Buckling of composite plates in hygrothermal conditions

A thesis submitted in partial fulfillment for requirements of degree in

Bachelor of technology

In

Civil engineering

By

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Roll No:10601028

Under The Guidance of
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CERTIFICATE

*This is to certify that the thesis entitled "**Buckling of Composite Plates in Hygrothermal Conditions**" submitted by **Mr.Deepak Kumar Samal** in partial fulfillment of requirement of **Btech** Degree in **Civil Engineering** at the NATIONAL INSTITUTE OF TECHNOLOGY, **ROURKELA**(Deemed University) is an authentic work carried out by him under my supervision and guidance.*

To the best of my knowledge the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any degree or diploma.

Date: ***Prof. S.K. Sahu***

*Place**:*** ***Dept of Civil Engineering***

National Institute of Technology

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Deepak Kumar Samal

CONTENTS

ABSTRACT

This paper deals with the analysis of buckling effects of composites in an hygrothermal environment. It is found from the analysis of various researchers world over that the effect of temperature and moisture which the composite materials are generally subjected to in case of space crafts and all have a considerable effect on the critical load carrying capacity of the composite plates which decreases linearly with uniform increase in moisture content and non-linearly with increase in temperature. The objective is to check the consistency of above results using different set of material properties of composites and further it within the scope of available resources.

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Chapter-1

Introduction

Introduction

Composites are materials consisting of two or more different substances which differ in their properties and are insoluble in each other but as a combination gives rise to a new form of improved material characteristics.

Composites consists therefore of various phases. They may be two phase, three phase or so on. But we are mainly dealing with two phase composites. The two phase composites is broadly divided into two types. They are mainly particulate composites or fibre reinforced composites. The particulate composites are those in which the particles are dispersed in a matrix in a random fashion. Hence they may be a non metal dispersed in a non metallic matrix(mica flakes reinforced with glass), a metal dispersed in a non metal matrix(aluminium particles in polyurethane rubber), a metal particle dispersed in a metal matrix(lead particles in copper alloys) or a non metal dispersed in a metallic matrix(silicon carbide particles in aluminium).

Fibre reinforced composites are the one we deal with mostly for all the analysis. They may be of polymer matrix composites(E glass fibre with Epoxy matrix), metal matrix composites(boron fibre in aluminium matrix), ceramic matrix composites(silicon carbide fibres in silicon fibre matrix) or carbon/carbon composites(carbon fibre in carbon matrix).

The popularity of composite materials has been due to their better material properties which is absent in case of normal isotropic materials. The properties exhibited by the composite materials which has been instrumental in their wide popularity and high usability are its greater specific modulus, higher specific strength , better impact resistance, better damping of vibrations, high stiffness, corrosion resistant, light weight,low maintenance costs etc . Hence their applicability is numerous in the fields like electrical application , welding machine parts, automotive field to produce racing cars and all, in sporting goods for production of tennis rackets or snow skis, aircrafts or space crafts, marine field and so on.

Review of Literature

Limited research has been done to characterize the hygrothermal buckling response of the structures made of composites. However, much of the published works on hygrothermal buckling is based on deterministic analysis, notable among them are Whitney and Ashton(1971) , Lee and Yen(1989) , Ram and Sinha(1992) , Flaggs et al.(1978) , Parhi and Ram and Sinha(2001) . Nakagiri et al.(1990) have studied all edges simply supported by a laminated plate with the stochastic finite element method taking fiber orientation, layer thickness and number of *layers as random variables, and found that the overall stiffness of FRPs laminated plates is largely dependent on the fiber orientation.*

Singh et al. (2001) have presented the buckling of composite cylindrical panels with uncertain material properties using the higher shear deformation theory (HSDT) based finite element method (FEM) with the first order perturbation technique (FOPT).

Englested and Reddy(1994) studied metal matrix composites based on probabilistic micro mechanics nonlinear analysis. They used Monte Carlo Simulation (MCS) with different probabilistic distributions to incorporate the uncertainty in basic material properties.

Chen et al.(1992) have presented a probabilistic method to evaluate the effect of uncertainties in geometrical and material properties of structure on the random vibration response.

Yadav and Verma(1997) studied the buckling response of thin cylindrical shells with random material properties using classical laminate theory and employed the FOPT for obtaining the second order statistics of the buckling loads.

Graham and Siragy(2001) have studied the variability of the random buckling loads of beams and plates with stochastically varying material and geometric properties using the concept of the variability response function.

Singh et al.(2001) have studied the effect of randomness in material properties on the free vibration and buckling analysis of the composite plate.

Aim and scope of Present Study:

To analyse the effect of buckling experimentally on composite plates in hygrothermal conditions, that is in conditions of application of temperature and moisture experimentally and validate the result with theoritical values.

Chapter-2

Experimental Study

Present developments:

For aluminium plates

The buckling loads of different isotropic aluminium plates were first studied experimentally using fixed end supports using a Universal Testing Machine.

SPECIFICATION OF THE ALUMINIUM PLATES:

TABLE-1(Specification of Aluminium Plates)

SAMPLE	***Lu***	***BREADTH***	***THICKNESS***	***WEIGHT***
A	*163mm*	*122mm*	*2mm*	*100gm*
B	*155mm*	*119mm*	*2mm*	*97gm*
C	*168mm*	*116mm*	*2mm*	*101gm*

For composite plates

FABRICATION OF COMPOSITE PLATES

The composite plates were fabricated in the laboratory using glass fibre epoxy and hardener. Other accessories like hand cuffs, sprayer, roller,weighing machine and scissors were used.

