# BONDSHIP - refreshing course and brief outlook

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- Project
- Partners
- Objectives
- Structure of the project
- Application Cases
- Lessons learned
- Outlook

# What was BONDSHIP?

## BONDSHIP

Project ID: G3RD-CT-2000-00101
Funded under: FP5-GROWTH

### Bonding of lightweight materials for cost effective production of high speed craft and passenger ships (BONDSHIP)

2000-04-01 to 2003-06-30

### Project details

| | |
|---|---|
| **Total cost:** | **Topic(s):** |
| EUR 4 568 914 | 1.1.3.-3. - Key Action Land Transport and Marine Technologies |
| **EU contribution:** | **Funding scheme:** |
| EUR 2 160 000 | CSC - Cost-sharing contracts |
| **Coordinated in:** | |
| Norway | |

**by DNV**



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# http://cordis.europa.eu/project/rcn/51636_en.html

## Participants

Expand all

| | |
|---|---|
| ALUSUISSE ROAD & RAIL LTD. | Switzerland |
| DÉLÉGATION GÉNÉRALE POUR L'ARMEMENT | France |
| FINCANTIERI - CANTIERI NAVALI ITALIANI SPA | Italy |
| FiReCO AS | Norway |
| JOS. L. MEYER GMBH | Germany |
| NDT SOLUTIONS LTD | United Kingdom |
| SIKA SCHWEIZ AG | Switzerland |
| STENA REDERI AB | Sweden |
| THE ITALIAN SHIP RESEARCH CENTRE | Italy |
| UNIVERSITY OF SOUTHAMPTON | United Kingdom |
| VOSPER THORNYCROFT LIMITED | United Kingdom |
| FRAUNHOFER IFAM | Germany |



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# Objectives

The BONDSHIP project is a major European initiative

- to introduce into shipbuilding the use of adhesive bonding for joining lightweight materials.
- The aim is to make European shipyards more competitive by achieving considerable cost savings in the production of passenger ships and high-speed craft (~30% for a small superstructure).
- This will be achieved by
  (a) studying the structural behaviour of bonded joints, including long-term performance in a marine environment,
  (b) designing, building, testing and repairing prototypes involving superstructures of patrol craft, secondary attachments to cruise ship superstructures and load bearing connections in superstructures, and
  (c) preparing guidelines for use of adhesive bonding in such applications.
  The main results are guidelines for the design and modelling of bonded joints; acceptance tests and criteria; inspection methods; documented application cases and joint designs; production and repairs procedures.

# Adhesive Bonding

- Thousands of adhesives are on the market
- The behaviour of an adhesive joint depends on
  - the geometry,
  - the environment,
  - the adhesive,
  - the adherends,
  - the manufacturing process,
    the load case,
  - the loading rate,
  - the manufacturing process,
  - ….

➔ (Class) approval of an adhesive does not help!

➔ How to approach the problem?



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# Work Packages and Tasks

Design and Modelling

Testing

Vosper Thornycroft: AC Patrol Vessel

Fincantieri: AC Cruise Ships

Meyer Werft: AC Cruise Ships

| WP1: DESIGN, MODELLING AND TESTING OF JOINTS |
|---|
| 1.1 Modelling of joints |
| 1.2 Testing of joints |
| 1.3 Structural analysis and global strength analysis |
| 1.4 Design of joints |
| **WP2: ACCCEPTANCE AND QUALIFICATION OF JOINTS** |
| 2.1 Specify application cases |
| 2.2 Selection of materials |
| 2.3 Define guidelines and procedures |
| 2.4 Inspection of joints |
| 2.5 Feedback from trials on a ship |
| **WP3: APPLICATION CASE 1** |
| 3.1 Prototype design |
| 3.2 Production of prototype |
| 3.3 Repair trials |
| 3.4 Performance of joints and critical defects |
| **WP4: APPLICATION CASE 2** |
| 4.1 Prototype design |
| 4.2 Production of prototype and testing |
| 4.3 Repair trials |
| **WP:5 APPLICATION CASE 3** |
| 5.1 Prototype design |
| 5.2 Production of prototype and testing |
| 5.3 Repair trials |
| **WP6: PROJECT MANAGEMENT AND EXPLOITATION OF RESULTS** |
| 6.1 Co-ordination of project |
| 6.2 Technical coordination of WP's |
| 6.3 Preparation of exploitation of results |



