



Co-Patch project logo

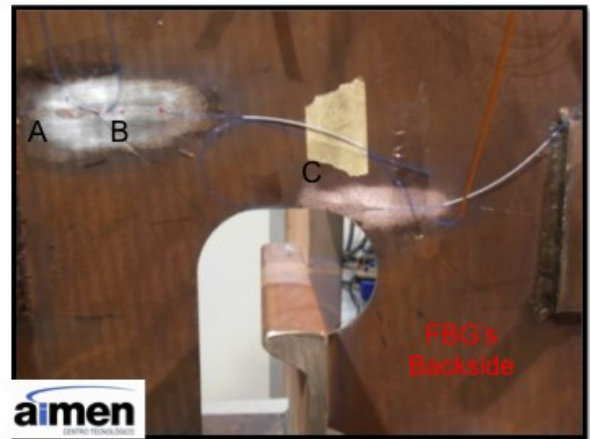
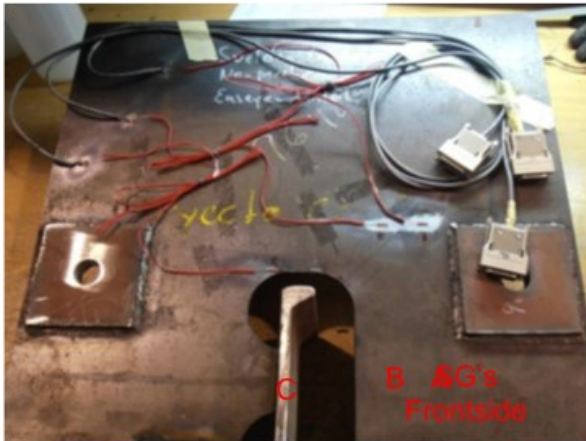
The Co-Patch list of participants and their contact details is as follows:

Participant Number	Participant organization name	Business activity	Contact person
1 (Coordinator)	NATIONAL TECHNICAL UNIVERSITY OF ATHENS (NTUA), Greece	University – Teaching and research	N. Tsouvalis tsouv@mail.ntua.gr
2	ASOCIACIÓN DE INVESTIGACIÓN METALÚRGICA DEL NOROESTE (AIMEN), Spain	R&D and consultancy – Welding, materials, manufact. processes, NDE	E. Rodríguez erodriguez@aimen.es
3	FRANCISCO CARDAMA S.A. (CARDAMA), Spain	Industry – Shipbuilding, construction & repair, <i>SME</i>	M.B. Cardama bca@astilleroscardama.com
4	CETENA S.p.A. (CETENA), Italy	R&D and consultancy – All naval fields	G. Riso giovanni.riso@cetena.it
5	ESTALEIROS NAVAIS DE PENISCHE S.A. (ENP), Portugal	Industry – Shipbuilding, construction & repair in steel and composites, <i>SME</i>	F. Manuel f.manuel@enp.pt
6	HELLENIC REGISTER OF SHIPPING S.A. (HRS), Greece	R&D and consultancy – Classification society, <i>SME</i>	A. Theodoulides theo@hrs.gr
7	INSTITUTO DE SOLDADURA E QUALIDADE (ISQ), Portugal	R&D and consultancy – Materials and joining, design and fabrication, NDE	G.F. Pimenta GFPimenta@isq.pt
8	METTLE SARL (METTLE), France	R&D and consultancy – All naval fields, <i>SME</i>	M. Labrosse m.labrosse@mettle.org
9	NORGES TEKNISK - NATURVITENSKAPELIGE UNIVERSITET (NTNU), Norway	University – Teaching and research	A. Echtermeyer Andreas.Echtermeyer@ntnu.no
10	SHIPBUILDERS AND SHIPREPERAIRS ASSOCIATION (SSA), UK	Industry – UK trade association of shipyards, <i>SME</i>	M. Lightfoot martyn@ssa.org.uk
11	TWI Ltd. (THE WELDING INSTITUTE) (TWI), UK	R&D, consultancy and training – Materials joining technology	E. Kellar ewen.kellar@twi.co.uk
12	ALVEUS d.o.o. (AS2CON), Croatia	R&D and consultancy – All naval fields, <i>SME</i>	A. Klanac alan.klanac@as2con.com
13	THE UNIVERSITY OF SURREY (UNIS), UK	University – Teaching and research	M. Chryssanthopoulos mkchry@surrey.ac.uk
14	UMOE MANDAL AS (UM), Norway	Industry – All composite shipbuilding, repair in steel and composites	T. Salvesen tormod.salvesen@um.no
15	BUREAU VERITAS (BV), France	R&D and consultancy – Classification society	A. Larsen Allan.Larsen@bureauveritas.com