Six different plates were fabricated the details of which are tabulated below.

Table-2(Specification of composite plates)

SPECIMEN	***WEIGHT(gm)***	***WT. OF EPOXY(gm)***	***WT. OF HARDENER(gm)***
1	*364*	*300*	*24*
2	*366*	*300*	*24*
3	*410*	*273*	*22*
4	*358*	*240*	*20*
5	*356*	*192*	*16*
6	*404*	*220*	*18*

The plates were then cut using a cutter mainly of square dimensions and further test are to be carried out.

fig-1(a):before buckling

fig-1(b):after buckling

N.B:*All through the experiment the support condition was taken to be fixed at both ends*

Chapter-3

Results and discussions

GENERAL THEORITICAL FORMULA FOR BUCKLING WHEN BOTH ENDS ARE FIXED:

Pcr = (4*(3.141)^2*EI)/(Lu^2)

Where Pcr=critical load

E=modulus of elasticity of aluminium=69 GPa

I=least moment of inertia of plate about a axis

Lu=unsupported length of the plate

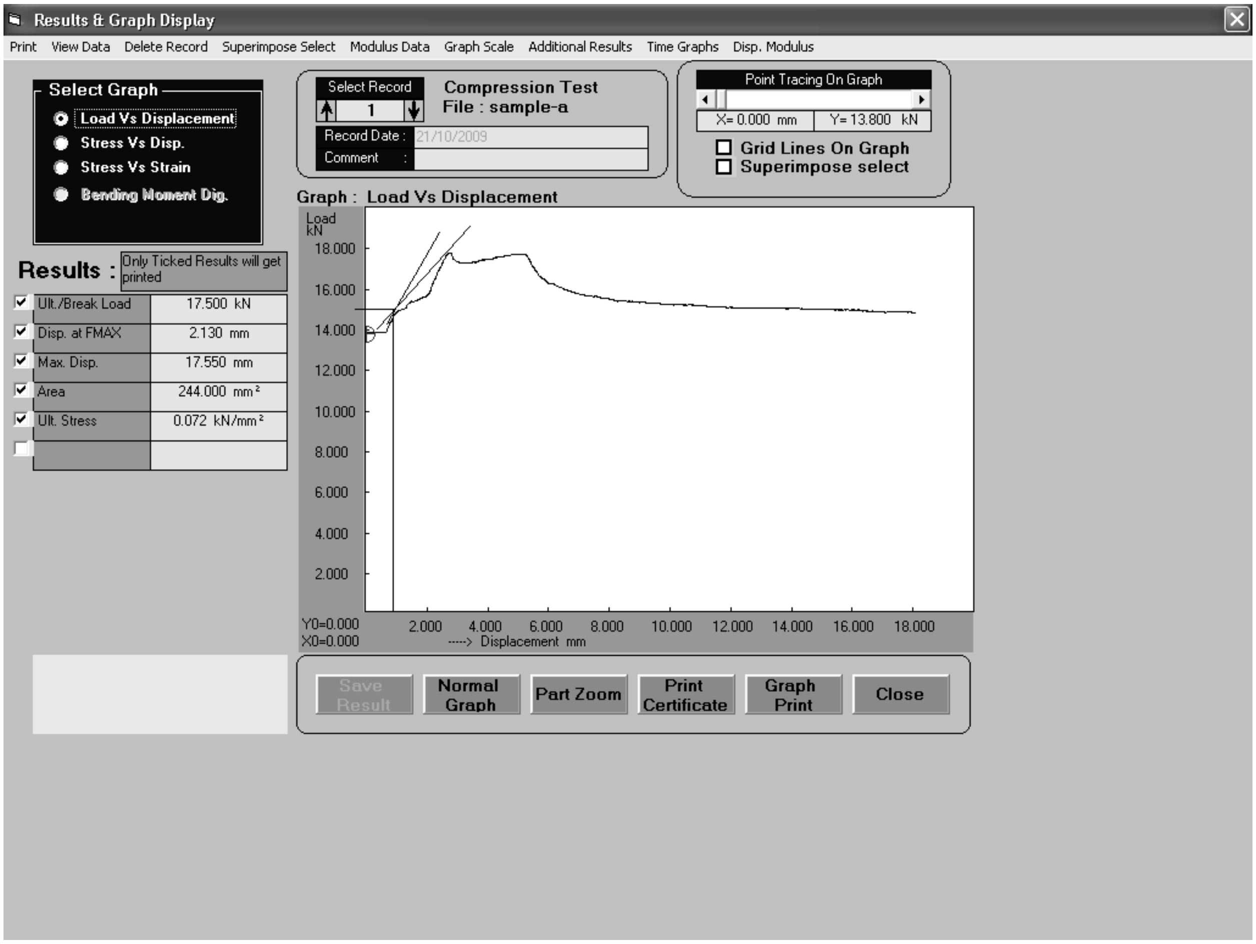
The buckling load is found by drawing tangent from the pre and post buckling stage of a load displacement graph.

