IJRAME
ISSN (ONLINE): 2321-3051
INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

FINITE ELEMENT SIMULATION OF TRANSIENT RESPONSE ANALYSIS OF WOVEN GLASS/EPOXY LAMINATED PLATES

Sanjay.V.Dambal[#1], Dr.Ramesh S Sharma[#2]
Department of Mechanical Engineering, R V College of Engineering Bangalore – 560 059.
sanjaydambal@gmail.com rssharma25@yahoo.com

Abstract

A developed finite element analysis investigation into failure behaviour of woven fabric laminated composite plate subjected to dynamic loads was undertaken using ANSYS. Transient analysis was carried out for two different boundary conditions viz. Clamped Free Free Free (C-F-F-F) and Clamped Free Clamped Free (C-F-C-F) boundary conditions. Work was concentrated on studying failure criteria in woven glass/epoxy laminate for both before and after damage conditions. Dynamic load is applied to the plate in form of half sine wave. Failure analysis of woven laminates was analysed bases on Tsai-Wu theory.

***Key words**:* Laminated composite plates; Transient analysis; Woven fabric; ANSYS; Half-sine wave; Tsai-Wu theory.

1. INTRODUCTION

Fibre reinforced composites are extensively used in aerospace, marine, transportation, electrical, chemical, construction and consumer goods industries. In most of the cases they are subjected to dynamic loads. Hence there is great scope in the area dynamic failure analysis of laminated composites. The high specific strength, superior stiffness to weight ratio and other desirable properties of fibre reinforced properties make them candidates for number of structural applications. These applications frequently necessitate composite structures to withstand high dynamic stresses. Most of the research work is concentrated on static mode failure analysis and dynamic failure analysis of unidirectional fibre reinforced composites. A. Bogdanovich et al. [1] employed the theoretical prediction of the initial failure and ply-by-ply failure processes in laminated composite structures under dynamic loading. A static and transient dynamic finite element computational procedure is presented for failure analysis of pretwisted rotating plates subjected to center point transverse load by A. Karmakar et al. [3]. B. G. Prusty [4] carried out progressive failure analysis of laminated stiffened and unstiffned composite panels. J. Eskandri Jam and N. Garshasbi Nia [5] conducted dynamic failure analysis of unidirectional composite plates. A present study is concentrated on dynamic analysis of woven fabric laminated composite plates.

1. TRANSIENT ANALYSIS

Transient dynamic analysis, sometimes called Time-History Analysis**,** is a technique used to determine the dynamic response of a structure under the action of any general time dependant loads. This type of analysis is used to determine the time-varying displacements, stresses, failure factor. The main objective of finite element analysis is to accurately represent the behavior of the physical structure being analyzed. For the present study ANSYS analysis program was used. Transient analysis was conducted on a 160x160 mm square laminated plate composed of 10 layers of 0.3mm each with lay-up orientation of 0°/90°for both damaged and undamaged specimens. Damage is induced in the plate in the form of 5mm diameter hole at center of the plate. Shell-181 element is used to build the model. The orthotropic material properties listed in table 2.1 are used. The modeling is done as per the required specification. Then laminate model is map meshed with quadrilateral elements. Input for transient analysis is Psinωt half sine wave. Transient analysis output i.e. Time vs. Failure factor graphs are plotted as shown below.

2.1 Orthotropic material properties of glass/epoxy woven fabric.

E_{12} (GPa)	E_{23} (GPa)	E_{31} (GPa)	ν_{12}	ν_{23}	ν_{31}	G_{12} (GPa)	G_{23} (GPa)	G_{31} (GPa)
31.54	10.76	10.76	0.1486	0.4508	0.4508	4.77	4.8	4.8

