KU LEUVEN

MATERIALS ENGINEERING

Composite Materials Group

HyFiSyn

Proper tension-tension fatigue testing of unidirectional composites

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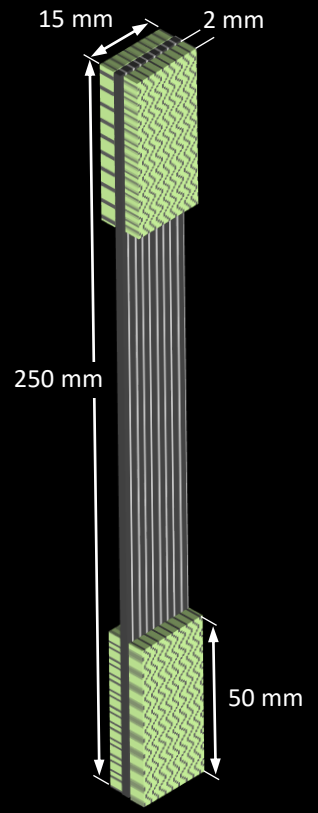
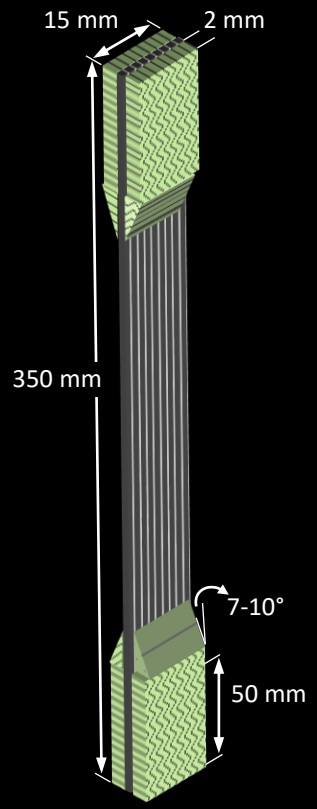
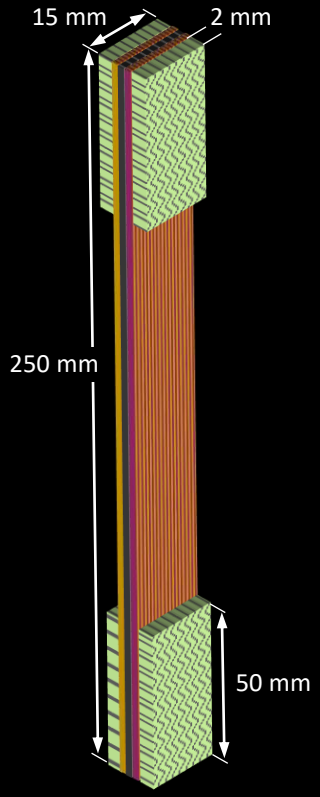
Specimen designs for tension-tension fatigue tests



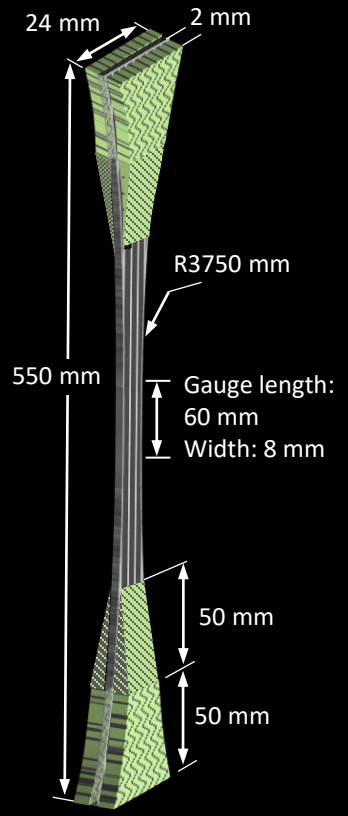
Rectangular specimen with rectangular end tabs



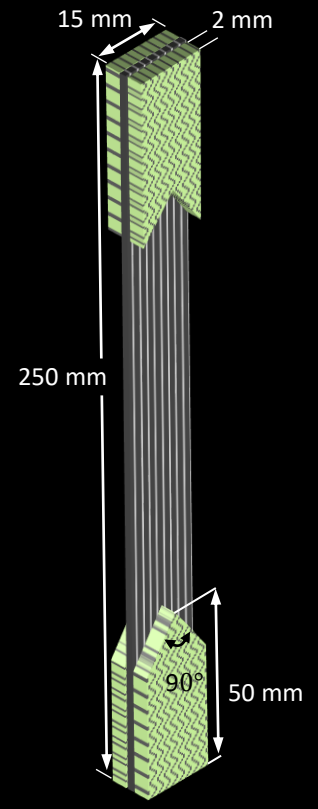
Rectangular specimen with tapered end tabs



