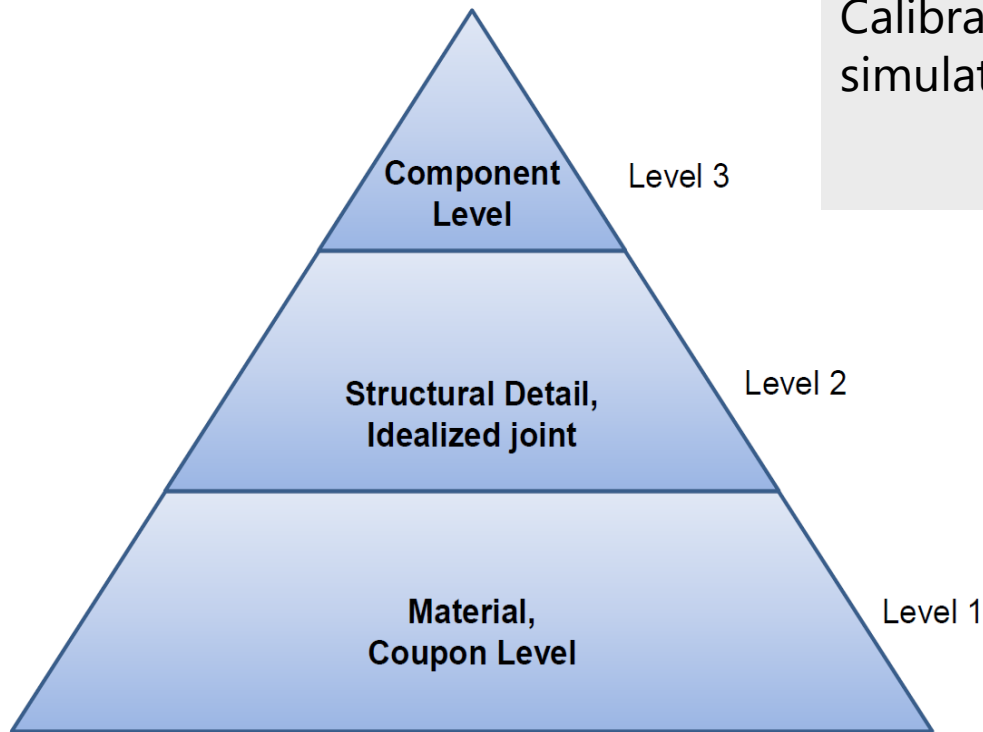


STRUCTURAL INTEGRITY OF BI-MATERIAL THICK ADHESIVE JOINTS: A MULTI-SCALE APPROACH



A MULTI-SCALE TEST PYRAMID (REVIEWED BY CLASS)

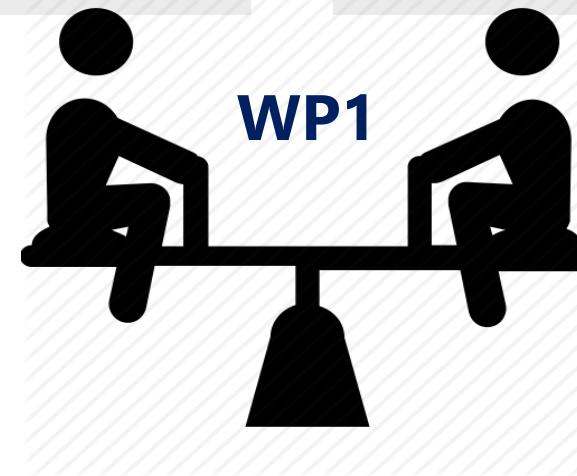


EXPERIMENTS

Understand materials and joints
Calibrate and validate simulations

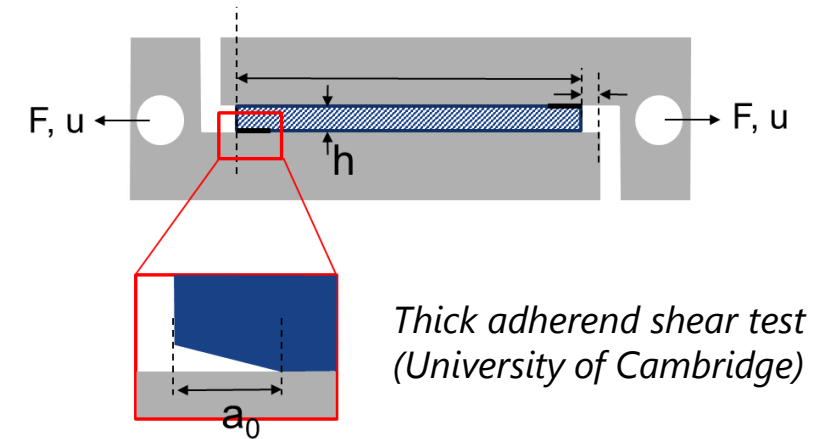
SIMULATIONS

Develop (multi-physics) numerical models
Value: predict complex joints, less (expensive) experiments

