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EXPERIMENTAL AND ANALYTICAL COMPARISON OF GFRP LAMINATES FROM VATRM METHOD

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Abstract:

Experimental validation with analysis approach is an important criterion to check the practical effective differences in material characteristics. The present paper focused on the laminate strengthening properties check with analytical software to find out the feasibility of laminate bonding for the mechanical load. Vacuum assisted transfer moulding processed laminates has been taken for further analytical approaches to check the deformations with natural loading conditions. Detailed experimentation study has to done to find out tensile strength of laminate for simulation approach for GFRP laminates. The impacts of reinforcing on endurance limit and impact of degree of failure are talked about in subtle element. The outcomes demonstrate that the heap conveying limit of bars was essentially expanded as the quantity of layer expanded. The acceptance of the trial results was finished by utilizing ANSYS programming. To concentrate on the flexural conduct of the pillar, the examples were just subjected to two-point stacking system just.

Key words: GFRP laminates, VARTM process, Mechanical properties, Ansys

1.0 Introduction

Upgrading of solid structures may be required for a wide range of reasons. The solid structures may have turned out to be fundamentally in sufficient for instance, because of material deterioration, poor configuration or development, maintenance absence, redesigning of outline burdens, for example, natural causes like earthquakes. But GFRP and solid epoxy paste can strengthen the structures. Fundamentally the method includes giving extra layers of GFRP to concrete surfaces. These plates act compositely with the solid and increase the load carrying capacity. The utilization of GFRP to steel and solid structures has turned out to be progressively alluring because of the understood great mechanical properties of these materials. These properties are good strength to density proportion, good corrosion resistance, less cost of maintenance and less installation time with routine materials.

1.1 Objectives

1. To predict the flexural behaviour of circular cross-section with FRP sheet with VATRM method.
2. To check the impact load results on the GFRP laminate using Ansys work bench
3. To compare the maximum stress limit with simulation and practical for actual losses.

2.0 Literature review

[1] Abdalla F. H.1, Megat M. H.1, Sapuan M. S. and B.B. Sahari ; "Determination of volume fraction values of filament wound glass and carbon fibre reinforced composites" With the expansion of composites into application like pipes and pressure vessels, there exists a need for further studies on the properties of these materials. Donald F. Adams, Leif A. Carlsson and R. Byron Pipes. 2003. Experimental characterization of advanced composite materials. This study focuses on the use of control factors (volume fraction of fibres (A), aspect ratio of fibres (B) and fibres orientation (C)) to determine the optimum tensile strength of plantain fibres reinforced polyester resin [2]. Some experimental investigations addressing impact behaviour of composite plate using falling drop weight were reported in literature. Aslan et al. [3] studied experimentally the behaviour of E-glass/epoxy laminate under low energy impact using different masses of indenter and the indentation in laminate was discussed. It was concluded that the delamination in the target plate increased with the span size of plate. The effect of diameter of indenter on delamination in the target plate was studied by Icten et al. [4] and it was concluded that the induced damage in the target was more in case of impact by bigger indenter. Mishra and Nayak [5] studied analytically the deflection, stresses and contact force variation in the composite target due to low velocity impact by considering nonlinear Hertizian contact low. It was reported that the contact force increased with impact velocity. Some numerical approach to study low velocity impact phenomenon in the composite plate was also reported in the literatures. Tiberkak et al. [6] studied numerically the effect of impactor mass and incidence velocity on contact force and stress variation in the composite target. It was found that the peak of contact force increases with impactor mass and velocity. Another numerical study of in this regard was performed by Malik et al. [7] by using ABAQUS and impact energy absorption in target plate was discussed. Whereas, the damage in carbon /epoxy composite plate was studied by Zhang et al. [8], with ABAQUS software and it was concluded that the delamination and matrix crack were predominant cause of failure.

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The material properties of GFRP laminate were obtained as required in the material model presented by Hayhurst et al. [12]. Three strain gauges were applied on the surface of specimens; one along longitudinal, second along transverse and third along the thickness.