1.2 Results

Transient analysis is conducted for both C-F-F-F and C-F-C-F boundary conditions, for both damaged and undamaged specimens. Results obtained are recorded and plotted below inform of graphs. Figure 2.1 represents Time vs. Failure factor for C-F-F-F condition (before damage) for different loads. Glass/Epoxy woven laminate fails at pressure P=1.1MPa. Figure 2.3 represents Time vs. Failure factor for C-F-F-F condition (after damage) for different loads. Glass/Epoxy woven laminate fails at pressure P=0.4MPa.Figure 2.5 represents Time vs. Failure factor for C-F-C-F condition (before damage) for different loads. Glass/Epoxy woven laminate fails at load 3.3MPa. Figure 5.14 presents Time vs. Failure factor for C-F-C-F condition (after damage) for different loads. Glass/Epoxy woven laminate fails at pressure P=1Mpa.

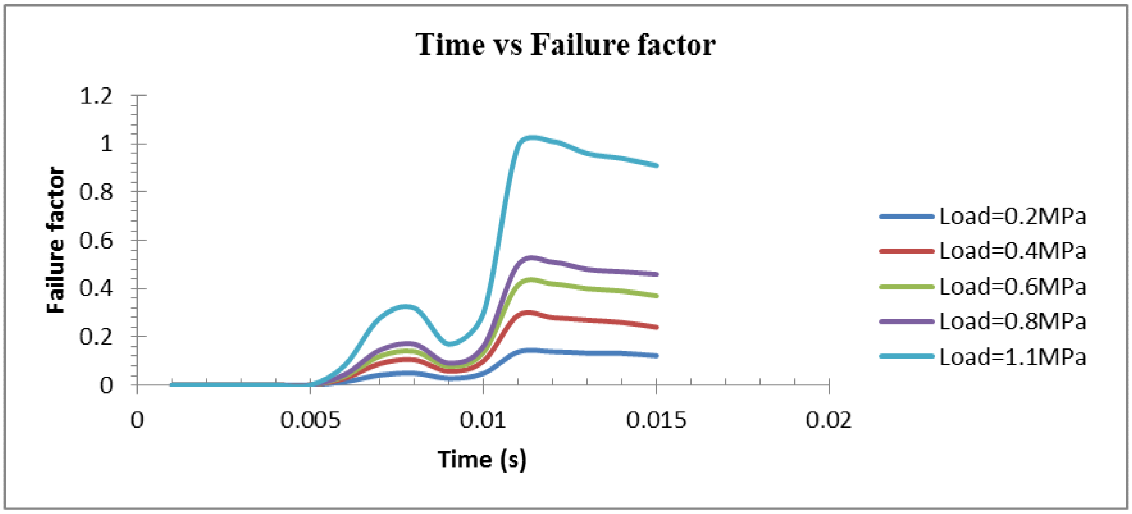

Figure 2.1: Graphs of Time vs. Failure factor for C-F-F-F condition (before damage)