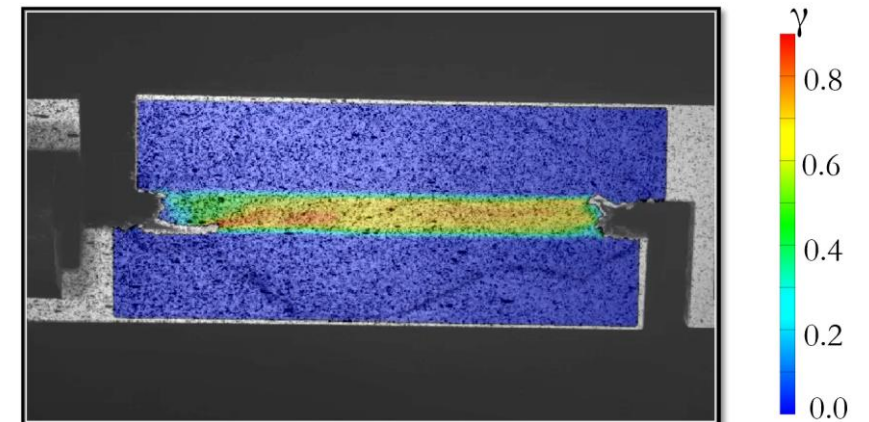


LEVEL 1 TESTING: MATERIAL, COUPON LEVEL

- Basic mechanical and physical properties of constituents
 - Tensile testing
 - Water uptake / diffusion coefficient
 - Dynamic mechanical analysis
 - Thick adherend shear stress
 - Single and double lap tensile test

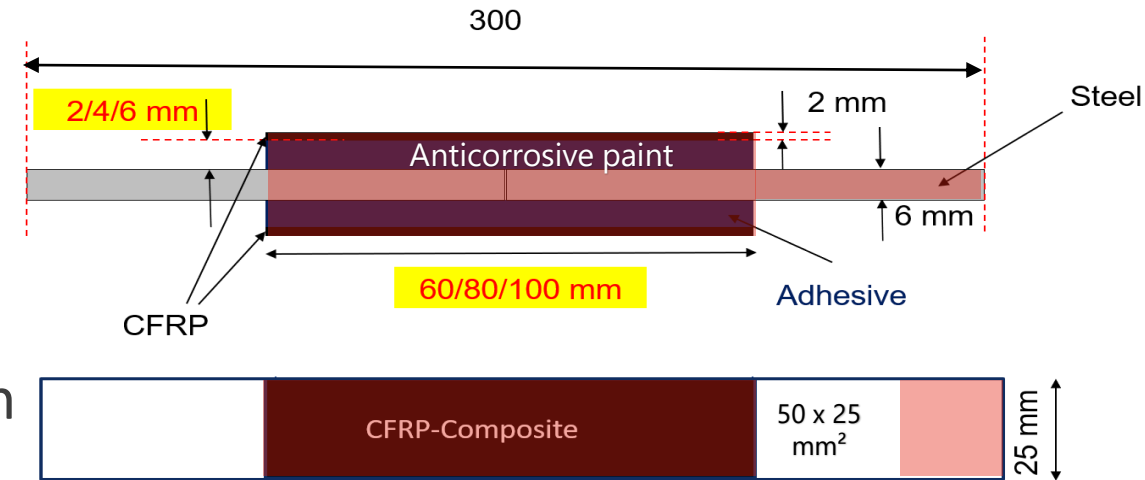
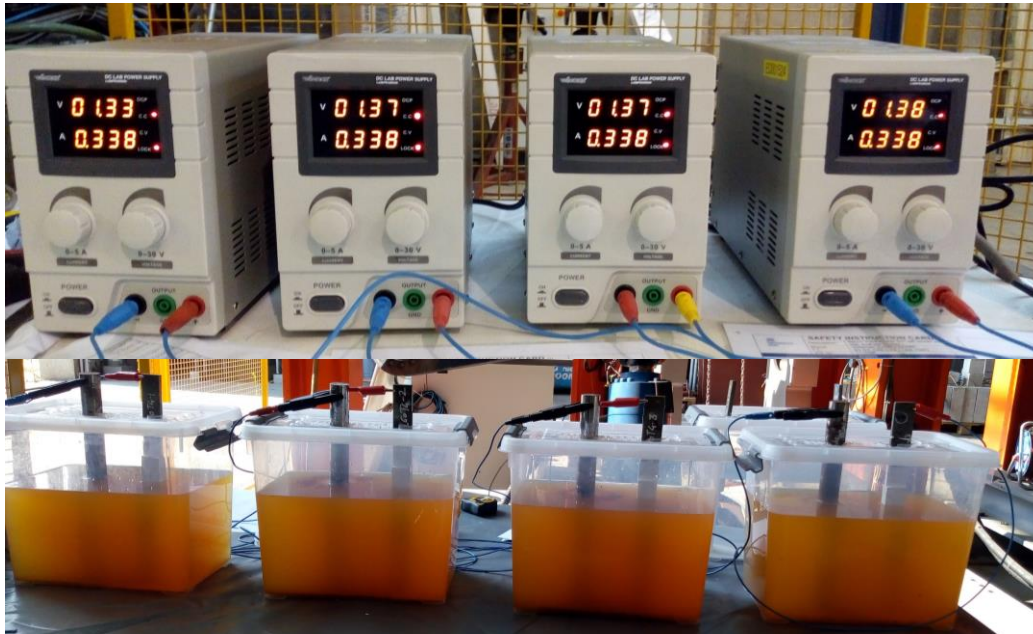