3.0 Methodology

The first level of finite element model of lugs is the model of description of the casting process of plates from PEEK material. Modeling of the injection casting of the plate was carried out using the complex Moldex3D programme. The Moldex3D software is intended for the modeling of hydraulic processes of casting under pressure of thermo-flexible materials reinforced by short fibers. The feature of the cast materials is high and variable viscosity depending on casting speed. Moldex3D allows orientation of short fibers in material to be defined in the casting process and after polymerization. The file with information on the rated grid and on fiber orientation is the result of modeling of the casting process of the plate.

Finite Element Model. For the composite plate-cone reticulated shell, the FEM analysis model only with the top member, without bottom members and middle members, is adopted in this paper. ,e model considers the joints of the top members as hinged and the bottom joints as rigid In the ANSYS model, the spatial truss element Link8 with 2 nodes and 6 degrees of freedom is used to model the top truss members, and the finite strain shell element Shell181 with 4 nodes and 24 degrees of freedom is used to model the triangular plate elements. ,is element type was demonstrated to suit for analyzing layered composite structures where material properties were varied at different layers.

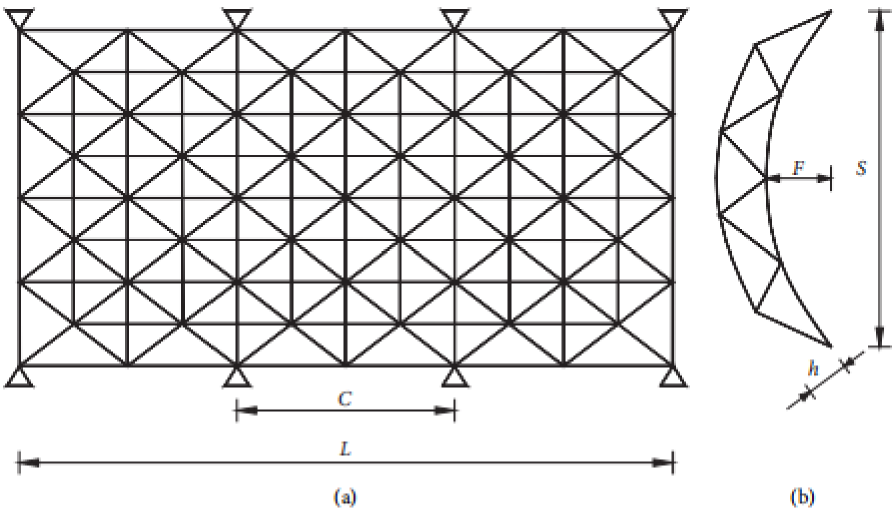

Figure1: Geometric parameters of the plate-cone cylindrical reticulated shell

Table-1 Properties of MAT GFRP for analysis

S. NO.	LAYERS-FORCE	TENSILE STRENGTH			AVERAGE VALUE (N/mm^2)
		1	2	3	
1	4L-350mm of Hg	69.952	71.547	68.447	69.982
2	4L-450 mm of Hg	82.276	80.277	85.244	82.599
3	4L-550 mm of Hg	62.153	65.147	67.146	64.8153
4	5L-350 mm of Hg	78.472	80.284	77.216	78.6573
5	5L-450 mm of Hg	93.109	94.841	89.234	92.3947
6	5L-550 mm of Hg	64.548	67.254	65.215	65.6723

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7	6L-350 mm of Hg	101.693	99.251	98.215	99.7197
8	6L-450 mm of Hg	98.254	97.328	101.251	98.9443
9	6L-550 mm of Hg	67.592	70.354	66.648	68.198

