FLUID STRUCTURE INTERACTIONS
RESEARCH GROUP

UNIVERSITY OF
Southampton
School of Engineering Sciences

An Investigation into the face sheet debonding of glass balsa sandwich composites

Mathieu Colin de Verdiere – mcdv1u07@soton.ac.uk - School of Engineering Sciences

Supervisors – **Professor J.M Barton, Professor Ajit Shenoi and Dr J.I.R Blake**

Motivation & Aim

- The aim of this investigation is to better understand the damage process in navy ship decks made from glass - balsa sandwiched structures.

- Glass fibres and balsa wood sandwich structure provides good strength, stiffness and weight properties at low cost. But naval ship decks can receive considerable bad treatment during service from extreme weather conditions, green seas to tools and machinery falling on the deck. In these cases the sandwich face sheet can debond from the core which can lead to reduced strength and stiffness of the ship. Furthermore the debonding can grow further during stressing of the structures (for example from waves) hence reducing further the resistance of the ship to loading.

Figure 1: Mine countermeasure vessels using glass-balsa sandwiched structures

- The delamination under Mode I, II and Mix mode is considered. Digital image correlation (DIC) is used to track the strain during delamination and the crack growth. Strain energy release rates are computed in Mode I, II and Mix Mode.

- To better understand the crack growth several material and crack parameters are changed (type of resin, thickness of the balsa core, crack thickness and type of the interface layer).

Figure 2: Typical (failed) naval deck sandwich structure (glass fibres and balsa core)

Generic Panels

- Research has designed generic specimens representative of naval ship deck
- Specimens manufactured through resin infusion
- 4 mm glass fibre face sheet and 15 to 40mm balsa wood core
- Epoxy or Vinylester resin for comparison
- Core thickness varies between 20 to 40 mm.
- Interface layer is either glass chopped strand mat (CSM) mat or unidirectional.
- The crack thickness ranges between 14 to 120 microns.
- DIC can be used to track the crack locations in difficult case

- Simulations are performed in 2D and 3D to assess the possibility to predict the crack propagation.

Conclusion

- Irregular mechanical properties of balsa wood lead to some scatter in the results.

- Load displacement traces achieved in Mode I, II and Mixed mode. For Mixed mode it provides trends for which the load to propagate the crack increases while the amount of Mode II increases.

- The G_{IC} data can be computed by recording of the crack location during loading. Also G_{MMB} calculation showed scatter due to the difficulty to locate the crack. But in Mode II (G_{IIC}), the crack location was not detectable to the naked eye. To improve this reading, usage of DIC can help to refine the crack location.

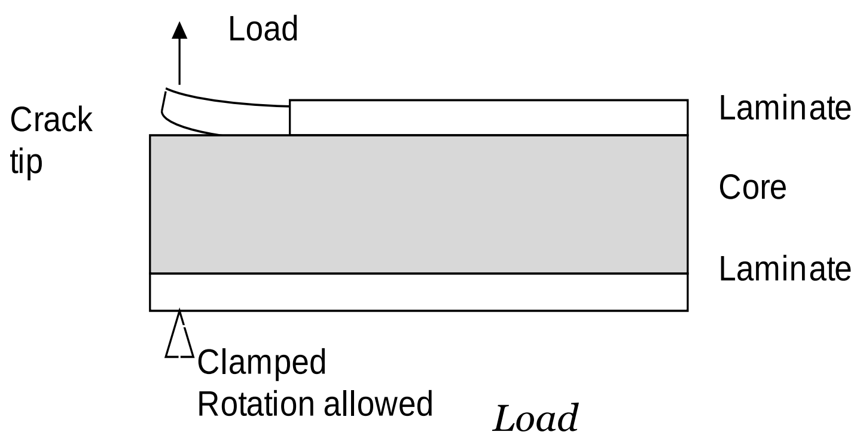
- Thicker core specimen provides less reproducible results. The energy to propagate the crack is lower than for thinner core specimens. The stress state in the specimen is understood to be higher in the thick specimen as their stiffness is considerably higher which intensifies the stress at the crack tip for the same applied load. DIC and numerical analyses may provide information on this hypothesis.

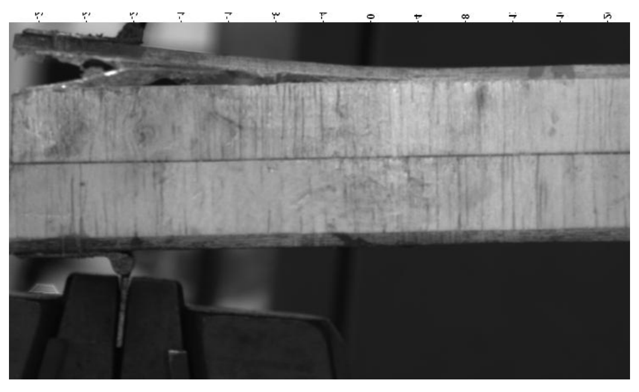
- Thick crack film lead to unsteady crack initiation and propagation and should be avoided.