*Thick adherend shear test
(University of Cambridge)*



TENSILE TESTS ON CORRODED DOUBLE LAP SPECIMENS

- Acceleration of corrosion process in electrochemical setup
- Evaluation of residual strength
- Effect of adhesive thickness and overlap length

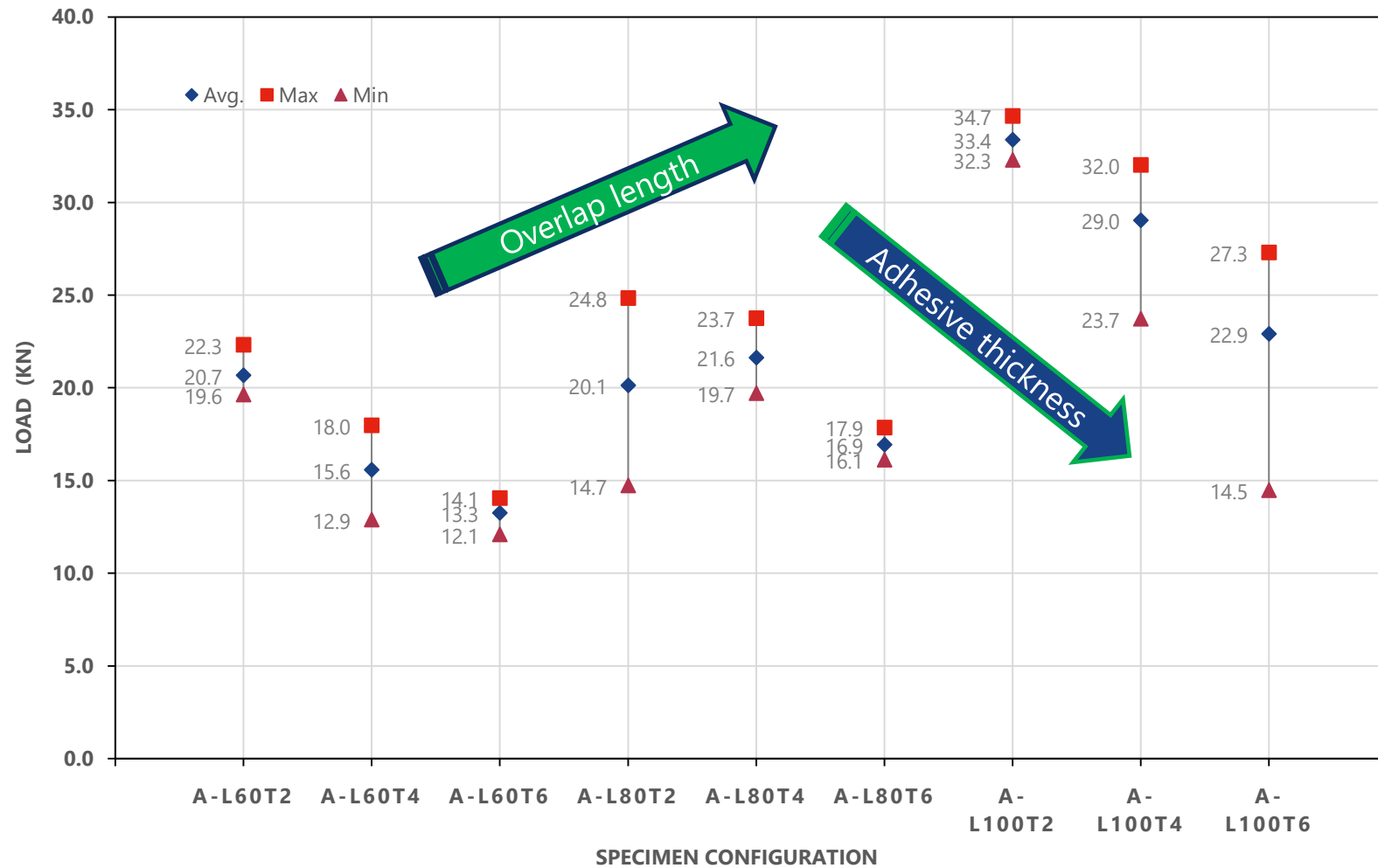


