DEPARTMENT OF MECHANICAL & AERONAUTICAL ENGINEERING
DIVISION OF APPLIED MECHANICS, TECHNOLOGY OF MATERIALS AND BIOMECHANICS
LABORATORY OF TECHNOLOGY & MATERIALS RESISTANCE

DIPLOMA THESIS

Optimization of the design of a disbond arrest feature in co-consolidated thermoplastic composite materials through numerical models

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ABSTRACT

The connection of composites with welding or adhesive is widely used, but this way of connection presents risks as it can lead to catastrophic failure of the construction due to the disconnection. In order the construction to fail safely, additional mechanisms are installed which slow down the spread of the disconnection. In the present diploma thesis, the design of disbond arrest features (DAFs) of two adherends was optimized using finite element analysis. The joining method of these two plates was the direct bonding of co – consolidation. A parametric analysis was performed in order to design the disbond arrest features by using rivets on the CLS and ENF specimen. CZM was used.

MODELING

The simulation models were prepared with the aid of the graphical preprocessor Ls-PrePost of the finite element package of LS-DYNA.

Parametric analysis for:

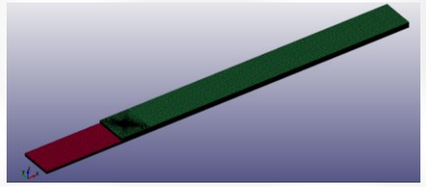
CLS specimen:

1. diameter of the rivets for 3 mm, 5 mm ,7 mm
2. distance from the beginning of the bonded area which was 10 mm, 20 mm and 30 mm
3. the way of placing two rivets in a row, changing the distance between them from 3 mm to 5 mm and 7 mm

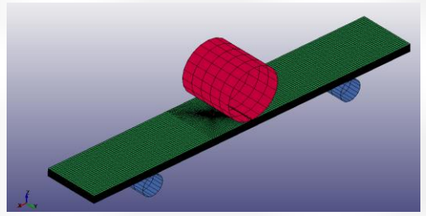
ENF specimen

1. diameter of the rivets for 3 mm, 5 mm ,7 mm ,the distance from the begging of the bonded area was 10 mm

CLS SPECIMEN



ENF SPECIMEN



Lay – up of each laminate: $[0/45/90/45/-45]_s$

Materials:

Adherends: a carbon-fiber reinforced thermoplastic composite based on Low – Melt PolyArylEtherKetone (LM - PAEK) matrix, TC1225

DAF: Stainless steal

Bonded Area: Low – Melt PolyArylEtherKetone (LM - PAEK)

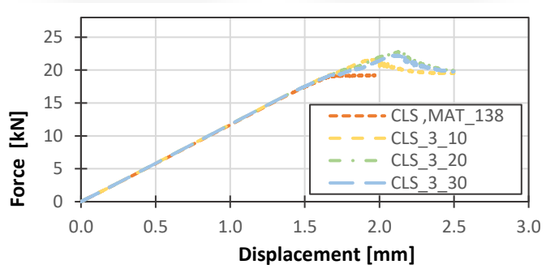
Cylinders are used to model the DAFs.

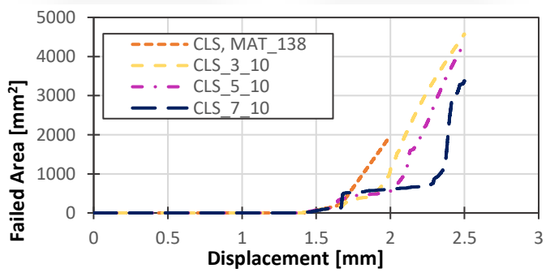
RESULTS

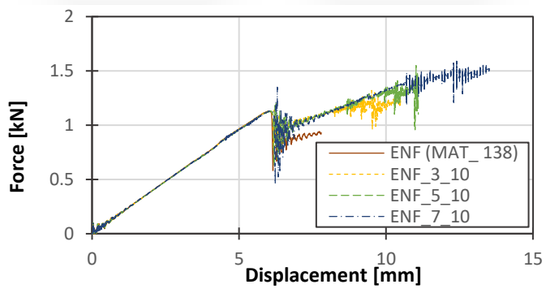
PERCENTAGE INCREASE IN FORCE FOR 1 DAF FOR CLS

Distance from the bonded area (mm)	Diameter 3mm	Diameter 5mm	Diameter 7mm
10	13.12 %	17.8 %	32.23 %
20	18.16 %	22.47 %	32.95 %
30	15.57 %	18.06 %	28.9 %

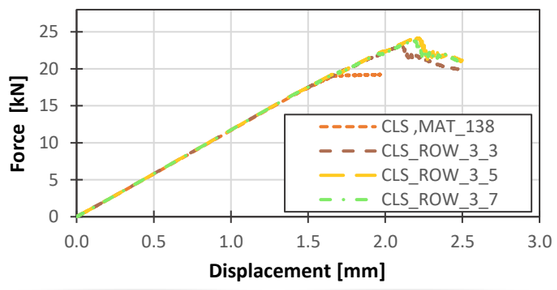
PLOTS FOR 1 DAF

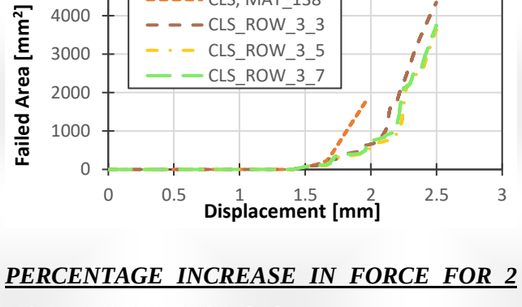






PLOTS FOR 2 DAFs IN ROW

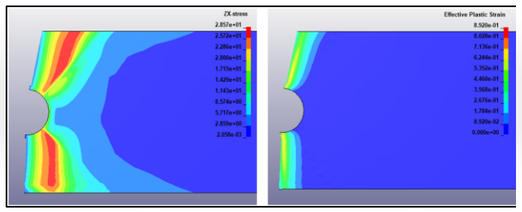




PERCENTAGE INCREASE IN FORCE FOR 2 DAFs IN A ROW FOR CLS

Simulation's Specimen	Max Force (kN)	Increase (%)
CLS, MAT_138	19.27	
CLS_ROW_3_3	22.97	19.2
CLS_ROW_3_5	24.17	25.43
CLS_ROW_3_7	23.81	23.56

DISTRIBUTIONS



zx-shear stress Effective plastic strain

CONCLUSIONS

Diameter is more important parameter than the distance from the beginning of the bonded area, as increasing the diameter there is a more significant increase in the bearing capacity of the connection. The introduction of a second disbond arrest feature increases even more the forces that the bond can carry and disbonding slows down even more. The longer diameter slows down more the disbond than the other diameters but observed faster disconnection after the mechanism's area.