Table of Co-Patch Stakeholders Forum members

#	Company	Business field	Country
1	ABS	Classification society	USA
2	AMBER COMPOSITES	Composite materials manufacturer	UK
3	ANEK Lines	Ship owner	Greece
4	AVIN International S.A.	Tanker Operator	Greece
5	ATLANTIC BULK CARRIERS MANAGEMENT Ltd	Bulk carriers operators	Greece
6	BABCOCK MARINE DIVISION	Composite technology	UK
7	Basque Maritime Forum	Association - Maritime cluster	Spain
8	CARNIVAL SHIP BUILDING	Cruise ship operator	UK / Italy
9	CIRIA	Construction Industry Research and Information Association,	UK
10	CRS	Classification society	Croatia
11	DCNS	DCNS Research - Centre d' Expertise des Structures et Matériaux Navals	France
12	DEPARTMENT OF DEFENCE, DEFENCE SCIENCE and TECHNOLOGY ORGANISATION	Defence	Australia
13	DEVOLD AMT	Fibers manufacturer	Norway
14	ERS Equipment Rental & Services (SAIPEM)	Offshore oil and gas	Italy / France
15	ESR Technology Ltd	Repair and strengthening of metallic bridges	UK
16	FINCANTIERI	Shipbuilding	Italy
17	FURMANITE	Plants and pipelines maintenance	UK
18	GRIMALDI GROUP	Ship owner: Car Carriers, Multipurpose, Full Containers, General Cargo and Car Ferry	Italy
19	GURIT	Development and manufacture of advanced composite materials	UK
	GURIT Italy SpA		Italy
20	HAVEL COMPOSITES	Composite materials supplier	Czech republic
21	HIGHWAYS AGENCY	Executive Agency of the UK Department for Transport – Public Sector	UK
22	ICC	CFRP & GFRP repairs, mining industry	Australia
23	LONDON UNDERGROUND	London underground network management	UK
24	Marine Technical Limits	Repair consultancy	UK
25	Neptune Research Inc.	Composite repair solutions - pipelines	USA
26	NETWORK RAIL	Railways operator	UK
27	NOOR & Partners	Consulting in materials	Italy
28	ONR - Office of Naval Research	Office of Naval Research - executive branch agency within the Department of Defence	USA
29	Pauger Carbon Ltd	Shipbuilder (race ships) in carbon composites	Hungary
30	PETROBRAS	Oil and gas	Brasil
31	Port of Lisbon Administration	Port authority	Portugal
32	REICHOLD AS	Resin manufacturer	Norway
33	SolarTech International Ltd.	Repairs, oil and gas	UK
34	TANKERSKA	Ship owner	Croatia
35	Walker Technical Resources Ltd.	Composite repairs, pipes	UK

MONITORING METHODS AND PROCEDURES



Typical steel structural detail with crack, instrumented with optical FBG gauges and electrical strain gauges



OPTICAL BACKSCATTER REFLECTOMETER™
(Model OBR 4600)

Patched plate test specimens with Optical Backscatter Reflectometry fibres and measurement unit



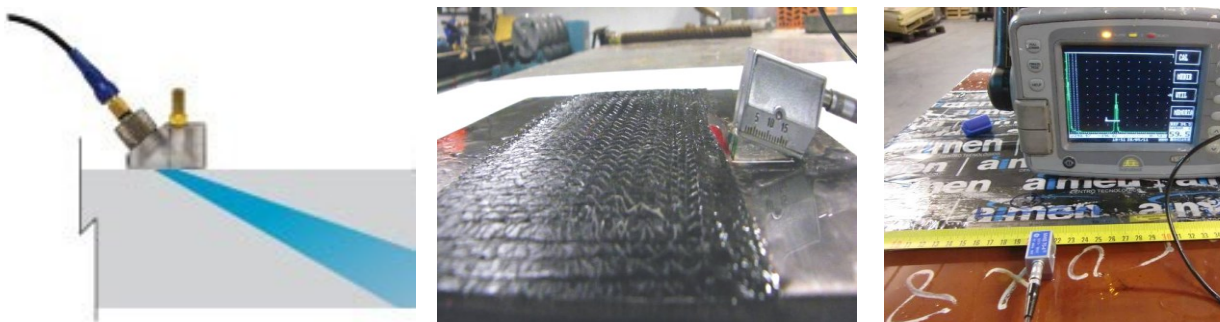
BondMaster acousto-ultrasonic NDE device applied to the Co-Patch full-scale catamaran application



Findings in patched plate specimens after inspection with BONDMASTER device prior to testing

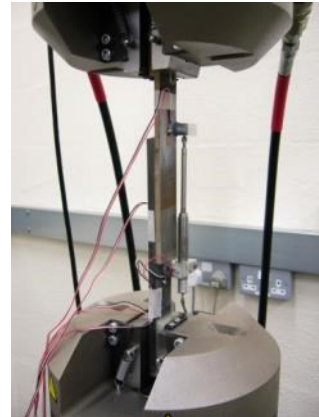
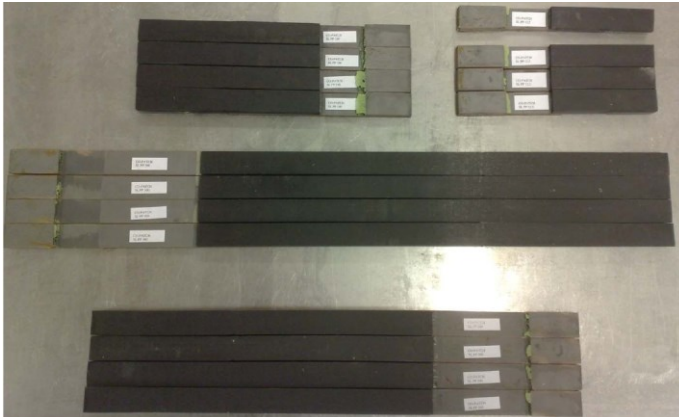


FBG attached to the steel (left), OBR applied to the CFRP composite patch (centre), embedded monitoring systems (right).

