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FAILURE CHARACTERIZATION OF ADHESIVELY BONDED COMPOSITE JOINTS USING A MODIFIED ARCAN FIXTURE

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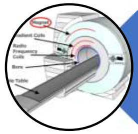
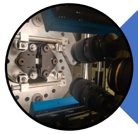
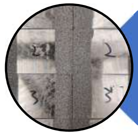
Outline



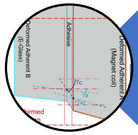
Background



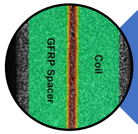
Experimental procedure



Control samples



Contemporary materials

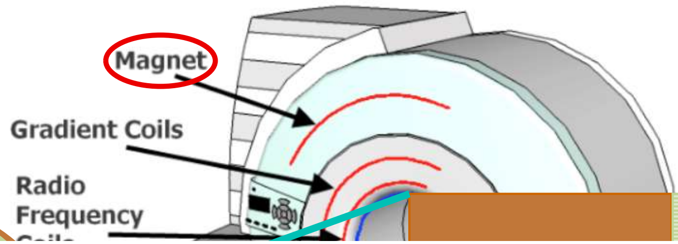


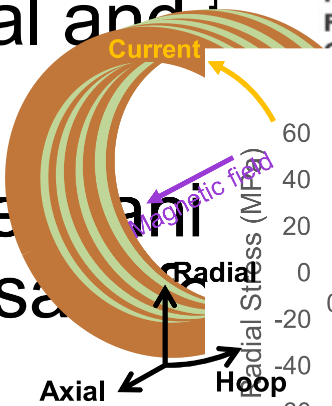
Results

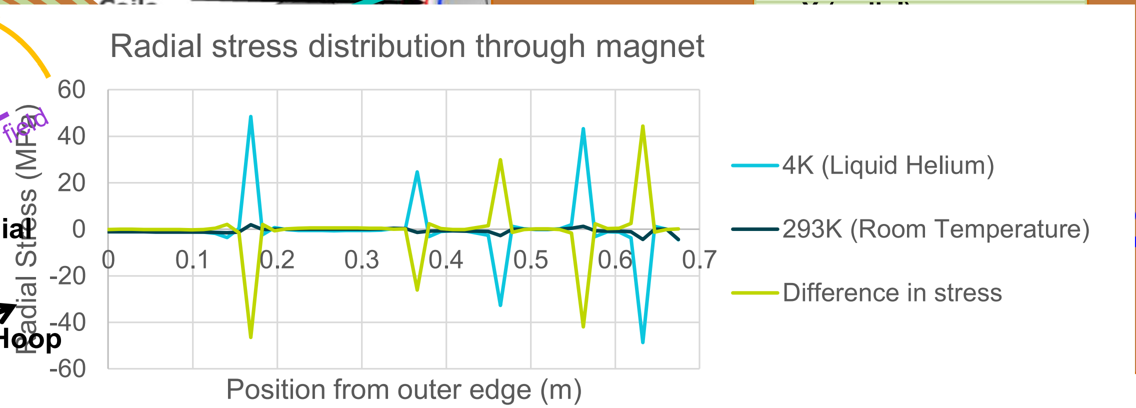
Conclusion and further work

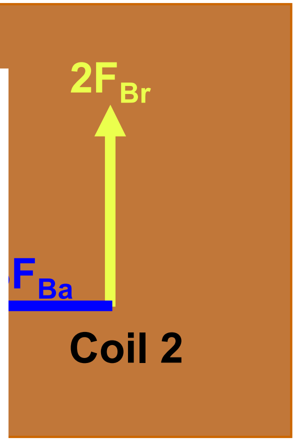
Background

- MRI machine, used for non-invasive medical imaging, consisting of a bonded magnet capable of >3 Tesla
- Solenoids induce … forces (~1MN) on composite space … genic conditions
- Mechanical and t… state
- Thermome… are necessa… analysis









