Article citation info:
Abdulaziz FH, Abd-Ali NK, Al-Mayali MF. Effect of fibers orientation on the health monitoring of multi-layers composite material. Diagnostyka. 2025;26(1):2025103. https://doi.org/10.29354/diag/197293.

DIAGNOSTYKA, 2025, Vol. 26, No. 1

e-ISSN 2449-5220
DOI: 10.29354/diag/197293

EFFECT OF FIBERS ORIENTATION ON THE HEALTH MONITORING OF ULTI-LAYERS COMPOSITE MATERIAL

Falah Hassan ABDULAZIZ, Nabel Kadum ABD-ALI *, Maasi Faisal AL-MAYALI

College of Engineering, Mechanical Engineering Dep., University of Al-Qadisiyah, Iraq
* Corresponding author, e-mail: nabel.abdali@qu.edu.iq

Abstract

The major goal of this research is to create a reliable model for predicting the mechanical properties of composite material with fatigue failure and to determine how changing the fiber orientation and the layer arrangement with regard to the applied loading direction affects the mechanical characteristics of the result components in order to establish the service life with health monitoring of these structures. A multilayer composite consisting of five layers which represent shell structure, with the middle layer reinforced by carbon fiber and the top and bottom layers reinforced by glassfiber random mate and unidirectional glassfiber. According to the tensile test results, the orientation (2 L- GF- (0o/90o)s) had the maximum tension load (13 kN) due to the asymmetrical arrangement of layers and identical distribution of the load within layers, whereas the orientation (2 L- GF-0o) had the lowest tension load (5.6 kN) compared with other fiber orientations. The compression strength of the orientation 4 (2 L- GF- (0o/90o)2) with (1.72 kN) and orientation 7 (2 L- (90o/ RGF)s with (1.7 kN) is greater than that of the other orientations. The specimen fails in the test at about (519318 cycles) with time (352 minute) for orientation number 3.

Keyword: health monitoring, multilayers laminate, random mate, fatigue life, compression

1. INTRODUCTION

The applications of composite materials is becoming more popular because it is possible to modify their mechanical properties to satisfy the exacting design specifications of contemporary mechanical devices by carefully choosing the materials and designing the layups. Today's applications must tolerate intense mechanical loads and hostile conditions, such as those with extremely high or extremely low temperatures [1]. In contrast to minerals, a composite material keeps its mechanical, physical, and chemical characteristics. Composite materials are created by combining reinforcement and matrix. The matrix is constructed of polymer, ceramic, or metal, while the reinforcement is composed of fibers, flakes, or particle that are stronger and harder [2]. For instance, in the fiercely competitive aviation industry, one is constantly searching for strategies to reduce the total mass of the vehicles without reducing stiffness and the strength with respect to its component parts [3]. The reinforcement come in a variety of shapes, including fibers, flakes, and particles, also fibers may be added with different orientations as shown in fig. (1). Each of these has a specific set of qualities that can be added to composites.

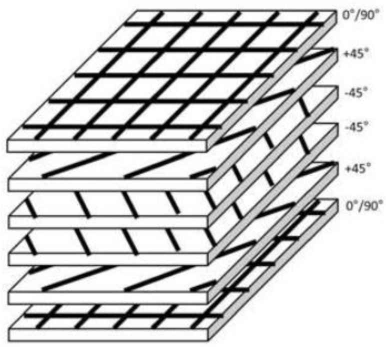

Fig. 1. Fibers orientations

Many studies have been performed with laminated composites. This section will discuss a wide range of studies, including studies on the characteristics of composite materials and studies on the responses of multi-layered plates to various loads. The behavior of various fiber-reinforced laminated composite materials was investigated experimentally. This work was done on seven

Received 2023-08-27; Accepted 2024-12-12; Available online 2025-01-09

© 2025 by the Authors. Licensee Polish Society of Technical Diagnostics (Warsaw. Poland). This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).