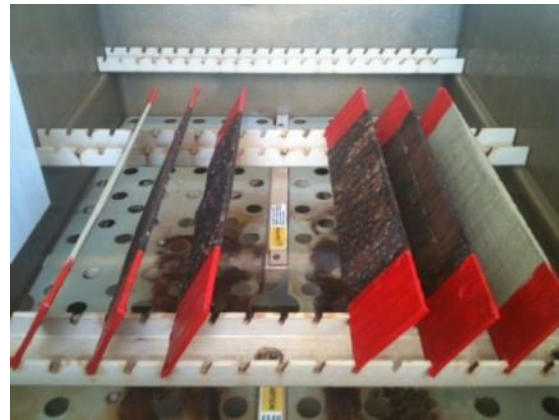


Application of the ultrasonics Pulse-Echo technique on the patched plate

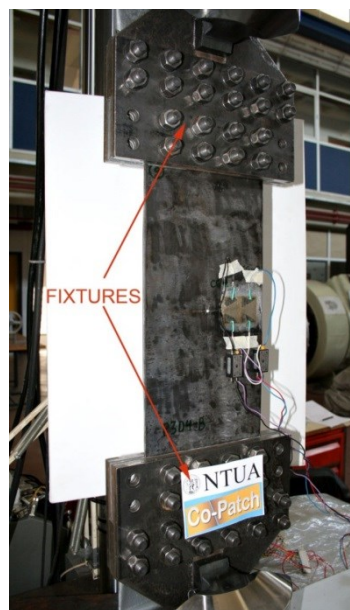
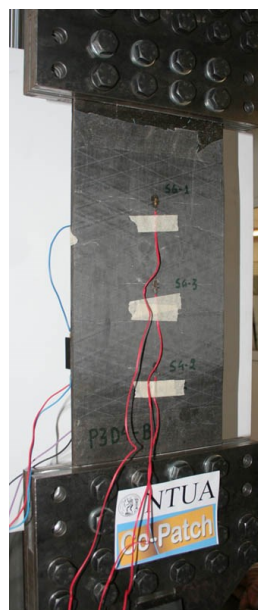
LABORATORY TESTS



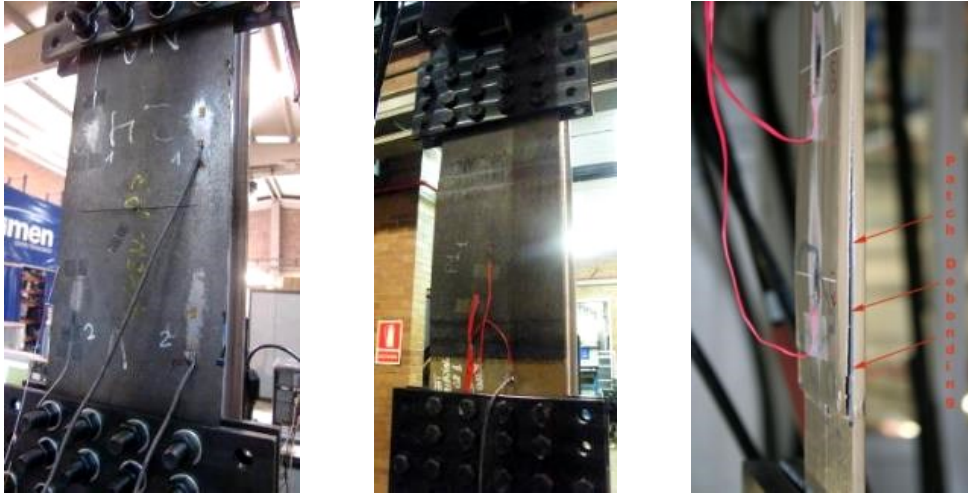
A batch of Single Lap Shear test specimens (left) and typical test arrangement (right)



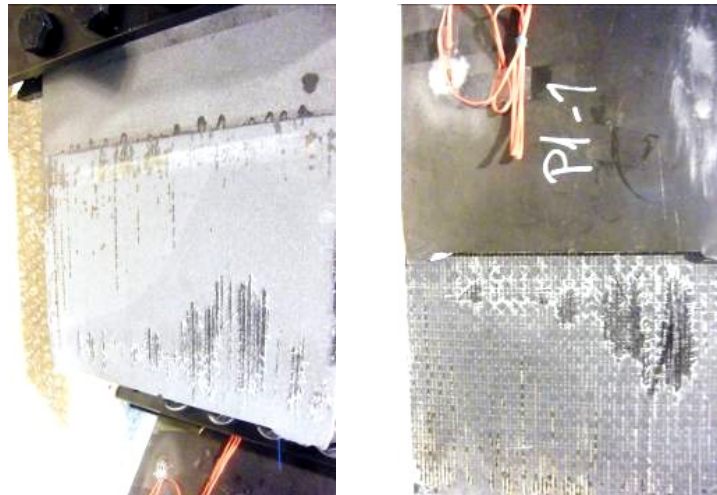
Manufacturing (left) and artificial aging (right) of P2 plate specimens