Rectangular specimen with continuous tabs

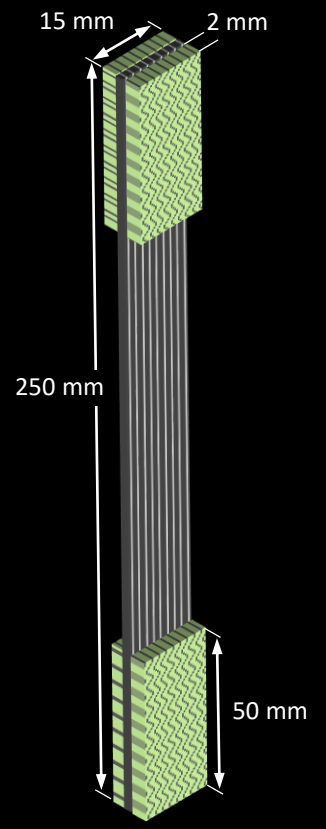


Butterfly specimen

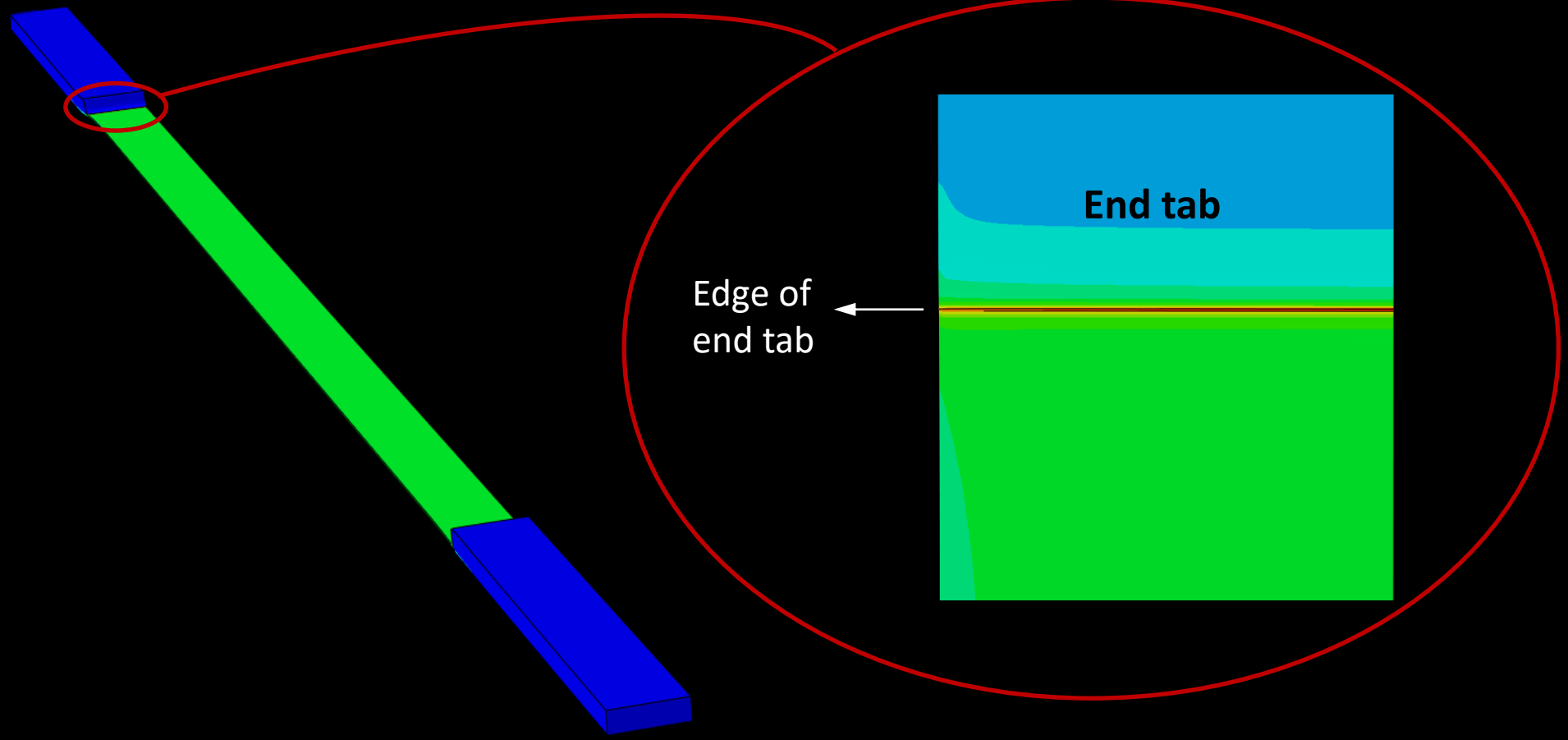


Rectangular specimen with arrow end tabs

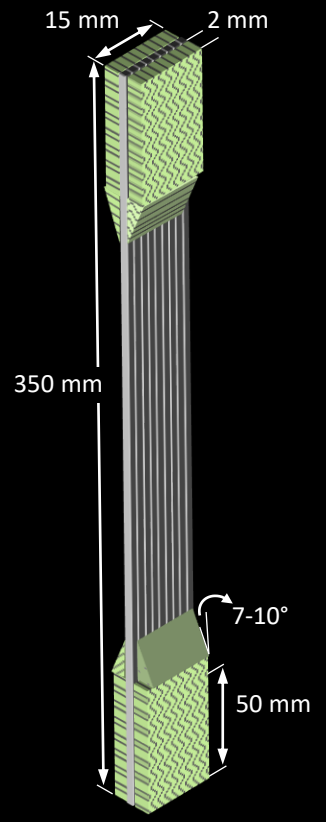
Rectangular end tabs



Rectangular specimen with rectangular end tabs



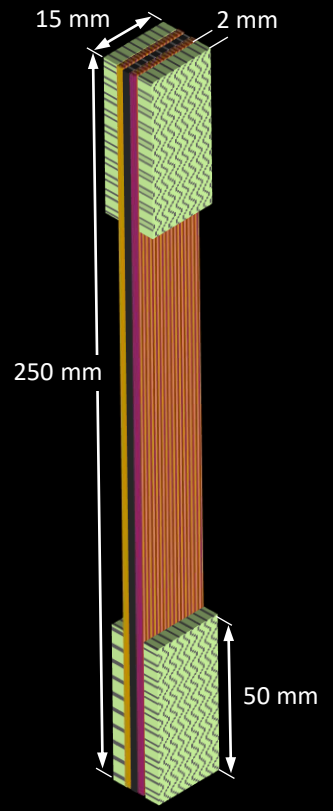
Tapered end tabs



Rectangular specimen with tapered end tabs