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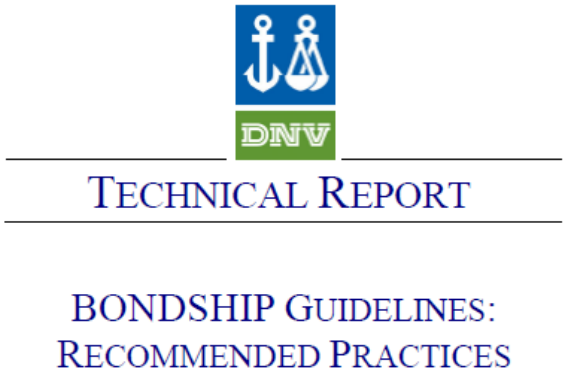
# BONDSHIP

BONDSHIP is about the procedure to use adhesive bonding

in shipbuilding and to bond on shipyards



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# Application cases an Requirements

List of requirements with 17 main features following a general design method:

| List of Requirements<br>A. Test plant: Wall with frame segment | | C=Claim<br>D=Desire |
|---|---|---|
| Quotat. No. | Product | Worked out by |
| 399042mb | **AC 1 Load Bearing Structures with Large Dimensions**<br>Bonding of Funnel or Deckhouse to Deck | |

| Requirements | | | | |
|---|---|---|---|---|
| C<br>D | No. | Designation | Values, Data<br>Explanations<br>Changings | Responsible<br>Clarified by: |
| | 1.1 | Geometry: Actually single stanchions resp. shell of sec. structure immediately welded to deck, see e.g. drawing No.: 0640 110 C 08 25 | Drawings of actual constructions | JLM |
| | 1.2 | Geometry: Bonding joint has to be designed acc. to loads | Designing of | IFAM |
| | 1.6 | Geometry: Companion dimensions to adjacent parts of the structure have to be considered | 0-20 mm | JLM |
| | 2.1 | Kinematics:<br>DNV Pt. 3 Ch. 1 Sec 4, Other Rules for Bonding ? | Rules of classifi-cation society? | DNV |
| | 2.2 | Kinematics: Longitudinal acceleration | ≈ 0.2 g in ($m/s^2$) | JLM |
| | 2.2 | Kinematics: Transversal acceleration | ≈ 0.5 g in ($m/s^2$) | JLM |
| | 2.3 | Kinematics: Vertical acceleration | ≈ 1.2-1.5 g in($m/s^2$) | JLM |
| | 2.4 | Kinematics: Vibrations, frequency (e.g. rolling periode 13 s) | 0-50 1/s | JLM |
| | 2.5 | Kinematics: Vibrations, amplitude | (4 – 10 mm/s)<br>+- 50 kN | JLM |



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# Application Cases

VT-AC 1: Superstructure of high speed craft
Fin-AC 1: Fairings on cruise ships
Fin-AC 6: External casing
Fin-AC 8: Internal corrugated bulkheads
JLM-AC 1: Load bearing secondary structures with large dimensions
JLM-AC 2: Foundations on deck
JLM-AC 3: Fixturing profiles for internal outfitting walls
JLM-AC 4: Lightweight Structures (Sandwich Panels)
JLM-AC 5: Cargo lashing devices on RoRo decks
JLM-AC 6: Doors, windows and hatches
JLM-AC 7: Gutterways on decks
JLM-AC 8: Joints of large external structures connected to load-carrying primary structures
JLM-AC 9: New modular structures for balconies in cruise ships
JLM-AC 10: Attachments below decks