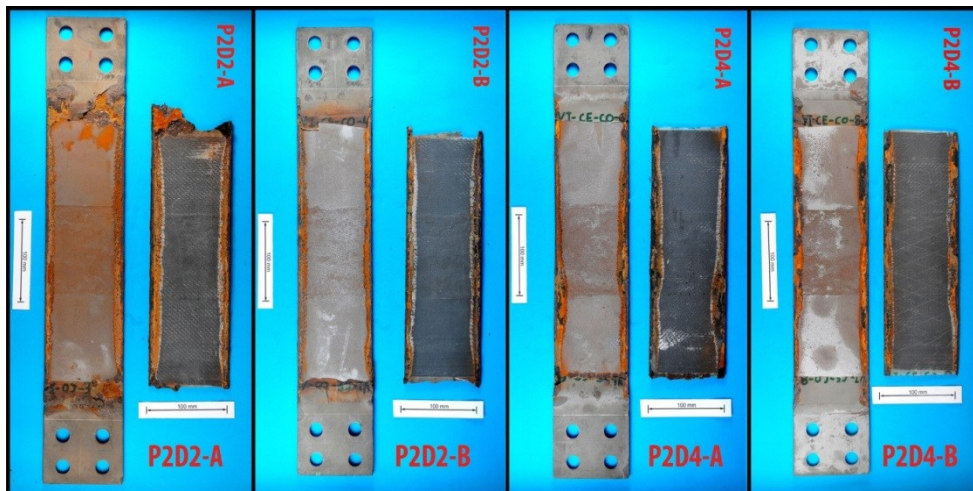
Patched plate specimens tested in fatigue (patched side-left, unpatched side-right)



Back side (left) and patched side (middle) of a plate tensile test; patch debonding on a plate specimen (right)



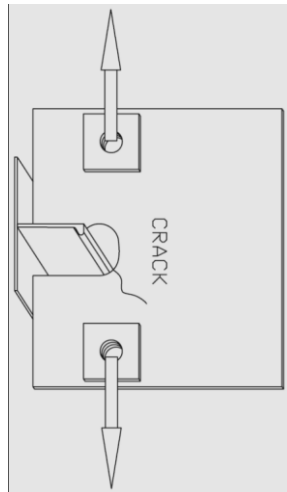
Indicative patch debonding of grit blasted plate specimen after failure



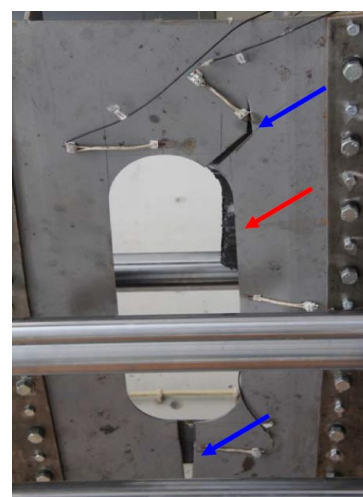
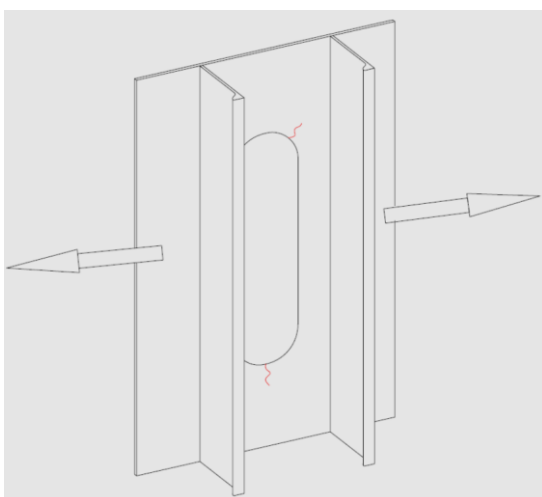
Reduction of the effective bonding area due to corrosion infiltration in unpainted, aged corroded specimens (after testing)



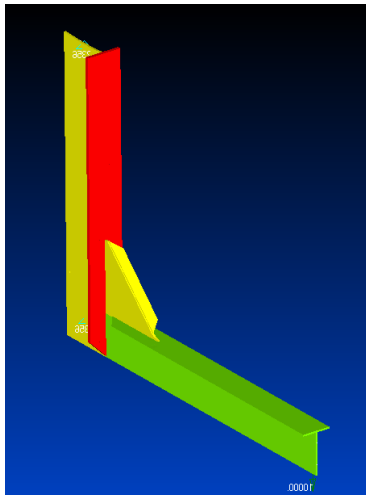
4-point bending test arrangement of patched beam specimens (left) and patch debonding (right)