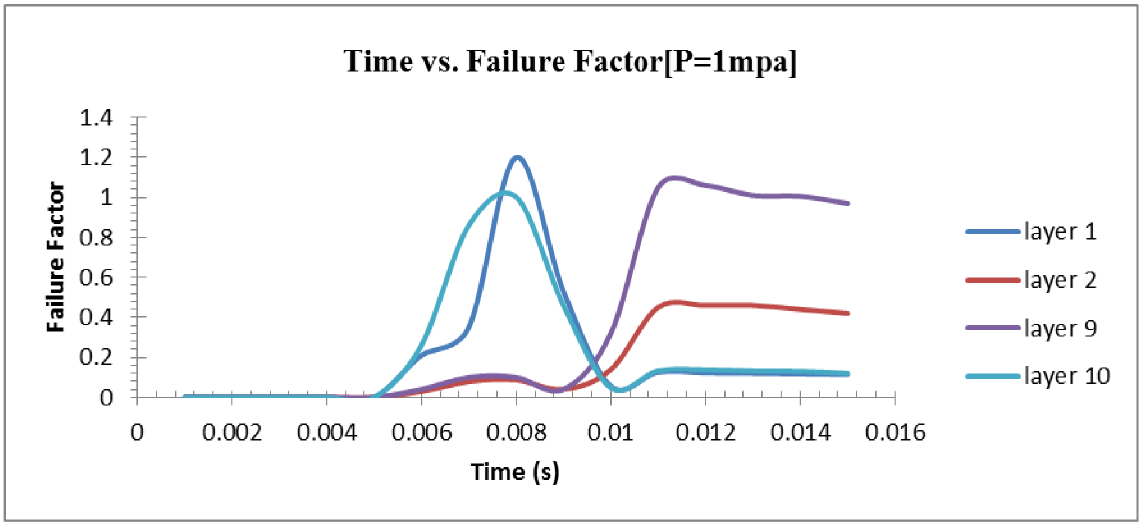

Figure 2.2: Graphs of Time vs. Failure factor for different layers for load 1 MPa under C-F-F-F condition (before damage)

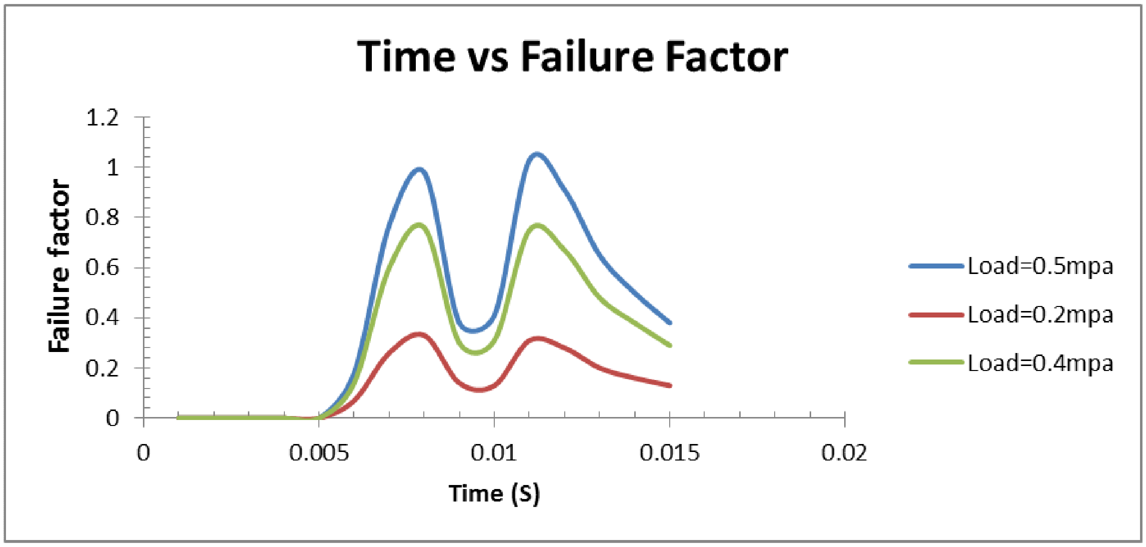

Figure 2.3: Graphs of Time vs. Failure factor for C-F-F-F condition (after damage)