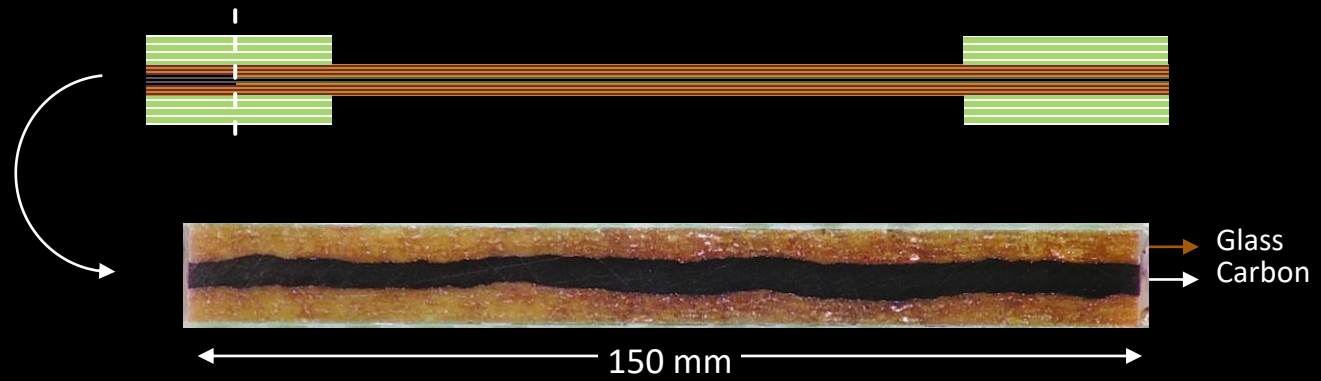
- ✓ Reduce stress concentration by reducing geometric discontinuity.
- ✗ Delamination over tapered section of the end tabs.

Continuous tabs

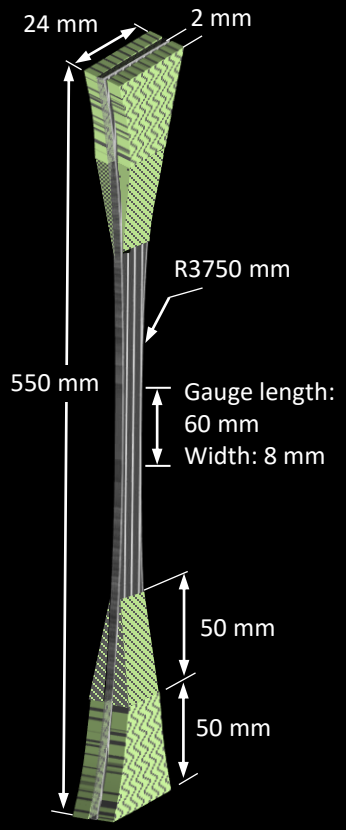


Rectangular specimen with continuous tabs

- ✓ Avoid or minimized stress concentration.
- ✗ Determining stress required back-calculation.
- ✗ Inconsistent cross-section in co-curing continuous tabs and specimen.