Before ageing



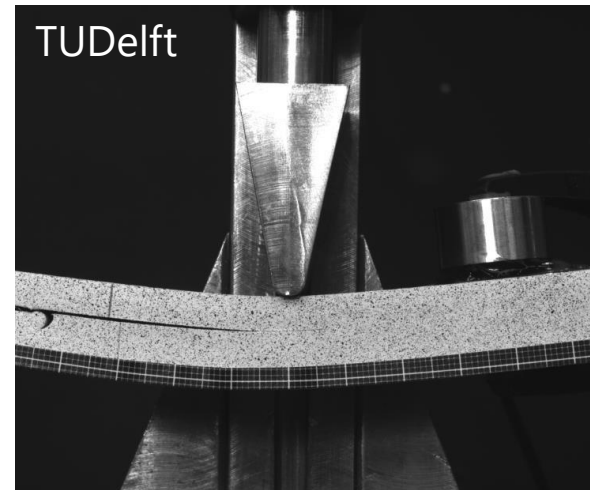
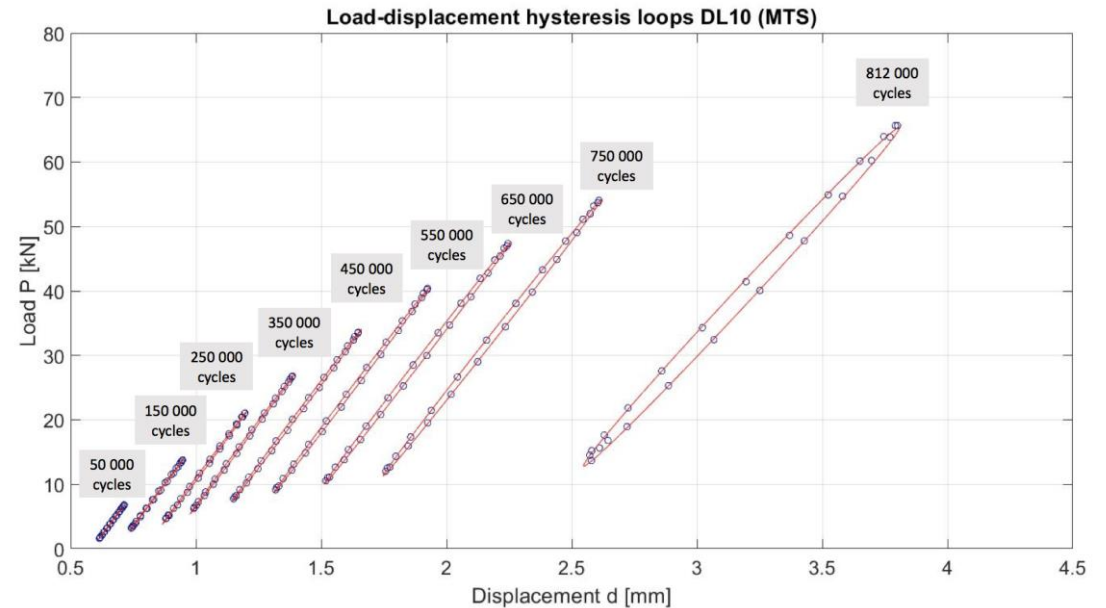
After ageing

SUMMARY OF TEST RESULTS

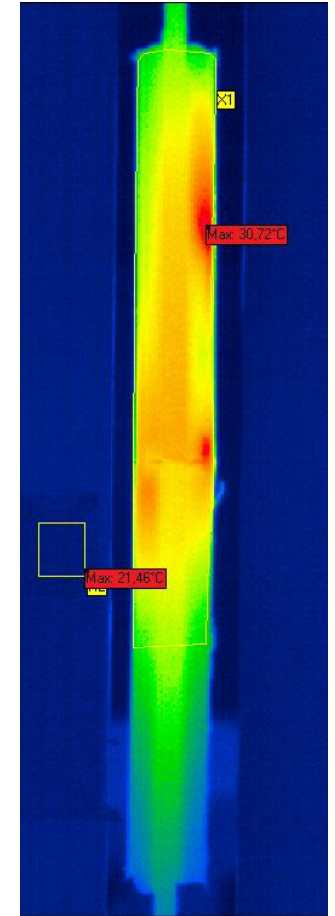
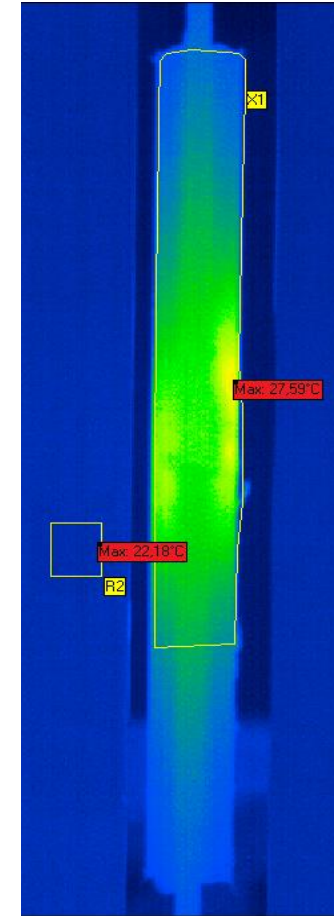
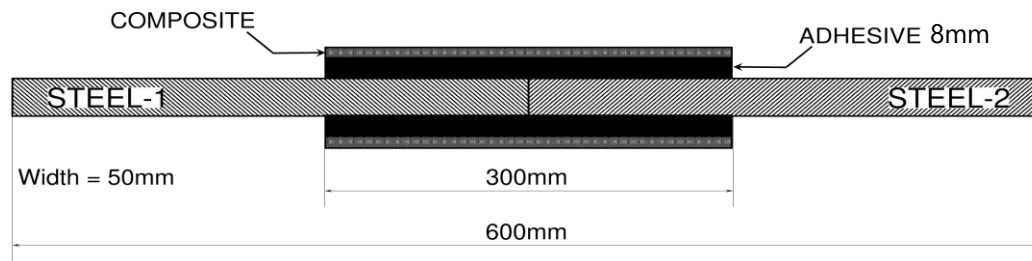