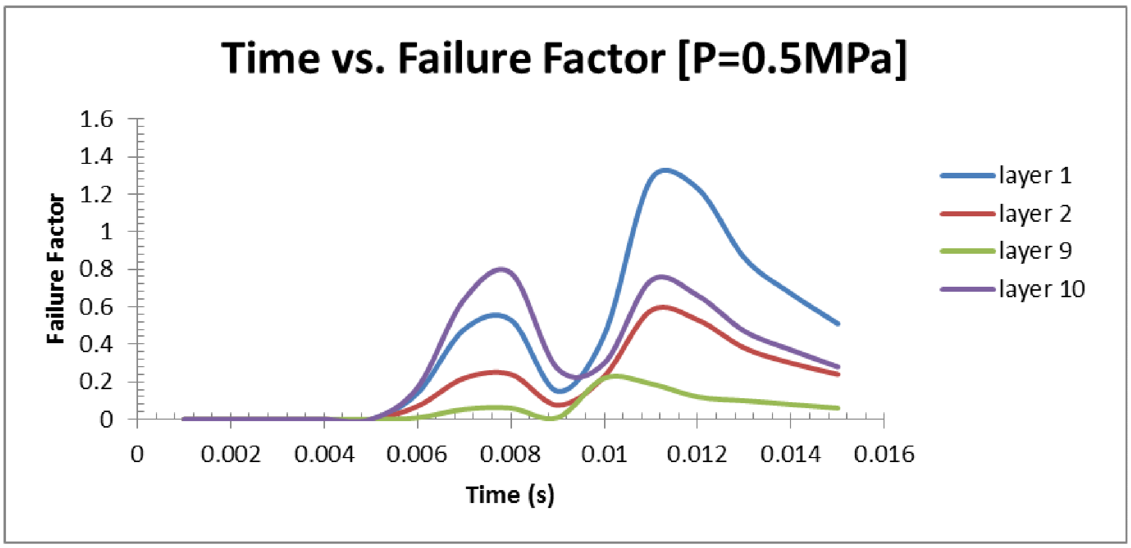

Figure 2.4: Graphs of Time vs. Failure factor for different layers for load 0.5MPa under C-F-F-F condition (after damage)

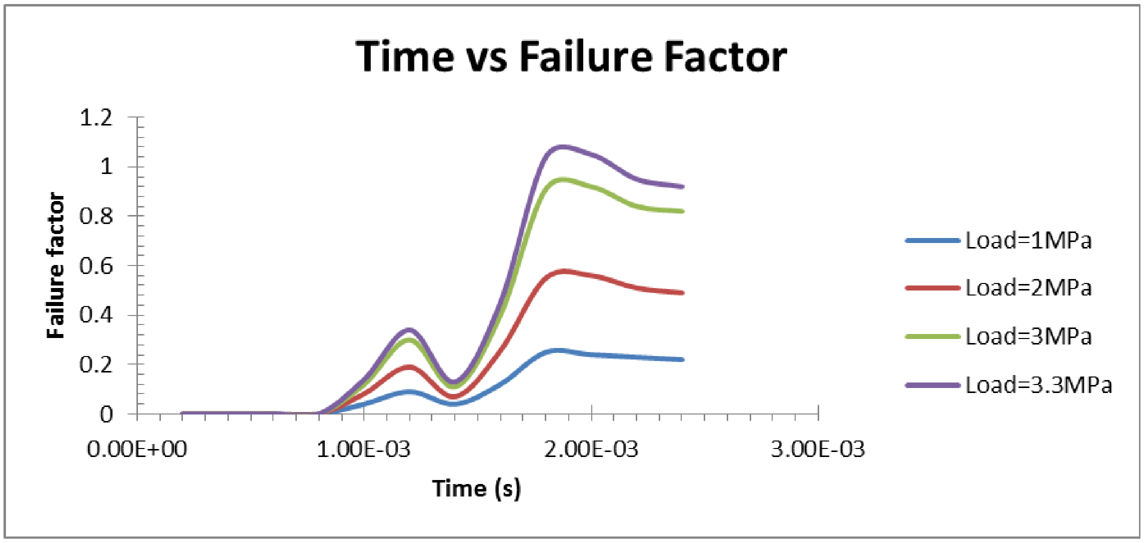

Figure 2.5: Graphs of Time vs. Failure factor for C-F-C-F condition (before damage)