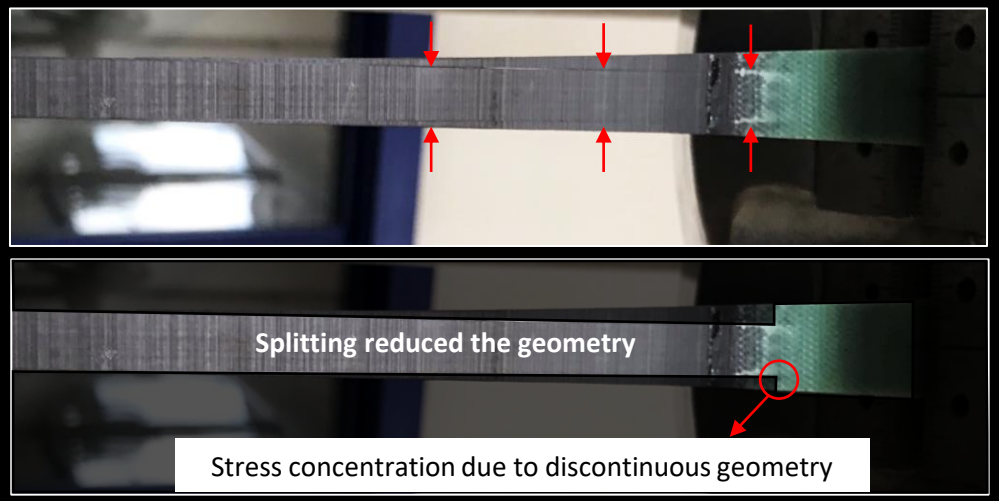


Butterfly specimen

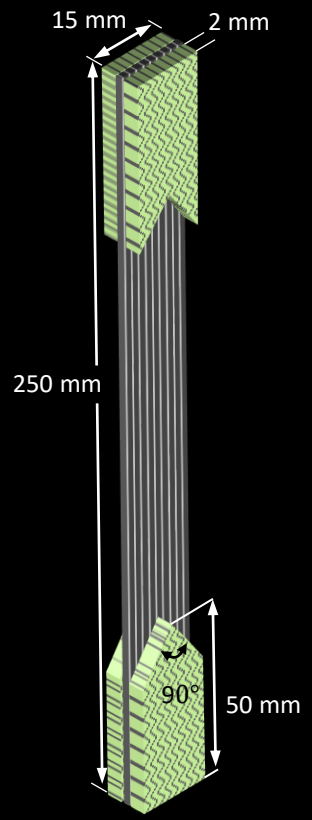


Butterfly specimen

- ✓ Remove stress concentrations from gauge section.
- ✗ Longitudinal splitting reduced the geometry to rectangular.
- ✗ Stress concentration owing to introducing geometric discontinuity.



