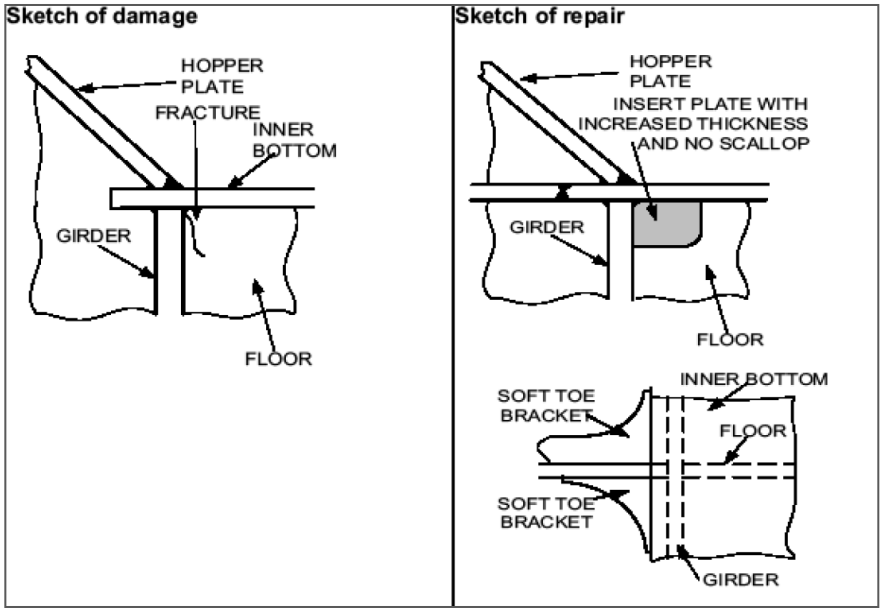
OPENINGS ON LONGITUDINAL BULKHEADS OF CRUISE VESSELS



- MAIN LOADING: Shear Stress (zx) due to hull girder deformation
- DEFECTS TO FIX\ AVOID: Crack initiation on corner edge and propagation into long. bulkhead and primary structure
- AREA THICKNESS: 8 mm – 12 mm – 18 mm
- CONVENTIONAL CORRECTIVE ACTION (DH\EH): 1.5 or 2 x Thickness – 35 mm
- MOSAIC CORRECTIVE ACTION (HSLA): 12 mm
- **FSW APPLICABILITY: YES**