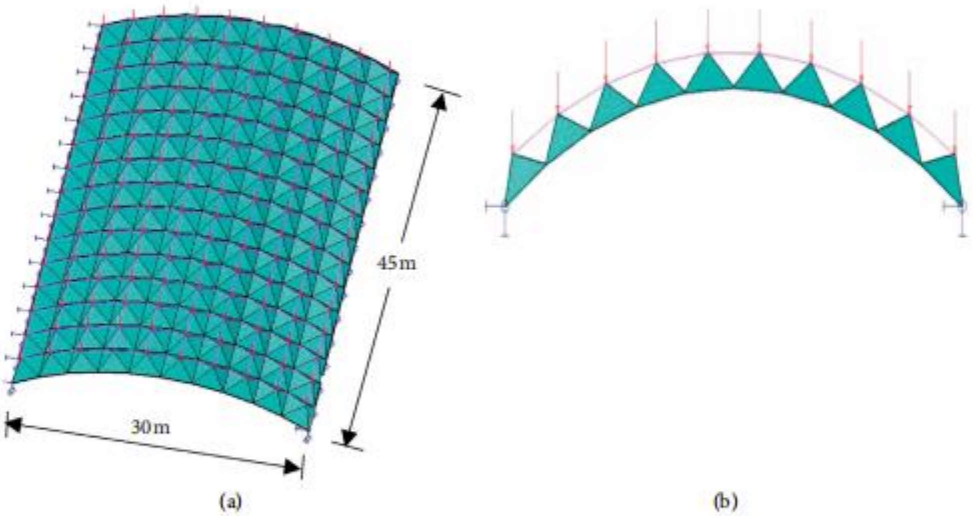

Figure2; FE model of the plate-cone cylindrical reticulated shell.

4.0 Parametric analysis of GFRP laminate

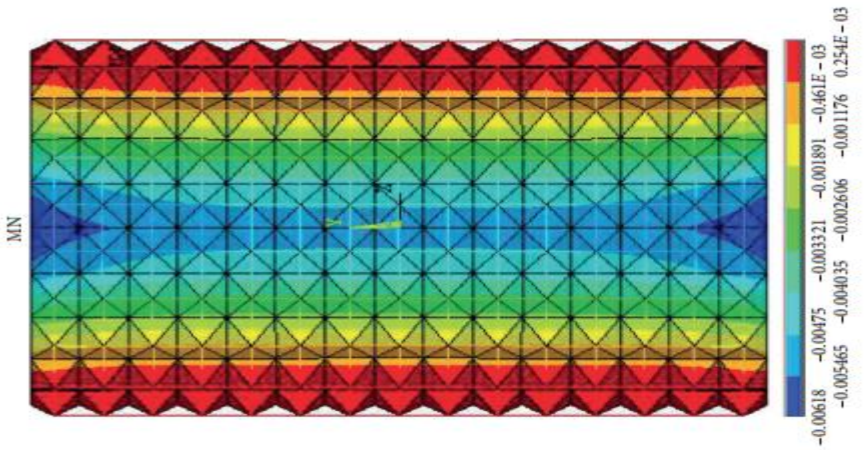

Figure3 ; Vertical displacement of the plate-cone reticulated shell (m).

The maximum axial compression force of top members is −32.732 kN, and the maximum axial compression force of plates is -51.055 kN. ,e strength of each layer of laminates was calculated according to equations and the results show that the strength of the first and fourth layer of composite laminates is 0.007029, and the strength of the second and third layer of composite. laminates is 0.071455. Therefore, the composite plate-cone reticulated shell has notable residual strength. However, the internal force distribution is not uniform among layers of laminates, so it is necessary to analyze the reasonable laying design for laminates of the composite plate-cone reticulated shell.

The laying direction of laminates is another critical parameter of laminates. Because the laying structures are different, that is to say, if the order of each layer in the laminate is different, the ultimate strength of the laminate may be totally different even for the same material system. Therefore, for the composite platecone reticulated shell, studying the influence of laying direction on the strength of the laminate is very necessary and of significant importance in practice. In order to discuss the influence of laying direction on the strength of the structure, the

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mechanical properties of eight kinds of laying directions (total thickness is 8 mm, and the thickness of each layer is uniform) are calculated using finite element analysis.