For aluminium plates

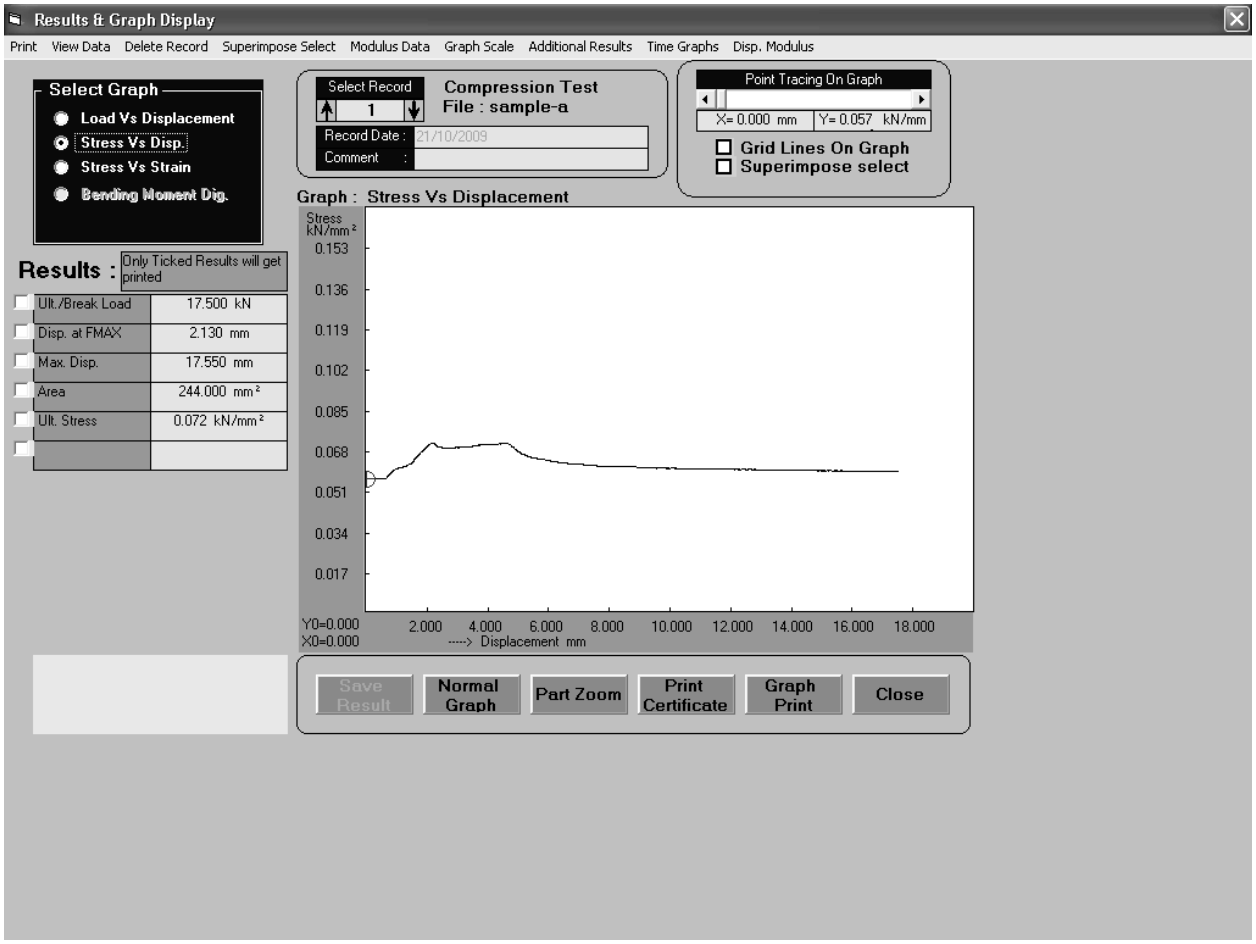
Table-3(ultimate load carrying capacity)