Selected Case Study HSLA

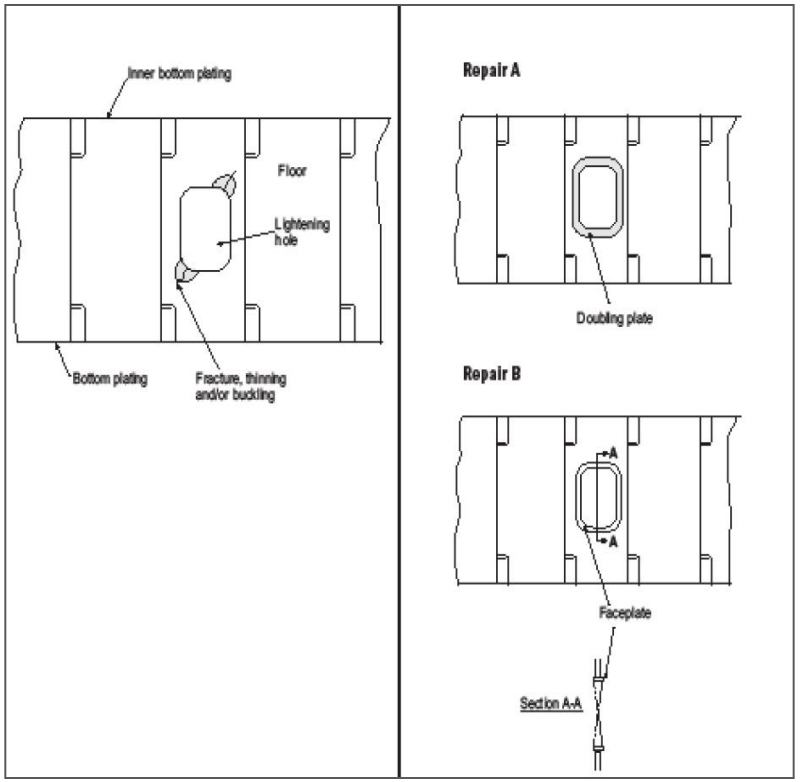
MISALIGNED PLATES – KNUCKLED HOPPERS



- MAIN LOADING: Combined due to static and dynamic loads from liquids
- DEFECTS TO FIX\ AVOID: Crack initiation on floor vertex and on hopper plate\ web
- AREA THICKNESS: 15 - 17 mm
- CONVENTIONAL CORRECTIVE ACTION (DH\EH): 18 – 20 mm
- MOSAIC CORRECTIVE ACTION (HSLA): 18 mm
- **FSW APPLICABILITY: NO**

Selected Case Study HSLA

DOUBLE BOTTOM FLOORS\GIRDERS LIGHTENING OPENINGS



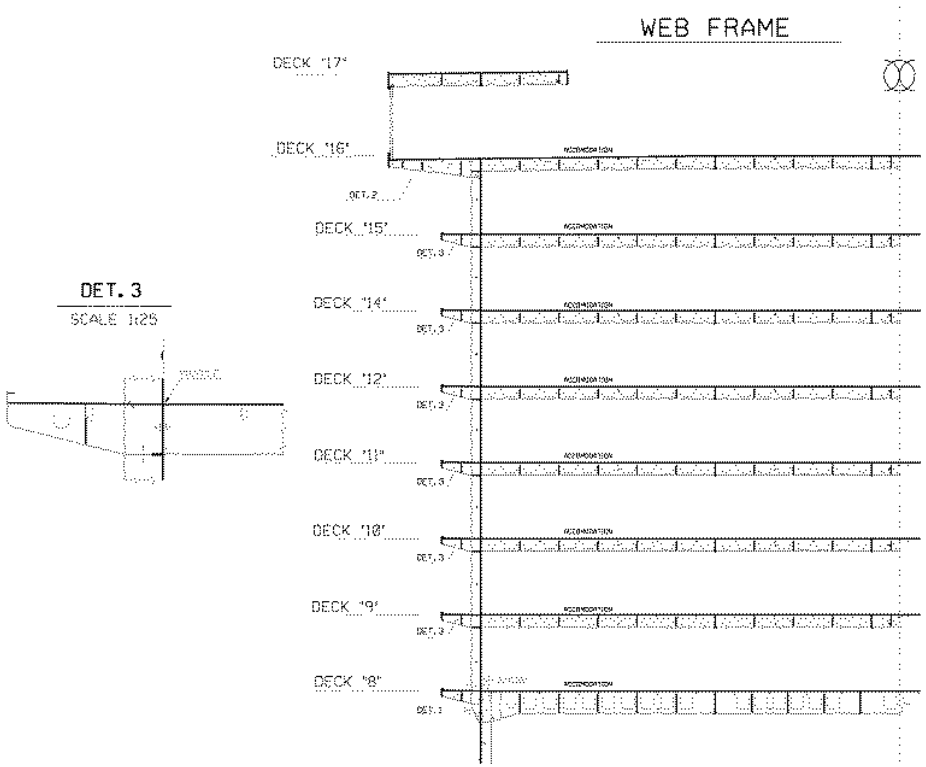
- MAIN LOADING: Combined (direct & shear stress) cause by both global and local loads
- DEFECTS TO FIX\ AVOID: Crack initiation in way of lightening opening
- AREA THICKNESS: 12 mm
- CONVENTIONAL CORRECTIVE ACTION (DH\EH): Doubling plate 12 mm - Spigot
- MOSAIC CORRECTIVE ACTION (HSLA): Insert plate 12 mm
- **FSW APPLICABILITY: YES**

Selected Case Study Composite

- Bow enclosure.