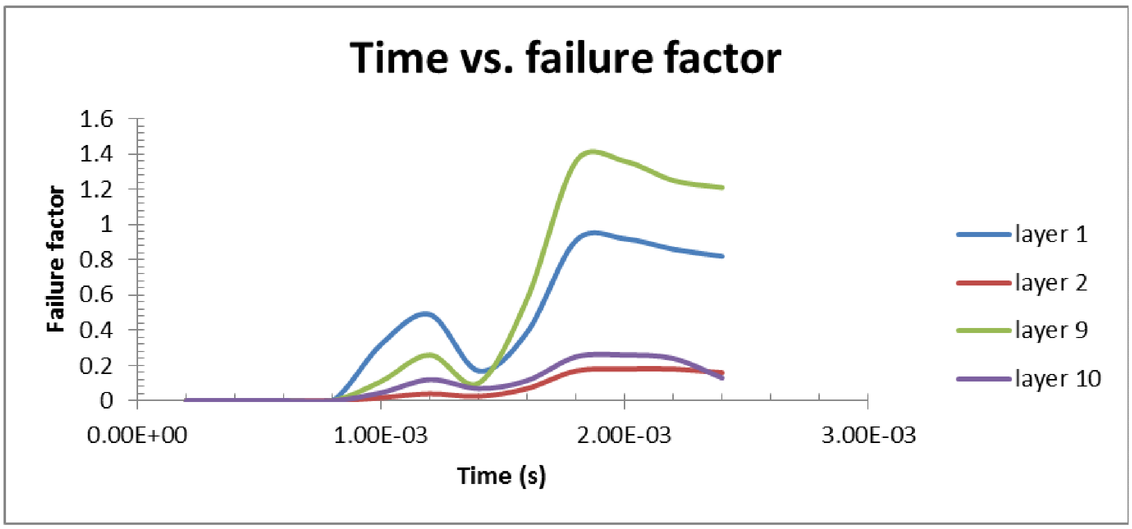

Figure 2.6: Graphs of Time vs. Failure factor for different layers for load 3.3MPa under C-F-C-F condition (before damage)

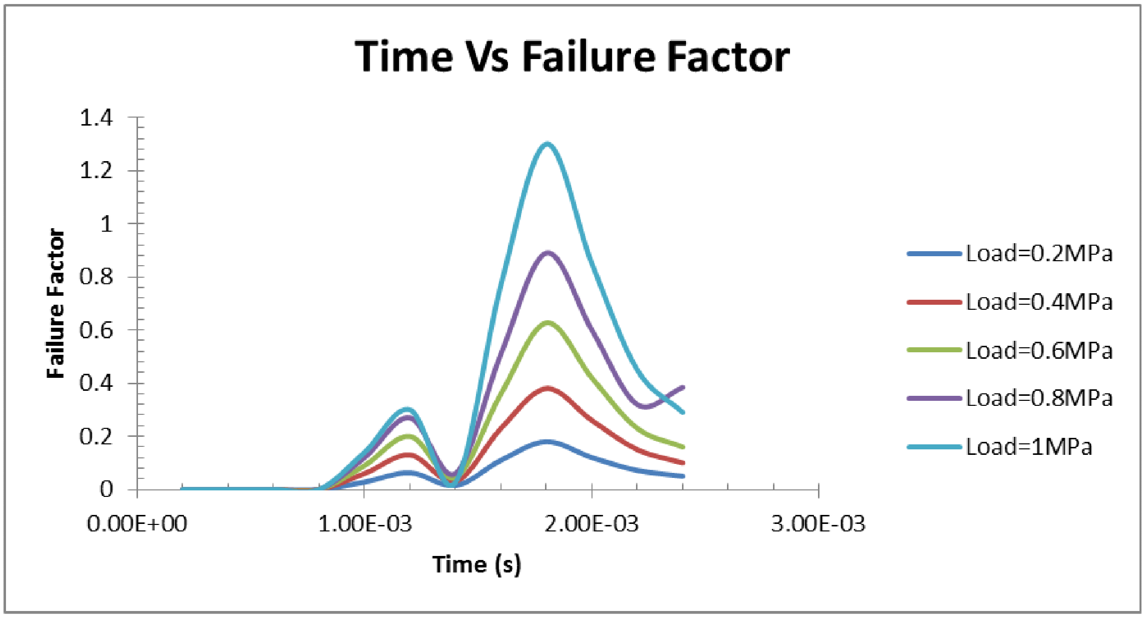

Figure 2.7: Graphs of Time vs. Failure factor for C-F-C-F condition (after damage)

