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Experimental Stress Analysis of Composite Beam Using Polariscope

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Abstract: *Photoelasticity is an experimental method to determine the stress distribution in anelastic material having optical property. Now a day's large numbers of photo elasticity experiments are based on the principle of light polariscope. This method is mostly used, where mathematical methods are being validated. Itis experimentaltool for determining critical stress points and stress concentration instructures made up of various ductile materials.In this paper we used this experimental technique and attempted to determine stresses in a rectangular cross section beam made up of a composite: aralditeD resin material (cy230). A four point load is applied on the beam. Simulation method wasalso proposedto evaluate stress and deflections of composite beam using software. The experimental values of deflection and stress are compared with the numerical values obtained by ANSYS.*

Keywords: *Polariscope, Beam, stress, araldite (cy230).*

I. Introduction

Many researchers are using the principle of Photoelasticityto determine experimental stress and strain analysis when elastic component deforms due to various type of loading. In this method, the isochromatic and isoclinic fringes are extracted, and photo-elastic parameters, isochromatic fringe orders or relative retardations and isoclinic angles, are assigned to the respectivefringes. The isochromatic fringe order is linearly related to the principal-stress difference, and the isoclinic angle is the inclination of either of the principal stresses to the reference axis of a polariscope. In general, to obtain each stress, the principal-stress difference and principal-stressdirection are used in the shear difference method. Introduction of the digital image processing technique to photoelastic analysis has simplified the experimental analysis and has provided hope for the full automation of the extraction.It isa tool for determining critical stress points and stress concentration of irregular geometries in material. Fang Li [1] investigated stress measurement using polariscope for thin, flat crystalline solids and applied to multi-crystal silicon as a model material. The anisotropic properties of silicon in the measurement were studied and the anisotropic stress optic coefficients were characterized for different crystal and stress orientations. A new system setup of polariscope was developed to measure large samples. By using shear difference method the stress components were determined using polariscope. Finally, the thermally induced stress was modelled using ANSYS. A.Bilek, T.Touat, S.Larbi, S.Djebali[2] proposed two methods : the Photoelasticity method and the finite element method on rectangular cross section beam. Stresses were determined in the neighbourhood of the contact zone for a plane subjected to a normal load and tangential load via a pin of rectangular cross section. The photoelastic fringes obtained on the analyzer of a polariscopeallowed them to obtain stress values on the plane, particularly in the neighbourhood of the contact zone, in order to compare them with the numerical results comparisons were also made between experimental and simulated isochromatic and isoclinic fringes. Naveen Y A, Ramesh K, and VivekRamakrishnan[3] used this technique for the measurement of residual stress along an edge of a glass plate is carried out using the carrier fringe method in photo elasticity. The influence of the carrier fringe density on the edge stress measurement and the variation of the residual stress along the edge are studied.All above studies are concentrated isometric materials. In this paper we attempted those methods on composite beam. Very few authors attempted this technique on composite materials due to the random orientation of various laminates in metal matrix and lack of good optical properties. After preparing a composite beam specimen with material having good polarization properties, we adopted bending test in the load frame of polariscope equipment. The results obtained are included in the paper. The paper is organised in the following manner.

Section 2 describes the working principle of photoelasicity on polariscope and description of experimental setup to test the composite beam. The experimental results obtained are discussed in the section 3.simulation studies on composite beam also made in section 4 to validate experimental values and stress values. Finally the conclusions are drawn in section 5.

II. Experimental Setup

The experimental stresses basically consist of linear polarizer's and a light source. Depending upon the experiment the light source can emit monochromatic or white light. As the light is passed through the polarizer where it is converted into plane polarized light. It is setup in such a way that this plane polarized light passes through each point of the stressed specimen along the direction of the principal stress at that point. Finally, it is made to pass through the analyzer where the fringe pattern is observed.The fringe pattern is combination of isochromatics andisoclinics. Isochromatics represents contour of difference in principle stress and isoclinics represents contour of principle stress orientation. The schematic diagram to explain working principle of polariscope is shown inFig2.1