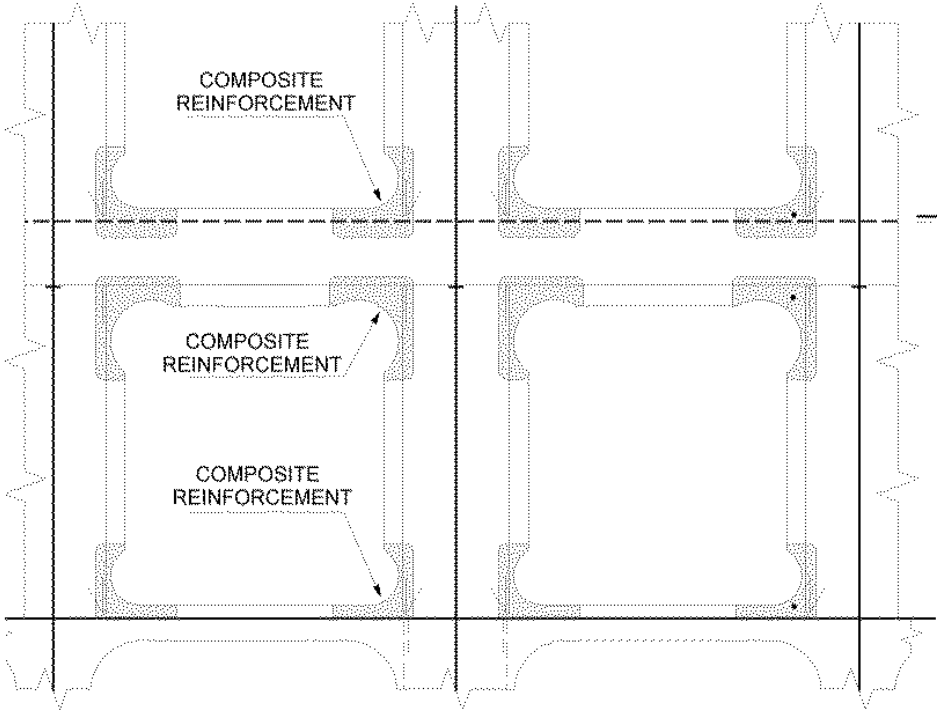
Selected Case Study Composite

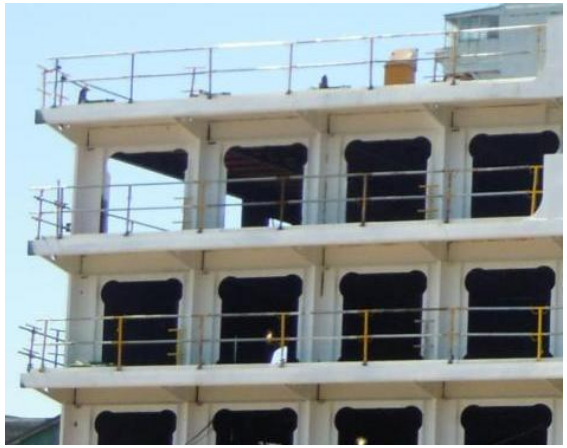
- Balcony gangways (overhangs) on cruise vessels.



Selected Case Study Composite

- Strengthening of (balcony) opening edges





Results at Project Month 12

- Characterisation of materials: HSLA
  - Characterization testing
  - Measurement of mechanical properties :
    - Tensile properties
    - Measurement of fracture toughness properties
    - Fatigue crack growth tests
    - Microstructural characterization
- Composite materials selection and characterization
  - Selected test standards
  - Model behaviour and strength (Material properties)
  - Selected manufacturing process and parameters
  - Defined composite materials defect detection techniques (NDT)
- Design and numerical modelling of Composite Joints