LEVEL 2 TESTING: STRUCTURAL DETAIL, IDEALIZED JOINT

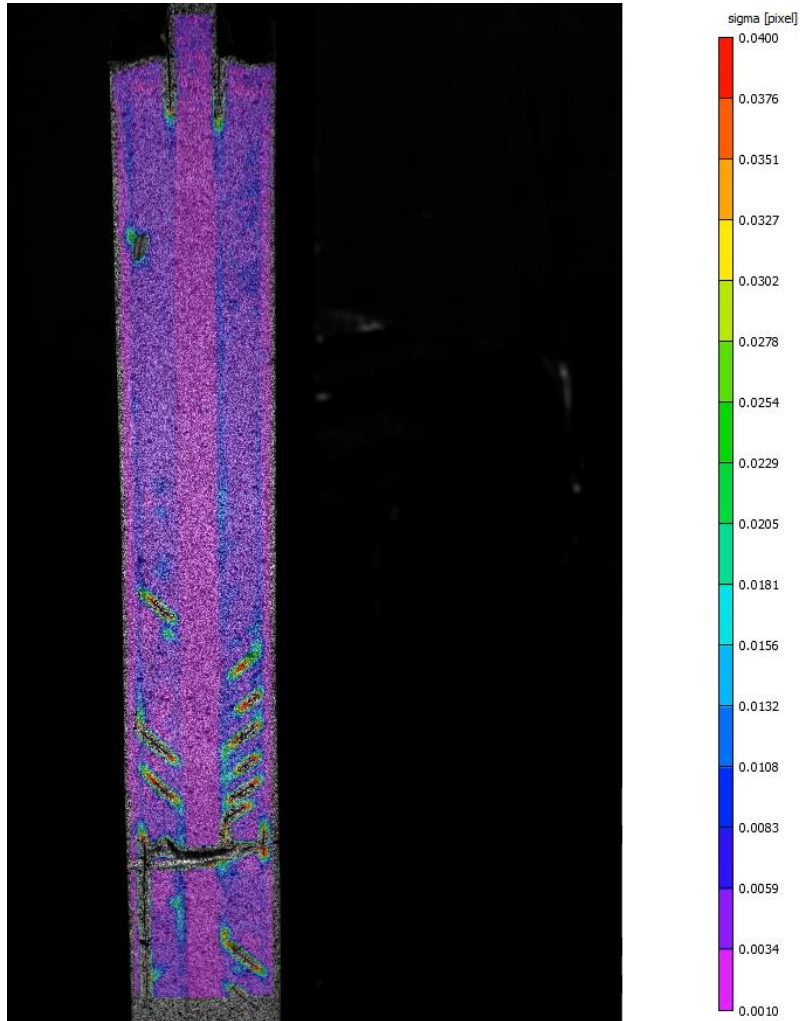
- Strength, failure and toughness characterization, accelerated determination of fatigue properties
 - Double strap joint
 - Double cantilever beam
 - End notched flexure



