

## Applications of Photoelasticity – A review

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### ABSTRACT

Photoelasticity is an experimental method for analyzing stress or strain fields in mechanics. Now-a-days it has become so advanced that it can analyze a 3-dimensional model; this technique is known as integrated photoelasticity. When plane polarized light passes through the model, the state of polarization changes from point to point depending on the principal stress direction and magnitude of principal stress difference. Stress analysis by using polariscopes plays a vital role in advancements in dental sciences, aerospace technology etc. This paper deals with use of polariscope in various fields.

### 1. Introduction

Photoelasticity is an experimental technique used for the purpose of stress analysis in members under different loading conditions. For some cases analytical methods are very difficult to apply. It is based on the property of some transparent materials that shows fringes when load is applied on that and observed through the monochromatic light or white light. This effect is the result of refraction of the polarized light by internal deformations due to stresses occurred in the model. Interpretation of these fringes gives all stress distribution and allows the measurement of their direction and magnitude in any model points. Materials having photoelastic properties, change in the refractive index occurs according to the application of different load. [2]

Experiment in photoelasticity utilizes a polariscope that is an optical system. Birefringent phenomena of a photoelastic specimen in the polariscope make fringe patterns that depend on stress induced in the specimen the specimen. The fringe patterns are recorded manually or by using a programming in computer. They are analyzed to get information about stress induced in the specimen. This means that full-field measurement is available at once on the complete area of specimen through non-contact methods in the photoelasticity experiment which is less complicated as compared with conventional point-by-point methods. [1]

### 2. Applications of photoelasticity

The photoelastic techniques have been proven to be very helpful in various engineering as well as other fields. Following are some of its applications:

#### 1) Aerospace:

Researchers have performed experiments on the Photoelastic evaluation of fiber surface treatments in the interfacial performance of a polyester photoelastic model composite. In this work the interfacial adhesion between the epoxy and polyester fiber was improved by using chemical and topological modifications. Photoelasticity method was exploited to measure the maximum shear strength and to find the

performance in pull-out single-fiber composite specimens. An increase of the interfacial shear strength was observed when plasma-treated or surface-modified fibers were used. [3]

#### 2) Dentistry:

The study of photoelasticity in the specific area of dental implant system is of great interest since it can be useful to analyze the stress distribution. In a research Jao Cesar Zielak studied colorimetric photoelastic analysis of tension distribution around dental implants subjected to axial loads. In this study eight different designs of implant from two manufacturers were connected to their abutments, placed into epoxy resin blocks and observed under a polariscope coupled to a universal testing machine while subjected to axial loads. [5, 6, 7]. Figure below shows the use of photoelasticity in dental science.

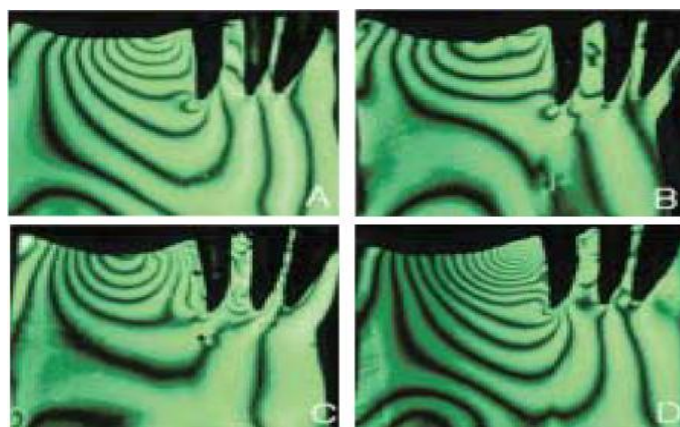


Figure: 1

#### 3) Civil structures:

J. Jayamohan et al. has done the photo elastic analysis for the measurement of internal Stresses in Indeterminate Structures. Author concluded that the technique of photoelasticity can be effectively explored to experimentally measure the internal stresses in indeterminate structures with complicated shape and loading [8]. The following figure shows the use of photoelasticity in stress analysis in structures.