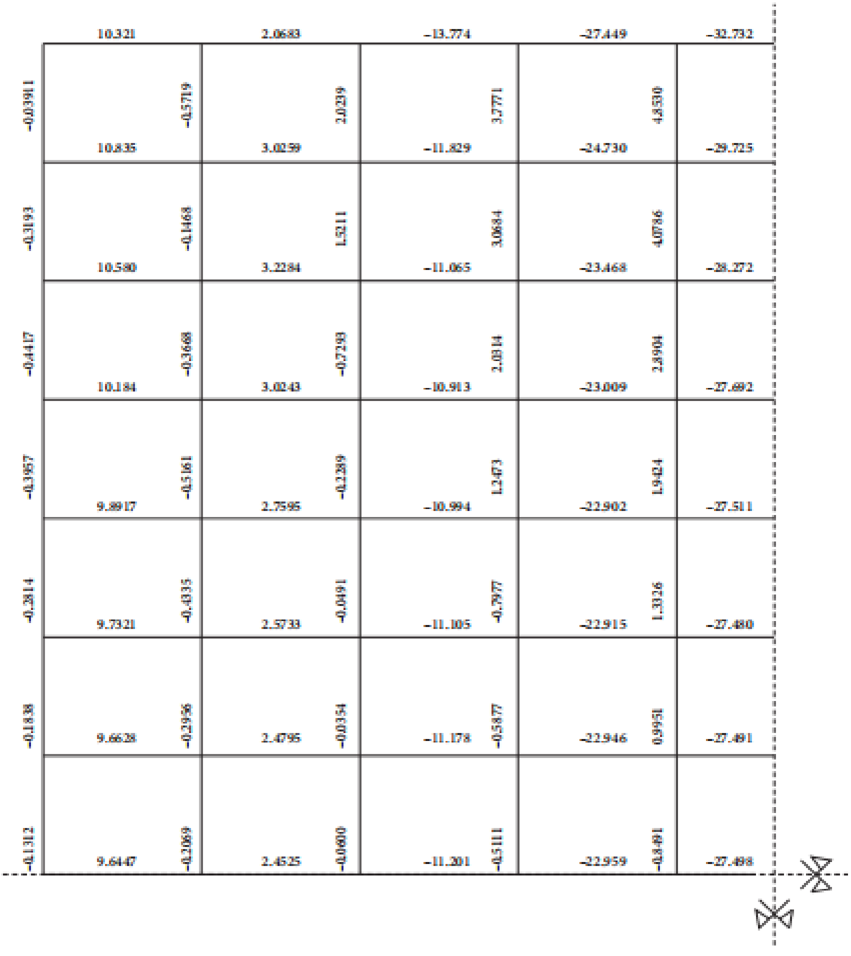

Figure 4: Axial force of top members of the plate-cone reticulated shell (kN)