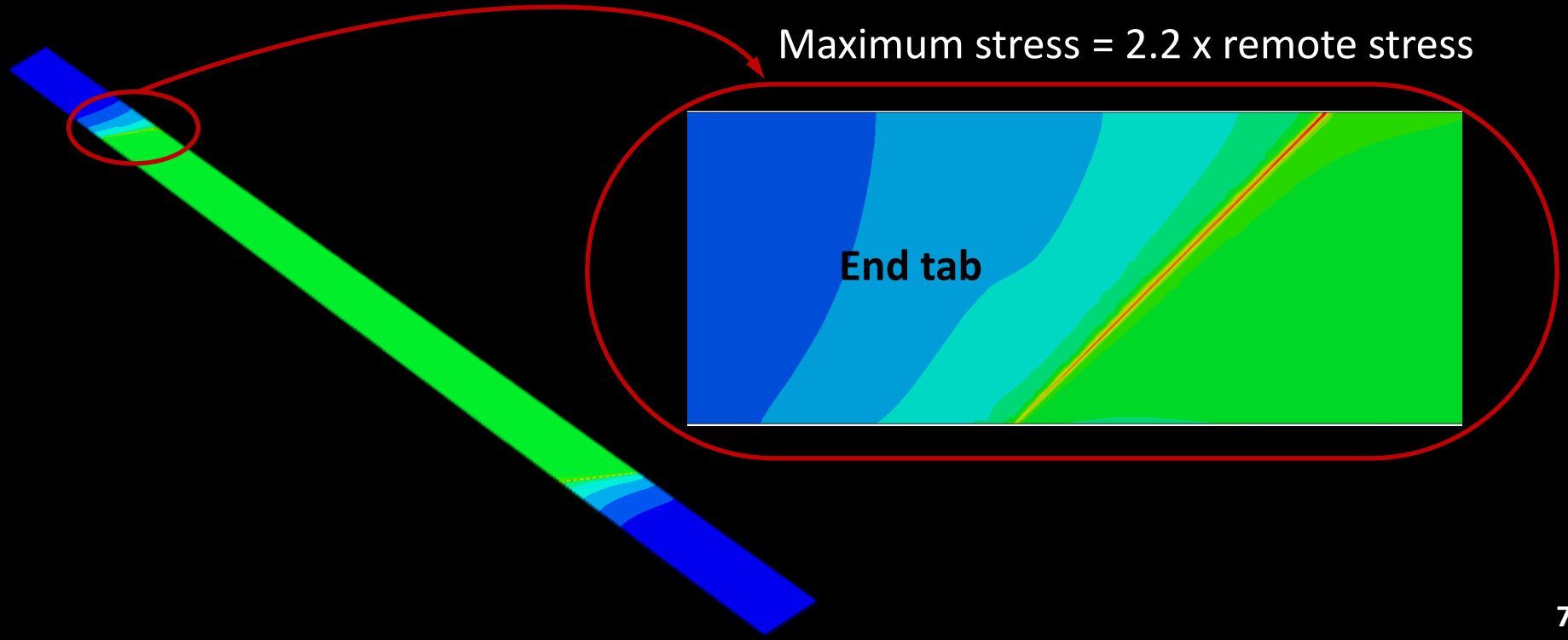
Arrow end tabs



Rectangular specimen with arrow end tabs

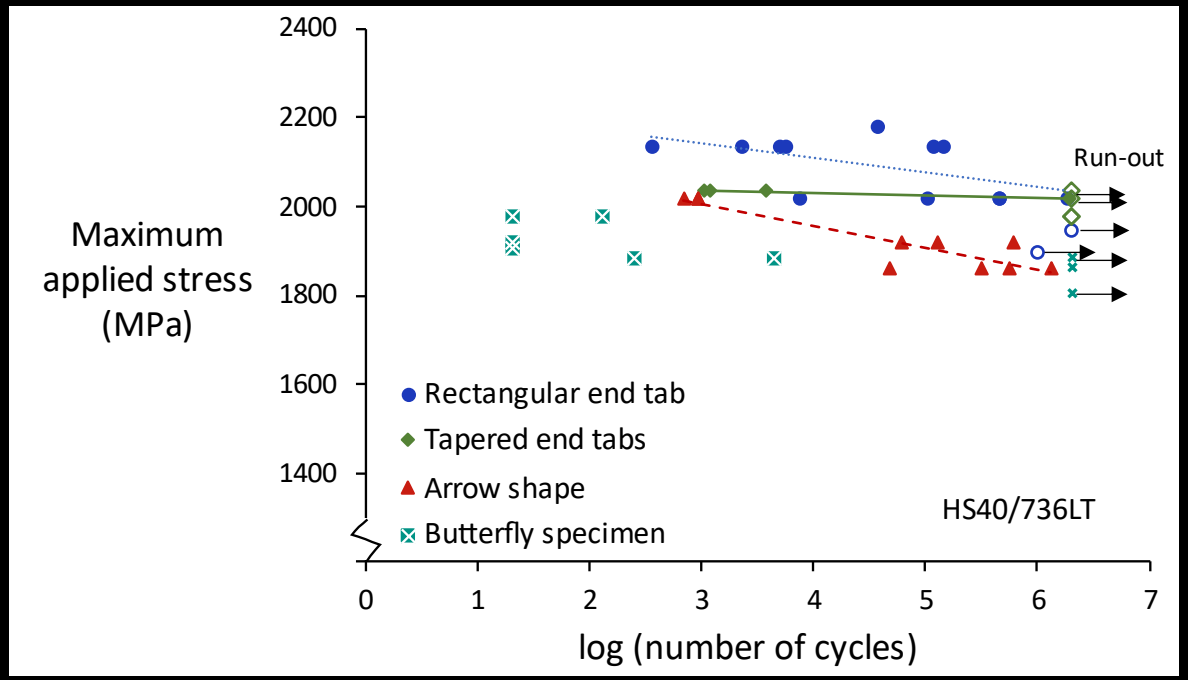
- ✓ Allow partial Poisson's contraction.
- ✓ Smear out stress concentration over the arrow section.
- ✗ High stress concentration at the tip of arrow section.

