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Determination the material properties of twill-woven glass fabric polymer composite using experimental modal analysis and numerical technique

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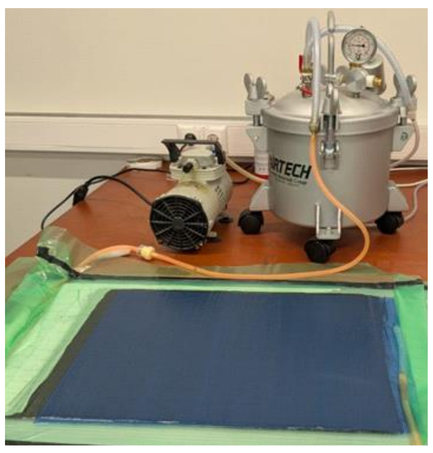
INTRODUCTION & AIM

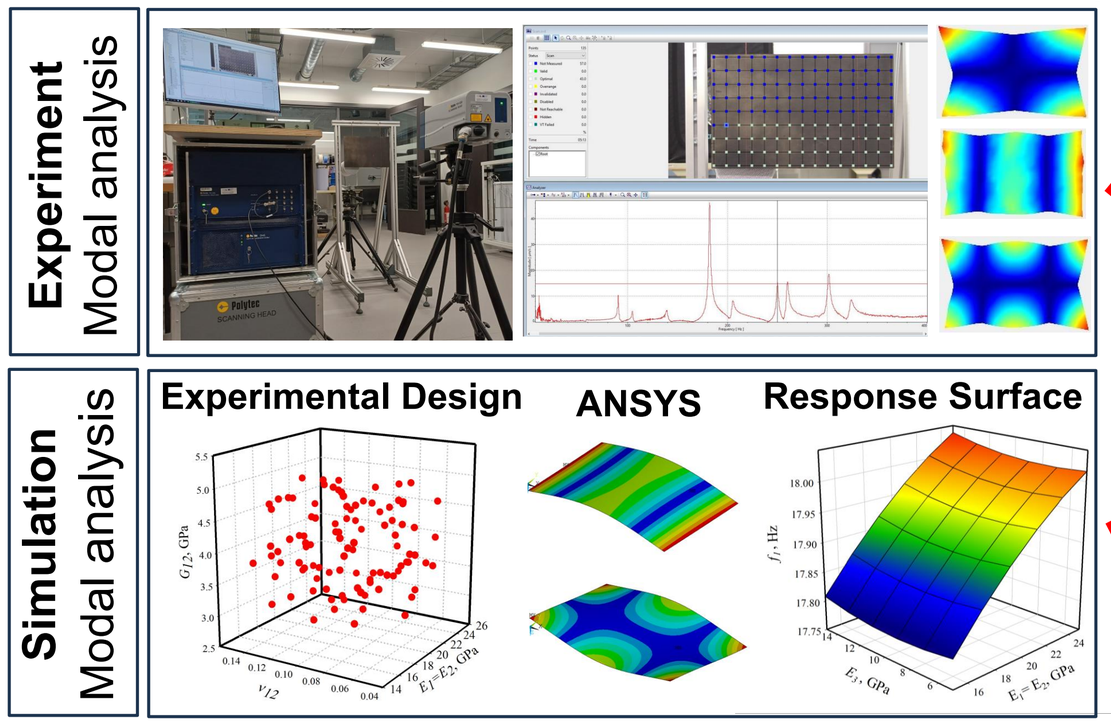
The work considers the numerical–experimental method for identifying the elastic characteristics of composite materials using experimental data on the natural frequencies and vibration modes of plate-shaped specimens using twill-woven glass fibre fabric material.

METHOD

The composite layered plates (8, 12, 16 layers) are fabricated using the vacuum infusion process.



An experimental modal analysis is performed on the plate to determine its natural frequencies and vibration mode shapes.



a) An experimental plan is created. b) Finite element modal analysis was performed. c) Approximation equations are obtained for each frequency.

The discrepancy between the calculated values of natural frequencies is estimated.

$$\Phi_i(\boldsymbol{x}) = \sum_{i=1}^{m} \frac{\left(f_i^{\exp} - f_i^{FEM}\right)^2}{\left(f_i^{\exp}\right)^2} \Rightarrow \min$$

$$x = [E_1, E_2, G_{12}, \upsilon_{12}]$$

Identified characteristic.

RESULTS & DISCUSSION

1. Elastic characteristics determined by numerical–experimental method.

Elastic Const.	8 lays.	12 lays.	16 lays.	Aver.	CV, %
E_1=E_2, GPa	19.66	21.36	21.29	20.77	4.63
G_{12}, GPa	4.27	4.26	4.27	4.27	0.14
υ_{12}	0.12	0.11	0.105	0.112	6.84

const: E_3=9.5 GPa, $G_{13} = G_{23}$ =2.5 GPa, $\upsilon_{13} = \upsilon_{23}$ =0.25

2. The identified elastic characteristics were used for a comparative analysis of the natural frequencies.

No	8 lays.			12 lays.			16 lays.		
	f_i^{exp}	f_i^{FEM}	Δ, %	f_i^{exp}	f_i^{FEM}	Δ, %	f_i^{exp}	f_i^{FEM}	Δ, %
1.	23.0	23.0	0.0	34.3	34.5	0.7	46.0	46.0	0.1
2.	29.3	30.3	3.4	46.3	47.3	2.2	60.5	62.9	4.0
3.	54.5	55.7	2.2	83.8	84.6	1.0	111.8	112.6	0.8
4.	80.0	77.8	2.8	125.0	121.5	2.8	168.0	161.7	3.8
…	…	…	…	…	…	…	…	…	…
12.	223.0	214.7	3.7	345.5	335.0	3.0	460.6	445.3	3.3
Avrage:			2.2			1.8			2.1

3. Comparison of Elastic modules and Poisson's ratio from the vibration and static tensile test.

Elastic Const.	Static Tension Test				Identified	Δ, %
	8 lays.	12 lays.	16 lays.	Average	Average	
E_1, GPa	21.02	21.09	22.61	21.57	20.77	3.7
υ_{12}	0.108	0.096	0.105	0.103	0.112	8.0

CONCLUSION

The advantages of this methods are the ability to determine the material properties after external influences (temperature, aging, water absorption, etc.), which allows one to reduce the consumption of material

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