DEPARTMENT OF MECHANICAL ENGINEERING AND AERONAUTICS
DIVISION OF APPLIED MECHANICS, TECHNOLOGY OF MATERIALS AND BIOMECHANICS
LABORATORY OF APPLIED MECHANICS AND VIBRATIONS

Name: Evangelia Makri
AM:1054487
Year: 2021
Supervisor Professor:
Kostopoulos Vasileios
Supervisor researcher:
Psarras Spyridon

Step scarfed repair of composite structures using elliptical patches

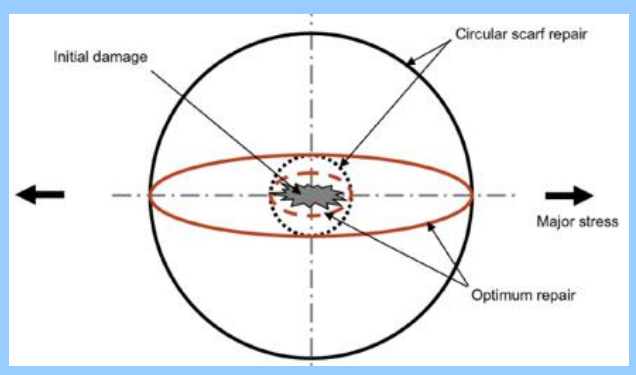
Aim of Thesis:

The aim of the present thesis is the selection of the optimal elliptical patch for the repair of a composite plate, with primary criterion the ratio of the minor to the major axis b/a of the plies of each patch.

Theoretical background:

The optimization of the scarf shaping of a composite repairing structure has been a significant issue for many searches. The optimal scarf shape of the plies is elliptical, and it is given from the numerical solution: $\left(\frac{x}{A}\right)^2 + \left(\frac{y}{B}\right)^2 = 1.$

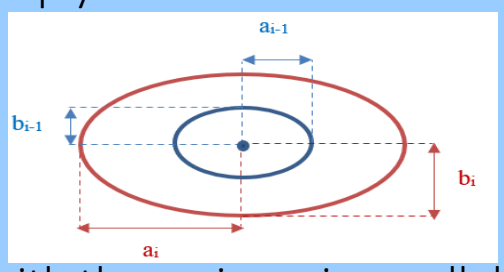
So, the optimal scarf shape comes out to be conical, according to the equation: $z = r \cdot \tan\alpha(\theta) - A.$



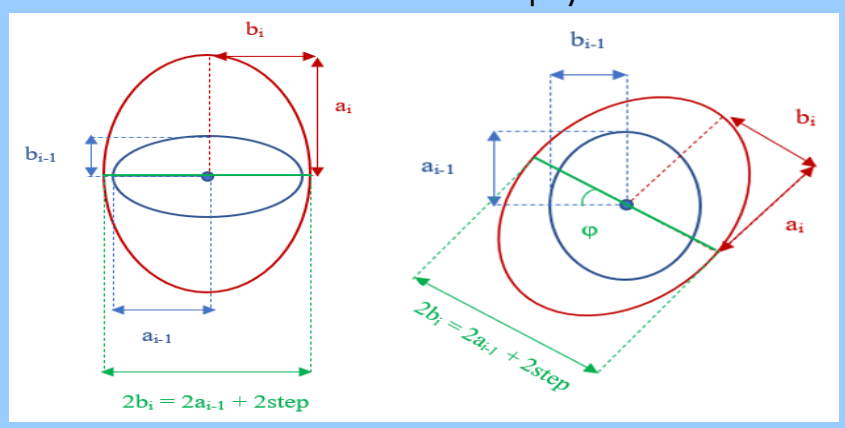
Computational analysis at the finite element analysis program Abaqus:

- Design of a repaired composite plate made of the material Graphite / Epoxy IMS 24K 997-2.
- The elliptical repairing patches differ from each other in both the b/a ratio and the orientation of the major axis of each ply.

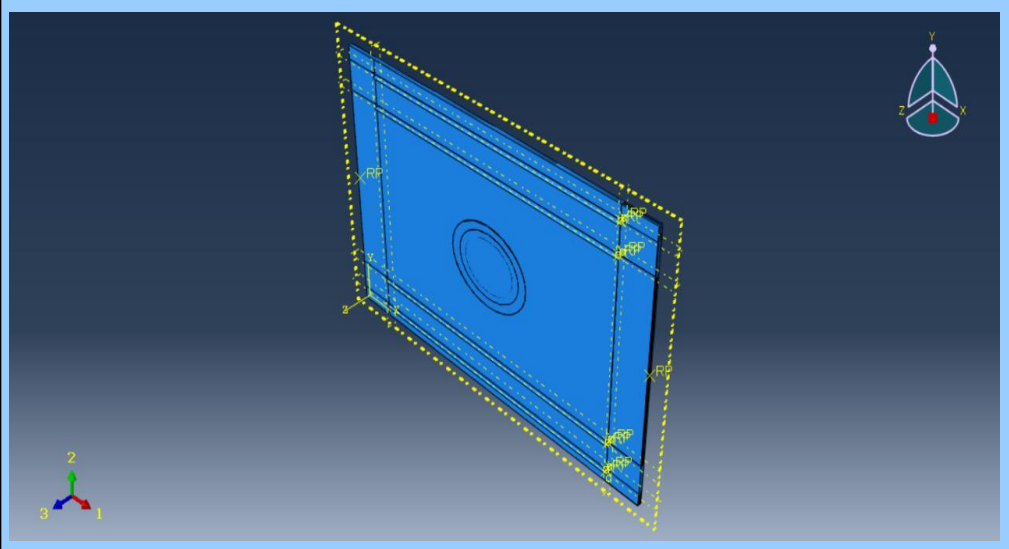
1) Elliptical patches with the major axis parallel to the direction x.



2) Elliptical patches with the major axis parallel to the fibers' orientation of each ply.



The analyses were conducted for the allowable b/a ratios, according to the geometrical restrictions.



Results:

Patches	Strength (N)	Percentage difference from the circular patch's strength (%)	$V_{mat,loss}$ (mm^3)	Percentage difference from the circular patch's $V_{mat,loss}$ (%)
R-0.9-1	**60078.3**	**21.6**	**307.9**	**75.2**
R-0.85-1	**60955.2**	**20.5**	**495**	**60.1**
R-0.8-1	**76654.9**	**0**	**815.8**	**34.3**
NR-0.9-xy	**68468.4**	**10.7**	**88.2**	**92.9**
NR-0.8-xy	**72815.7**	**5**	**352.3**	**71.6**
NR-0.7-2	**76655.5**	**0**	**471.6**	**62**
NR-0.6-2	**76659.8**	**0**	**564.9**	**54.5**
NR-0.5-2	**76655.3**	**0**	**695.4**	**44**
NR-0.4-1	**76660.4**	**0**	**430.9**	**65.3**

The comparison of the patches was mainly carried out according to the recovered strength, which should be as high as possible, and simultaneously according to the undamaged material removal, which should be as low as possible. Additionally, the detachment status of each patch just before the failure was taken into consideration, as well as the matrix and the fibers failure according to the Hashin failure criterion. Finally, the NR-0.8-xy patch was selected as the optimal one.