laminated composites that were made using polyester resin as a bonding matrix and reinforced with Jute, Glass, Carbon and Perlon fibers using the vacuum bagging technique [4]. The impact response of glass and epoxy laminates applied to impact energy were numerically investigated in the article that was presented using the widely used finite element program LS-DYNA. Maximum displacement, contact force at impact, and energy absorption were used to evaluate the impact response [5]. A size dependent laminated composite materials microtube's frequency is analyzed utilizing a nonlocal strain-stress gradient model. The motion equations for the composite laminated microtubes are generated by using energy methods [6]. In particular, the penetration processes under low-velocity impact are taken into account to understand the dynamic response of foam core sandwich panels with composite face sheets [7]. Several studies have been conducted on the failure analysis of composite laminated shells at temperature environments during buckling as well as impact loads [8-10]. Experimental study is done on the dynamic response and failure modes of sandwich structures made of carbon/epoxy and PVC foam that have been subjected to underwater impulsive loading [11]. Halpin-Tsai method was used to determine the composite elastic characteristics and focuses on the induced vibration response of a composite laminated plate that has graphene platelets as reinforcement (GPLs) [12]. The application of failure theories to the health monitoring of composite laminated shell as well as plate structures made of functionally graded materials [13,14].

The impact of a multi-wall carbon nanotube on the behavior of composite plates is investigated and evaluated the dynamic vibration response for plates and vessels using analytical and numerical methods [15,16]. By using an experiment and finite element modelling, the dynamic crushing properties of unidirectional carbon fiber reinforced plastic composite under the two loading types of dynamic 3-point bending and axially crushing are studied [17]. Other research examined the effect of on the mechanical characteristics of several polymers, including rubber that is natural [18-19]. The effects of the loading path on the failure of laminae made of unidirectional carbon reinforcement materials polymers (CFRP) and zircon silicide particle to capture the linked effects of fibers, matrix, and fiber/matrix interface on the failure [20,21]. A comparison study was carried out to optimize the failure strain of several woven fibers reinforced composite materials under both on-axis (0°/90°) and off-axis (45°) loading. Carbon-epoxy, E-glass-epoxy, and jute-epoxy composite are among the materials [22]. The influence of nanomaterials on mechanical properties to avoid damage to structures was studied [23, 24] During the static loading testing, the unidirectional glass - reinforced polymer matrix composite was examined using non-destructive (NDT) acoustic emission [25]. Waste from the rubber recycling process was employed to increase rolling barrier protection, and various rubber estimates reinforced with scrap fibers and crumbs of rubber [26, 27]. Conclusions of computing studies on damage localization in the structures are based on a technique of application of specified time-frequency distributions to the modal by using finite element analysis on the estimation of modal forms of structural analysis were studied [28, 29].

The purpose of this work is to determine how changing the fiber orientation and the layer arrangement with regard to the applied loading direction affects the mechanical characteristics of the result components of shell structure, and also analyze the effect of combining numerous fiber layers in various orientations. This research focuses on the utilization of various fibers as reinforcement materials. The originality of this work represented by the specific orientation of fibers that reinforced polymer matrix, epoxy under different loads such as tensile, compression and fatigue test to evaluate the mechanical behavior of these multilayer composite materials.

2. EXPERIMENTAL WORK

Mechanical tests were conducted in order to know the properties of the specimen that were manufactured. A comparison of properties was made to determine the best specimen. A multilayer composite consisting of five layers, with the middle layer reinforced by carbon fiber (CF) and the top and bottom layers reinforced by glassfiber random mate (RGF) and unidirectional glassfiber (GF), as indicated in table (1).

Table 1. Multi-layers composite material content

No.	Fiber orientation
1	2 L- RGF
2	2 L- GF-0^o
3	2 L- GF-90^o
4	2 L- GF- (0^o/90^o)2
5	2 L- GF- (0^o/90^o)s
6	2 L- (0^o/RGF)s
7	2 L- (90^o/RGF)s

2.1. Tensile Test

The tensile test was carried out at the University of Babylon using Electronic Universal Testing Machine model WDW-200 as shown in the fig. (2). Where the maximum load of the machine is 200 kN and it works with a three-phase motor of 3 kW.

Five specimens from each condition were examined at room temperature as shown in fig. (3), (4) and (5). ASTM D 638 certified work.

Fig. 2. Tensile test machine

Fig. 3. Tensile Specimens mold

Fig. 4. Tensile specimens

2.2. Compression Test

The aim of this test is to give information regarding the compressive characteristics of polymers when used under conditions that are comparable to those used in the testing. The compression test was carried out at the laboratory of University of Babylon / college of engineering, using the places shown in fig. (6) and (7). A compression force applied along the plates compresses a cylindrical specimen of material with an ASTM D 695 recommended constant circular cross-sectional area.

Fig. 5. Tested tensile specimens

Fig. 6. Compression specimens

Fig. 7. The tested compression specimens

2.3. Fatigue Test

The test was done at the University of Babylon using the machine shown in the figure (8).