# AC Patrol Vessel  (Vosper Thronycroft)




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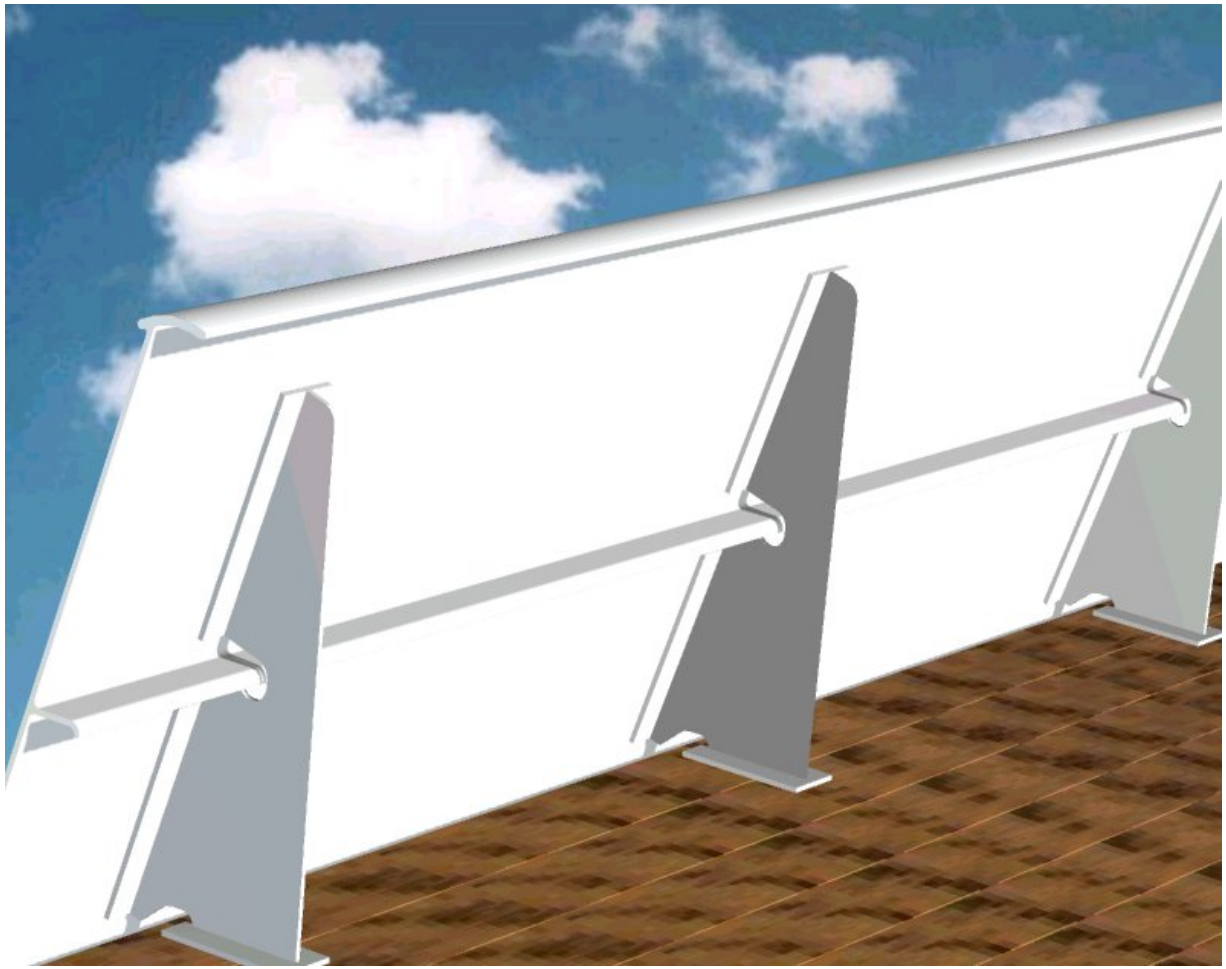
# Fairings (Fincantrieri)