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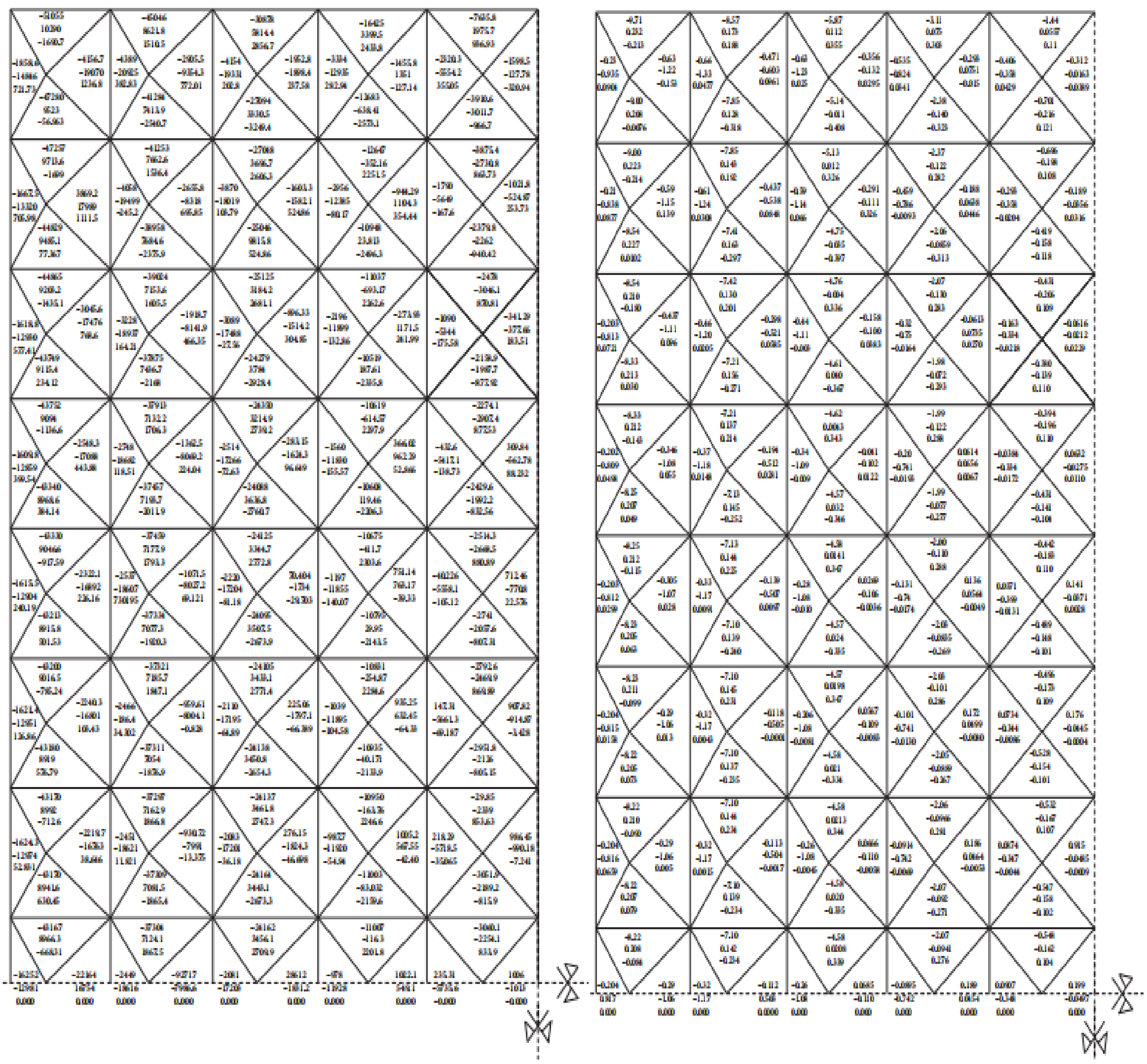

Figure 5: a)Axial force of laminates of the plate-cone reticulated shell (N) and (b) : Normal and shear stress (σx, σy, τxy) of the fifirst and fourth layers of laminates (MPa).

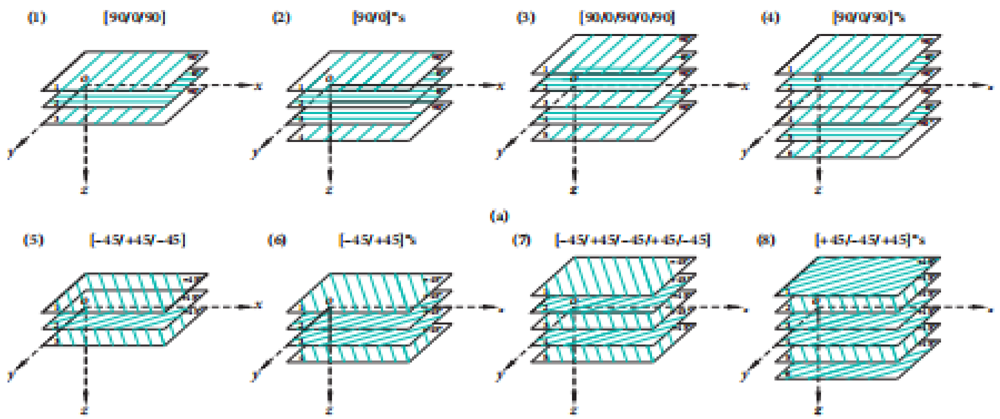

Figure 6; Composition of FRP laminates with fifibers oriented in difffferent directions. (a) Group 1. (b) Group 2