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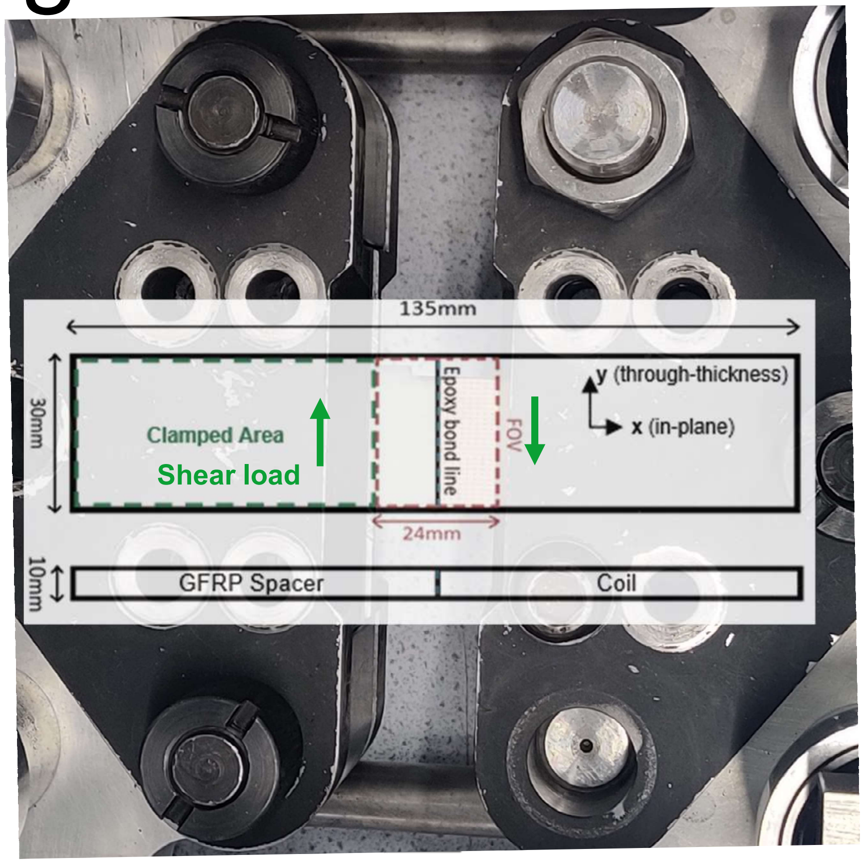
Establishing interface strength

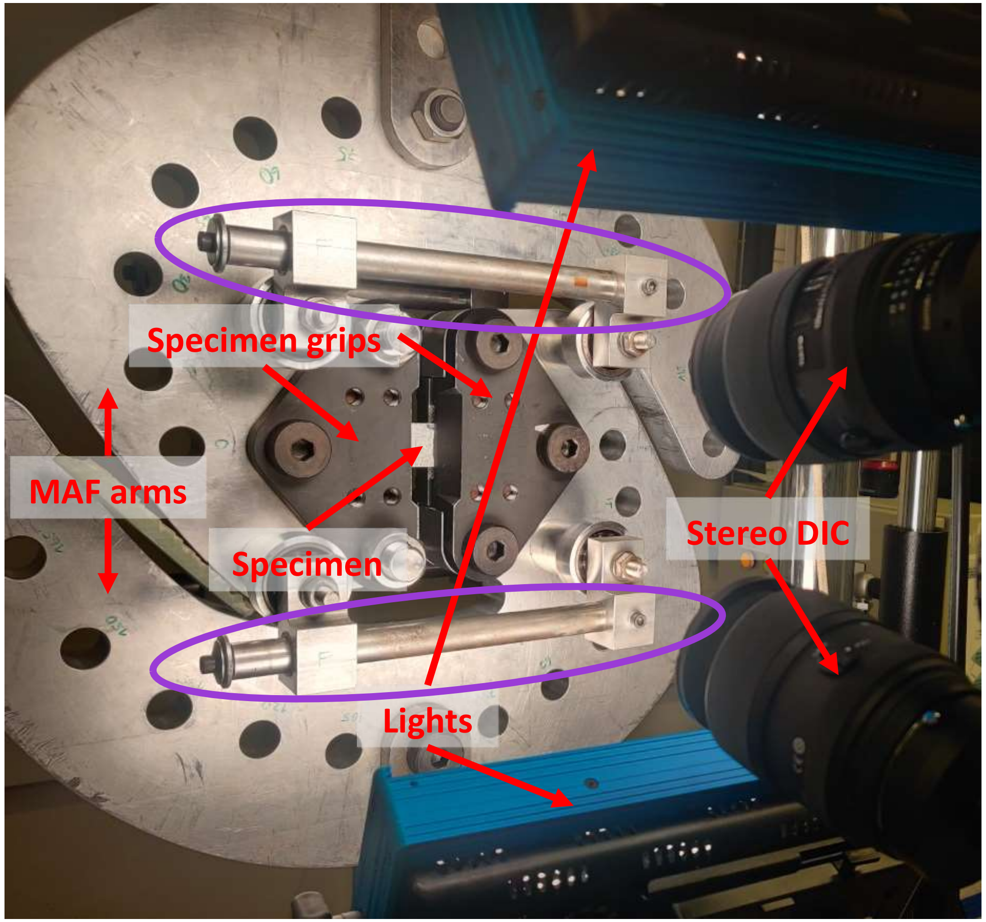
- Interface identified as a region with a large complex stress state and potential location of failure
- Strength, stiffness and toughness properties needed for analysis can be found through experimental testing
- Modified Arcan fixture (MAF) used in quasi-static loading
- Shear stress applied across specimen interface to examine shear strength