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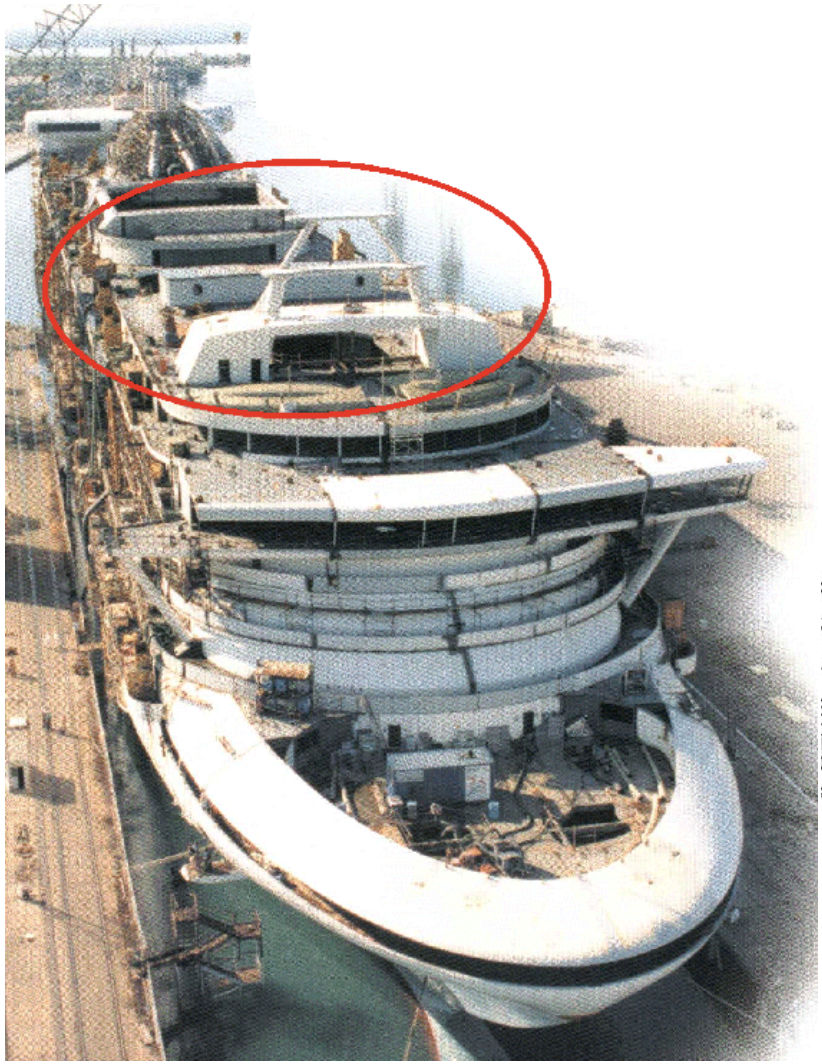
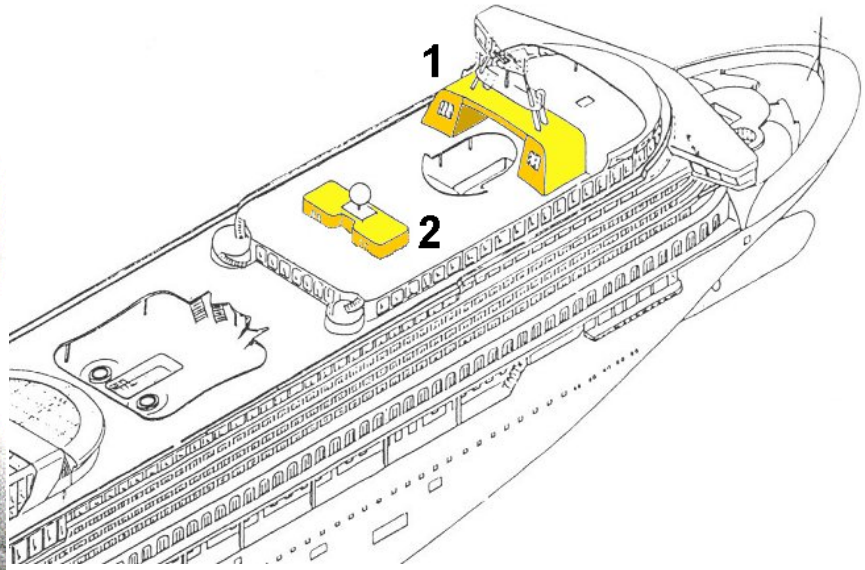
# External casings (Fincatieri)





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# JLM-AC9: Balcony

2002


Bonding in Shipyard Environment



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# JLM-AC9: Balcony (load carrying structures)


2002



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# JLM-AC9: Balcony – testing

crane with load cell
(max. 5000 kg)



08.2002



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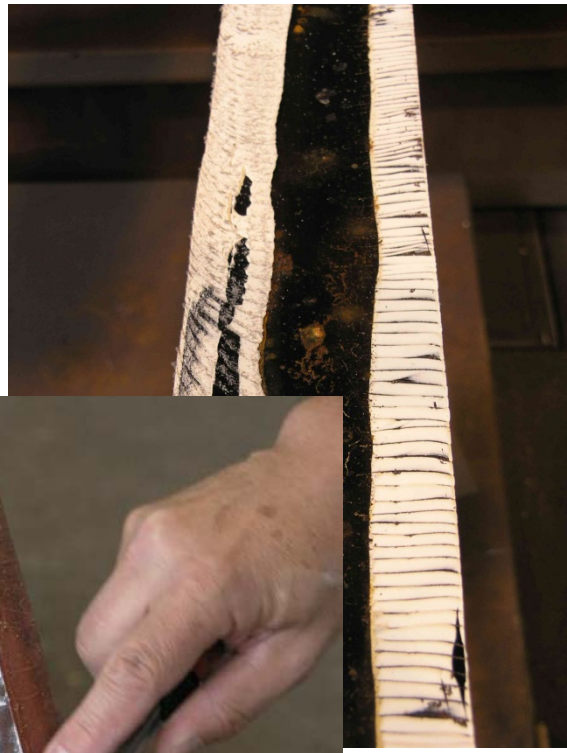
# JLM-AC9: Balcony – manufacturing and ageing