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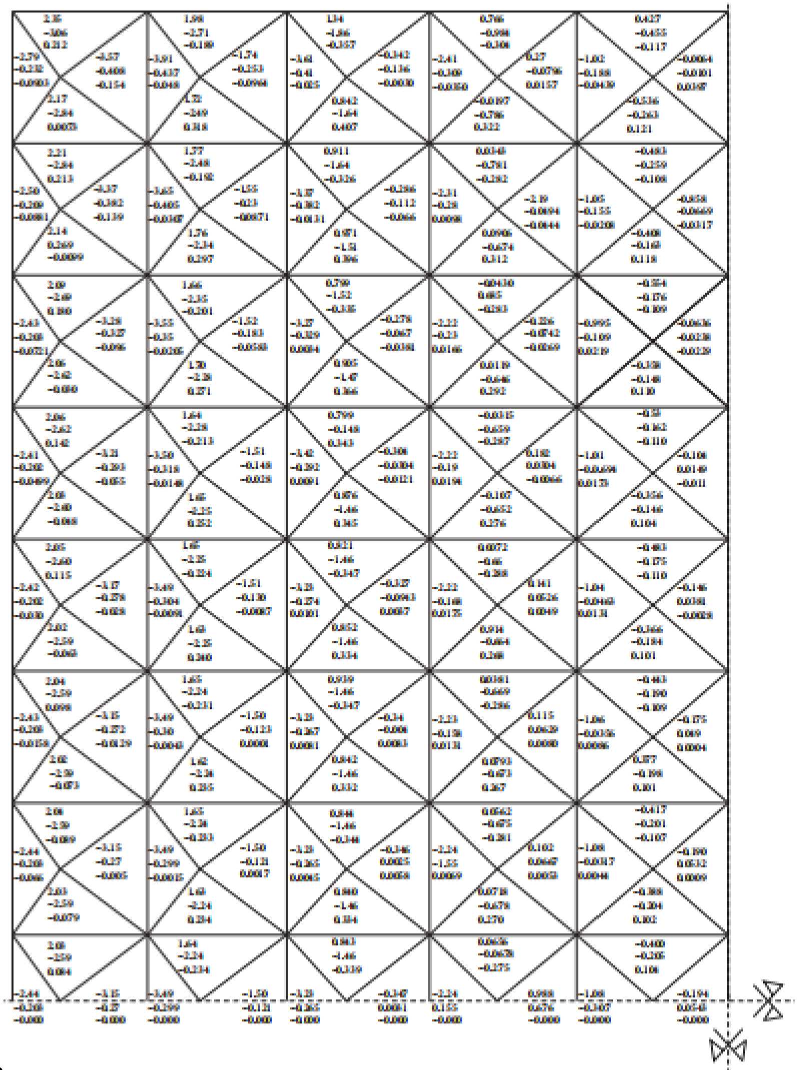

b

Figure7: Normal and shear stress (σx, σy, τxy) of the second and third layers of laminates (MPa).

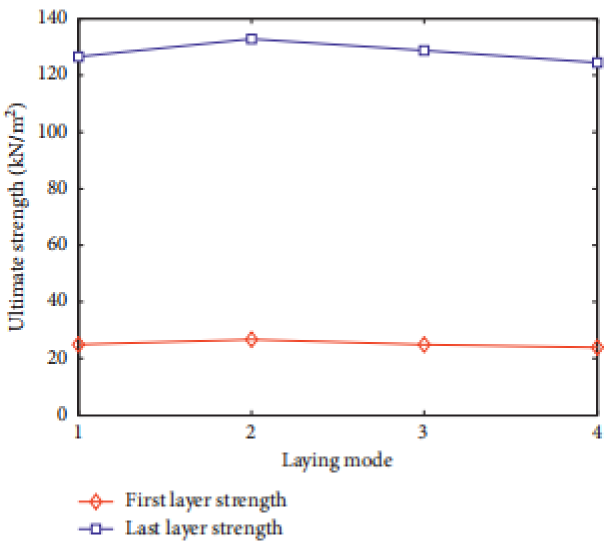

Figure 8: Ultimate strength of the reticulated shell composed with fifirst group laminates.