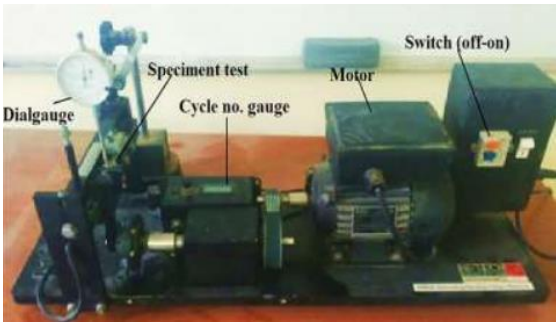

Fig. 8. Fatigue test machine

A cantilever with a constant stress amplitude and totally reversed (R= -1) is used for the fatigue test. The specimen is carried out in accordance with the machine specification and has dimensions of (100 mm length) and (10 mm width), as show in the fig. (9), (10) and fig. (11) after test.

Fig. 9. Fatigue specimens mold

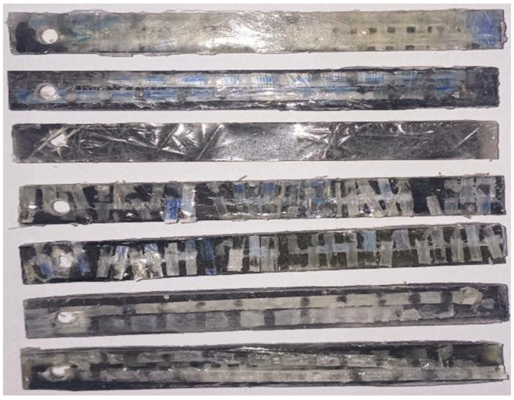

Fig. 10. Fatigue specimens

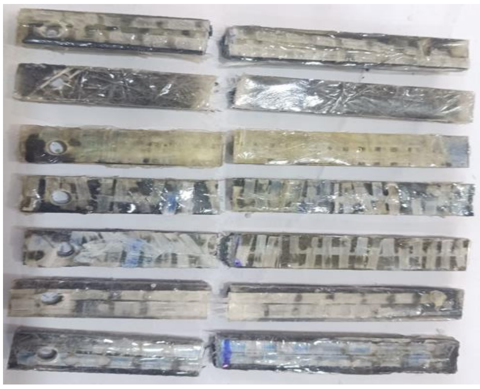

Fig. 11. Tested fatigue specimens

3. RESULTS AND DISCUSSION

Structural health monitoring may be utilized successfully to offer accurate information for decisions and management in the application scenarios. Health monitoring may be configured to collect information concerning global structural parameters such as mechanical tests, as well as component-level characteristics such as strain and stress.

3.1. Tensile test

Tensile test results are shown in table 2 which indicate how fiber type and orientation affect the properties of composite materials.

Table 2. Maximum load and extension results

No.	Load (KN)	Extension (*mm*)
1	6.2	4.3
2	7.5	4.7
3	9	7
4	5.6	2.8
5	13.5	10.5
6	8	7.7
7	11	8.5

According to these results, the orientation (2 L-GF- (0º/90º)s) had the maximum tension load (13 kN) and extension (10.5 mm) as shown in the fig. (12) due to the asymmetrical arrangement of layers and identical distribution of the load within layers, whereas the orientation (2 L- GF-0º) had the lowest tension load (5.6 kN) and the smallest extension (2.8 mm) as illustrates in the fig. (13) compared with other fiber orientations because of the applied load in the transverse direction and the unidirectional fiber arrangement of layers. These results are consistent with the results of tensile test of [30]. Carbon fiber with random mat and fiberglass with different fiber orientation provides materials with the highest overall strengths which effect on health monitoring of the structure. The polymer's outstanding strength is due to numerous inter-chain bonding.

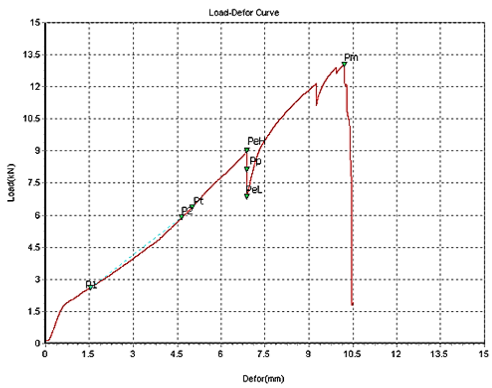

Fig. 12. Load- extension of (2 L- GF- (0o))

3.2. Compression test

This testing technique is frequently used to evaluate materials whose end-use applications are anticipated to include compressive forces. It enables scientists and engineers to comprehend the material's ability to yield (the stress at which it starts to deform permanently), compressive strength (the highest compressive stress it can bear), and other qualities.