Sample	***Ultimate load(kn)***
A	*17.5*
B	*16*
C	*16.45*

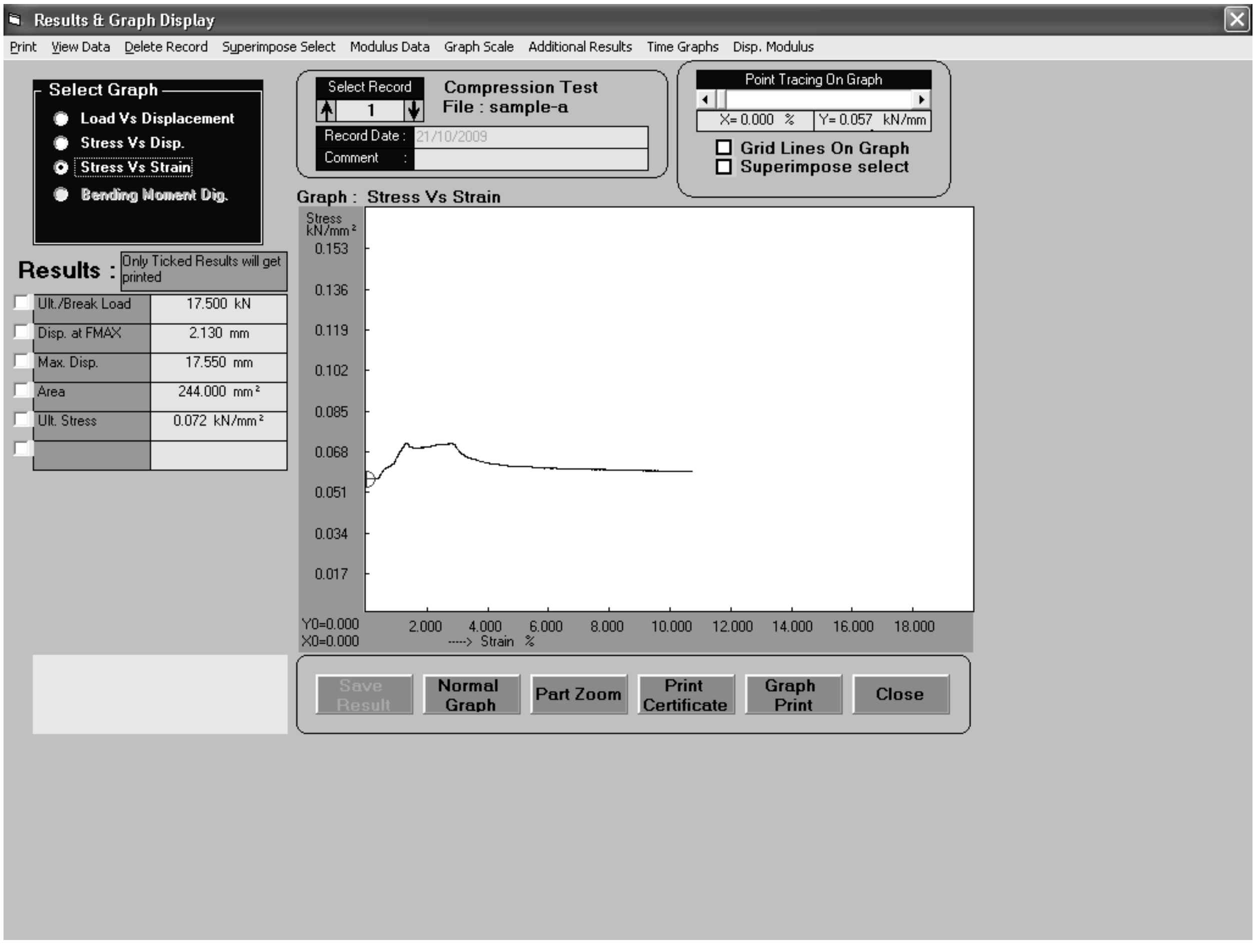
Sample graphs



Graph-1(load vs displ of aluminium plate-sampleA)



graph-2(stress vs displacement)



Graph-3(stress vs strain)

For composite plates

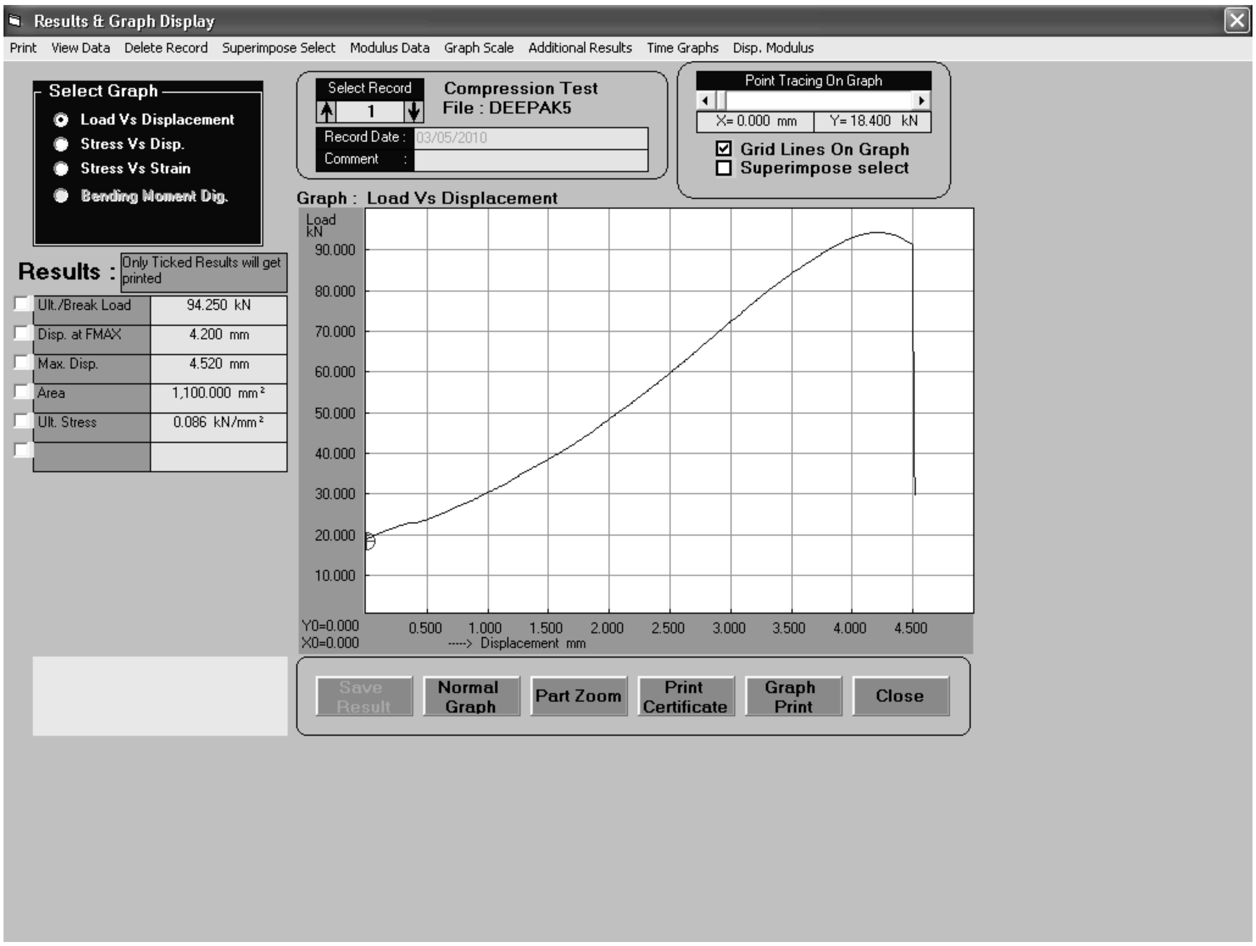
(list of specimen used and their specifications)

