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Titolo III 'Creazione di nuovi Distretti e/o Aggregazioni Pubblico Private' Intervento di formazione

Development of Analytical and Numerical models applied to stress-interface determination in aeronautical stringer-reinforced structures with de-bond defects.

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SPIA Project Code: PON03PE_00067_3

Research activities are about a project aimed at analysing **aeronautical composite-made structures**, characterized by **defects** or **damage**.

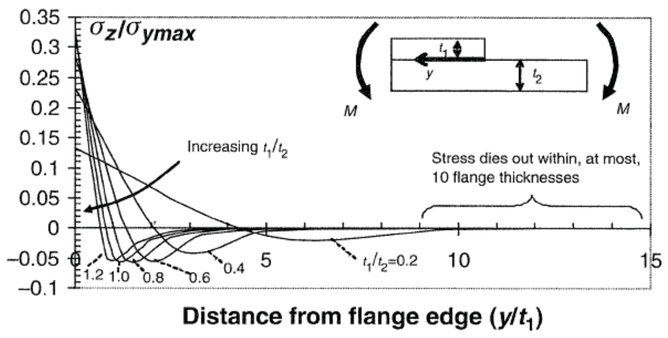
Two different approaches are exploited: an **analytical method**, providing stress-prediction at interface of a stiffened structure, and a **numerical method**, providing residual strain and fracture strength of a stiffened structure with a de-bond defect.

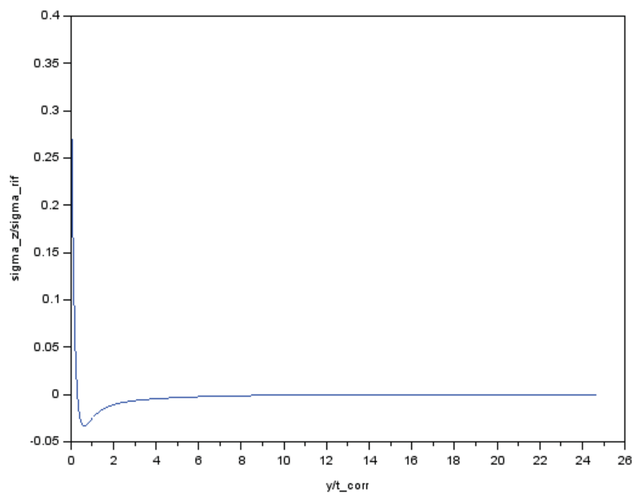
Analytical Model

This activity is related to the implementation of an analytical model in *Scilab* software, providing **stress-prediction at interface** of a composite stringer-reinforced structure. It is based on 'energy release rate' calculations and describes a tridimensional state of tension; its constitutive equations have some input parameters, such as:

- laminates material properties
- skin and flange layup
- loading situation
- skin/flange thickness ratio.

The model has been calibrated to literature data, with particular reference to interface normal stresses curve. Skin-flange layup and thickness are assumed to be the same. (References: Design and analysis of composite structures, C. Kassapoglou)