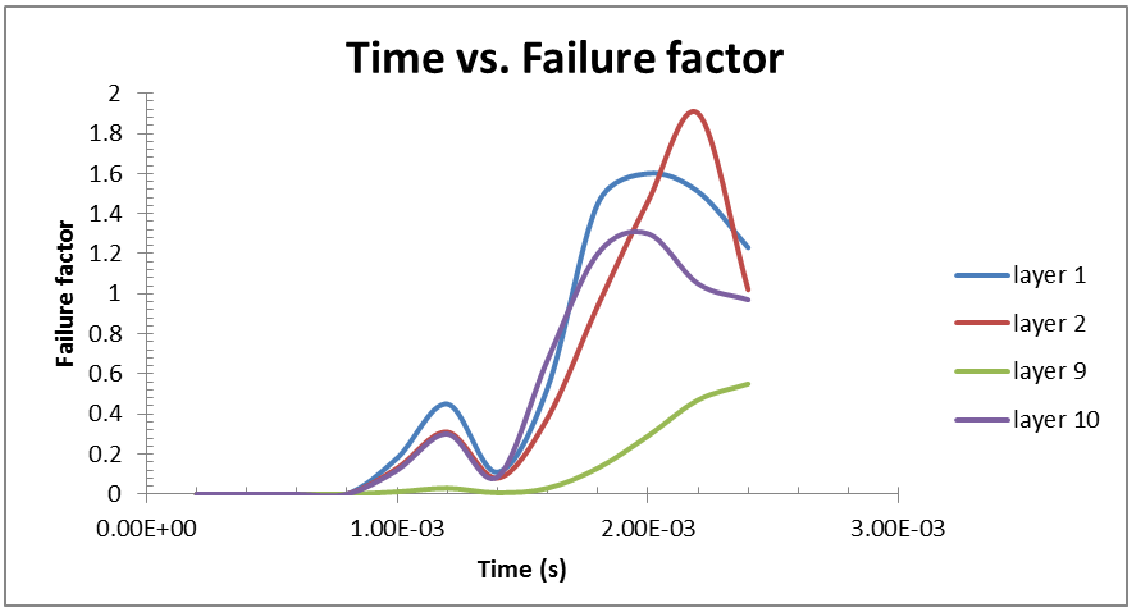

Figure 2.8: Graphs of Time vs. Failure factor for different layers for load 1MPa under C-F-C-F condition (after damage)

2. Validation

Transient analysis results obtained from finite element analysis in ANSYS is being validated through problem presented in the journal paper titled Dynamic analysis of laminated composite plates submitted by J.Eskandri Jam and N.Garshasbi Nia. Paper concentrates on studying dynamic characteristics of unidirectional Glass/Epoxy laminate. Transient analysis is conducted on Square plate of dimensions 1.27x1.27m made of 4 layers, 0.0254m each with fiber orientations (0, 30, 60, 90) is map meshed. Time vs. failure factor graph is plotted with time duration t_d 0.01s.

Time (s)	Failure factor			
	Layer 1	Layer 2	Layer 3	Layer 4
0.002	0.072	0.025	0.41	0.12
0.004	0.87	1.09	0.88	1.89
0.006	1.29	1.71	2.51	4.72
0.008	0.73	1.15	1.19	2.14
0.01	0.47	0.39	0.54	0.86

Figure 2.9: Results of time vs. failure factor for C-F-F-F condition from literature review

Time (s)	Failure factor			
	Layer 1	Layer 2	Layer 3	Layer 4
0.002	0.017	0.0016	0.13	0.26
0.004	0.33	0.78	1.007	1.5
0.006	0.93	2.05	2.21	4.37
0.008	0.28	0.94	0.91	1.82
0.01	0.21	0.63	0.82	1.17

Figure.2.10: Results of time vs. failure factor for C-F-F-F condition obtained from ANSYS