Compression testing offers a measurable technique to evaluate a material's performance under compressive stresses, which is one of its major advantages that influence on health monitoring of the structure. Development and research, quality assurance, failure analysis, and material selection can all benefit from this knowledge. Table (3) displays the compression test results.

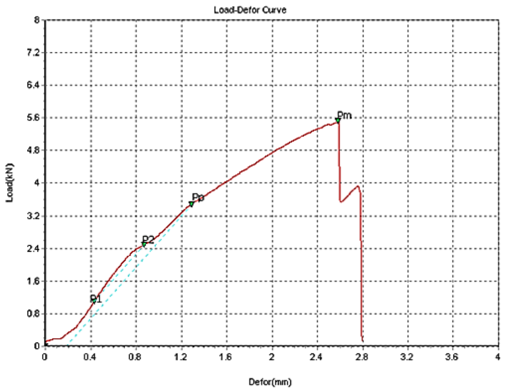

Fig. 13. Load- extension of (2 L- GF- (0o/90o)s)

Table 3. Compression test results

No.	Compression load (kN)
1	0.61
2	0.44
3	0.68
4	1.72
5	0.5
6	1.1
7	1.7

The compression strength of the orientation 4 (2 L- GF- $(0^o/90^o)_2$) with (1.72 kN) and orientation 7 (2 L- $(90^o/RGF)_s$ with (1.7 kN) is greater than that of the other orientations as in the fig. (14). This is because the fiber orientation with 90^o produced significant resistance to compression stress at the top and lower surfaces of the specimen and measuring load during the compression test, and the findings of the current arrangement are consistent with [31].

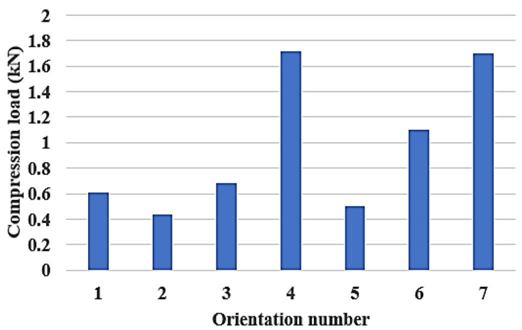

Fig. 14. Compression with different orientation

3.3. Fatigue test

Predicting fatigue life for structures is essential for trying to foresee potential failures and understanding the usable life and declining returns of a product as well as material. Evaluating fatigue characteristics of materials using real- life modelling is frequently an efficient method for reducing revenue loss throughout the product life cycle. The local monitoring may be planned and performed to assess performance in terms of dependability and degradation over time for each monitored structural component. The structural elements that will be instrumented, as well as the variables to be monitored, should be carefully chosen.

Fig. (15) indicates that the specimen fails in the test at about (519318 cycles) with time (352 minute) for orientation number 3. The maximum number of cycles denotes the defined "failure" stress that occurs in this cycle number. The first two specimens had essentially identical results, whereas the seventh specimen is a little off. This might be due to improper fiber orientation setup; possibly it was not entirely orientated before commencing the test and has some slack within it. Because of the similarities between specimens 3 and 4, these will be the approved fiber orientation values in the fatigue test for this investigation and the fatigue life results of the current arrangement are consistent with [32]. All these data represent the failure values of stress-cycles curve for each recipe.