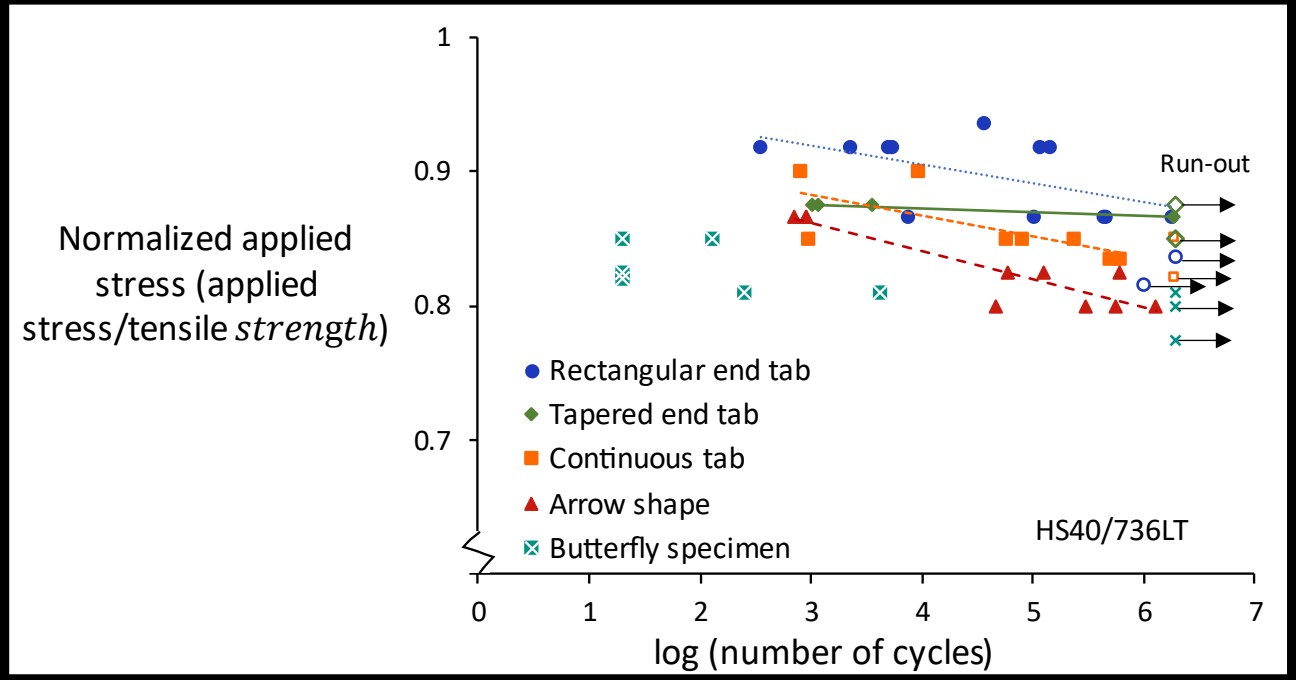
Maximum stress = 2.2 x remote stress



Experimental results of tension-tension fatigue

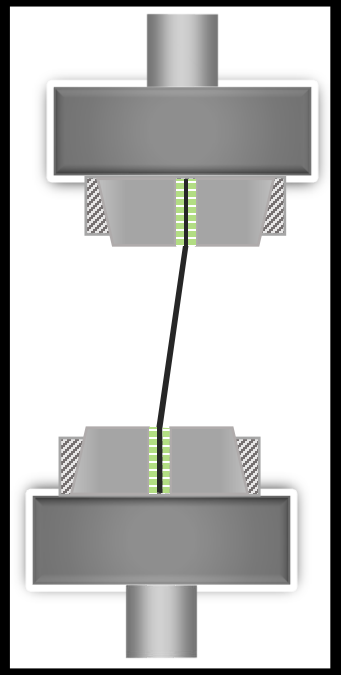
Carbon/epoxy (Hs40/736LT)
Layup: $[0]_{10}$
Stress ratio: 0.1
Frequency: 5 Hz