Test of large-scale marine case 1



Test of large-scale marine case 2



Test of large-scale marine case 3

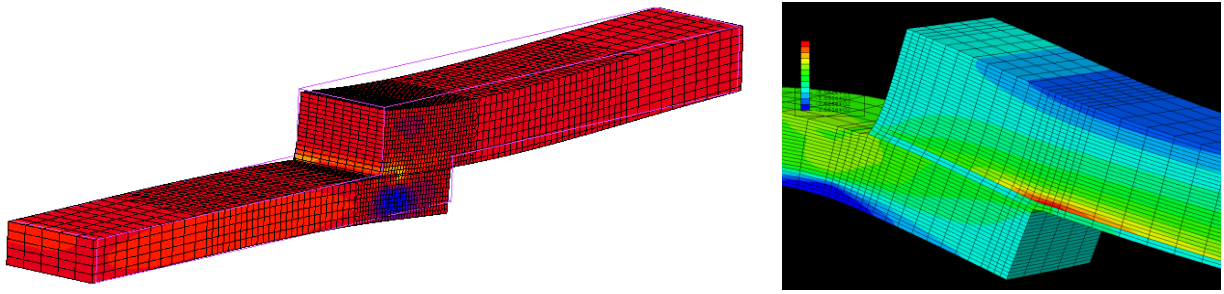


Patch lamination at the bottom flange of a civil engineering application girder

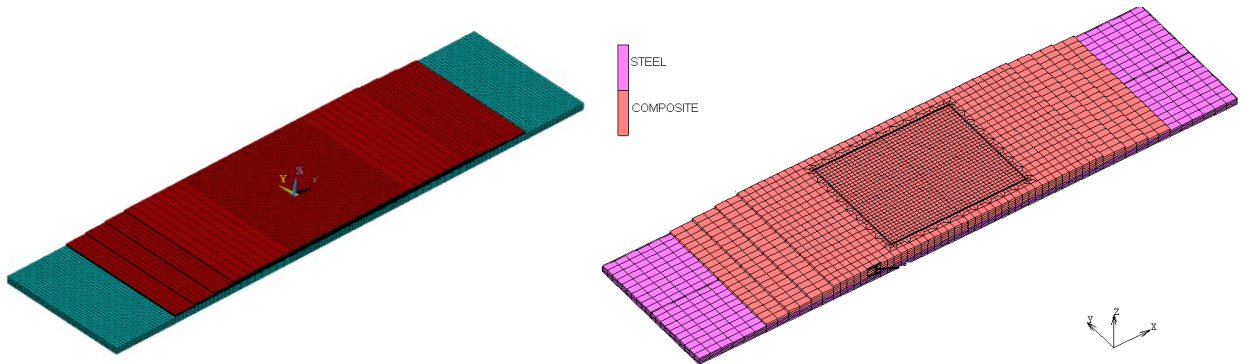


4-point bending test arrangement (left) and bonded composite beams against web breathing (right) in civil engineering applications steel girders

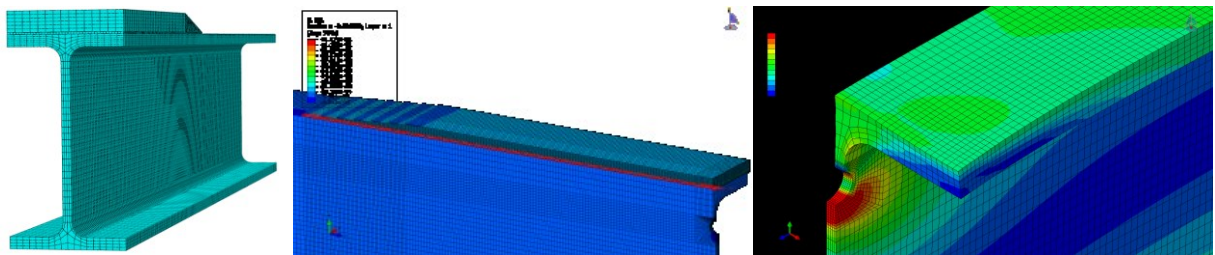
NUMERICAL SIMULATIONS



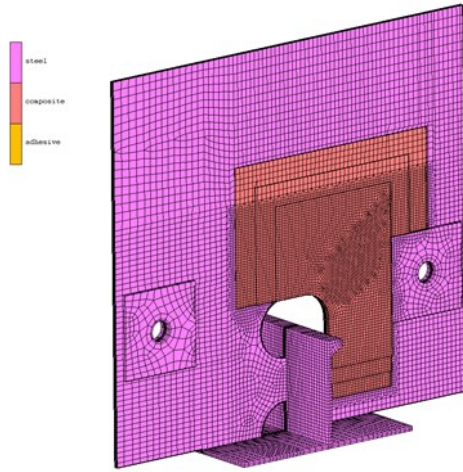
Numerical models of Single Lap Shear test specimens



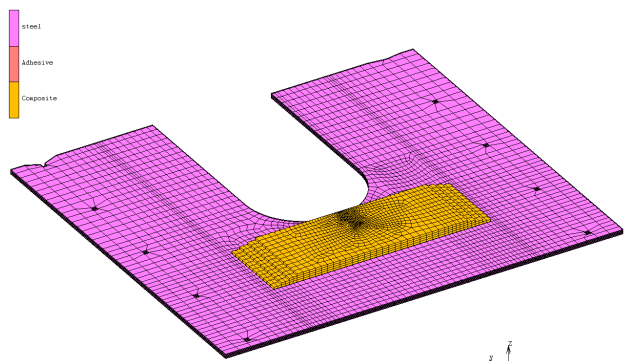
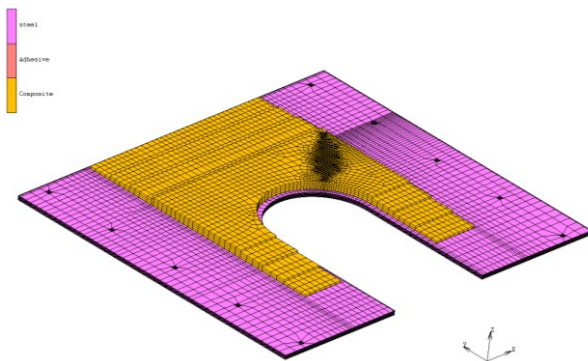
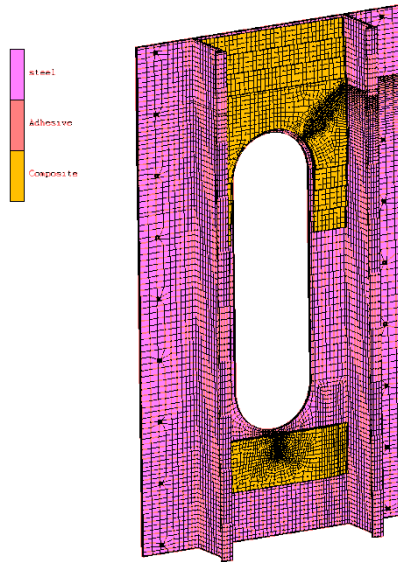
Numerical models of patched plate specimens