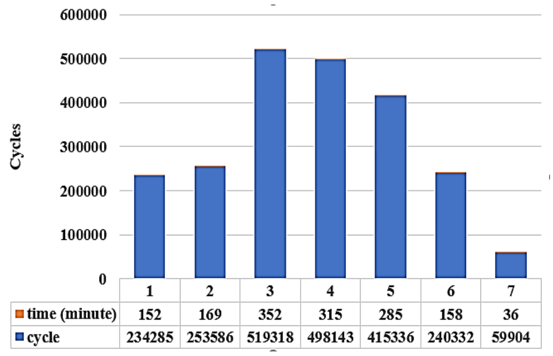

Fig. 15. Fatigue result with different orientation

4. NUMERICAL ANALYSIS

The majority of laminated shell composite structures are constructed s shell or plate components. This is so that the structure can carry membrane loads with greater efficiency. The difficulty in manufacturing thick laminates is a further important consideration. This section uses an Abaqus case study to provide a broad explanation of the mechanical tests along with specific methods for a basic finite element analysis which consider some of the factors that led to the formation of structural health monitoring systems. The individual components which make up a geometry are then given their material characteristics. On the geometry, loads as well as boundary conditions are then applied. The geometry is then divided into discrete elements, specified by the number of nodes with element connection in mapped mesh as illustrated in fig. (16) to (18). The element type has been selected in order to represent the kind of problem that has to be resolved. The model is then solved. The final step is computing and displaying the results.

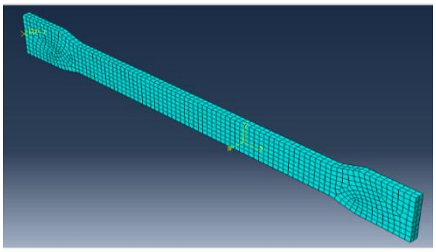

Fig. 16. Mesh of tensile specimen

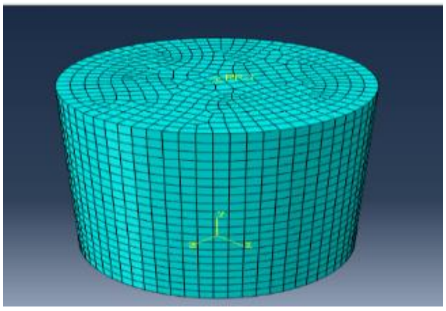

Fig. 17. Mesh of compression specimen

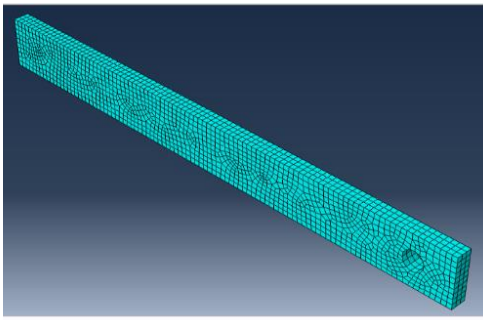

Fig. 18. Mesh of fatigue specimen

Failure criterion are curve fits that use experimental data obtained under uniaxial stress to predict failure with multiaxial stress. All of the failure criteria mentioned in this part may indicate the first lamina to fail, but they cannot monitor the failure's progression until the entire laminate fails. Damage evolution through laminate failure can be observed using damage mechanics. The composite laminated specimen under the influence of the tensile testing load is depicted in figures (19) and (20) indicating that it's based on normal stress and strain distribution for the optimum fiber orientation (2 L- GF- $(0/90)_s$). When the membrane load applied, the rate of deformation which depends on the stress and strain distribution during elastic deformations was lower than other fiber orientation. The energy loss increases with deformation due to plastic deformations and aids in the structural health monitoring of the shell construction.

The compression stress and strain of the orientation 4 (2 L- GF- $(0^o/90^o)_2$) with (1.72 kN) and orientation 7 (2 L- $(90^o/RGF)_s$ with (1.7 kN) as seen in figures (21) and (22), is greater than that of the other orientations. This was performed by producing a large amount of compression stress resistance at the specimen's upper and lower surfaces as well as by monitoring load throughout the compression test using fibers oriented at a 90° angle.