Experimental Parameters

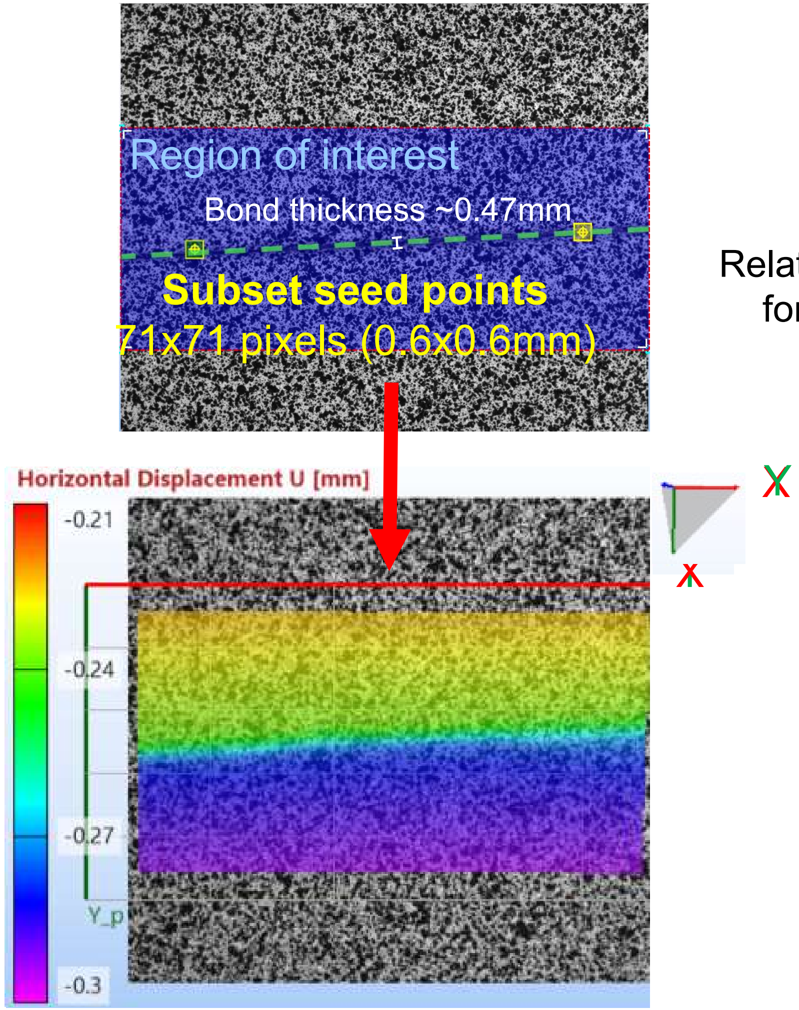
- Loaded in displacement control @ 0.2mm/min

Hardware	Stereo DIC
Camera	Flir Blackfly S USB3
Sensor	12 bit, 2448x2048
Lens	Tokina atx-i 100mm F2.8 FF MACRO PLUS
SOD / stereo angle	~350mm / 25°
Magnification	0.4
Pixel resolution / FOV	8.35μm/pixel / 20.4x17.1mm
Frame rate	1Hz



Analysis

Analysis parameters	Stereo DIC
Software	Match ID
Subset size	71 px
Step Size	35 px
Correlation Criterion	ZNSDD
Shape function	Affine
Spatial pre-filtering	Gaussian
Strain Tensor	Logarithmic
Strain window	5
Noise floor (SD of vertical displacement V)	0.00045