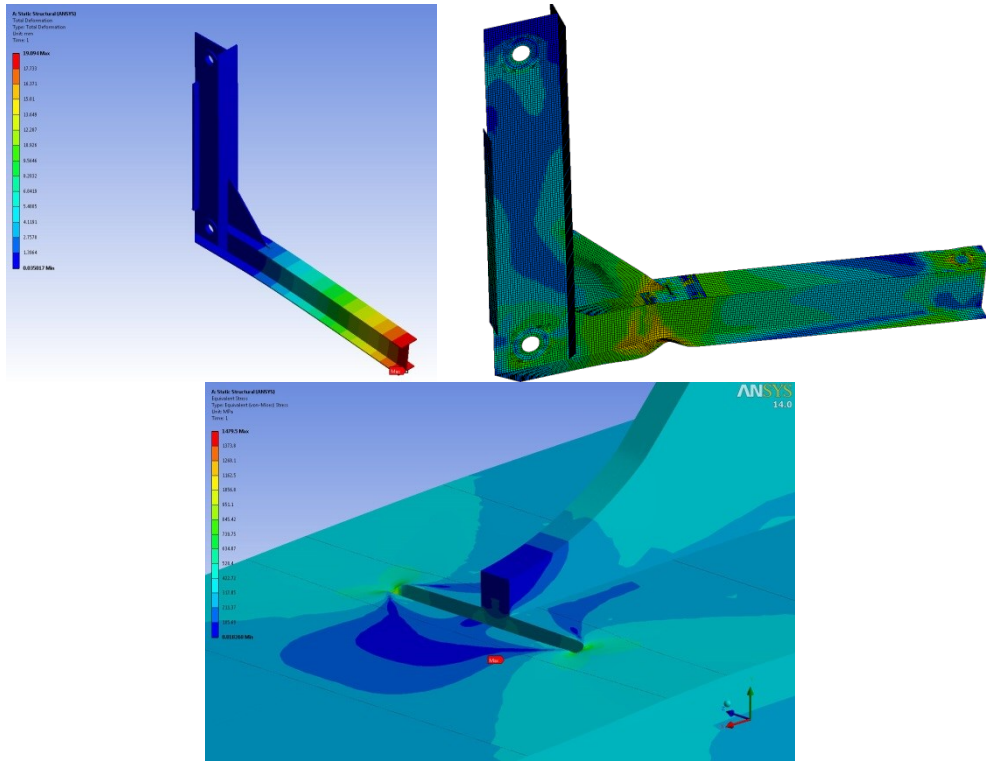
Numerical models of mid-scale patched beam specimens