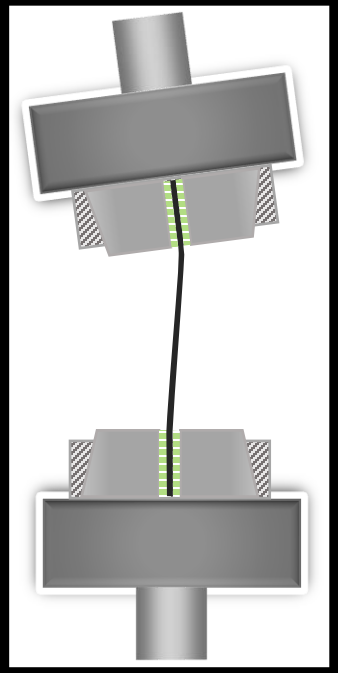


Concerns in performing tension-tension fatigue tests

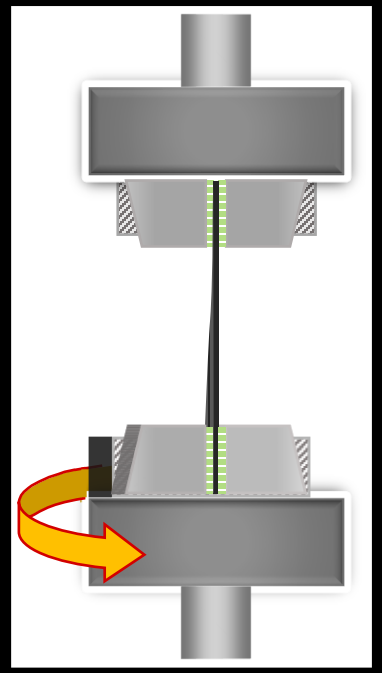
Grip misalignment



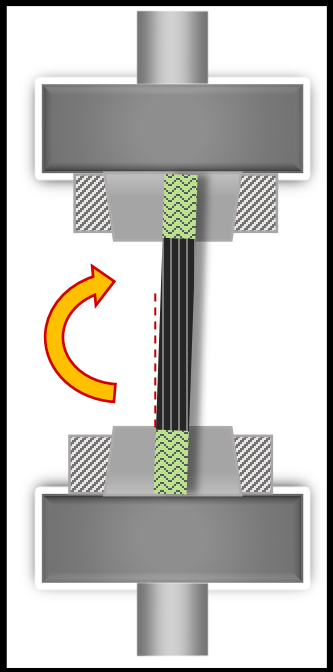
Normal misalignment



Tilted grip misalignment

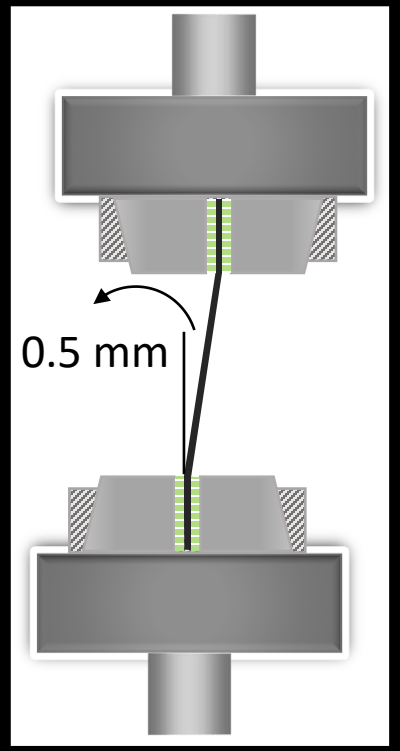


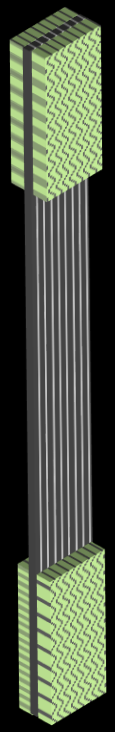
Rotated grip misalignment

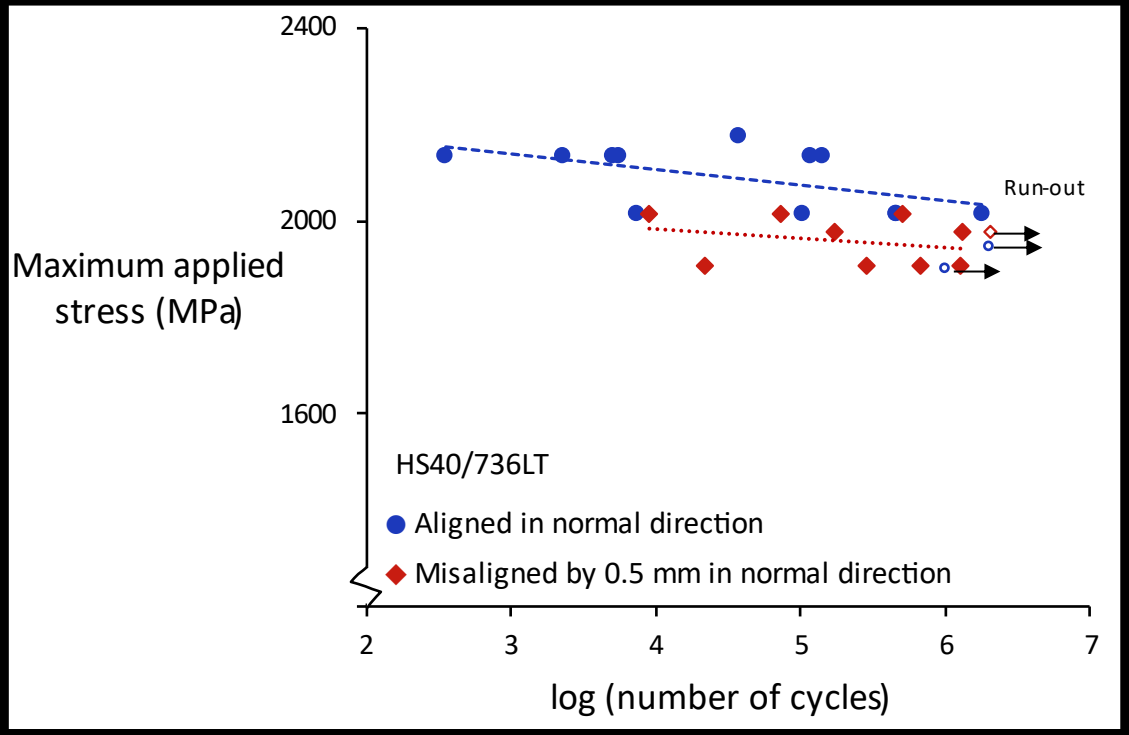


Tilted specimen

Normal misalignment

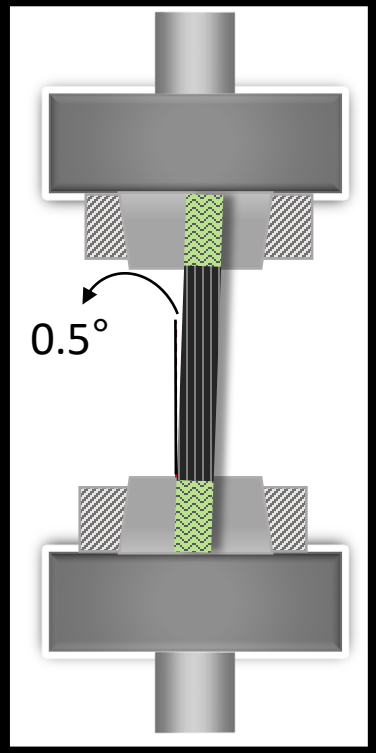


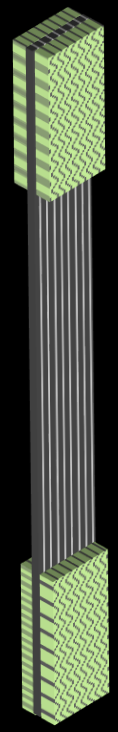