Relatively large subsets for noise reduction

Rigid body motion compensation and rotation transformation

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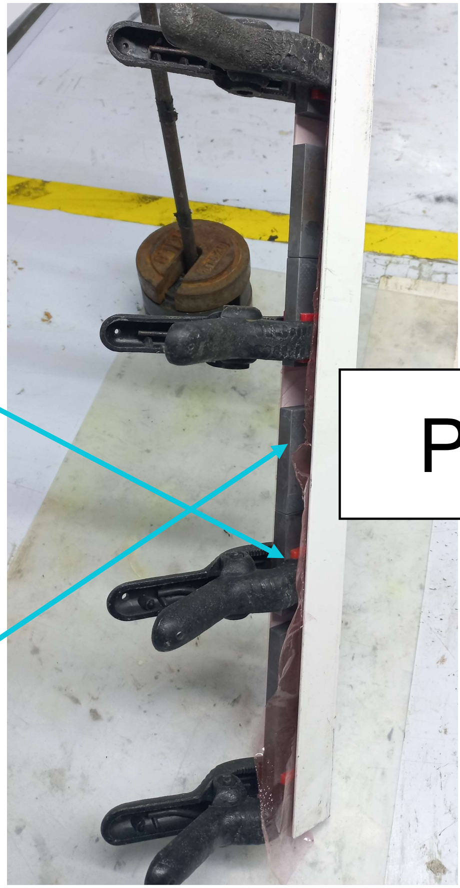
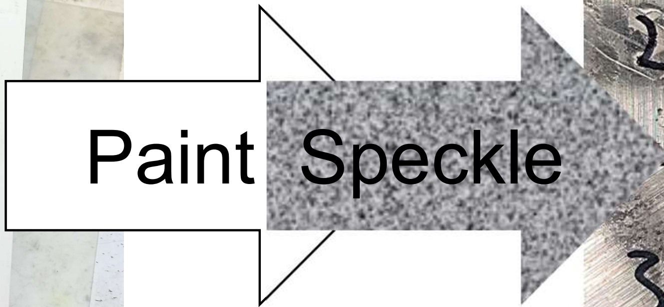
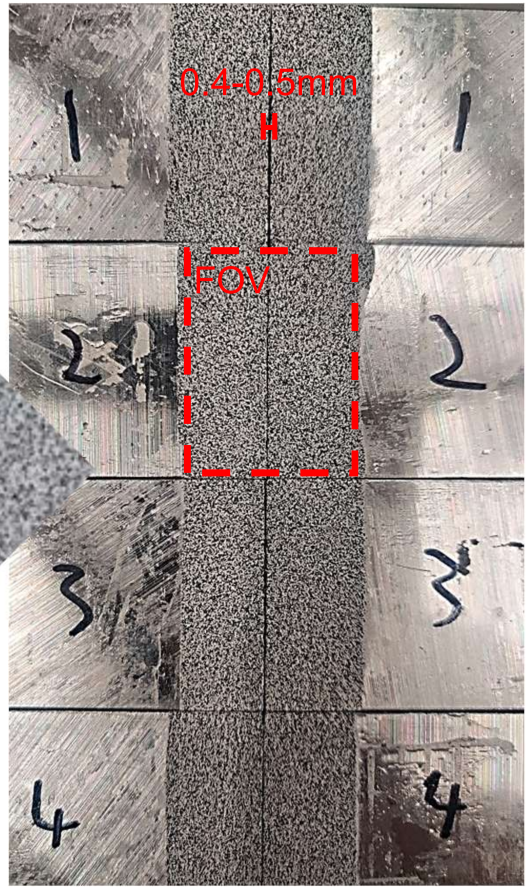
Manufactured Steel-Steel Specimen

Each specimen:

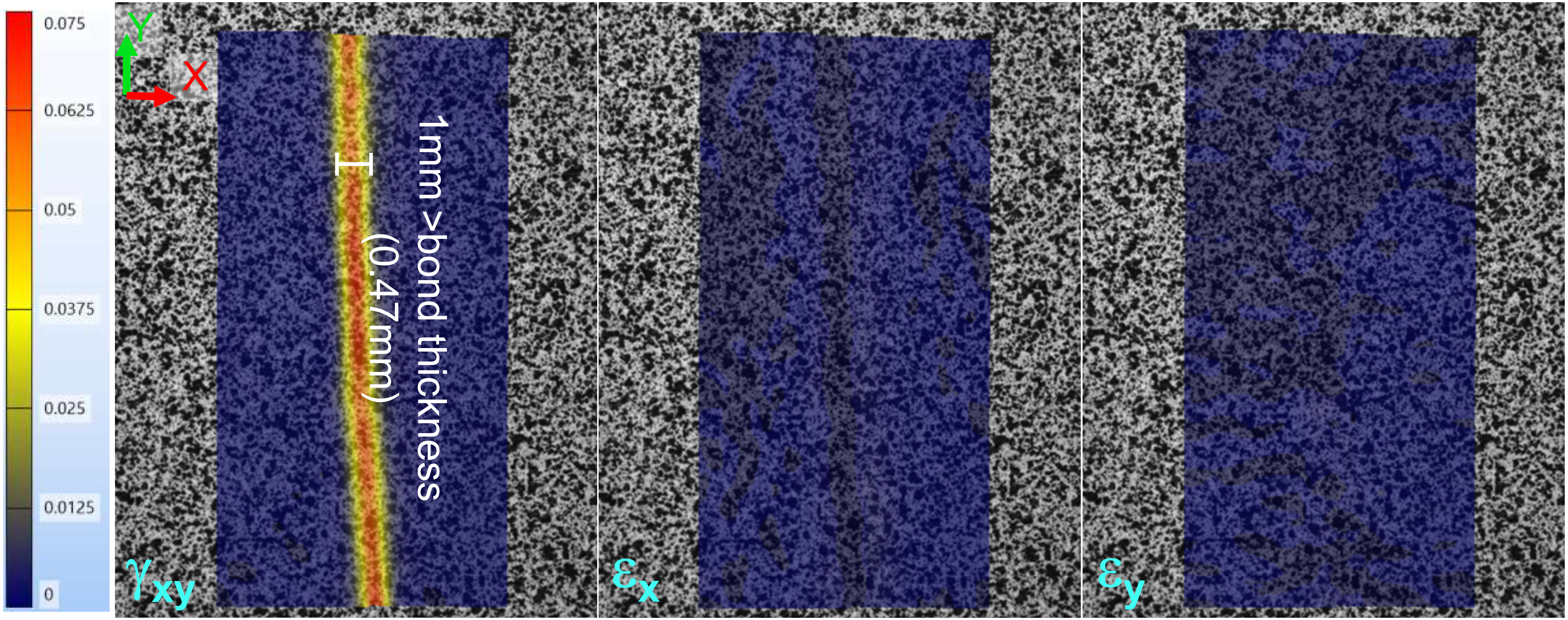
1. 2x Bright mild steel plates (10x30x60mm)
2. Bonding faces (10x30mm) finished with sand blaster
3. Plate 1 clamped on an angle
4. Plate 2's bonding face evenly coated with Araldite MY750 / HY5922 hardener
5. Plate 2 placed on plate 1, aligning the faces with the tool and using gravity as an even clamping force