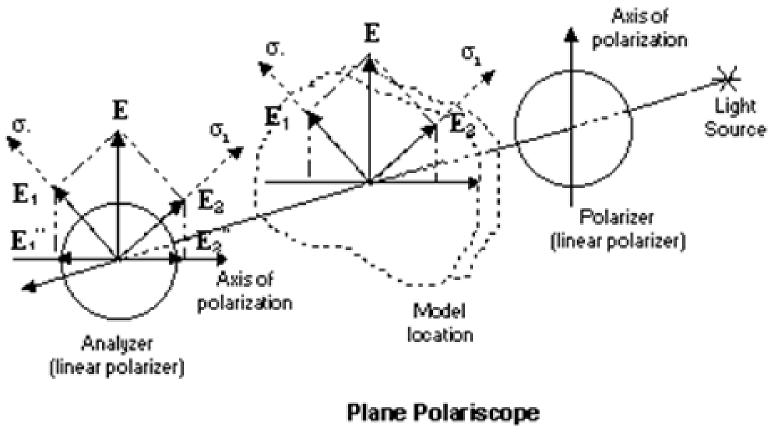

Fig 2.1: workingprinciple diagram of polariscope

The following devices are observed in the polariscope experimental setup a) monochromatic light source b) polarizer c) analyzerand d) load frame. Basically the load frame is designed to bend the composite beam with a two supports and two load points. The dimensions of the composite beam taken for testing are 150mm x 25mm x 6mm. the material properties of composite beam is computed with lever rules on the percentage of composition of matrix material and reinforced flakes. The values of given below
Young's Modulus (Ex) =36.4GPa, Poisson's Ratio = 0.33, Refractive index=1.43 and tensile strength = 2445 MPa.The overall setup of experiment is shown Fig 2.2.

Fig 2.2: experimental setup of polariscope

III. Experimental Results And Discussion

The composite beam specimen is exposed to suitable polarised light in the experimental setup and it is loaded with weights ranging from 20, 40, 80, 100N. Due to loading the beam is gets bended and the corresponding fringes are extracted through the analyzer. It is observed from the fringe pattern that the fringes order, fringe value and stress distribution are changed for different loading. The fringe pattern that are obtained due to various bending loads are shown inFig 3.1

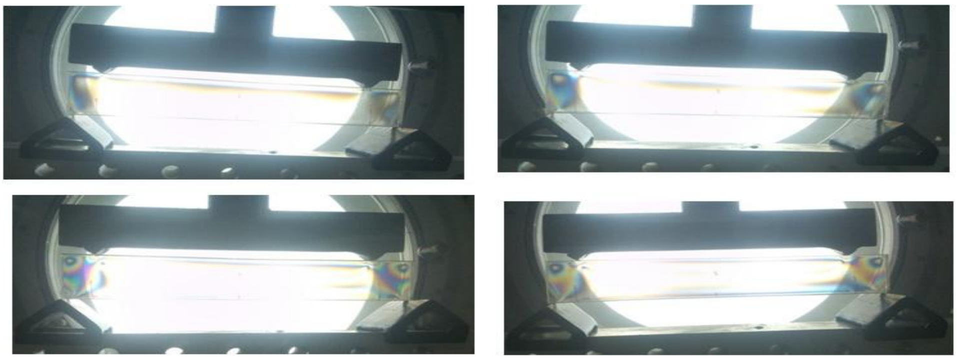

Fig 3.1: Fringe pattern observed on the beam due to loads 20, 40, and 80,100

By observing the fringe pattern on beam, calculations to determine stresses is made with the following expression:

$$\sigma_1 - \sigma_2 = \frac{N * f_\sigma}{b}, f_\sigma = \frac{12PLY}{nh^3}$$

Where, $\sigma_1 - \sigma_2$ = difference between principal stress
f_σ = fringe value
b= thickness of beam
Y = distance from neutral axis for n value 1, 2, 3
N= fringe order constant
The calculated stress value from the above formula for different loading is shown in the Table3.1

Table3.1 shows the stresses obtained through experiment.

S.NO	DIFFERENT LOADS	STRESSES (EXPERIMENTAL)(MPa)
1	20	7.2461
2	40	16.44
3	80	31.69
4	100	39.91

IV. Simulation Results And Discussions

This section covers thesimulation study using Ansys on the composite beam which is described in section 3.Following particulars related to Ansys pre-processor inputs have been considered for theanalysis of a beam under static load condition.

Young's Modulus (Ex) =36.4GPa, Poisson's Ratio = 0.33, Element: Shell 63, Number of DOF: 6 (Ux, Uy, Uz, Rotx, Roty, Rotz)Fixed conditions are imposed at thesupportsof the beam. A four point load is applied on the beam. The result obtained from the post processing stage of Ansys is shown fig. 4.1.Figure 4.1 shows the deformation and stress values of the beam when they are subjected to four different loads.