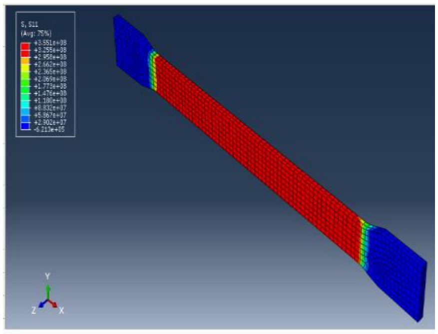

Fig. 19. Normal stress

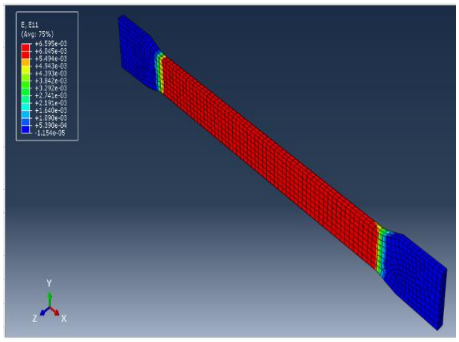

Fig. 20. Normal stress

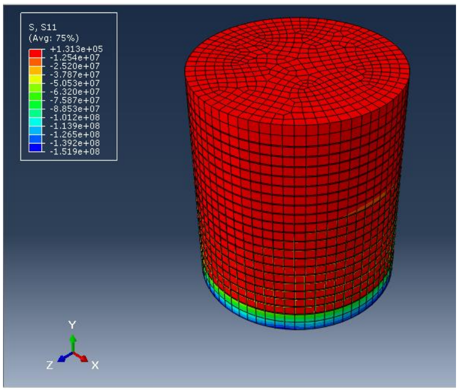

Fig. 21. Normal stress

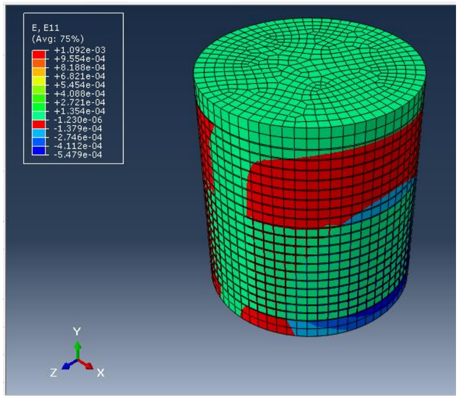

Fig. 22. Normal stress

Figures (23) and (24) shows that the specimen fails the test for orientation number 3 after approximately (519318 cycles) with time (352 minutes). The highest cycle count shows the designated failing stress that takes place at this cycle number.

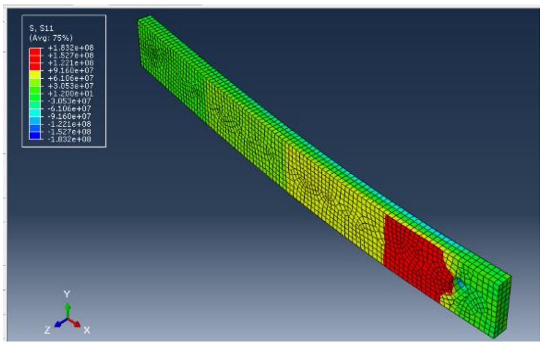

Fig. 23. Normal stress

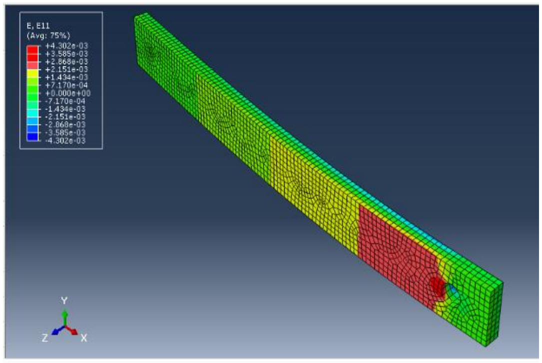

Fig. 24. Normal strain

5. CONCLUSIONS

The main conclusions highlight from the current work:

1. According to the tensile results, the orientation (2 L- GF- (0°/90°)s) had the maximum tension load (13 kN) due to the asymmetrical arrangement of layers and identical distribution of the load within layers, whereas the orientation (2 L- GF-0°) had the lowest tension load (5.6 kN) compared with other fiber orientations because of the applied load in the transverse direction and the unidirectional fiber arrangement of shell structure layers.
2. The compression strength of the orientation 4 (2 L- GF- $(0^o/90^o)_2$) with (1.72 kN) and orientation 7 (2 L- $(90^o/RGF)_s$ with (1.7 kN) is greater than that of the other orientations. This is because the fiber orientation with 90° produced significant resistance to compression stress at the top and lower surfaces of the specimen and measuring load during compression test in shell structure composite.
3. The specimen fails in the test at about (519318 cycles) with time (352 minute) for orientation number three. The maximum number of cycles denotes the defined "failure" stress that occurs in this cycle number.
4. Predicting the lowered modulus is a subset of the larger objective of estimating the failure cycle. As a result, the accurate forecast of the modulus change is less important compared to predicting of the failure cycles in shell structure.