Bonded 03.2002



… opened 01.2009 in DeLight



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# JLM-AC9: Balcony – re-bonding in DeLight


Re-Bonded 1.2009, 12.2009 and 01.2010



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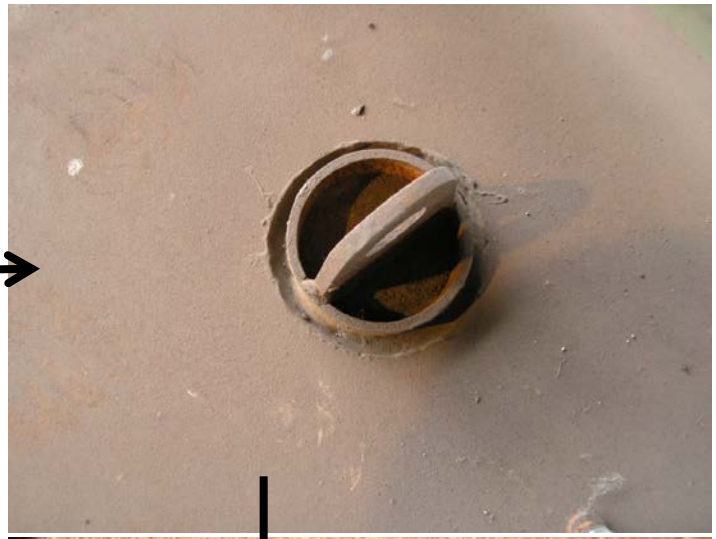
# Testing the new joints (approx. 700 kg)

# JLM - AC05 Cargo Lashing Device

Bonded 03.2002



Opened 07.2008



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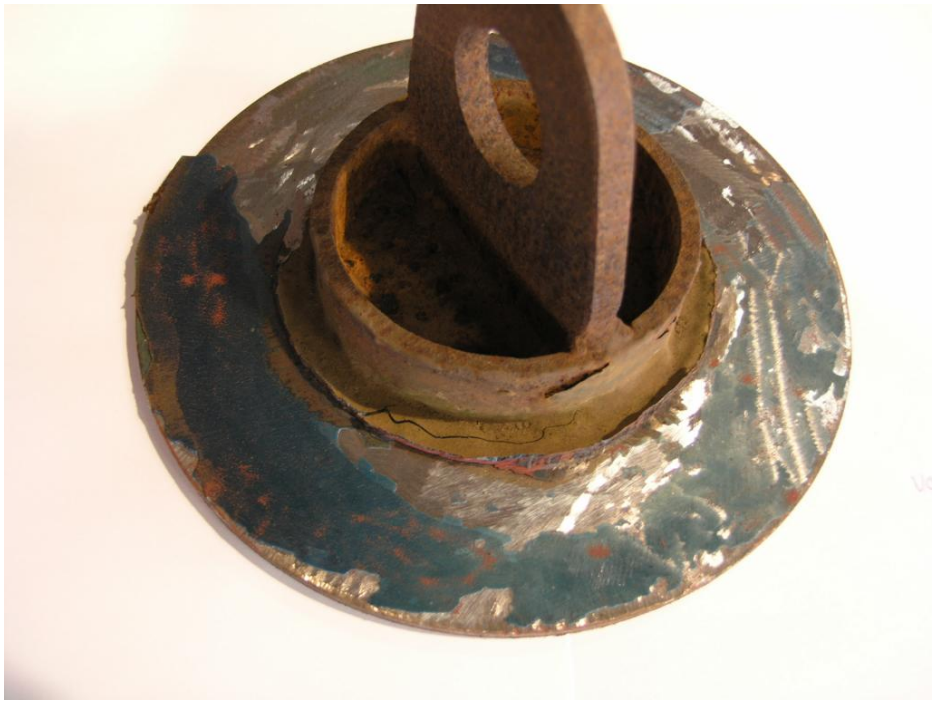
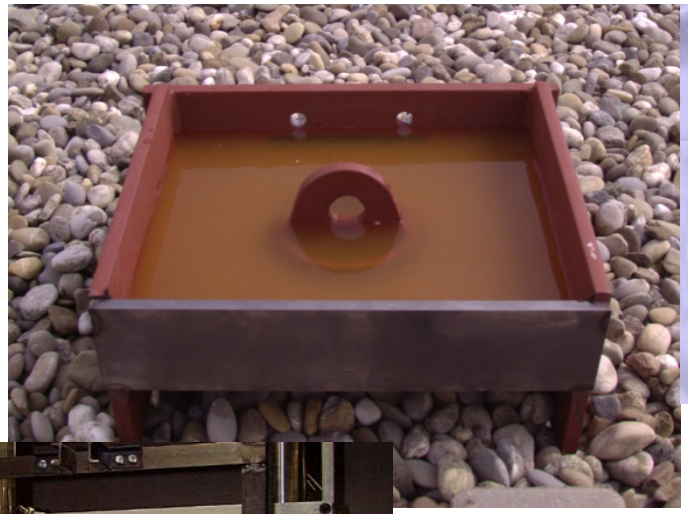
# Fracture Pattern after 6 years of ageing outside

