Structural integrity in fire:
An intermediate-scale approach for testing composites

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Abstract – Fiber reinforced polymer composites capture a brought spectrum of application (aviation, naval, construction etc.) as lightweight material of choice. Nevertheless, during fire composites may not only promote burning, but show a rapid loss in mechanical properties after a short time. Thus, the structural integrity during fire is a main limiting factor for their use in structural applications.

The variety of fibers, resins, core materials, lay-ups and coatings used for composites, as well as the various specific requirements makes testing a necessity. Hence, the task is to perform realistic investigations under adequate compression loads in fully developed fires.

Our approach uses specimens in the intermediate-scale with defined sizes either 500 mm x 500 mm or 1000 mm x 500 mm with a total thickness up to 50 mm. Compression load is supplied by means of a column furnace. Flame is directly applied on one side of the specimen by an oil burner which is usually used to determine the burn through resistance of thermal/acoustic insulation materials in aviation (Federal Aviation Regulations 25 Appendix F Part 7). Therefore the burner provides a fully developed (post-crash in aviation) fire with a heat flux ~180 kW/m².

The test setup consists of a compression device constructed to transfer load from the column furnace to the specimen. With its 3.6 m height the device has a weight of 2 tons to resist up to the maximum failure load calculated at 1 MN. During the experiments it is isolated, temperature monitored and additionally water-cooled in the vicinity of direct fire exposure.

The introduced test setup with component-like dimensions allows realistic investigations up to structural failure in absence of fire and structural integrity investigations under fully developed fire. Experimental procedures can be realized with preset loads or deformations in force or displacement control regarding time to failure. Additionally failure mechanisms, temperature distribution, decomposition behavior and different flame retardant approaches are in the scope of investigation. Promising results were obtained in test series with the variation of the applied load, the variation of the core structure and various flame retardant systems. Displacement controlled experiments showed a good reproducibility regarding structural failure load and load displacement curves.