- The presence of CSM is beneficial to obtain smooth crack propagation through bridging of the mat. It was observed that without the mat layer the crack propagation would be unsteady and sometimes catastrophic.

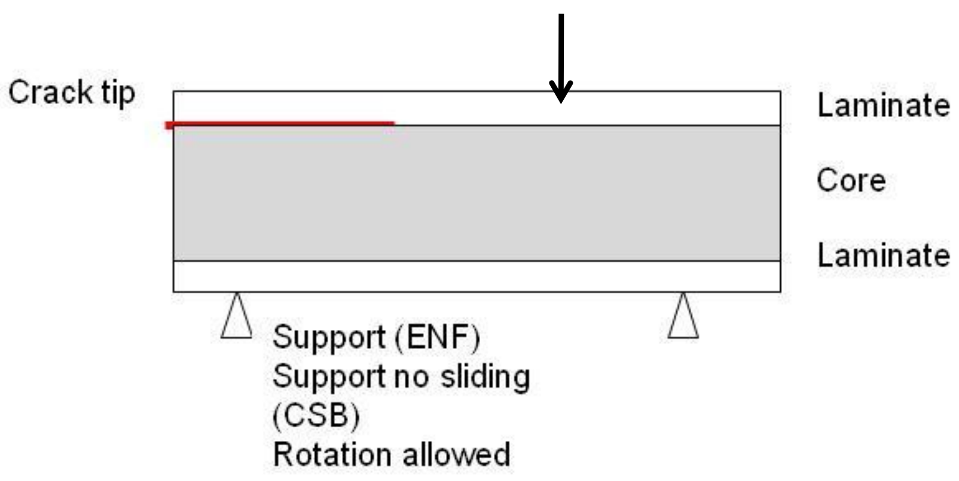
Testing

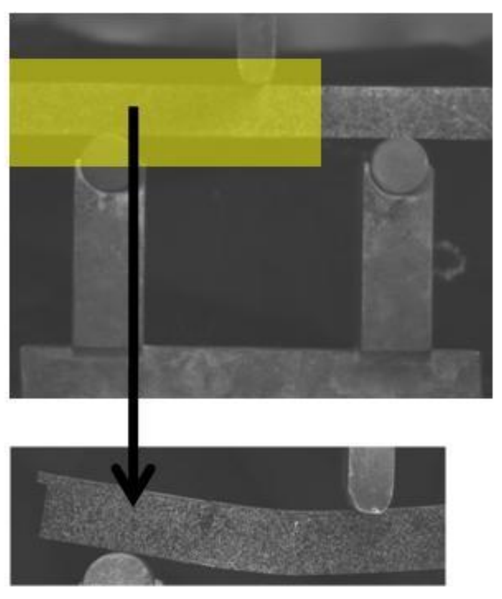
- Mode I



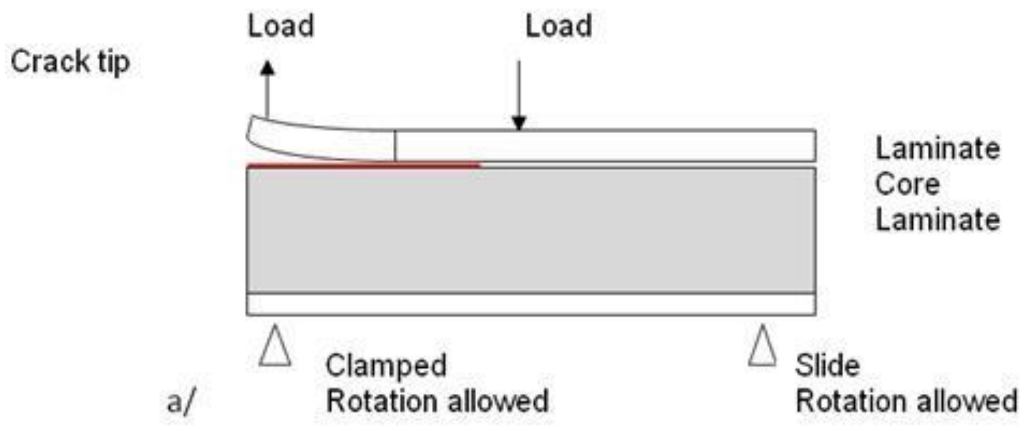


- Mode II





- Mixed Mode



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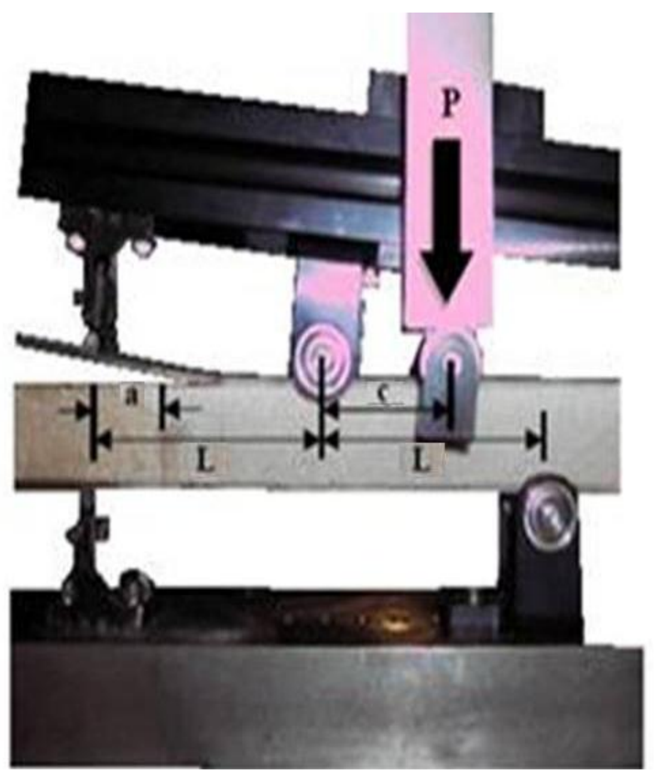