Source of funding: *This research received no external funding.*

Author contributions: *research concept and design, A.F.H., A-A NK., A-M M.F.; Collection and/or assembly of data, A.F.H., A-A NK., A-M M.F.; Data analysis and interpretation, A.F.H., A-A NK., A-M M.F.; Writing the article, A.F.H., A-A NK., A-M M.F.; Critical revision of the article, A.F.H., A-A NK., A-M M.F.; Final approval of the article, A.F.H., A-A NK., A-M M.F.*

Declaration of competing interest: *The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.*

REFERENCES

1. Riccio A, Saputo S, Raimondo A, Sellitto A. 4 - Modeling low velocity impact phenomena on composite structures. Dynamic Response and Failure of Composite Materials and Structures. 2017;13(1):129-158. https://doi.org/10.1016/B978-0-08-100887-4.00004-4.
2. Verma D, Gope PC, Shandilya A, Gupta A, Maheshwari MK. Coir fibre reinforcement and application in polymer composites: A review. Journal of Materials and Environmental Science, 2013;4(2):263–276.
3. Aboudi J, Arnold S, Bednarcyk B. Micromechanics of Composite Materials. Elsevier. 2013. https://doi.org/10.1016/C2011-0-05224-9.
4. Hamad QA, Oleiwi LK, Abdulrahman SA. Tensile properties of laminated composite prosthetic socket reinforced by different fibers. Mater. Today Proc., 2023;80(3):2353-2359. https://doi.org/10.1016/j.matpr.2021.06.348.
5. Thilak JAJ, Suresh P. Dynamic response of glass/epoxy laminated composite plates under low-velocity impact. Int. J. Eng. Trans. A Basics. 2022;35(7):1283–1290. https://doi.org/10.5829/ije.2022.35.07a.07.
6. Oyarhossein MA. Dynamic response of the nonlocal strain-stress gradient in laminated polymer composites microtubes. Sci. Rep. 2020;10(1):1–19. https://doi.org/10.1038/s41598-020-61855-w.
7. Zhu Y, Sun Y. Dynamic response of foam core sandwich panel with composite facesheets during low-velocity impact and penetration. Int. J. Impact Eng. 2020;139:103508. https://doi.org/10.1016/j.ijimpeng.2020.103508.
8. Madeh AR, Majeed WI. Effect of boundary conditions on thermal buckling of laminated composite shallow shell. Materials Today: Proceedings. 2021;42:2397-2404. https://doi.org/10.1016/j.matpr.2020.12.501
9. Madeh AR, Majeed WI. Effect of Thermal environment on transient response of laminated shallow shells with different boundary conditions. Journal of Engineering Science and Technology. 2020;17(5):3160-3173.