Only a few spots
With bondline
corrosion!



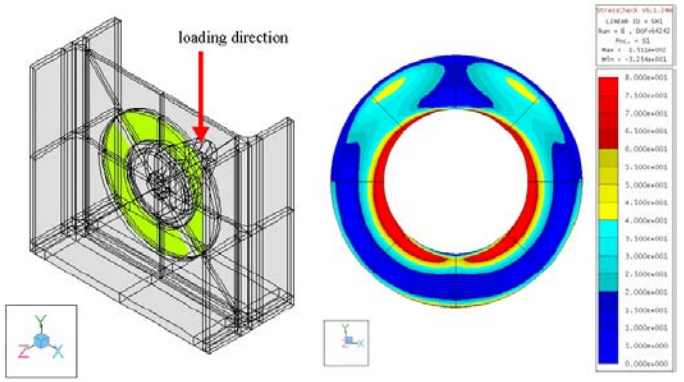
# Accelerated testing in BONDSHIP




04.2002 → 8 month → 01.2003

- Static testing before ageing: 90 / 290 kN

- Fatigue before and after ageing



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# JLM-AC 6 Doors, …

Bonded 03.2002

15 years

01.11.2017

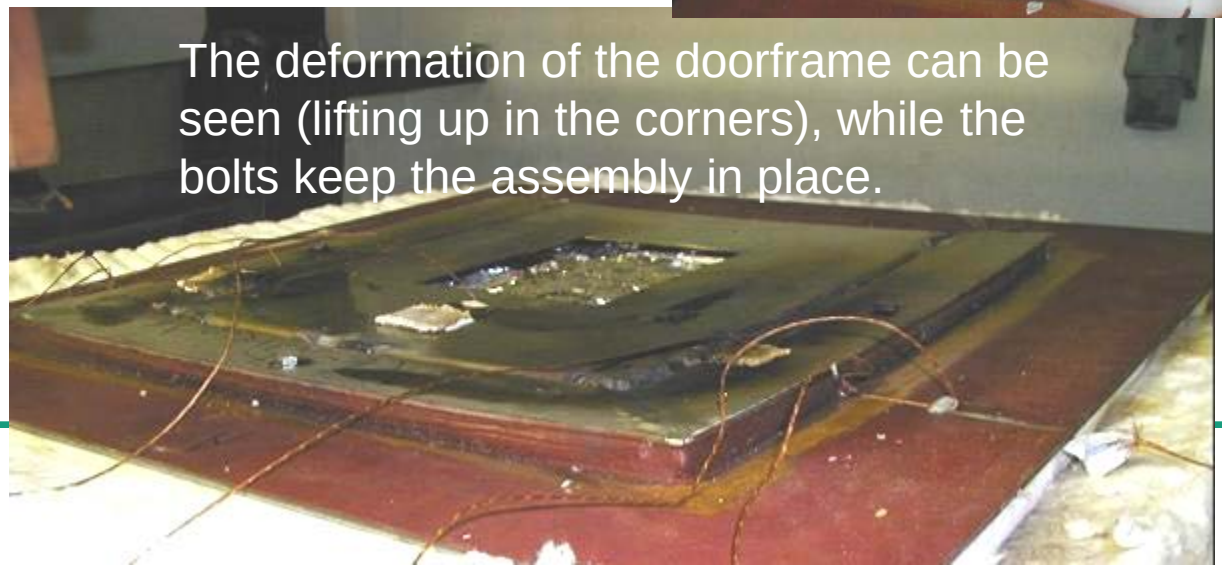
# JLM-AC 6 Doors, …

„Small“ door frame for fire testing.