FATIGUE TESTING OF DOUBLE STRAP JOINTS AND INFRARED INSPECTION

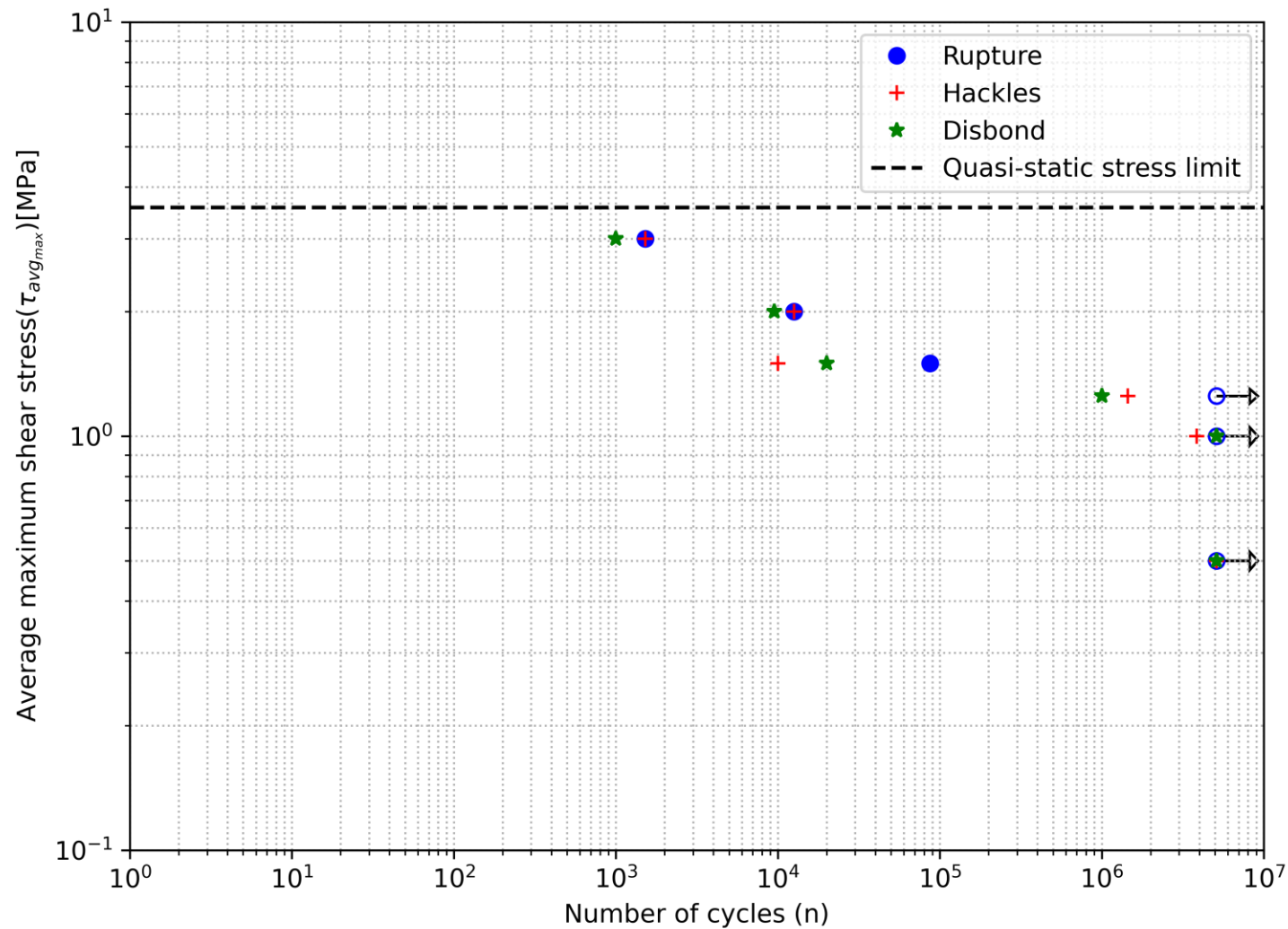


FATIGUE DAMAGE IDENTIFICATION USING DIGITAL IMAGE CORRELATION



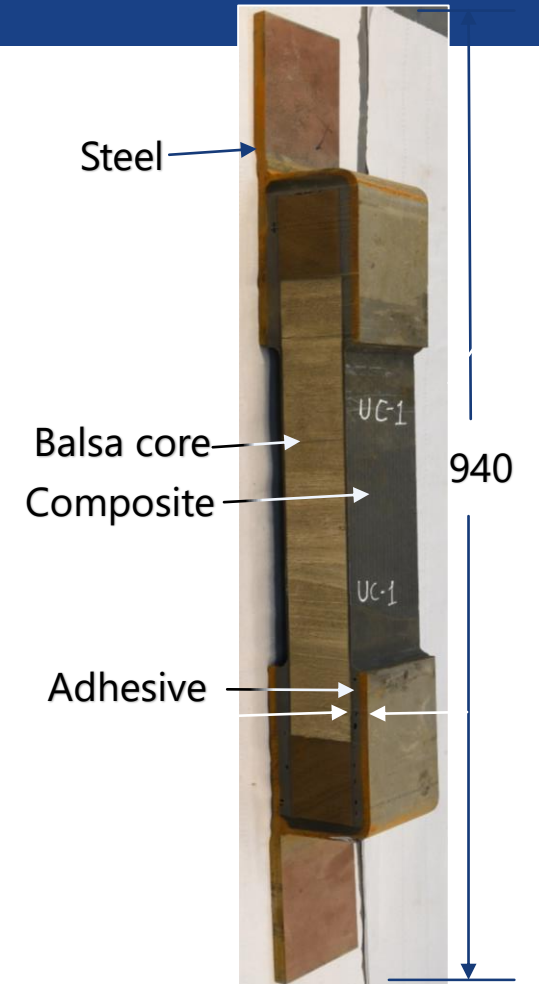
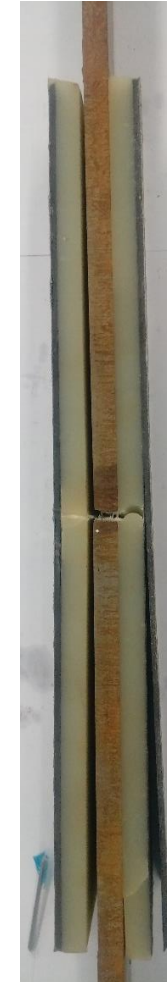
- Illustration for specimen tested at a maximum value of 1.25 MPa nominal average shear stress
- Disbond between the steel-composite interfaces at 1 million cycles
- Formation of hackles at 1,45 million cycles

