Bench-scale fire stability testing

Protective layers in carbon fibre reinforced polymer laminates

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CFRP Laminates with protective interlayers

Concept

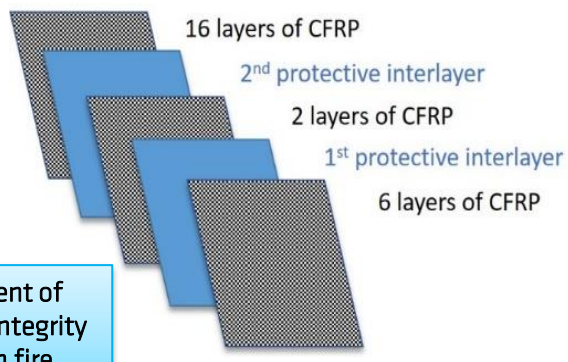
SACFRICE FEW TO SAVE MANY

The protection layers are integrated into laminate structure to provide structural connection with carbon fibres and fireproof protection.

TWO DIFFERENT INTERLAYERS

Fireproof protection + Very good structural connection with CF = Improvement of mechanical integrity of CFRP in fire

Lay-up: [[CF-6L]/1stPL/0/90/2ndPL/[CF-16L]

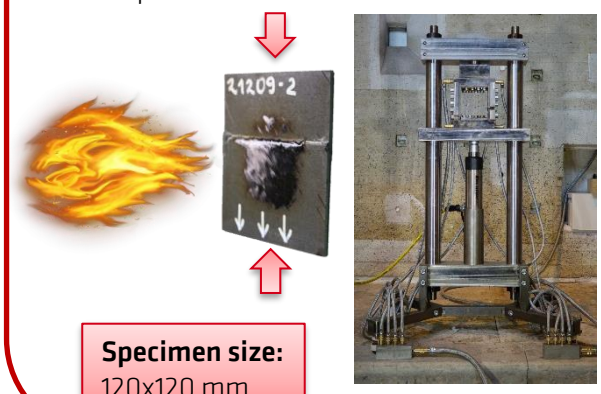


	1st protective interlayer	2nd protective interlayer
1.	Ceramic layer	Basalt fibres woven mat
2.	Titanium foil	PEI foil
3.	Kenaf fibres mat	Basalt fibres woven mat
4.	Rubber mat "Pyrostat"	PEI foil
5.	Ceramic layer	Rubber mat "Pyrostat"
6.	Ceramic layer	Titanium foil

Fire stability test

Principle

Mechanical load in form of compression is applied simultanously with fully developed fire.

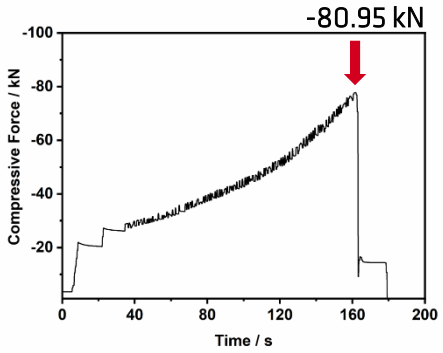


Specimen size: 120x120 mm

Bench scale setup

Ultimate failure

Increasing the compression force until sample will break



10% of failure load used for fire tests = -8 kN

Fire test

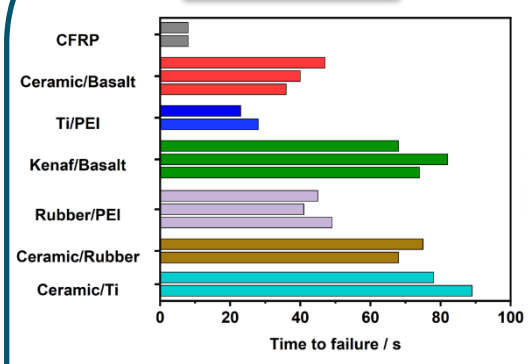
Parameters investigated at test:
- Time to failure
- Temperature (at back of specimen) at failure
- Heating rates

Heat flux: 182 kW/m²
Temperature: 1050 °C

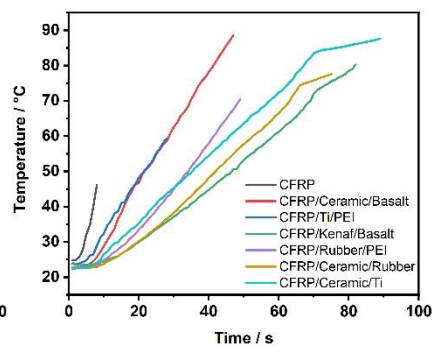
Bench scale setup with burner

Results & Discussion

Time to failure



Temperature at back of specimen



SYSTEM	Time to failure / s	Temperature at failure / °C	Heating rate – slope/°C	Thickness / mm
CFRP	8	46.1 ± 7.0	3.7	3.1
CFRP/Ceramic/Basalt	41 ± 5.6	77.8 ± 13.1	1.6	4.3
CFRP/Ti/PEI	25.5 ± 3.5	55.7 ± 4.7	1.5	3.6
CFRP/Kenaf/Basalt	74.7 ± 7.0	75.8 ± 8.4	0.8	5.6
CFRP/Rubber/PEI	45 ± 4.0	64.2 ± 2.8	1.3	4.7
CFRP/Ceramic/Rubber	71.5 ± 5.0	75.9 ± 13.5	0.9	5.2
CFRP/Ceramic/Ti	83.5 ± 7.8	85.6 ± 1.4	0.9	4.7

Photos of residues

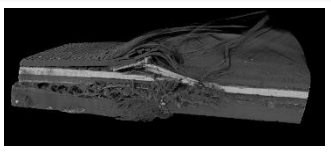
SYSTEM CFRP/Ceramic/Ti

Macroscopic photos of residue present different failure modes: delaminations, kink bands, translaminar fractures.

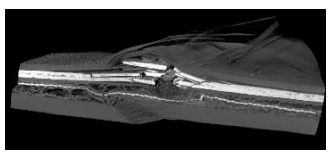
CT of residues

SYSTEM CFRP/Ceramic/Rubber

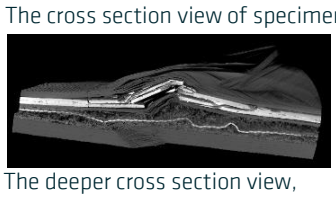
View from outside to inside specimen



Side view of the specimen – outside



The cross section view of specimen



The deeper cross section view, where the change of failure is visible

Conclusions

- CFRP laminates with protective interlayers show significant enhancement of fire stability
- Fire stability depends not only on thickness of specimens, but also on properties of individual interlayer
- Ti foil provides better structural integrity than other layers, thus CFRP/Ceramic/Ti achieved the longest time to failure