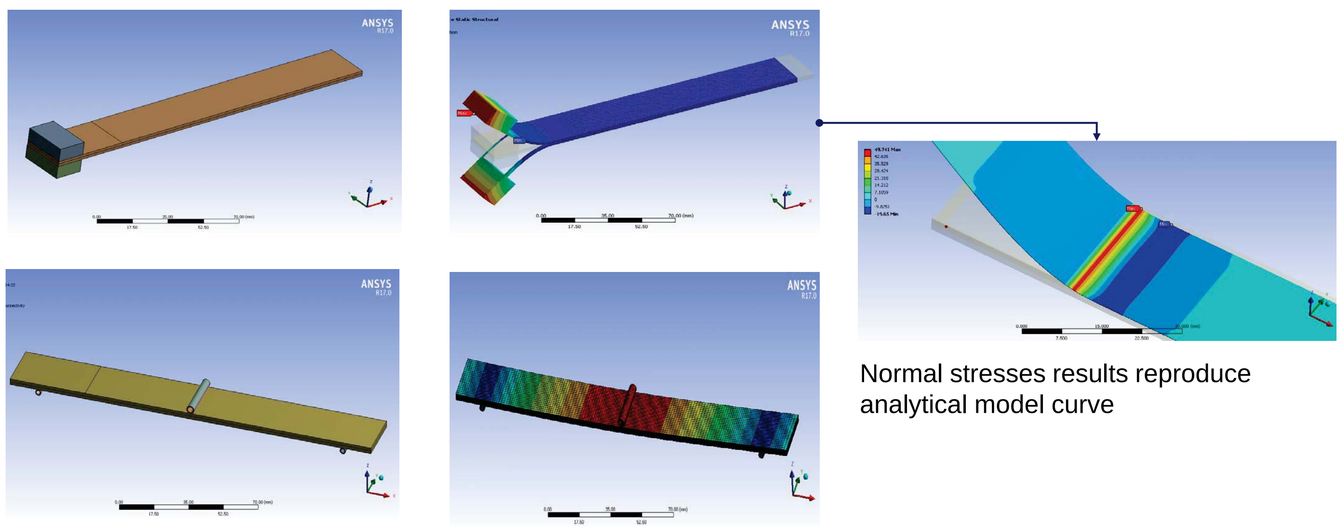


Setting a failure criteria, stresses distribution may describe an **incipient delamination/debonding**

Numerical Model

Interface properties have been developed in *Ansys* defining a **CZM (Cohesive Zone Material) model**. 'Interface Elements' and 'Contact Elements' have been investigated.

First activity: **DCB** and **ENF tests simulation** in order to calibrate CZM.

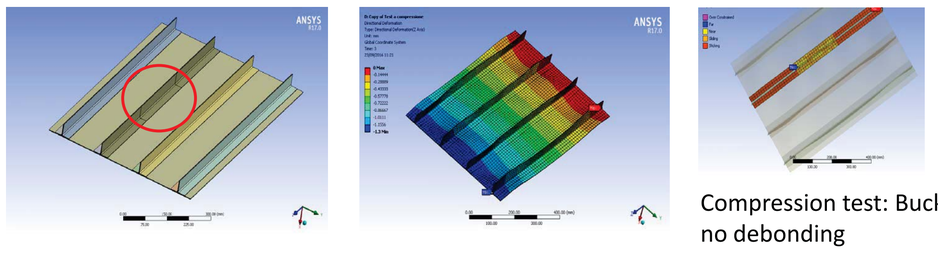


Normal stresses results reproduce analytical model curve

Second activity: Application of calibrated CZM to aeronautical composite-made structures with a **de-bond defect** (indicated with a red circle), in order to provide residual strain and fracture strength.

Tensile test: Residual strain at 4.3 mm

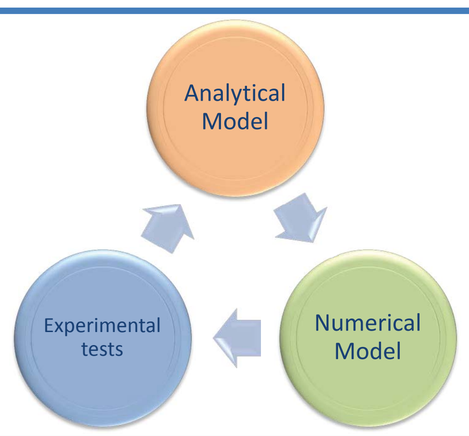
Compression test: Unchanged residual strain at 1.5 mm



Compression test: Buckling at 1.3 mm, no debonding

Conclusions

- Analytical Model can be assumed as an instrument to quickly evaluate the influence of different project parameters, while Numerical Model is a detailed description of structural behaviour to delamination/debonding
- **Integration of the two models** with experimental tests in the certification process of aeronautical structures is a future possibility, leading to structural optimization and reduction of the overall experimental tests number and related costs



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