Task 2.1 HSLA steel selection and characterisation materials

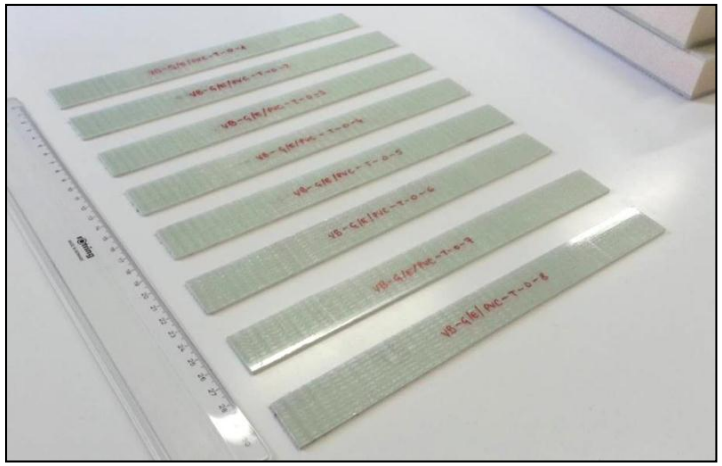
Steel Code	Supplier	Plate thickness (mm)	Partner in charge of testing
AH36	Fincantieri*	12	AIMEN
AH36	Fincantieri*	18	
DH36	Fincantieri*	12	AIMEN
DH36	Fincantieri*	18	
X65-1	Tata Steel	25	UoB
X65-2	Tata Steel	50	UoB
X65-3	Korinthos	12	UoB
S690	Thyssen	12	UoB
S690	Ruuki	12	UoB (only tensile)
FCA	Sumitomo	12	NTUA

Task 2.2: Composite materials selection and characterization

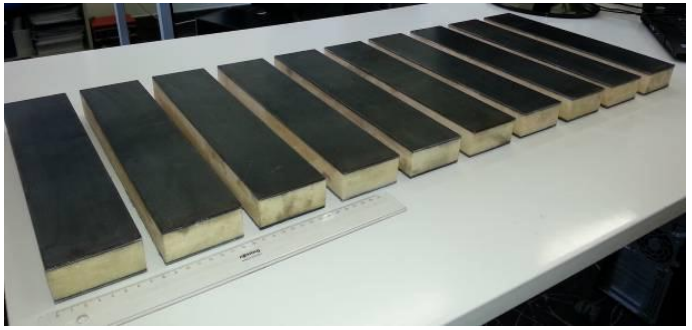
T2.2 COMPOSITE MATERIALS

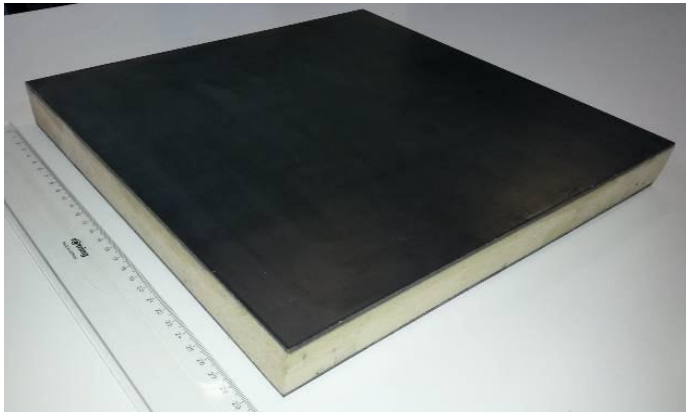
Material	Fabrication Method	Composite System	Fibers		Resin		Core	
			Type	*Supplier*	*Type*	*Supplier*	*Type*	*Supplier*
1 (AS2CON)	Hand Lay-Up	Glass/Epoxy	Biaxial stiched fabric 813 g/m^2	METYX Composites 5200.002.240	105/205 Standard	WEST SYSTEM	-	-
2 (ENP)	Vacuum Bagging	Glass/Vinylester	Biaxial stiched fabric 813 g/m^2	METYX Composites 5200.002.240	CRYSTIC VE679PA vinylester	SCOTT BADER	-	-
3 (AS2CON)	Hand Lay-Up	Glass/Epoxy Sandwich	Biaxial stiched fabric 813 g/m^2	METYX Composites 5200.002.240	105/205 Standard	WEST SYSTEM	Divinycell H100 100 kg/m^3	DIAB
4 (ENP)	Vacuum Bagging	Glass/Vinylester Sandwich	Biaxial stiched fabric 813 g/m^2	METYX Composites 5200.002.240	CRYSTIC VE679PA vinylester	SCOTT BADER	Divinycell H100 100 kg/m^3	DIAB
5 (ENP)	Vacuum Bagging	Glass/Vinylester Sandwich	Biaxial stiched fabric 813 g/m^2	METYX Composites 5200.002.240	CRYSTIC VE679PA vinylester	SCOTT BADER	ProBalsa Standard 155 kg/m^3	DIAB
6 (AS2CON)	Vacuum Bagging	Glass/Epoxy	Biaxial stiched fabric 813 g/m^2	METYX Composites 5200.002.240	105/205 Standard	WEST SYSTEM	-	-
7 (AS2CON)	Vacuum Bagging	Glass/Epoxy Sandwich	Biaxial stiched fabric 813 g/m^2	METYX Composites 5200.002.240	105/205 Standard	WEST SYSTEM	Divinycell H100 100 kg/m^3	DIAB
8 (AS2CON)	Skin bonded to core with structural adhesive	Steel Skins Sandwich	-	-	-	-	Divinycell H100 100 kg/m^4	DIAB