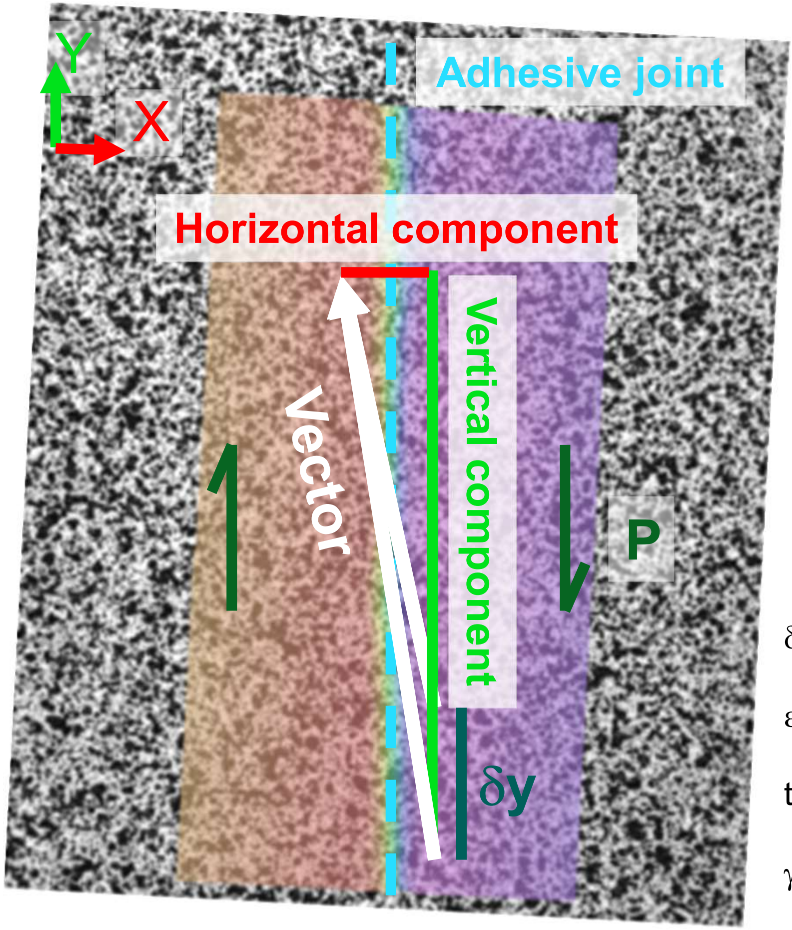




Strain calculation from MatchID algorithm



Virtual Bi-axial Extensometers



$$\varepsilon_J = \delta y / t_J$$
$$\gamma_J = 2\,\varepsilon_J$$