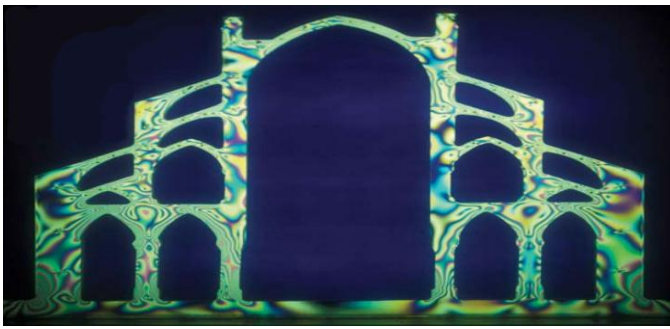


Figure : 2

#### 4) Automobile:

Rabah Haciane et al. [9] studied photoelastic analysis of sphere contact problem. They have experimentally analyzed the stress field, developed in a birefringent parallelepiped model by a sphere. The purpose was to analyze the stress field in the near the contact zone. Author concluded that number of fringes and stresses can be calculated easily for an isolated slice with sufficient accuracy by using photoelasticity method. The following figure shows the use of photoelasticity in stress analysis in automobile components.

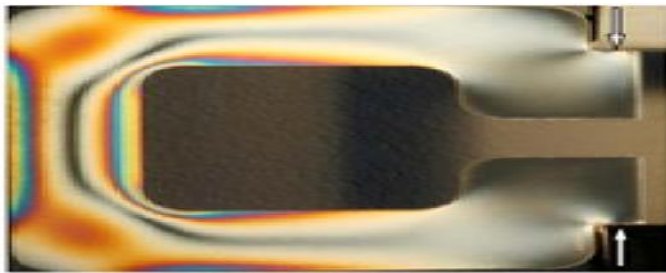


Figure: 3

#### 5) Electronics:

Y.C. Lee [4] studied how to find out residual stress for flexible electronics by using photoelasticity. In this work, a two-dimensional photoelasticity with higher measured speed and better uniformity was connected with two CCD cameras that were used for the purpose of capturing the intensity of right-hand and left hand circular polarization differently. These samples were exerted by increasing and decreasing forces and optical retardations are calculated from tensional stresses. This experiment was helpful in the analysis of residual stresses in various electronic devices. The following figure shows the use of photoelasticity in stress analysis in various electronic devices.

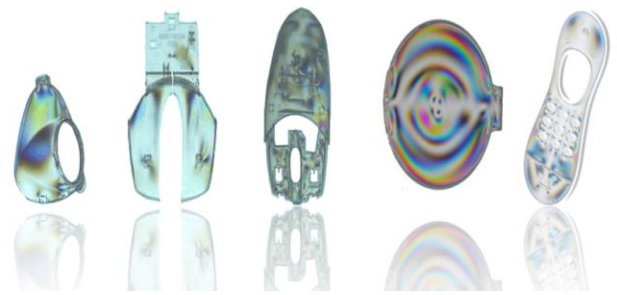


Figure: 4

### 3. Conclusion

- 1) In all the above applications, epoxy compound was used as the material for making the specimen. Epoxy compound is used due to its property of birefringence. A stress freezer can also be used for the analysis under stressed condition.
- 2) The method of photo elasticity can be effectively exploited to experimentally measure the internal stresses in structures with complicated shape and loading.
- 3) By biomechanical study, it is possible to demonstrate a correlation of some implant characteristics to the colored fringe areas of tension distribution.
- 4) The photoelastic analysis has played a vital role in health area, more specifically in Dentistry. Based on this method of analysis, it is possible to measure the stress distribution and deformation in structures with complex geometry.
- 5) Photoelastic method of stress analysis has played a major role in the analysis of stress in many engineering applications as well as other problems related to various fields by simply observing and analyzing the fringes that appear on the birefringent material.

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