CONSTRUCTION OF FATIGUE DESIGN CURVE: PRELIMINARY RESULTS

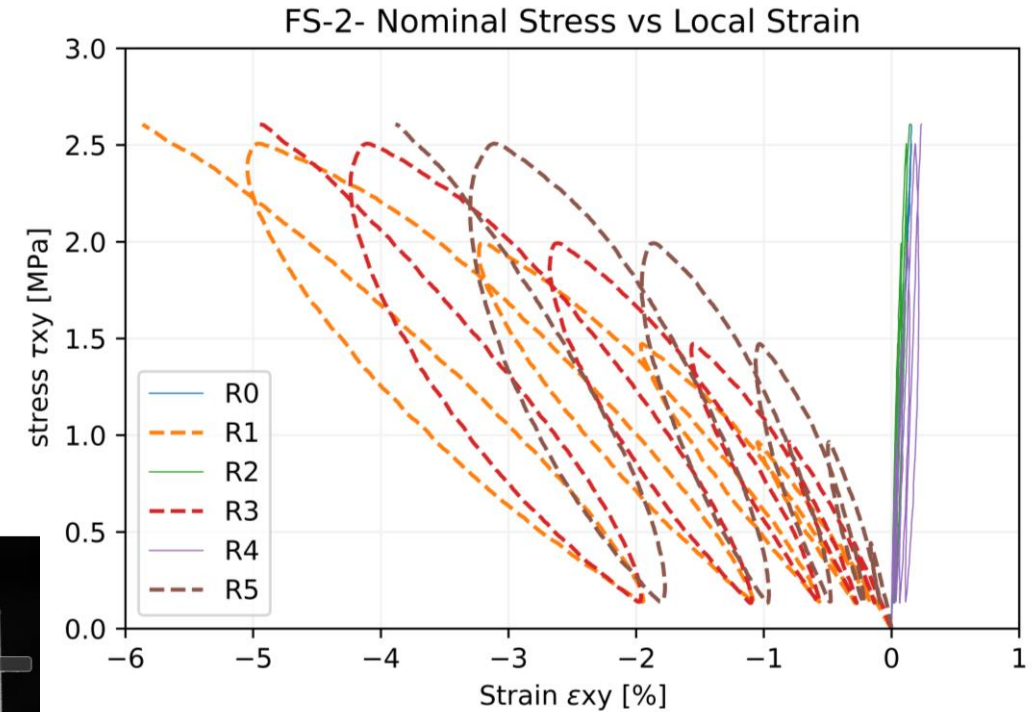
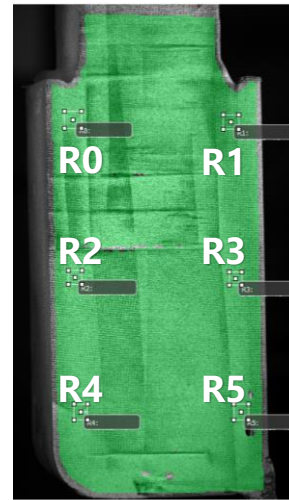
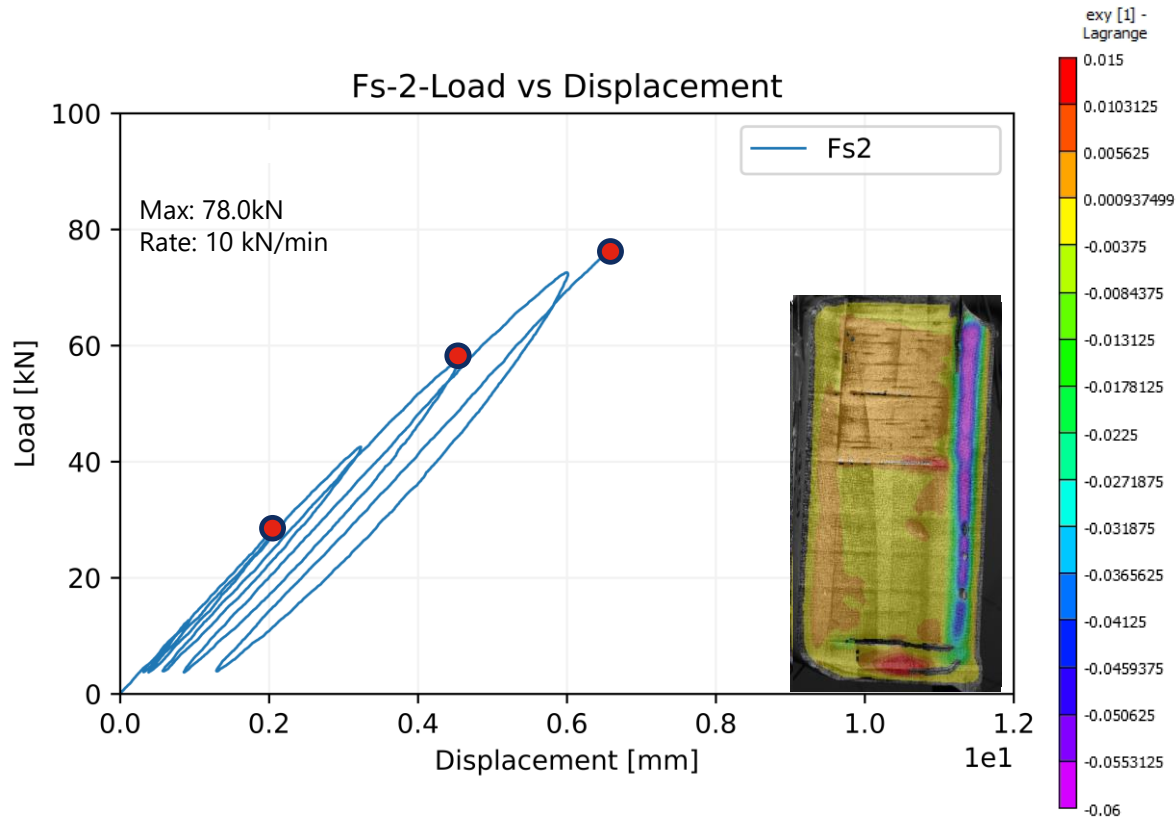