Table-4(Specification of composite plates after moisture treatment and the ultimate load carrying capacity)

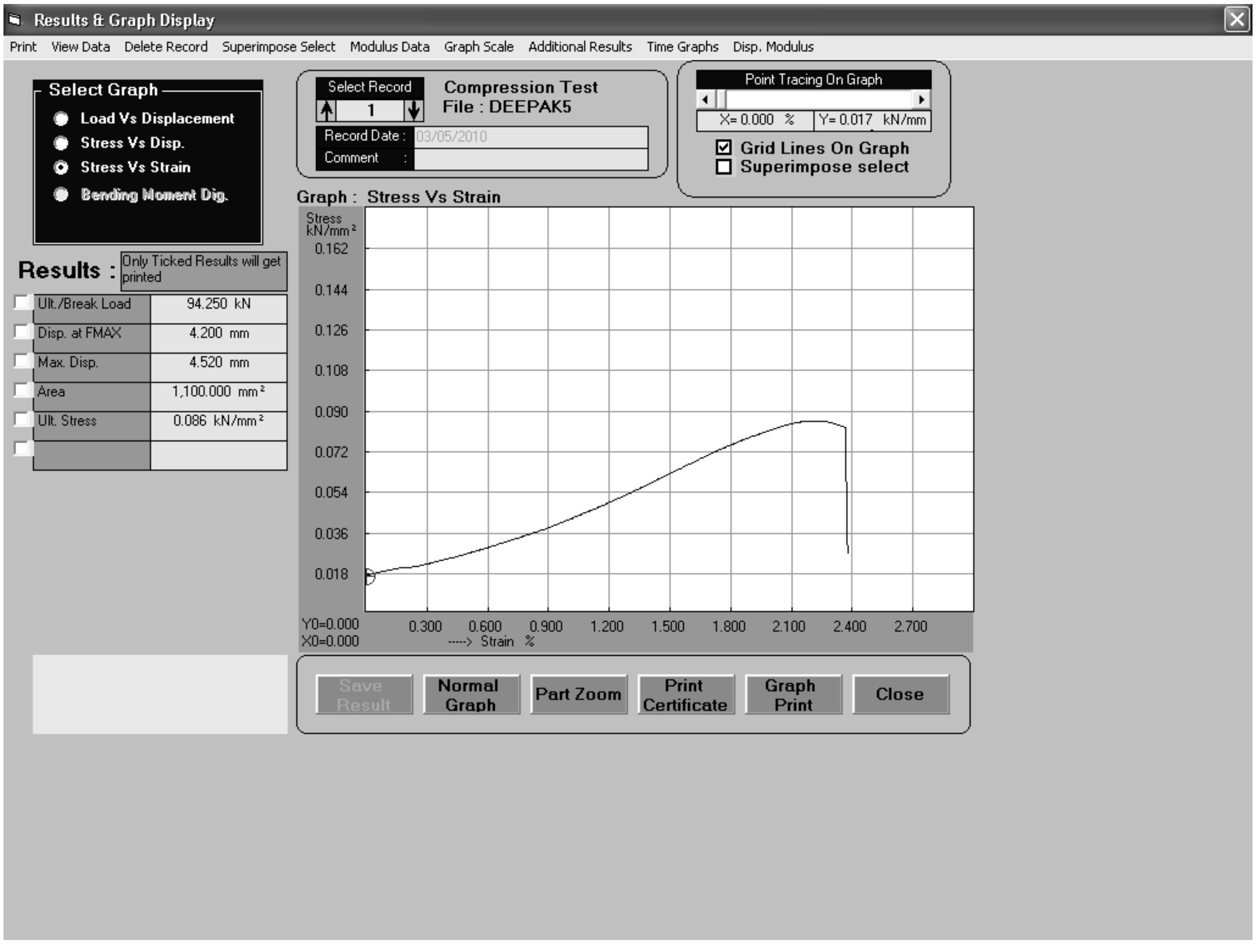
Specimen	***Size(cm)***	***Thickness(cm)***	***Moisture***	***Ultimate load***
1	*24*24*	*0.6*	*75%*	*78.3kn*
2	*22*22*	*0.6*	*60%*	*57.7kn*
5	*20*20*	*0.6*	*75%*	*94.25kn*
6	*21*21*	*0.6*	*60%*	*66.3kn*

Generally the effect of temperature and moisture has a deteriorating effect on the composite plates by bringing down its strength and stiffness characteristics. The effect of temperature generally causes a softening of the fibres and the effect of moisture causes plasticization due to absorbed moisture.This is evident from the results obtained.