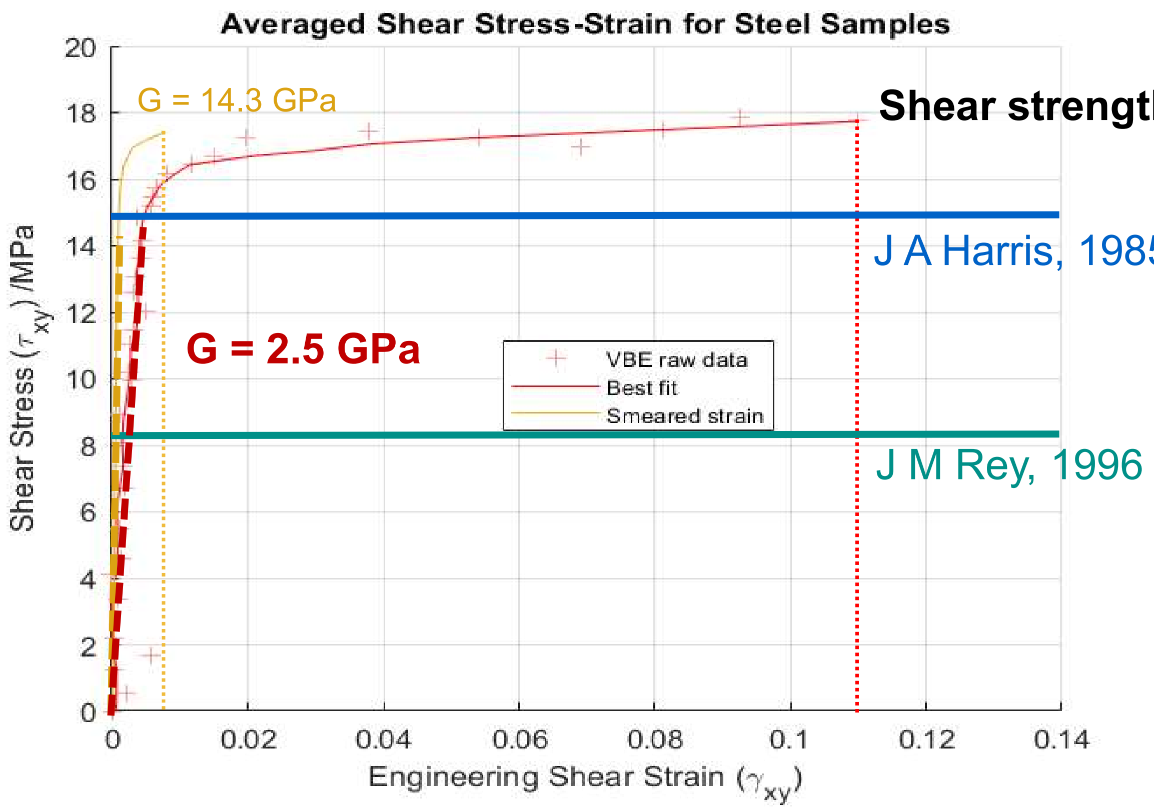
δ_y = Vertical extension of vector

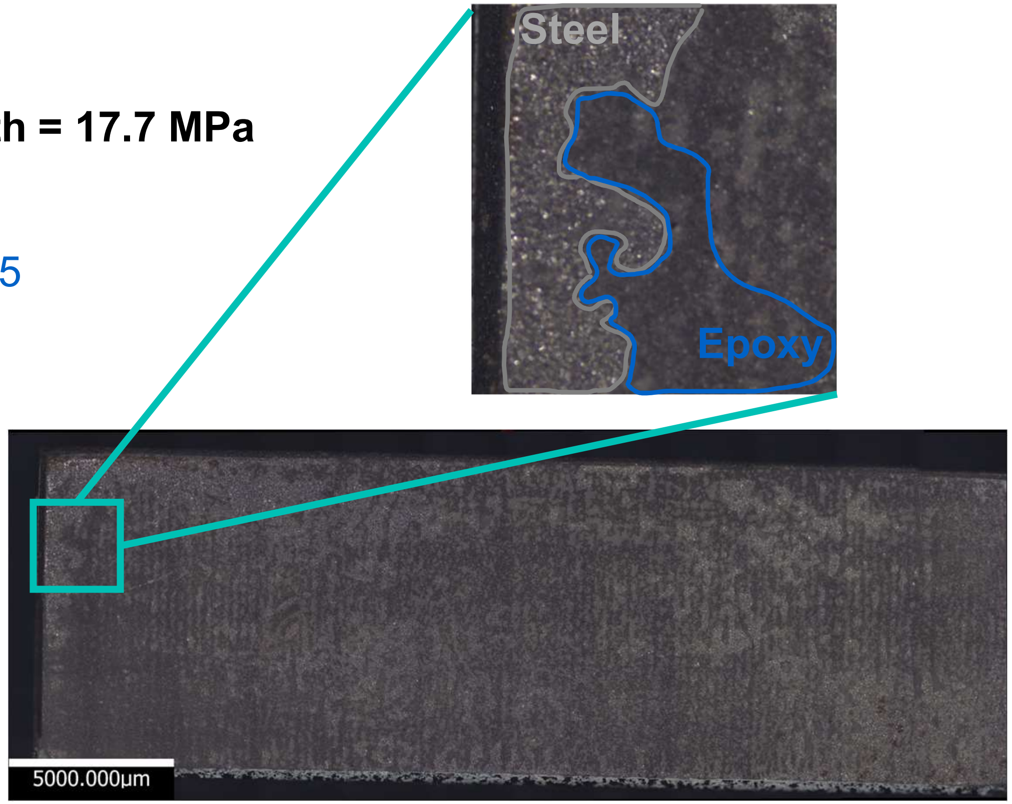
ε_J = Shear strain in adhesive joint

t_J = Adhesive joint thickness

γ_J = Engineering shear strain in adhesive joint