Task 2.2: Composite materials selection and characterization



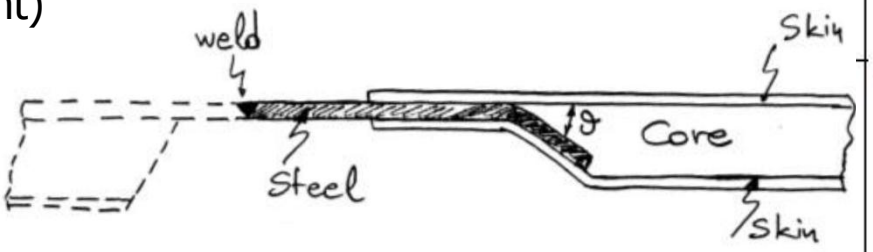
Task 2.2: Composite materials selection and characterization



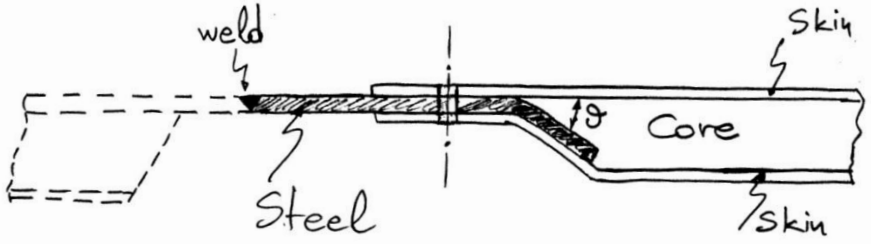


Types of composite-to-steel joints

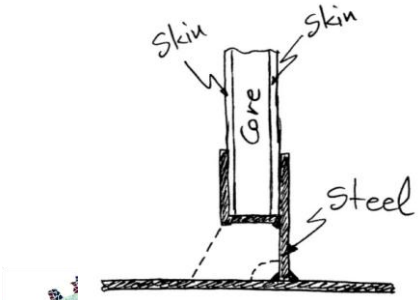
- Type A (bonded butt-joint)

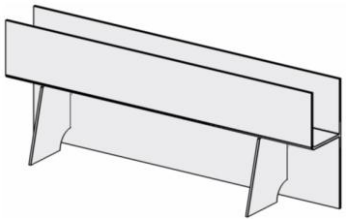


- Type B (bonded-bolted butt-joint)



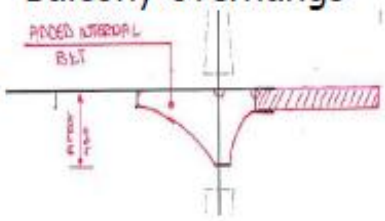
- Type C (bonded T-joint)