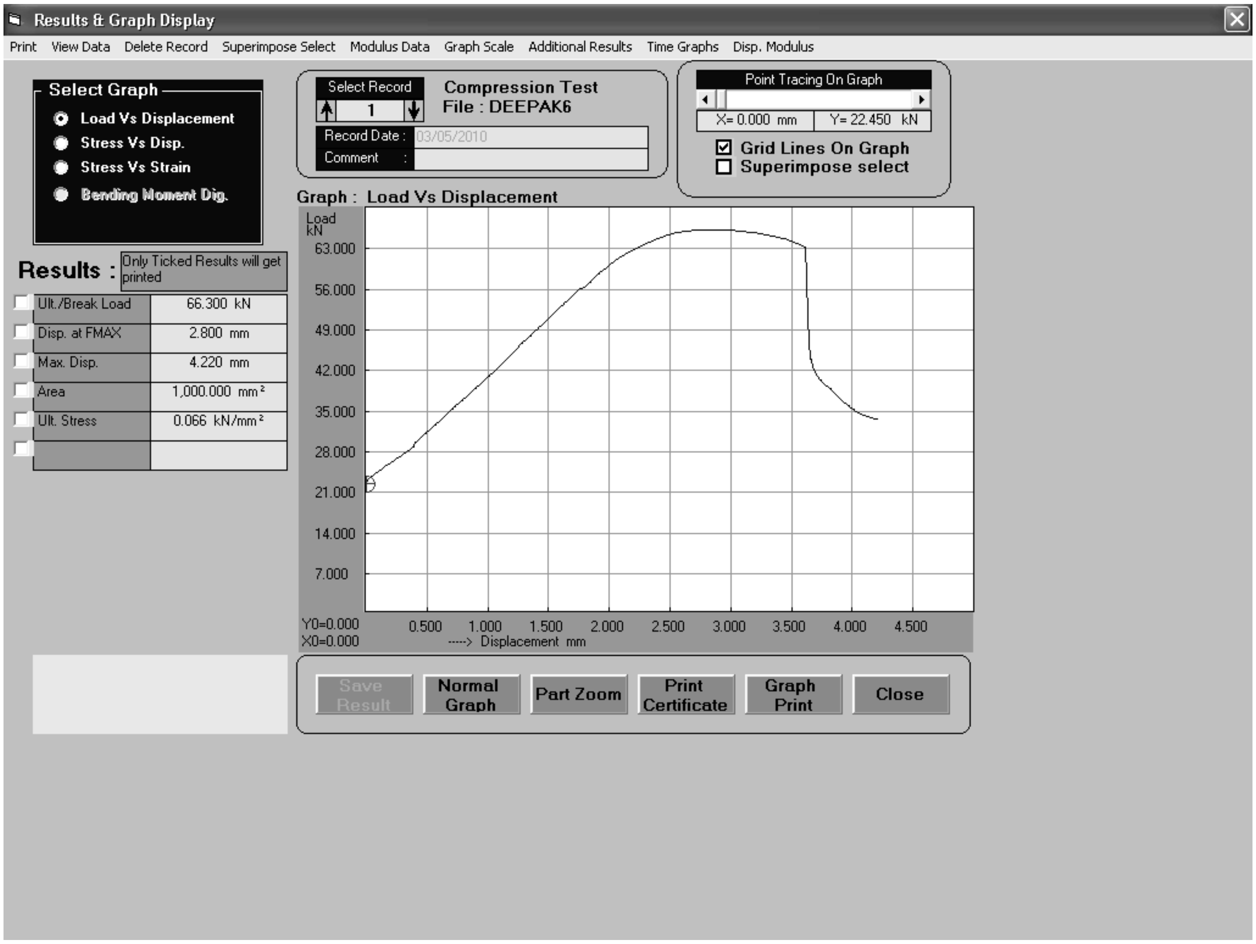
Sample Graphs



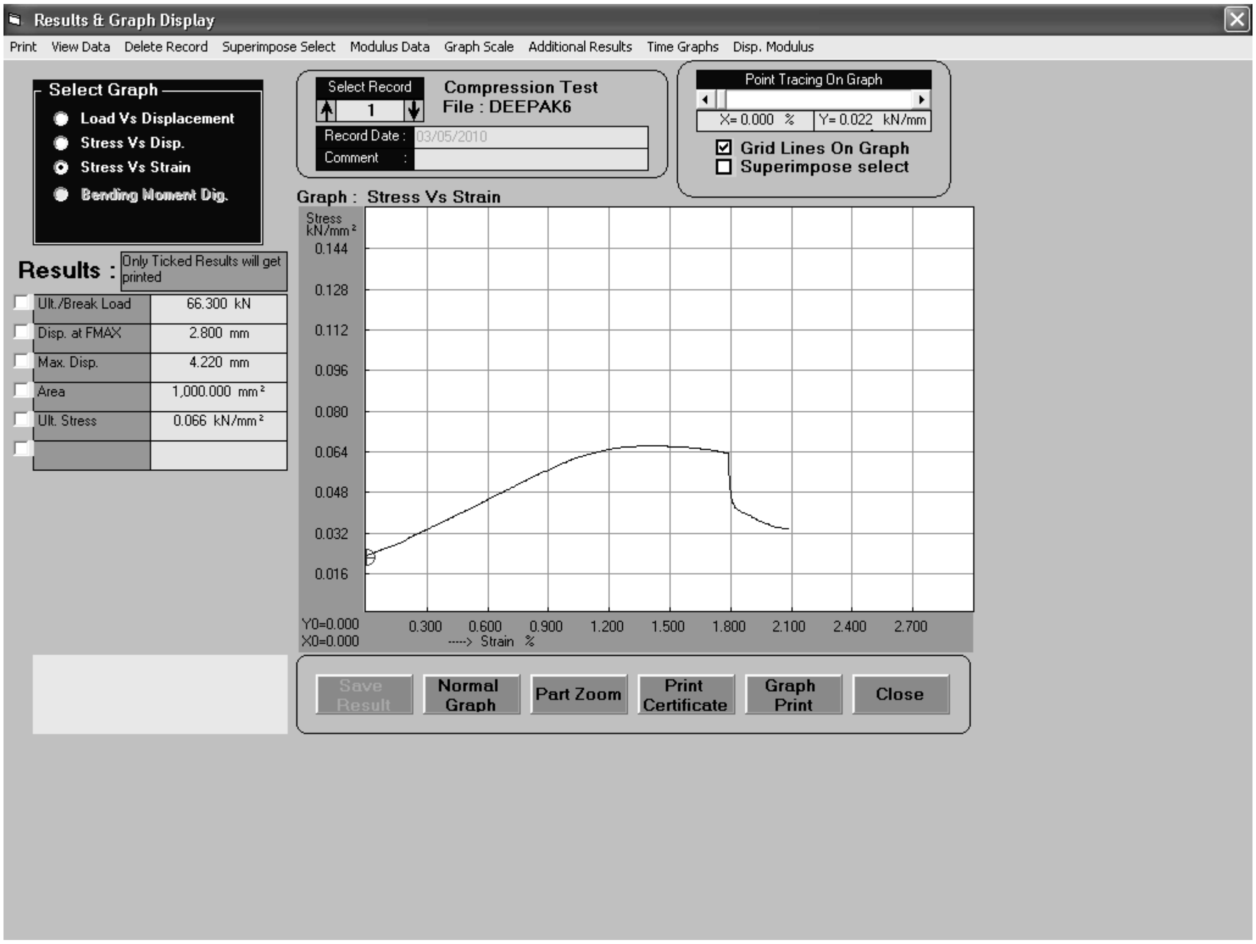
(graph-4-load vs. displacement of sample5)