LEVEL 3 TESTING: COMPONENT LEVEL

- Failure at real scale and representative loading conditions
 - Scoping tests to identify failure modes
 - Quasi-static tensile and compression tests
 - Bending tests
 - Fatigue tests (tensile, bending)
 - Mixed mode tensile tests (quasi-static and fatigue)

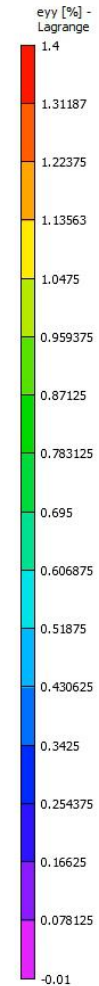
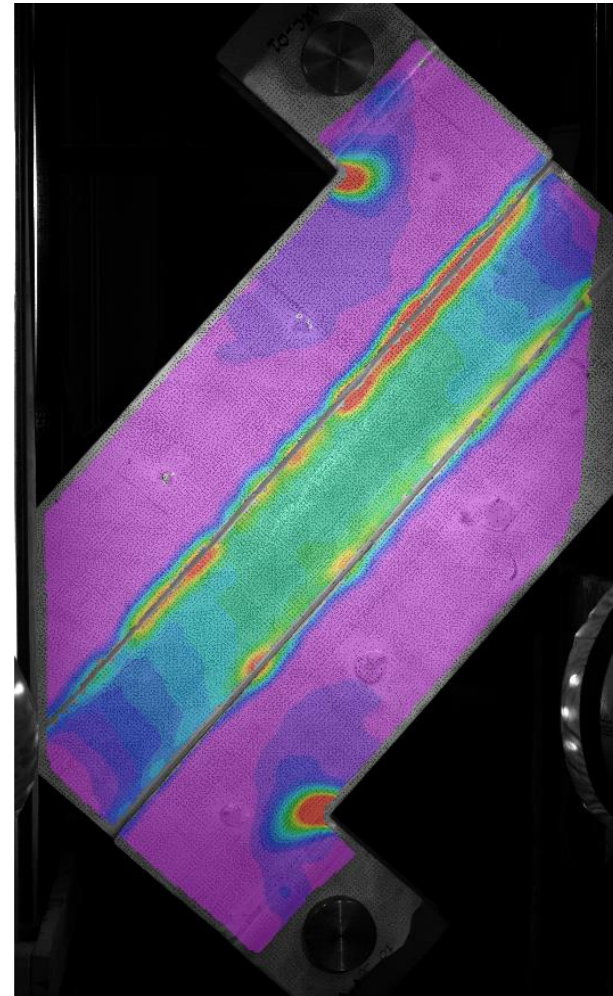
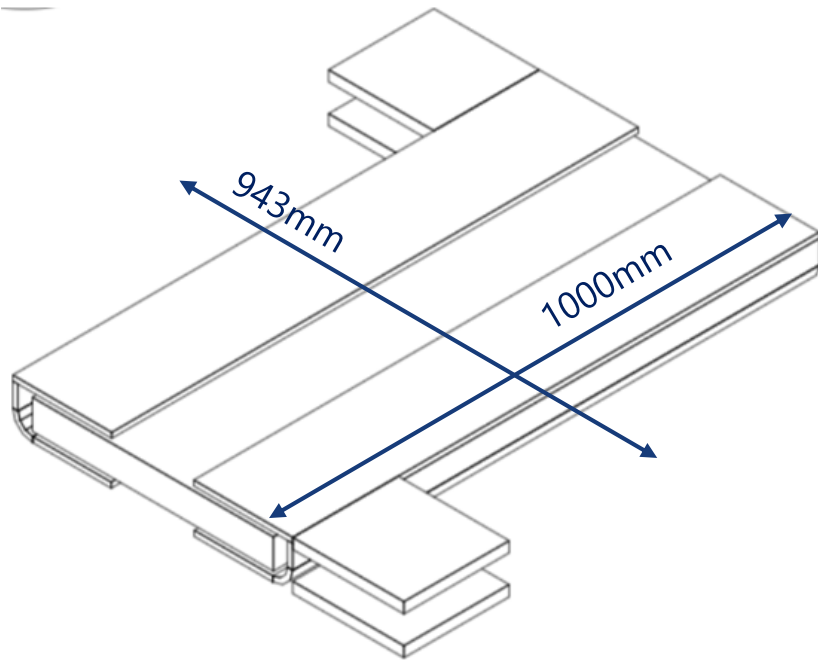


STEPWISE QUASI-STATIC TENSILE TEST ON REPRESENTATIVE 'DAMEN' JOINT



MIXED MODE TEST ON LARGE-SCALE 'DAMEN' JOINT CONFIGURATION

- Tension test on specimen mounted at an angle
 - Multi-axial stress state in adhesive
 - Illustration shows strain in vertical direction



TO CONCLUDE

- Evaluation of long term structural performance of bi-material thick adhesive joints
 - Testing at three different levels, using tailored testing equipment and instrumentation
 - Also serves as input/benchmark for finite element simulations
- Final goal: enable the certification of bi-material joints for primary structures





This research was carried out within the project “QUALIFY – Enabling Qualification of Hybrid Joints for Lightweight and Safe Maritime Transport”, co-funded by the INTERREG 2SeasMers Zeeën programme
<http://www.interreg2seas.eu/qualify>