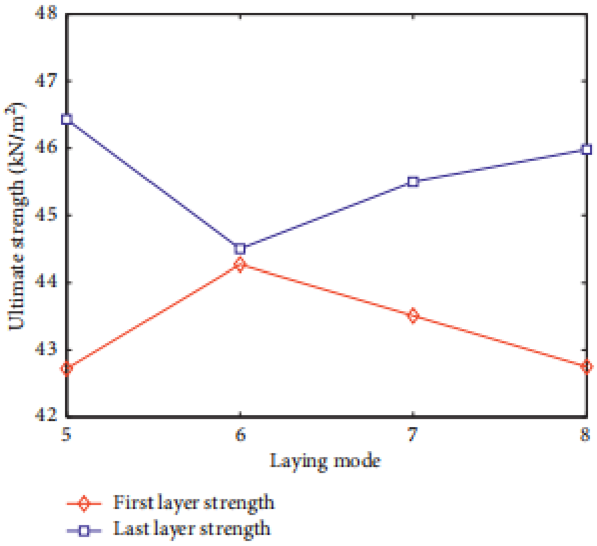

Figure9: Ultimate strength of the reticulated shell composed with second group laminates.

5.0 Discussions

Effect of thickness of Laminate.

To study the influence of the thickness of laminates on the ultimate strength of laminates, the parametric analysis for laminates with different total thicknesses and thicknesses of the individual layer was conducted. E triangular plates of a cone element are adopted with different laying design, i.e., the laying directions are all [90/0]°S, but the total thickness of the laminates and the thickness of each layer is different. In this paper, the mechanical properties of six kinds of laminates with varying modes of laying (seen in Table 2) are calculated, and the ultimate Strength of the structure under uniformly distributed loads are obtained by combining the Strength Criterion of work; more detailed results are shown in

Table 2. From Table 2, it can be seen that the thickness of composite laminates have a significant effect on the ultimate strength of laminates in plate-cone reticulated shells.

Laying mode	First layer strength (kN/m2)	Layers failed at first	Last layer strength (kN/m2)	Layers failed at last
[0/90]° S	26.6	2nd and 3rd layers	130.0	1st and 4th layers
[90/0]° S	26.5	1st and 4th layers	132.3	2nd and 3rd layers
[−45/+45]° S	44.5	All of four layers	44.5	All of four layers
[+45/−45]° S	44.4	All of four layers	44.5	All of four layers
[+45/0]° S	65.4	1st and 4th layers	83.0	2nd and 3rd layers
[0/+45]° S	65.5	2nd and 3rd layers	83.0	1st and 4th layers
[+45/90]° S	14.8	2nd and 3rd layers	43.6	1st and 4th layers
[90/+45]° S	14.8	1st and 4th layers	43.8	2nd and 3rd layers

6.0 Conclusions

Generally, the first and last layer strengths will increase with the total thickness and the thickness of the second and fourth layers. It can also be found that with the change of full-thickness, the strength interval between the first layer strength and the last layer strength of the laminates changes slightly. The ratios between the previous layer ultimate strength Q2 and the first layer maximum strength Q1 are about 5. The ultimate strength of the composite laminate in the plate-cone reticulated shell. The influence of laying directly on the ultimate strength and strength interval is significant. It should be fully used in the design of practical engineering to achieve a reasonable strength interval of laminate for full use of the potential and advantages of composite material. The influence of the thickness of the composite laminate property on the ultimate strength of the laminate is significant. The first layer strength and last layer strength will increase with the total thickness increase, and the the thickness of the second and fourth layers increase. But the influence of the total thickness on the strength interval is negligible.

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