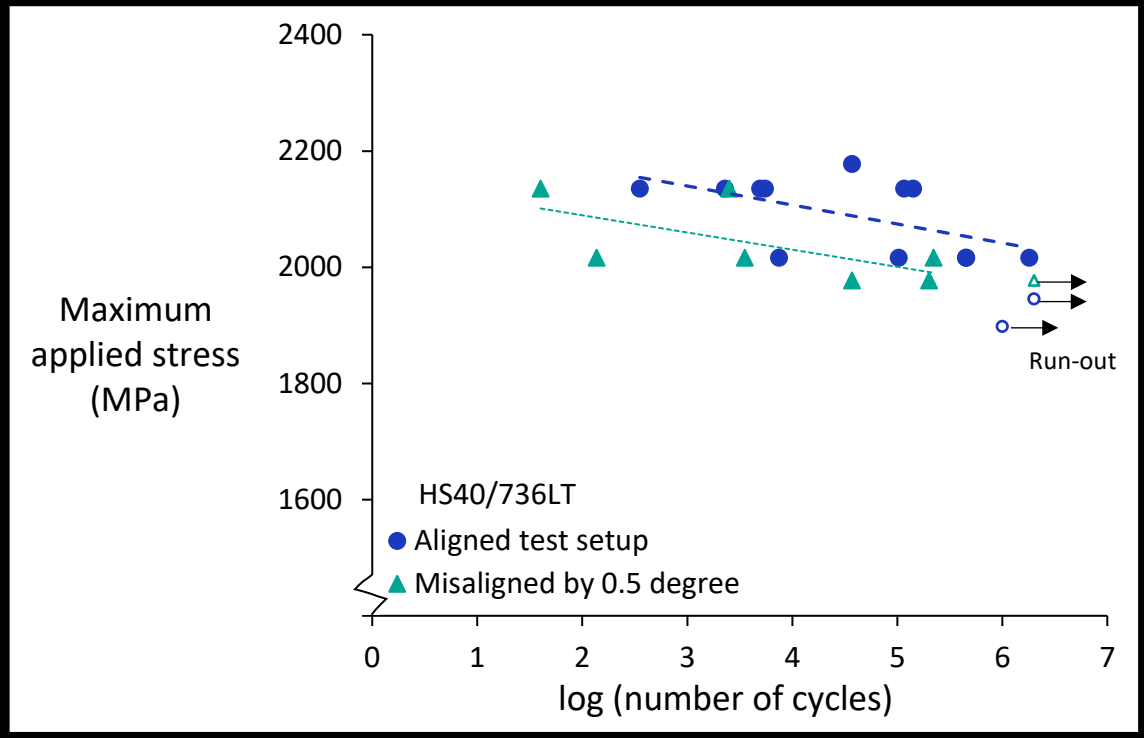
Normal misalignment

Tilted specimen





Tilted specimen



Conclusions

- Specimen designs affect the fatigue life.
- Butterfly design shows the lowest fatigue life.
- Rectangular specimen with rectangular end tab shows the highest fatigue life.
- Significant effect of test setup on fatigue life.
- 0.5 mm normal misalignment reduces the fatigue life by an order of magnitude.
- Specimen tilted by 0.5° reduces the fatigue life by more than two orders of magnitude.

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