08.2002

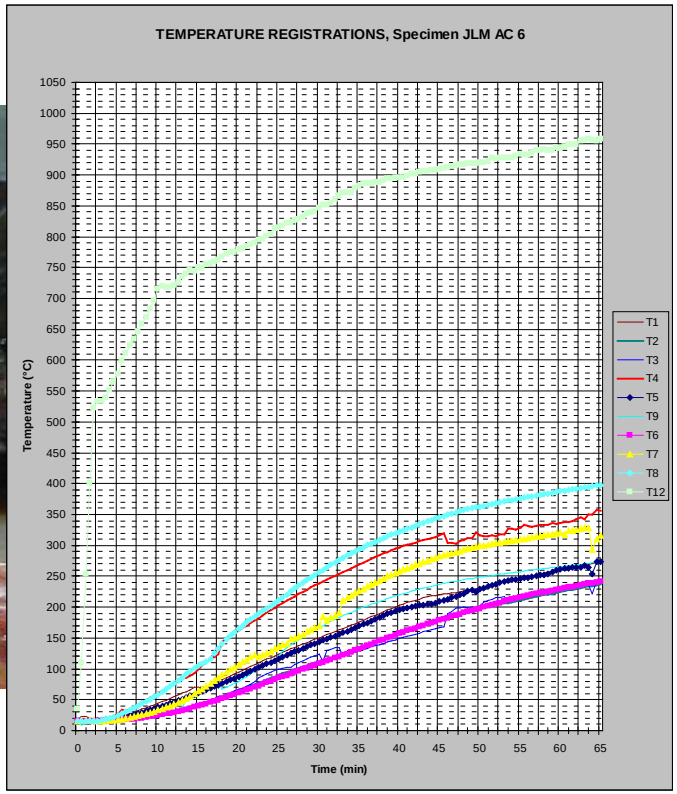
# Fire Testing

Photos showing smoke development during the first 5 to 10 minutes of fire test. From the photo on the right it can be seen that the smoke is not from the adhesive.



The deformation of the doorframe can be seen (lifting up in the corners), while the bolts keep the assembly in place.

# Fire Testing




- The adhesive layer is soft and permanently destroyed.
- The temperature rise on the door blade at 60 min is more than 250°C (T9).
- The temperature on the unexposed side of the door frame is 336-338°C (T4 and T8) at 60 min.
- The temperature in the bondline between bulkhead part and adhesive (T2 and T6) is approx. 225°C at 60 min, while the temperature behind the insulation (T1 and T5) was 260°C at 60 min .



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# JLM-AC 01 Load bearing secondary structures with large dimensions

Bonded 03.2002

15 years

01.11.2017



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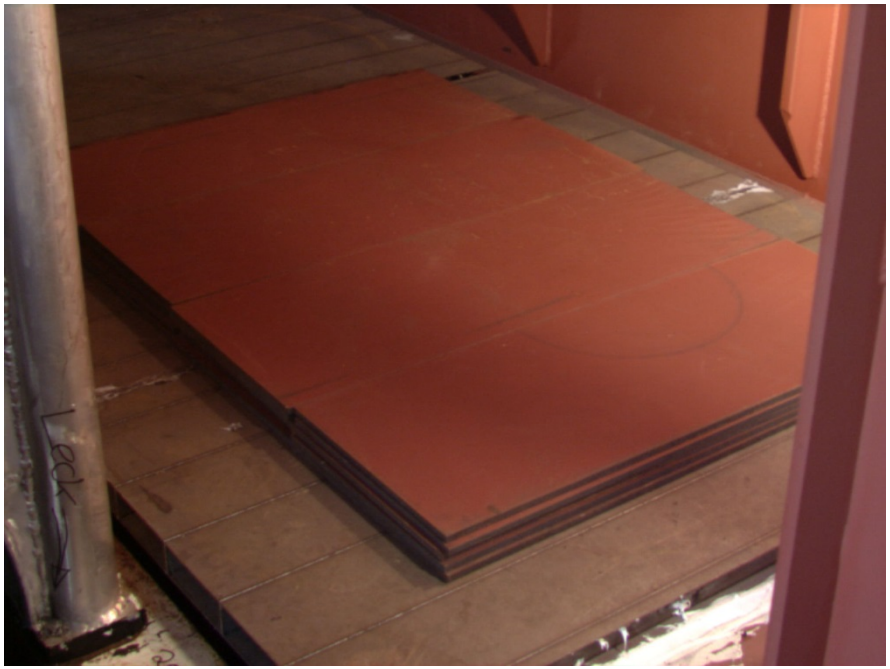
# JLM-AC 4: Lightweight Structures (Sandwich Panels)