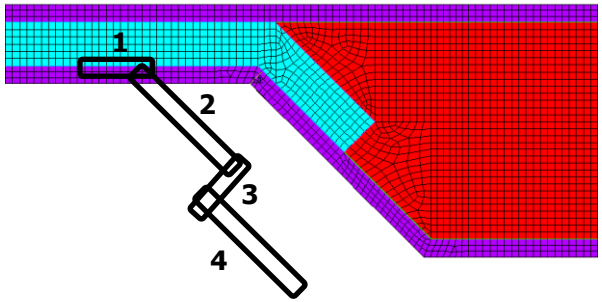


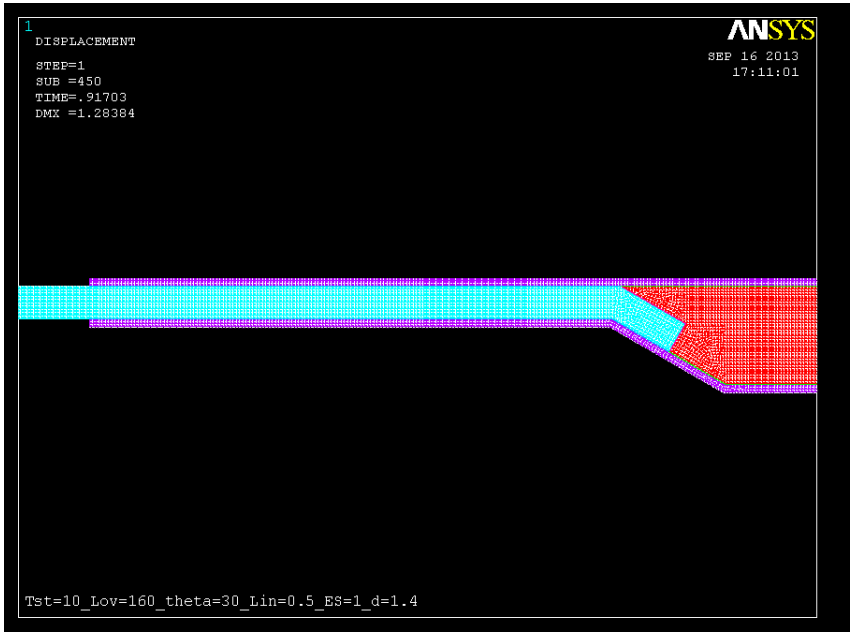
Bow enclosure

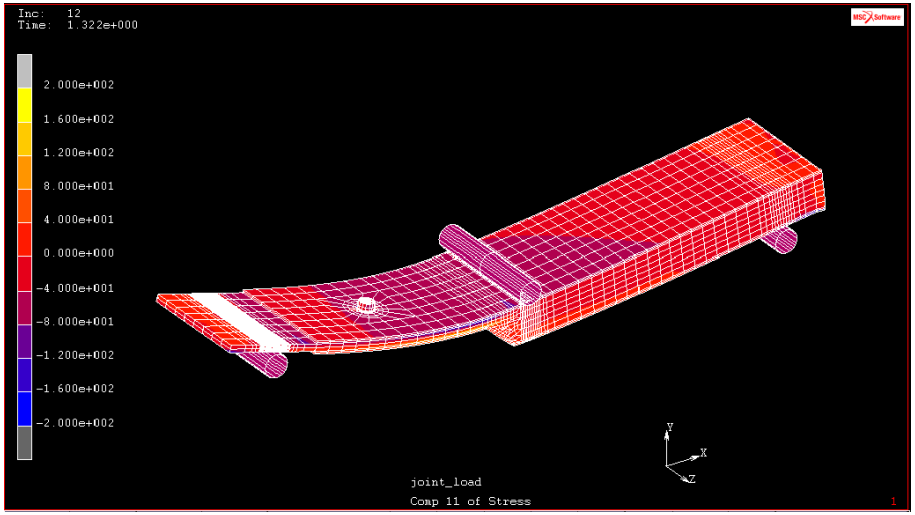
Balcony overhangs



FE simulation of type A joint – Initial results







THANK YOU FOR YOUR ATTENTION!