Experimental Results





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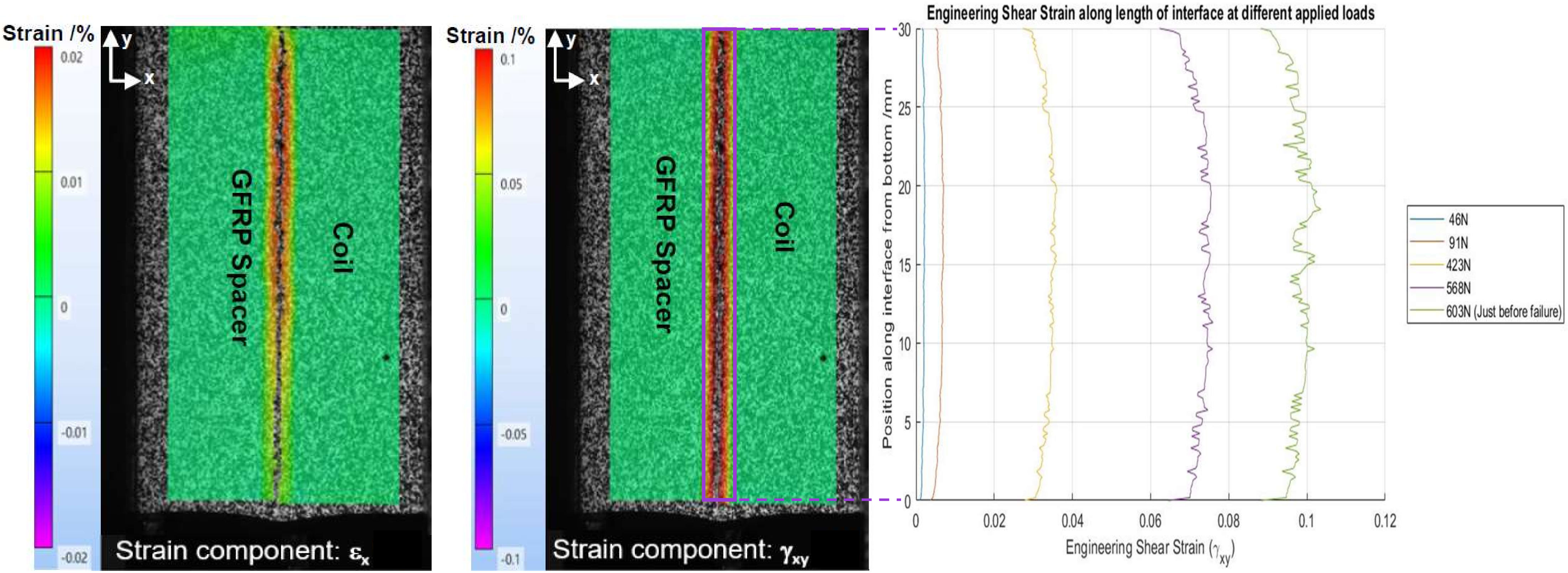
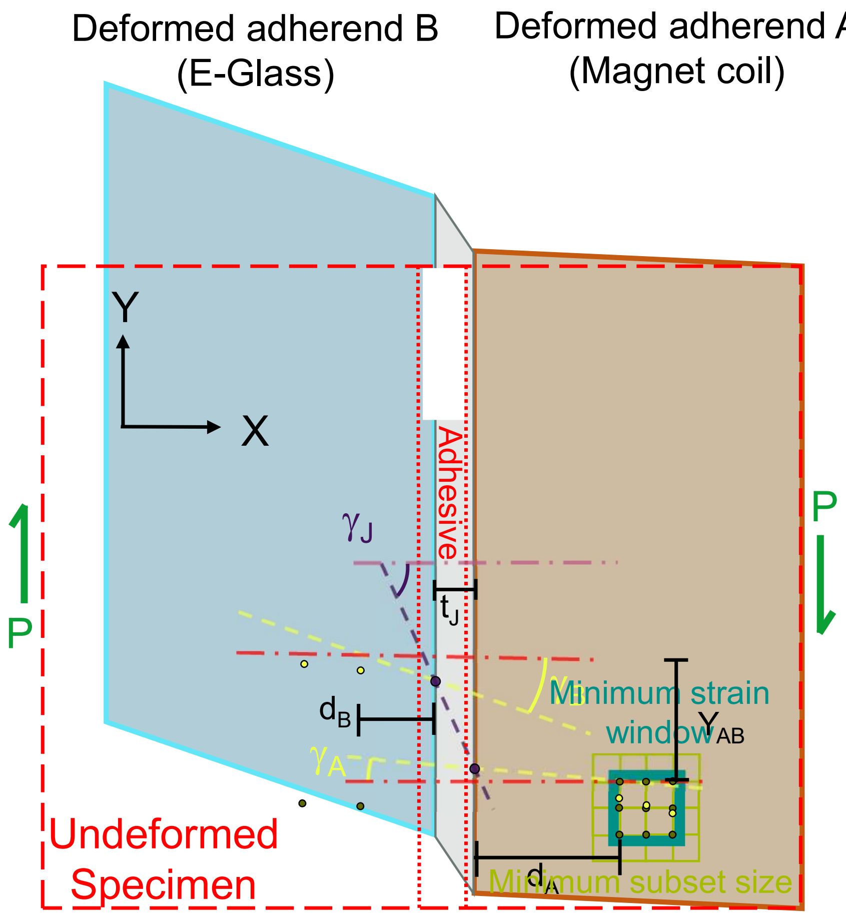
Stereo DIC results from magnet sample