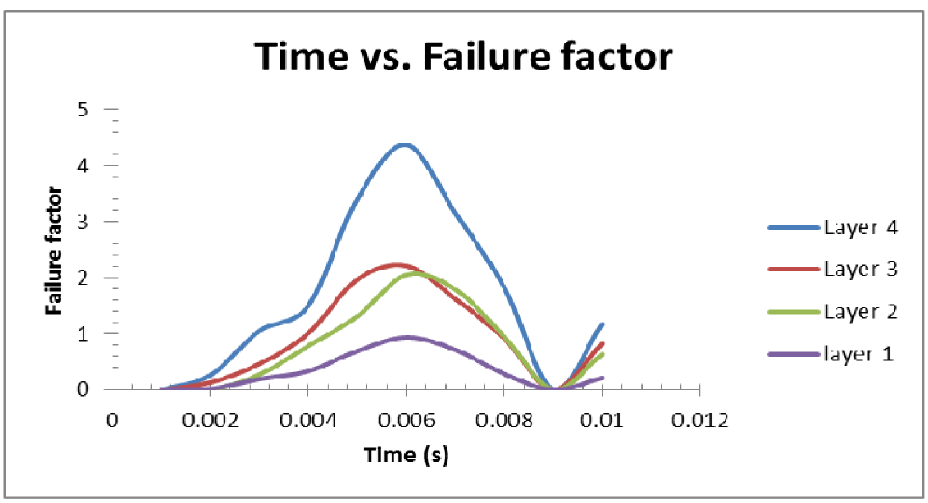

Figure 2.11: Time vs. failure factor plot for C-F-F-F condition for different layers

3. Conclusion

Transient analysis was carried out in ANSYS for C-F-F-F and C-F-C-F condition. Time vs. failure factor. Work is concentrated on studying failure criteria in woven glass/epoxy laminate before and after damage. Result interpreted from the study is that after damage load carrying capacity of laminate decreases. In order to increase load carrying capacity stiffeners need to be provided at the centre of the plate.

4. Acknowledgments

Authors thankfully acknowledge the Management, Principal and Head of the Department of Mechanical Engineering, R V College of Engineering for their constant encouragement and support in carrying out this work.

5. References:

[1] **Alexander Bogdanovich and K. Friedrich**, "Initial and Progressive failure Analysis of Laminated Composite Structures under Dynamic Loading", *Journal Composite Structures*, 1994,Vol. 27, pp. 439-456.

[2] **MK Rath and SK Sahu**, "Vibration of woven fiber laminated composite plates in hygrothermal environment", *Journal of Vibration and Control*, November 2012; Vol. 18, pp. 1957-1970.

[3] **A. Karmakar and P.K. Sinha**, "Failure Analysis of Laminated Composite Rotating Plates", *Journal of Reinforced Plastics and Composites*, 2001, Vol. 20, pp. 1326-1357.

[4] **B. Gangadhara Prusty**, "Progressive Failure Analysis of Laminated Unstiffened and Stiffened Composite Panels", *Journal of Reinforced Plastics and Composite*, 2005, Vol. 24, No. 6, pp. 633-642.

[5] **Sourabha S. Havaldar, Ramesh S Sharma, Arul Prakash M.D. Antony, Mohan Bangaru**, " Effect of cell size on fundamental natural frequency of FRP Honeycomb sandwich panels" , journal of minerals and materials characterization and Engineering, 2012, Vol. 11, pp. 653-660.

[6] **J.Eskandari Jam and N.Garshasbi Nia** , " Dynamic Failure Analysis of Laminated Composite Plates", *Journal of Association of Metallurgical Engineers of Serbia*, vol. 20, pp. 187-195.

[7] **Masoud Tahani**,"Analysis of laminated composite beams using layer wise displacement theories", *Journal of Composite Structures*, Vol. 79, August 2007, pp. 535-547.

[8] **Khalili, Malekzadeh and Mittal**, "Response of laminated composite plates subjected to static and dynamic loading", *Journal of* Composite *Structures*, Vol. 38, 2004, pp.251-275.