10. Madeh AR, Abd-Ali NK. The dynamic response of doubly curved shell under effect of environment sustainable temperature. In AIP Conference Proceedings. 2023;2776(1).
11. Ren P. Dynamic response and failure of carbon/epoxy composite sandwich subjected to underwater impulsive loading. Int. J. Impact Eng. 2020;143: 103614. https://doi.org/10.1016/j.ijimpeng.2020.103614.
12. Kiani Y. Influence of graphene platelets on the response of composite plates subjected to a moving load. Mech. Based Des. Struct. Mach. 2022;50(4): 1123–1136. https://doi.org/10.1080/15397734.2020.1744006.
13. Abd-Ali NK, Madeh AR. Structural analysis of functionally graded material using sigmiodal and power law. Diagnostyka. 2021;22(4):59-65. http://dx.doi.org/10.29354/diag/144171
14. Madeh AR, Abd-Ali NK. The stress analysis effect on structural health monitoring in functionally graded shell. Diagnostyka, 2022:23(3):2022302. http://dx.doi.org/10.29354/diag/152180.
15. Abbas EN, Jweeg MJ, Al-Waily M. Analytical and numerical investigations for dynamic response of composite plates under various dynamic loading with the influence of carbon multi-wall tube nano materials. Int. J. Mech. Mechatronics Eng., 2018;18(6):1–10.
16. LiaoBB, Jia TY. Finite element analysis of dynamic responses of composite pressure vessels under low velocity impact by using a three-dimensional laminated media model. Thin-Walled Struct. 2018;129:488–501. http://dx.doi.org/10.1016/j.tws.2018.04.023.
17. Zhou G. et al. Crushing behaviors of unidirectional carbon fiber reinforced plastic composites under dynamic bending and axial crushing loading. Int. J. Impact Eng. 2020;140:103539. http://dx.doi.org/10.1016/j.ijimpeng.2020.103539.
18. Abd-Ali NK, Farhan MM, Hassan NY. Improvement of mechanical properties of the rubbery part in cement packing system using new rubber materials. Journal of Engineering Science and Technology. 2021;16(2):1601–1613.
19. Abd-Ali NK. The effect of cure activator zinc oxide nanoparticles on the mechanical behavior of polyisoprene rubber. Journal of Engineering Science and Technology. 2020;15(3):2051–2061
20. Chen J, Wan L, Ismail Y, Hou P, Ye J, Yan D. Micromechanical analysis of UD CFRP composite lamina under multiaxial loading with different loading paths," Compos. Struct. 2021;269:114024. http://dx.doi.org/10.1016/j.compstruct.2021.114024.
21. Ding J, Yang T, Huang Z, Qin Y, Wang Y. Thermal stability and ablation resistance, and ablation mechanism of carbon–phenolic composites with different zirconium silicide particle loadings. Compos. Part B Eng. 2018;154:313–320. http://dx.doi.org/10.1016/j.compositesb.2018.07.057.
22. Khosravani MR. Mechanical behavior of restorative dental composites under various loading conditions. J. Mech. Behav. Biomed. Mater. 2019;93:151–157. http://dx.doi.org/10.1016/j.jmbbm.2019.02.009.
23. Farhan MM, Abd-Ali NK, Hassan NY. Development the performance of the rubbery discharge part in flexo-pump system. Journal of Engineering and Applied Sciences. 2018;13(24):10148–10157.
24. Abd-Ali NK. The effect of adding nanoparticles on the mechanical properties of acrylic removable denture. Journal of Engineering Science and Technology. 2022;17(4):2983–2996.
25. Khalid MY, Al Rashid A, Arif ZU, Akram N, Arshad H, Márquez FPG. Characterization of failure strain in fiber reinforced composites: Under on-axis and off-axis loading. Crystals. 2021;11(2):1–11. http://dx.doi.org/10.3390/cryst11020216.
26. Mahdi RA, Abd-Ali NK. Performance characteristics of some rubber recipes reinforced with scrap fibers and crumb rubber. AIP Conference Proceedings. 2023;2776:060006.
27. Mahdi RA, Abd-Ali NK. Design improvement of rolling barriers safety using tire recycling process waste. Journal of Engineering Science and Technology. 2023;18(2):1124–1136.
28. Katunin A. Localization of damage in beam-like structures applying time-frequency distributions to modal shapes of vibration. Diagnostyka. 2016;17:53-58.
29. Amarowicz M, Psiuk K, Rogala T, Rzydzik S. Diagnostic shell expert systems. Diagnostyka. 2016; 17(1):33-40.
30. Mohamed YS, Abdelbary A. Theoretical and experimental study on the influence of fiber orientation on the tensile properties of unidirectional carbon fiber/epoxy composite. Alexandria Engineering Journal. 2023;67:693-705. https://doi.org/10.1016/j.aej.2022.12.058.
31. Salman SD, Sharba MJ, Leman Z, Sultan MT, Ishak MR, Cardona F. Tension-compression fatigue behavior of plain woven kenaf/Kevlar hybrid composites. Bio-Resources. 2016;11(2):3575-3586.
32. Haller CL. Study of fatigue failure of composite materials. Doctoral dissertation. Naval Postgraduate School. Monterey, CA. 2020.

Falah Hassan ABDULAZIZ, Master student in Dep. of Mechanical Engineering, College of Engineering, University of Al-Qadisiyah, Iraq.
B.Sc. 2019, work at Ministry of Oil Midland Refineries Company, Authority Refineries External Diwaniya Refinery.

e-mail: Falah.hassan.abdulaziz@gmail.com

Prof. Dr. **Nabel Kadum ABD-ALI**, PhD (2013), applied mechanics from the University of Technology / Iraq. Work as a teacher in Dep. of Mechanical engineering / college of engineering/ University of Al-Qadisiyah, Iraq. Research topics: composite materials, rubber technology, polymer engineering, mechanical behavior of materials, waste management.
e-mail: nabel.abdali@qu.edu.iq

Assist. prof. Dr. **Maasi Faisal AL-MAYALI,** PhD (2017), applied mechanics from Cardiff university-UK. I'm working as a lecturer at Dep. of Mechanical engineering / college of engineering/ University of Al-Qadisiyah, Iraq. Research topics: Elastohydrodynamic Lubrication, Gear Lubrication, Mixed Lubrication, contact, Scuffing, Micro-pitting and stress analysis.
e-mail: maasi.almayali@qu.edu.iq