Shear Angle Extrapolation

- Compliance in the adherends means "bi-axial virtual extensometer" method for measuring shear strain can not be used
- Relatively large subsets makes it impossible to resolve strain within a narrow region of interest e.g. adhesive joint ~120µm
- Method is needed to overcome spatial resolution issue: predict the strain experienced by the adhesive based on the measured strain in the adherends

$$\gamma_J = \frac{Y_{AB} - d_A \gamma_A - d_B \gamma_B}{t_J}$$



γ_A = Shear strain in adherend A

γ_B = Shear strain in adherend B

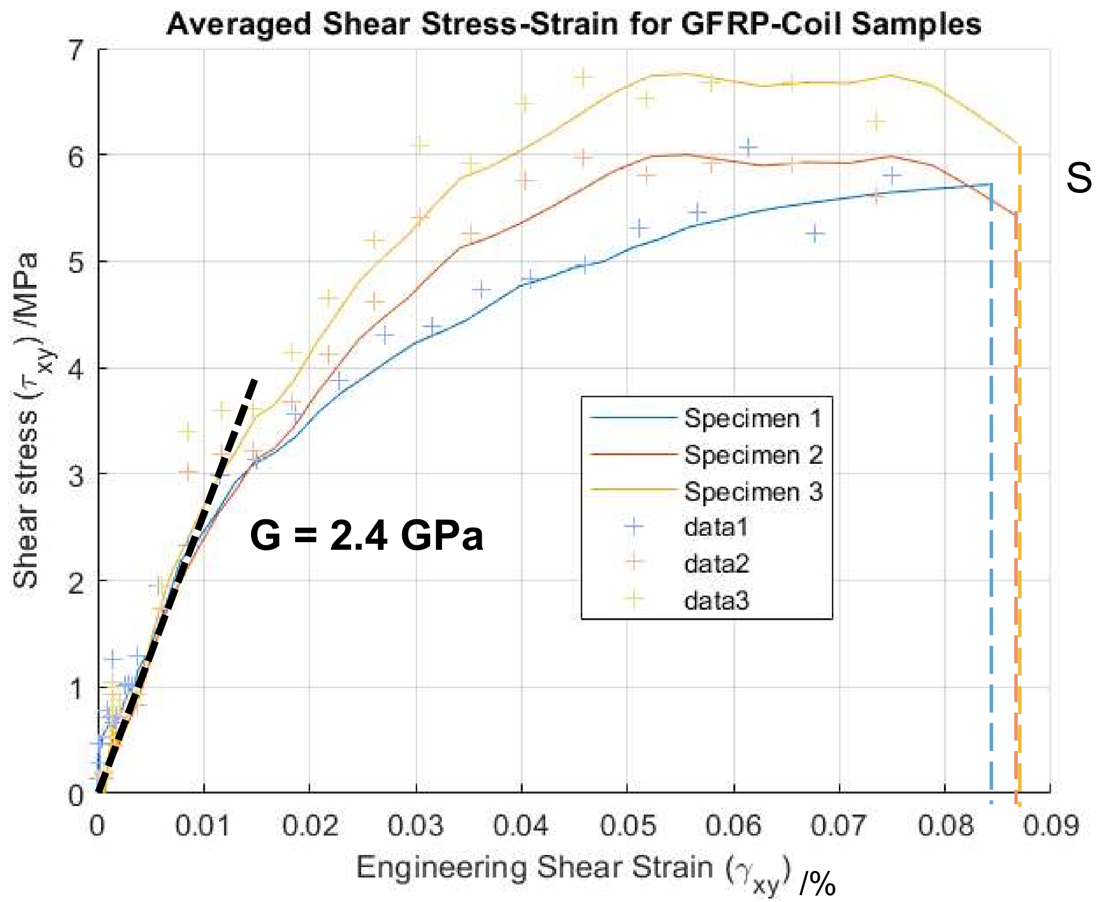
γ_J = Shear strain in adhesive joint

t_J = Adhesive joint thickness

d_A / d_B = X-distance from subset centroid on adherend A / B respectively, to interface

Y_{AB} = Y-displacement between measurement centroids

MRI magnet specimens



Shear strength = 5.75 MPa

Conclusions

- Steel-Steel specimens used to examine epoxy shear modulus and strength with simplified geometry (proof of concept of measurement methodology using MAF)
- MAF rig in shear configuration produces a near uniform shear strain distribution at interface
- Methodology developed to derive shear strain in interface/adhesive of composite/coil specimen overcoming limitations of spatial resolution
- Measured (apparent) shear modulus of 2.5 GPa
- Measured shear strength (average shear stress at failure) of 5.75 MPa

Further work

- Use different loading hole pairs in MAF to induce bi-axial stress states and generate failure envelope
- Modelling of interface fracture process using CZM model with both contemporary and control material cases using experimental values
- Repeat tests at cryogenic temperatures to generate failure envelope with in-situ conditions – test setup including cryostat of conducting in-situ measurements at cryogenic temperatures being developed

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Thank you for listening

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