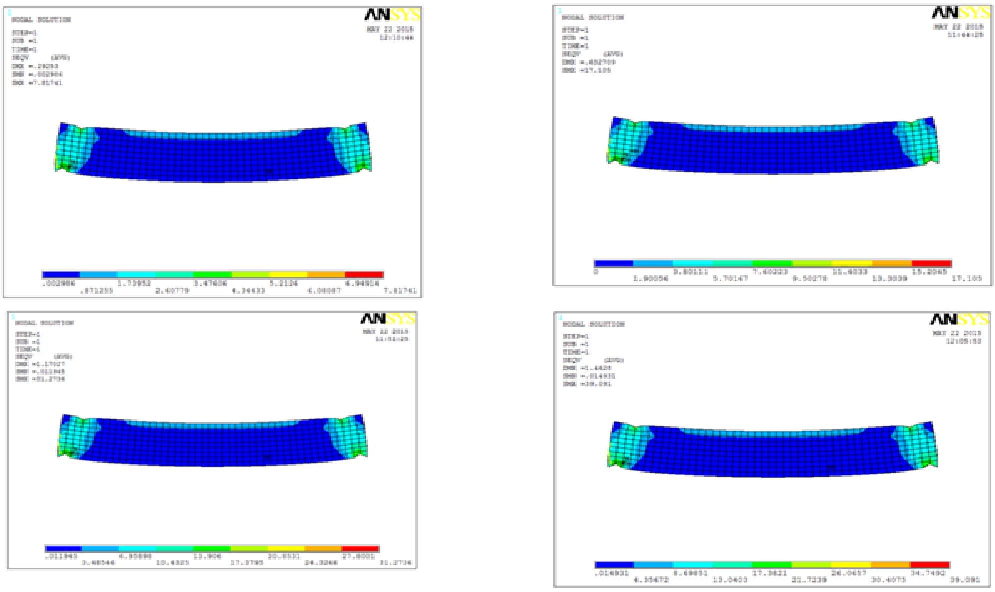

Fig 4.1: The stress anddeflection values obtained through ansys

The values of stresses and deflection due to loads 20,40,80,100N are extracted from the stress contour which are shown in the Fig 4.1. These values are placed in Table 4.1.

Table 4.1: stress and deflection values through ANSYS

S.NO	Different loads(N)	Deflection($\boldsymbol{\delta}$)	Stress ($\boldsymbol{\sigma}$)($\frac{\mathbf{N}}{\mathbf{mm^2}}$)
1	20	0.2952	7.8174
2	40	0.6327	17.105
3	80	1.1702	31.273
4	100	1.4628	39.091

The stress values in a composite beam obtained from ANSYS are also compared with the stress values obtained from the experiment and they are shown in the table 4.2

Table 4.2: comparison of stress values obtained through experimental and simulation

S.NO	Different loads	Stresses (Experimental)	Stresses (ANSYS)
1	20	7.2461	7.8174
2	40	16.44	17.105
3	80	31.69	31.273
4	100	39.91	39.091

Thecomparison of stress values in composite beam obtained from experiment and ANSYS software also shown in the fig.4.2

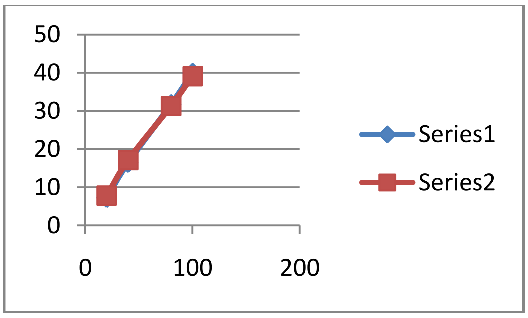

Fig.4.2.stress values of experiment and ANSYS.

V. Conclusion

In this paper, photoelasticity experiment with polariscope is conducted on acomposite beam whichis made up of material araldite (cy230). The standard four point load bending test is applied on the beam in the polarized light stream and fringes of isoclincis and isochromatics are extracted. The stress wave fringes were gathered and the stress distribution was observed in the tested specimen. The experimental stress values are also compared with the simulation results that are obtained from the ANSYS software.It is observed that the simulation values are in-tuned with the experimental values. The procedure and simulation models that are used in this paper are very useful to researchers who willing to work experimental stress analysis and composites.

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