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POLITECNICO DI BARI
Dip. Di Meccanica, Matematica e Management
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Activity 2.2.6.4
NUMERICAL AND EXPERIMENTAL ANALYSIS OF MECHANICAL BEHAVIOR OF T-JOINTS IN COMPOSITE MATERIAL

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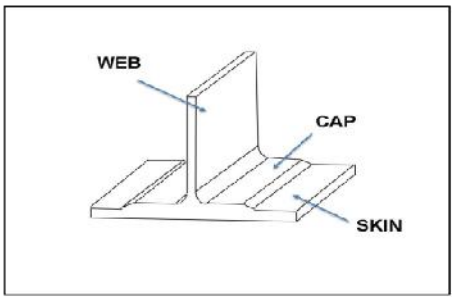
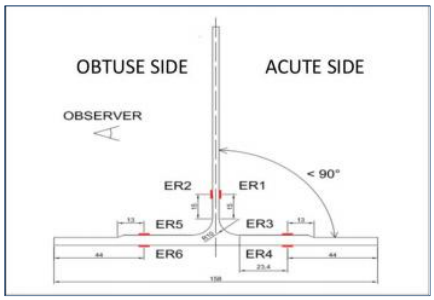
Aim of the work

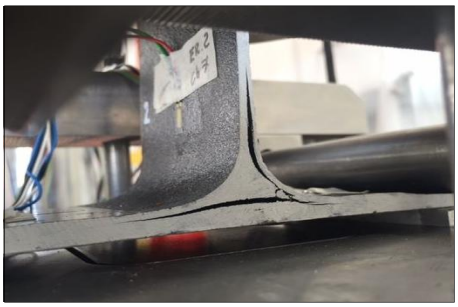
This study analyzes the mechanical behavior of a CRFP composite T-joint via T-pull experimental tests and finite element (FE) simulations. The objective of the study is twofold: (i) to determine experimentally the delamination load of the analyzed joint; (ii) to develop a FE model able to simulate the pull behavior observed in the experimental tests and predict the shear response of the component.

Experimental tests

Experimental tests were conducted on nine T-shaped specimens cut from a stringer component with a 85° inclined web with respect to the skin plane. A polymeric filler is included between cap and web.
Specimens geometry and layup:
Skin:[45/-45/0/45/-45/90/45/-45/0/-45/45/90]s (24 plies);
Spar web: [45/-45/0/90/0/45/-45/0]s (16 plies);
Spar cap: [45/-45/0/90/0/45/-45/0] (8 plies); Single ply thickness: 0.186 mm.; stringer height: 134 mm; skin width 157 mm; skin depth 76 mm.
Since no standard testing methodology was available, T-pull tests were conducted with ad-hoc designed loading systems, consisting of a support base onto which the specimen is constrained by two 25 mm diameter steel rollers at the cap-skin junction. The web of the specimen is held in a grip and subjected to traction. Strain gauges were located in the areas expected to be more critical. The tests were conducted at a speed of 1 mm/min with a Schenck two-column servo-hydraulic machine, equipped with a 250 kN load cell.



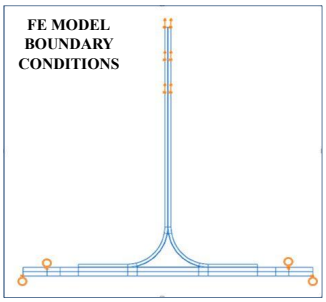


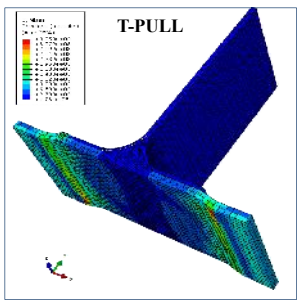


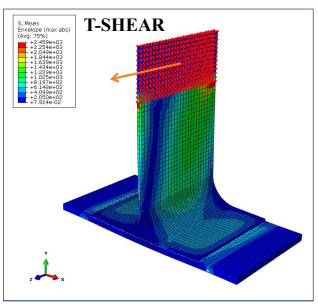
Provino	Carico di delaminazione [N]	Spostamento [mm]
1	7172	1,79
2	5784	1,46
3	9050	2,32
4	8872	2,33
5	11023	3,03
6	11145	2,55
7	9539	2,65
8	9729	2,8
9	6961	2,02
Media	**8808**	**2,33**
Dev. St.	**1839**	**0,5**

Finite Element Analysis

The FE model was developed in the ABAQUS software environment to reproduce the geometry of the tested component as well as the mechanical proprieties of the laminate and filler. The model is tridimensional and includes hexahedral elements with an average dimension of 2 mm.
The adhesive between the parts is modelled as a layer of cohesive material with a level of damage computed via the maximum nominal stress criterion. In the T-Pull FE model, boundary conditions and loads were respectively simulated by hinge constraints applied at the ends of the skin segment and selecting a velocity of 1 mm/min for the displacement of the upper clamped part of the web. The T-Shear model differs from the T-pull model only for the direction of the imposed displacement.







Conclusions

The load-displacement curve computed by ABAQUS for the T-Pull configuration test matched pretty well those obtained in the experimental tests campaign. Assuming the FE model to be reliable, finite element simulations were carried also for the T-Shear configuration by simply changing the direction of the applied load. It was found that shear load values leading to web debonding from the skin are considerably higher than the typical loads to which the analyzed component is subjected during its lifetime.