15 years



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# Describe Adhesives
# Data sheets for „Workhorse“ adhesives which follow the requirements in ship building

… after test specification and testing

| Materials Data Sheet | | | | | |
|---|---|---|---|---|---|
| **Manufacturer:** | Sika | | | | |
| **Trade name of** | | | | | |
| **1. Identificatio** | 3.43 Creep behaviour | | | | 7 |
| 1.1 Type of adh | 3.44 Knock down factor creep | | | | |
| 1.2 Chemical ba | | | | | |
| 1.3 Description | | | | | |
| | **4. Storage** | | | | |
| | 4.1 Shelf life(1) | 9 months | | | |

… based on more than 500 pages of test reports … which are still available.

# Lessons learned:

… the main obstacles to apply adhesive bonding are:

- Unused to methods to approach an application
- Long qualification procedures


- Qualification of people on all levels
  ➔ long term behaviour

## Open Question:

- Who is taking the risk if anything goes wrong?



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# Outlook

➔ Open remaining adhesive joints in mock-up – investigate the biotope


➔ Clearify how to use results from BONDSHIP in RAMSSES



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# Disclaimer

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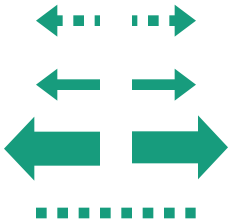
# Grafische Elemente
# Kästen, Pfeile, Verbindungen und Linien (Auswahl)

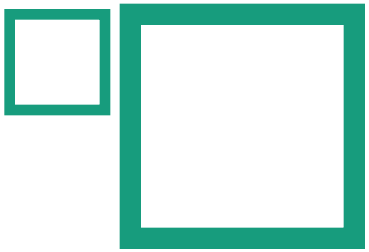
! DIESE FOLIE AUS FINALER PRÄSENTATION LÖSCHEN !

- folgende Elemente können hier per Rechtsklick kopiert und an gewünschter Stelle in der neuen Präsentation per Rechtsklick wieder eingesetzt werden:

Kasten gefüllt
- Grau



Pfeile und Verbindungen
- Fraunhofer-Grün



Kasten mit Outline
- Fraunhofer-Grün
- Linienstärke je nach Größe 2, 4, 6, 8 pt
- Je größer der Kasten, desto stärker die Linie

Linien
- Fraunhofer-Grün, bis 1 pt auch Schwarz
- Linienstärke gestrichelt: 1 pt
- Linienstärke durchgezogen: 1, 2, 3, 4 und 5 pt



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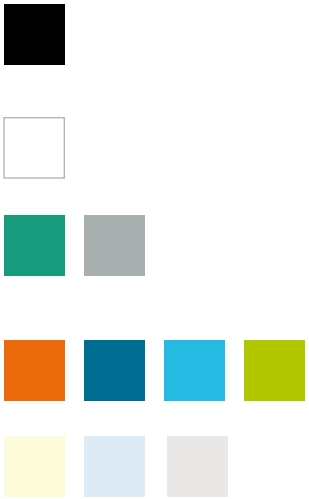
# Farben

! DIESE FOLIE AUS FINALER PRÄSENTATION LÖSCHEN !

- folgende Farben können über die Powerpoint-Farbauswahl hier aufgenommen und damit in der neuen Präsentation angewendet werden:

- Überschriften / Fließtext / Quellenangaben / Bildunterschriften / Grafikauszeichnungen
- Grafikauszeichnungen
- Aufzählungen / Nummerierungen erster Ebene / grafische Elemente
- Grafiken
- Fonds hinter Grafiken





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