(graph-5-stress vs strain of sample5)



(Graph-6-load vs displacement of sample6)



(Graph-7-stress vs strain of sample6)

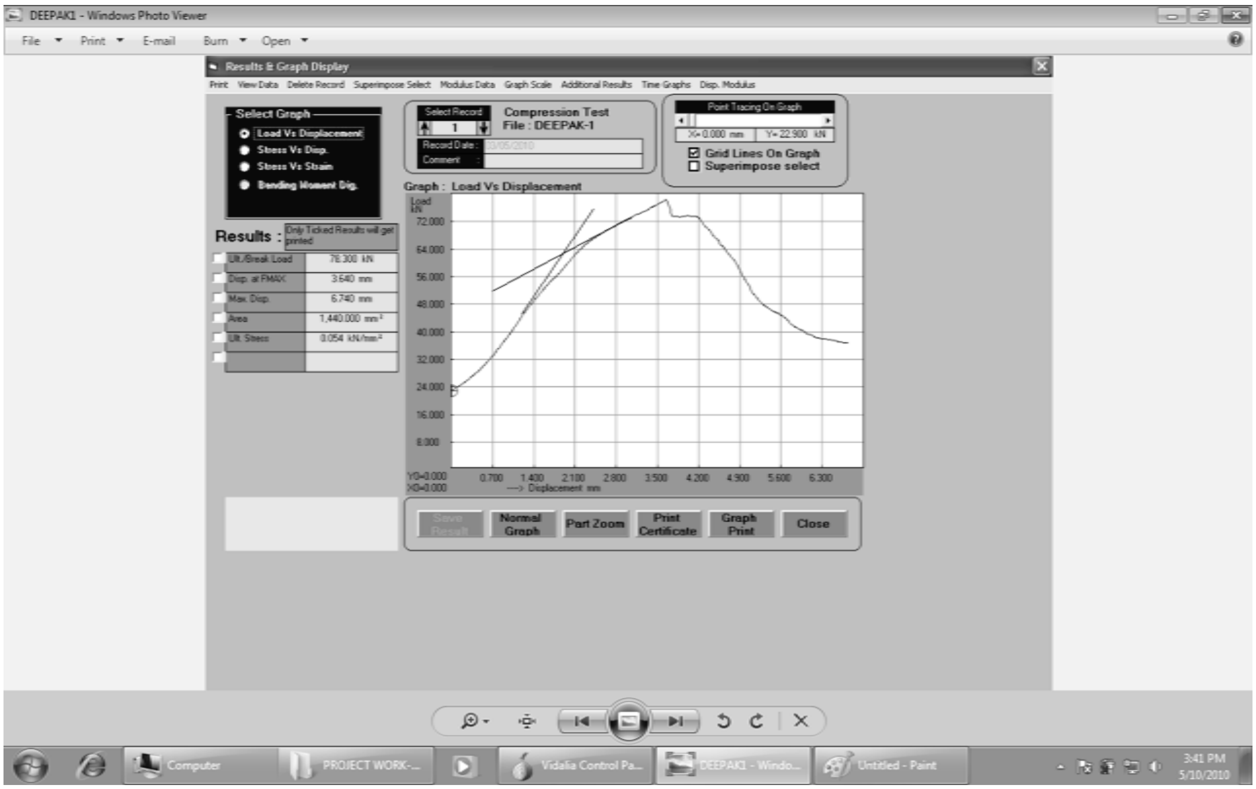
Chapter-4

Conclusion

Aluminium plates:

According to the theoretical results the buckling load comes to be around 9.5kn and experimentallyit is around 14.5kn. so a error of around 34% was obtained.