Experiment Results

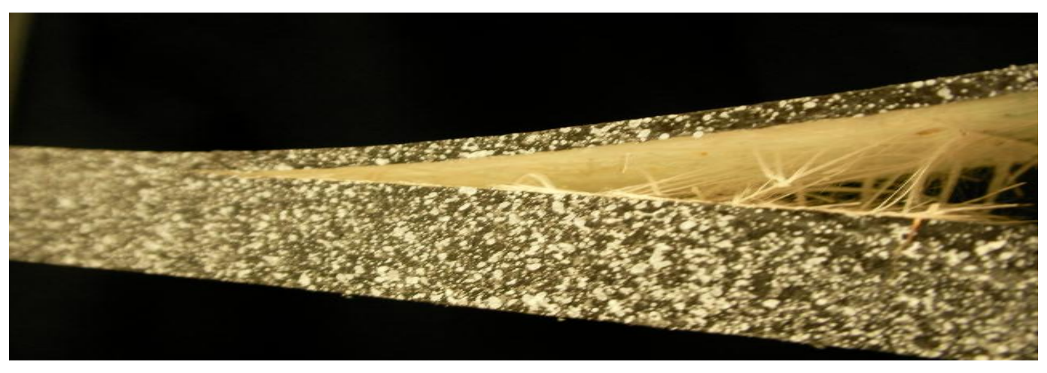

Figure 3: Fibres bridging in Mode I

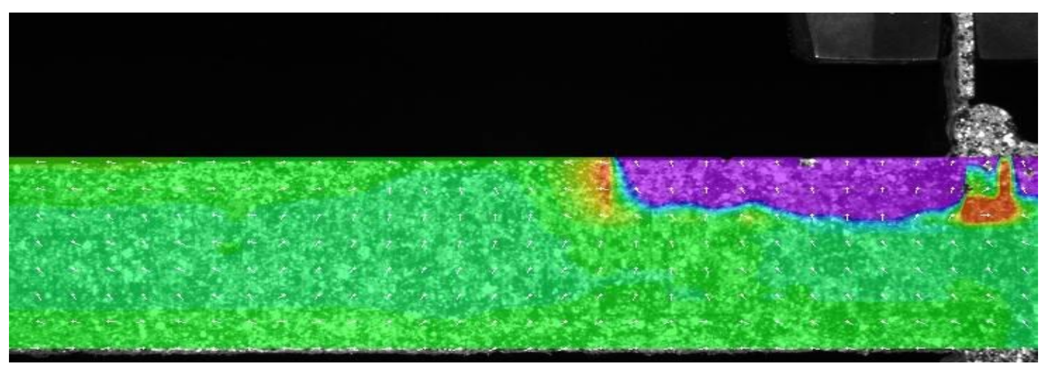

Figure 4: Digital Image Correlation in Mode I

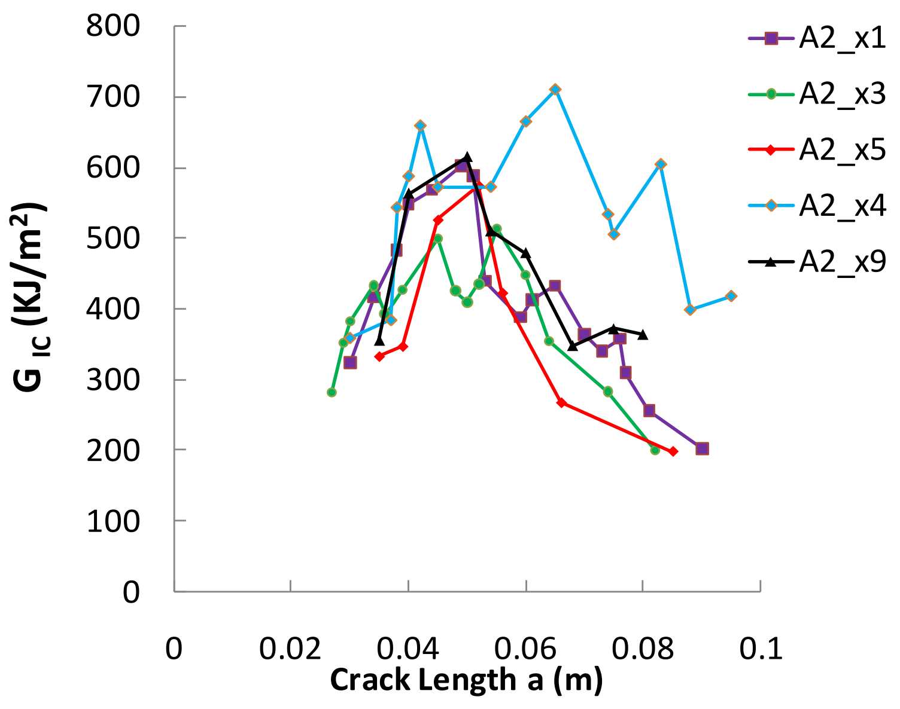

Figure 6: G_{IC} versus crack length for epoxy specimen in Mode I

Simulation Results

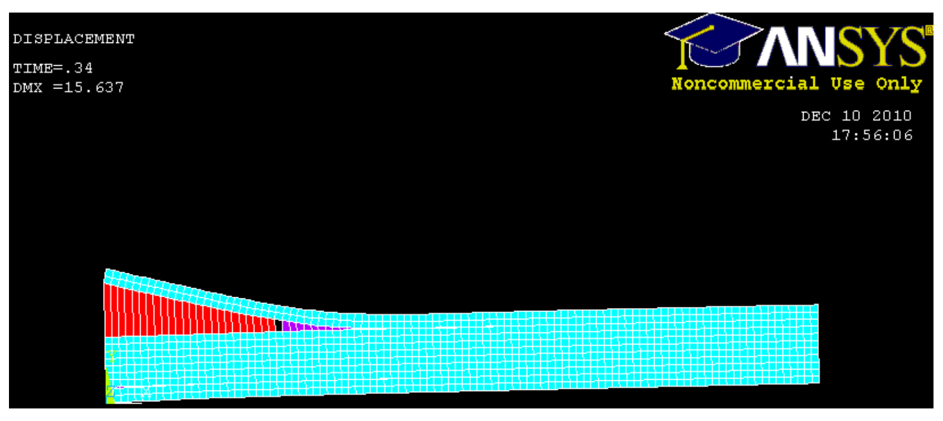

Figure 5: 2D debonding model

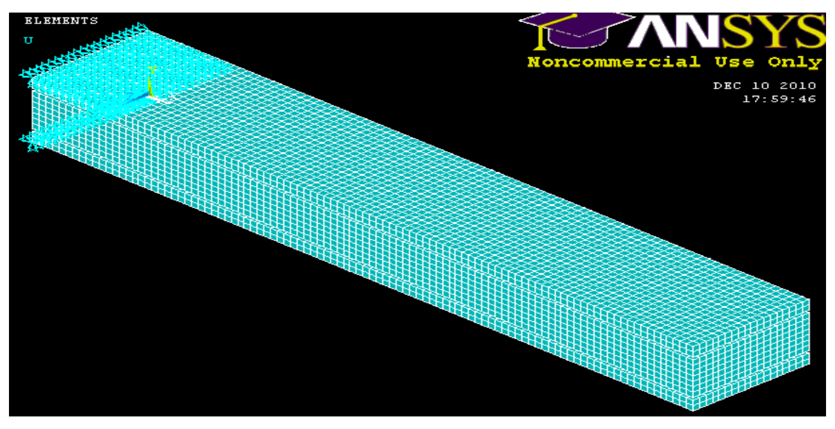

Figure 7: 3D debonding model

- 2 D model with traction law using interface elements (inter 202)
- 3 D model using bilinear law and contact elements (targe170 and conta175)

Future work:

- Experimental results refinement with Digital image correlation
- Calibration of numerical model
- Further post processing of experimental and numerical data

Acknowledgments

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