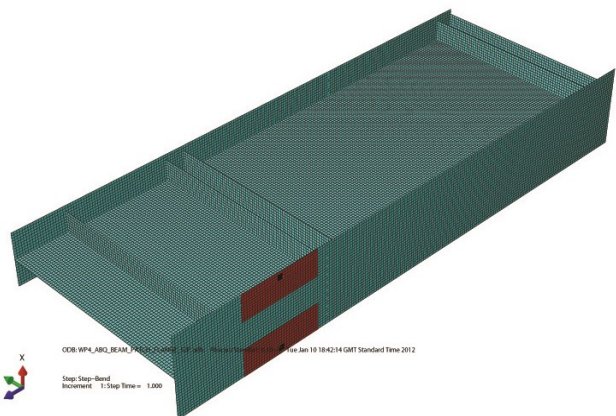
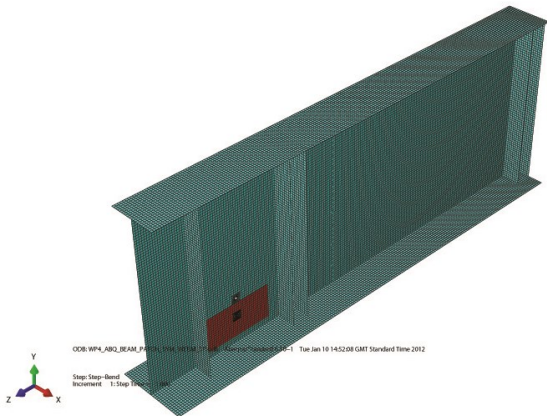
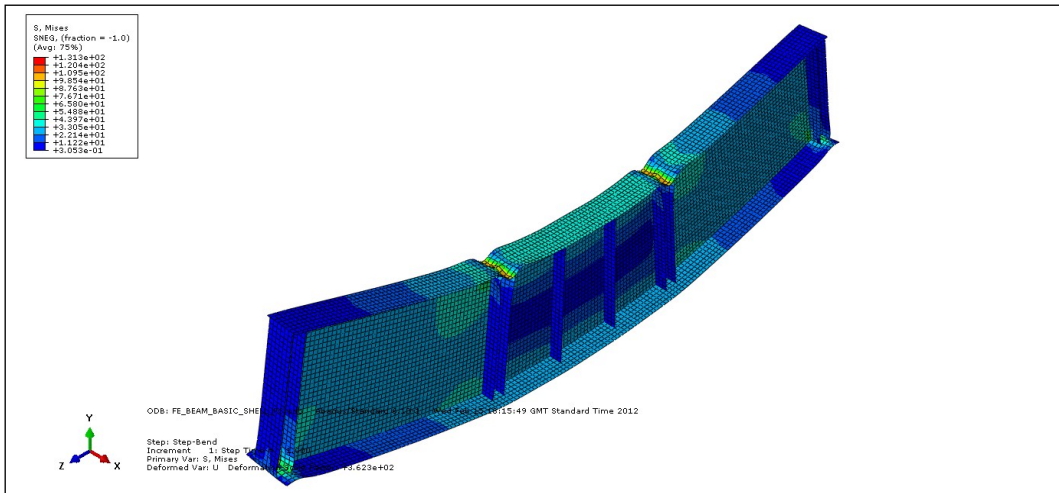
Numerical model of large-scale marine case 1



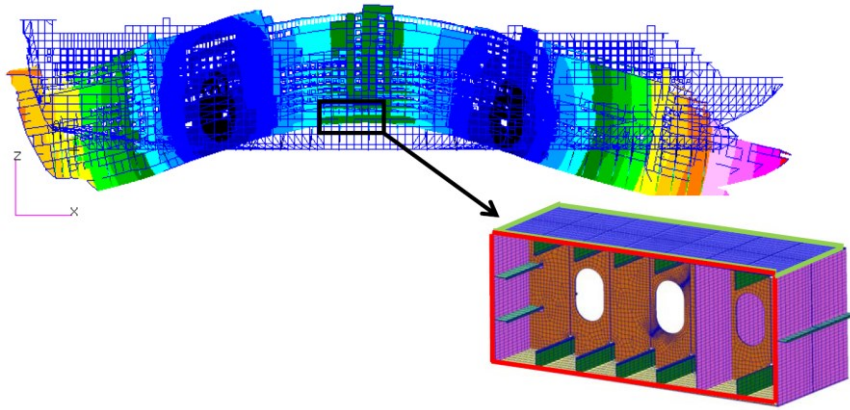
Numerical model of large-scale marine case 2



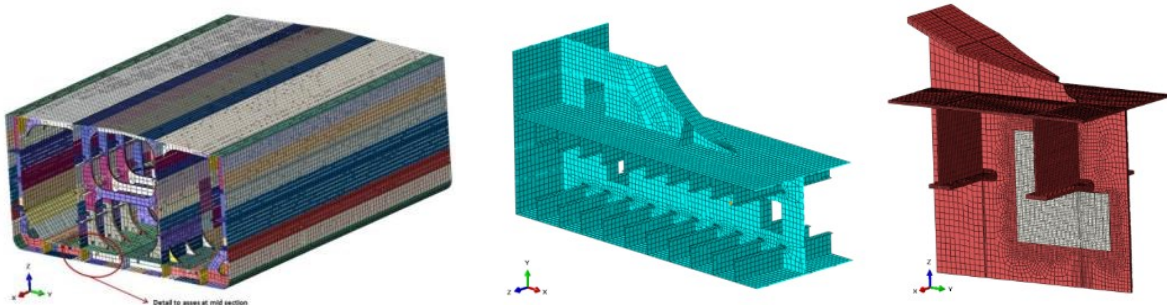
Numerical model of large-scale marine case 3