Composite plates:



(graph-8)

Considering the buckling load of sample-1 we obtain a value around 62 kn and theoretically it is around 72.9 kn. But the moisture treatment of composite plates reduces their buckling strength and stiffness due to plasticization of polymer by absorbed moisture. Hence the results are adequate.

Chapter-5

References

REFERENCES

1. *HYGROTHERMAL EFFECTS ON BUCKLING OF LAMINATED COMPOSITE PLATES-BY SAI RAM, KS SINHA,PK,ISSN 0263-8223,VOL. 21,NO.4,1992*

2. *HYGROTHERMAL EFFECTS ON POST BUCKLING OF COMPOSITE LAMINATED CYLINDRICAL SHELLS-BY HUI SHEN,MAR 1, 2000*

3. *BUCKLING CHARACTERISTICS OF SYMMETRICALLY AND ANTISYMMETRICALLY LAMINATED COMPOSITE PLATES WITH CENTRAL CUTOUT-BY OKUTAN ,BUKET,AYSUN,PUBLN: APPLIED COMPOSITE MATERIALS , VOL.14,ISSUE 4 ,PP265-276*

4. *VIBRATION AND BUCKLING OF LAMINATED PLATES WITH A CUTOUT IN HYGROTHERMALENVIRONMENT-BY SAI RAM,SINHA,AIAA JOURNAL(ISSN 0001-1452),VOL.30,NO.9,SEPT 1992*

5. *HYGROTHERMAL EFFECTS ON BUCKLING OF LAMINATED COMPOSITE PLATES WITH RANDOM GEOMETRIC AND MATERIAL PROPERTIES-BY BN SINGH AND VK VERMA, Journal of Reinforced Plastics and Composites 2009; 28; 409 originally published online Jun 24, , 10.1177/0731684407084991, 2008*
6. *Buckling Analysis of glass epoxy laminated composite plates by Arun Kumar R.(2009).*
7. *Mechanics of Composite materials and structures by Madhujit Mukhopadhyay.*
8. *Whitney, J. M. and Ashton, J. E. (1971). Effect of Environment on the Elastic Response of Layered Composite Plates, AIAA Journal, 9: 1708–13.*
9. *Lee, S. Y. and Yen, W. J. (1989). Hygrothermal Effects on the Stability of a Cylindrical Composite Shell Panel, Computers and Structures, 33: 551–9.*
10. *Sai Ram, K. S. and Sinha, P. K. (1992). Hygrothermal Effects on the Buckling of Laminated Composite Plates, Composite Structures, 21: 233–47.*
11. *Flaggs, D. L. and Vinson, J. R. (1978). Hygrothermal Effects on the Buckling of Laminated Composite Plates. Fiber Science Technology, 11: 353–65.*
12. *Parhi, P. K., Bhattacharyya, S. K. and Sinha, P. K. (2001). Hygrothermal Effect on the Dynamic Behavior of Multiple Delaminated Composite Plates and Shells, Journal of Sound and Vibration, 248: 195–14.*
13. *Sai Ram, K. S. and Sinha, P. K. (1992). Hygrothermal Effects on the Free Vibration of Laminated Composite Plates, Journal of Sound and Vibration, 158: 133–48.*
14. *Nakagiri, S., Tatabatake, H. and Tani, S. (1990). Uncertain Eigen Value Analysis of Composite Laminated Plates by SFEM, Composite Structures, 14: 9–12.*
15. *Singh, B. N., Yadav, D. and Iyenger, N. G. R. (2001). Stability Analysis of Laminated Cylindrical Panels with Uncertain Material Properties, Composite Structure, 54: 17–26.*
16. *Englested, S. P. and Reddy, J. N. (1994). Probabilistic Methods for the Analysis of Matrix Composite,Composite Science Technology, 50: 91–107.*

17. *Chen, S., Liu, Z. and Zhang, Z. (1992). Random Vibration Analysis for Larger Scale Structures with Random Parameters, Composite Structures, 43: 247–254.*
18. *Yadav, D. and Verma, N. (1997). Free Vibration Analysis of Composite Circular Cylindrical Shells with Random Material Properties, Composite Structures, 47: 385–391.*
19. *Graham, L. L. and Siragy E. F. (2001). Stochastic Finite Element Analysis for Elastic Buckling of Stiffened Panels, ASCE Journal Engineering Mechanics, 12: 91–97.*
20. *Singh, B. N., Yadav, D. and Iyengar, N. G. R. (2001). Natural Frequencies of Composite Plates with Random Material Properties using Higher Order Shear Deformation Theory, International Journal of Mechanical Sciences, 43: 2193–2214.*
21. *Singh, B. N., Iyengar, N. G. R. and Yadav, D. (2001). Effect of Random Material Properties on Buckling of Composite Plates, ASCE Journal Engineering Mechanics, 127(9): 873–879.*
22. *Reddy, J. N. (1984). A Simple Higher-order Theory for Laminated composite Plates. The ASME Journal of Applied Mechanics, 51: 745–752.*
23. *Reddy, J. N. (1993). An Introduction to Finite Element Methods, Tata McGraw-Hill, 3rd Edition, New Delhi.*
24. *Cook, R. D., Malkus, D. S. and Plesha, M. E. (2000). Concept and Applications of Finite Element Analysis, John Wiley & Sons, Singapore.*
25. *Liu, W. K., Belystschko, T. and Mani, A. (1986). Random Field Finite Elements, International Journal of Numerical Methods in Engineering, 23: 1831–45. Buckling of Laminated Composite Plates with Random Properties 427*