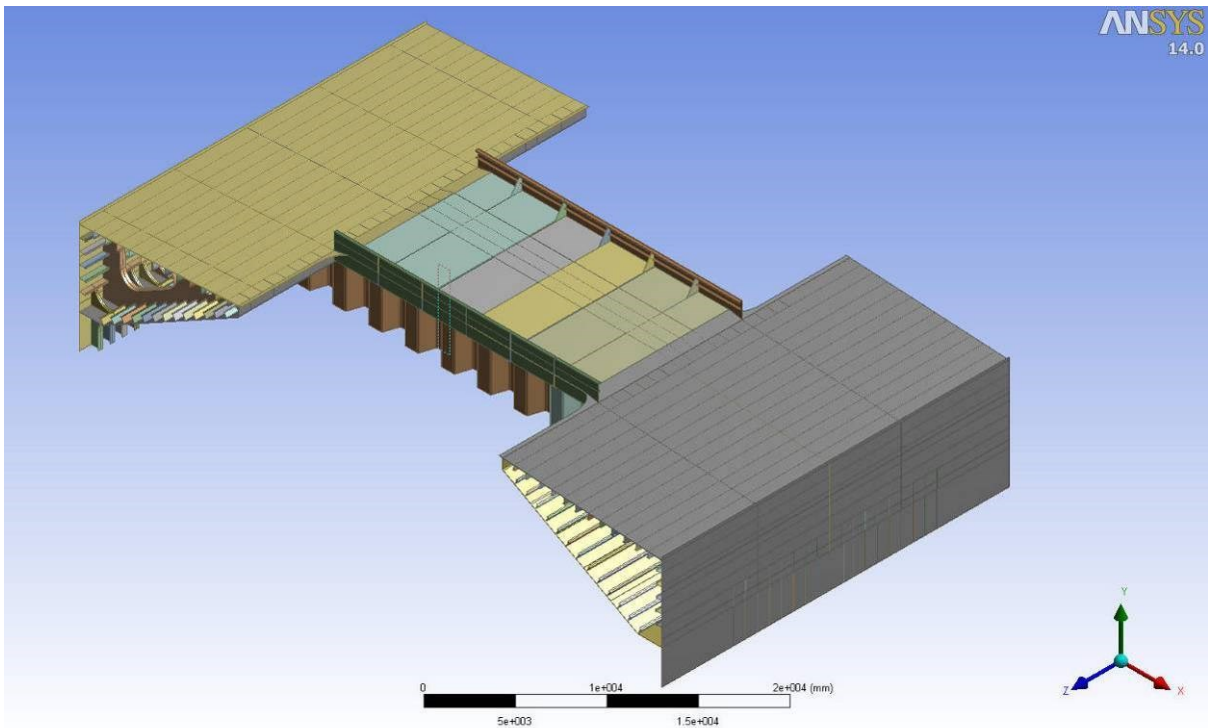
Configurations of civil details in FE modelling



Global / local modelling guidelines for a ship structure



Different FE models from global to local (one of the typical patch repair cases)

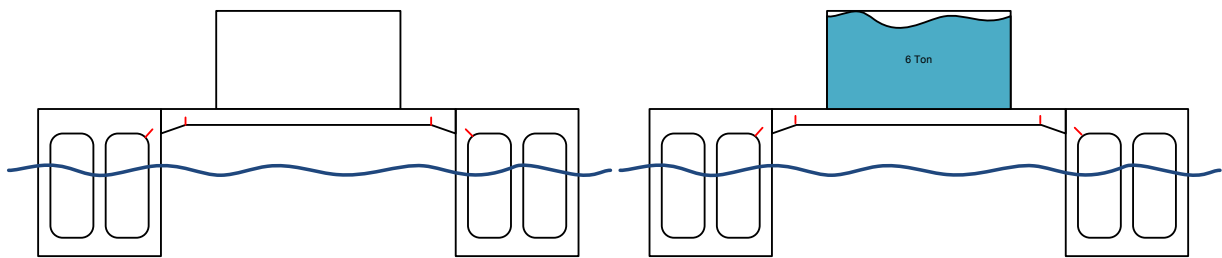


FE model of the typical repair case of strengthening the cross deck of a bulk carrier against buckling

FULL-SCALE TESTS

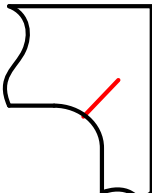
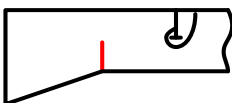
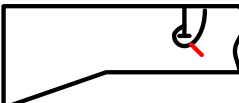
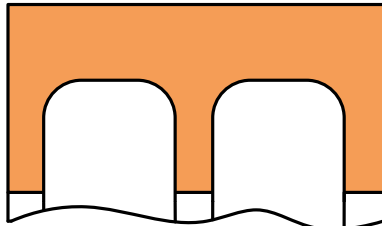


Patch installed on deck of M/V FRANKOPAN – unpatched plate (left), patched plate (right)



Section view of the specially built Catamaran. Upper tank is sequentially loaded and unloaded.

Matrix of different types of defects on Catamaran

<i>Crack 1</i>	<i>Crack 2</i>	<i>Crack 3</i>	<i>Corroded bulkhead</i>
			



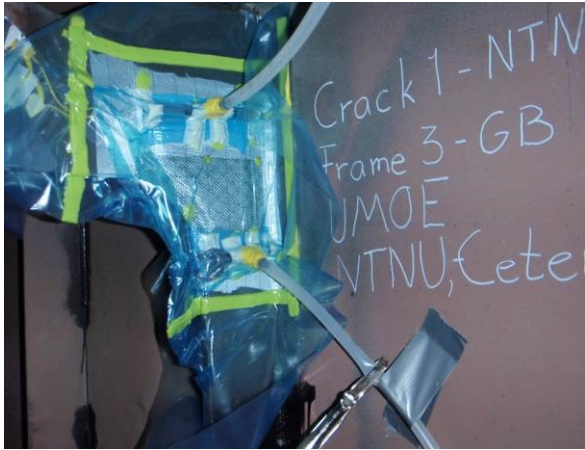
The Catamaran structure platform for full-scale tests



Different types of cracks on the transverse beams of the Catamaran



Sensors' wiring at the defects area for monitoring structural response



Vacuum infusion of patch repair inside the Catamaran (left) and finished patch (right)



Ro-PAX garage floor repairs – before repair (left), after patch repair (right)