Photoelasticity

Photoelasticity was developed at the turn of the twentieth century. The early work of E Coker and L Filon at the University of London enabled photoelasticity to be developed rapidly into a viable technique for qualitative stress analysis. It found widespread use in many industrial applications, as in two dimensions it exceeded all other techniques in reliability, scope and practicability. No other method had the same visual appeal or covered so much of the stress pattern.

The development of digital polariscopes using LEDs and laser diodes enables continuous online monitoring of structures and dynamic photoelasticity. Developments in image processing allow the stress information to be extracted automatically from the stress pattern. The development of rapid prototyping using stereolithography allows the generation of accurate three-dimensional models from a liquid polymer, without the use of the traditional moulding method.

The advent of superior computer processing power has revolutionised stress analysis. Finite element modelling (FEM) has become the dominant technique, overshadowing many traditional techniques for stress analysis. Despite FEM advances, photoelasticity, one of the oldest methods for experimental stress analysis, has been revived through recent developments and new applications.

When using FEM, it is crucial to assess the accuracy of the numerical model, and ultimately this can only be achieved by experimental verification. For example, a threaded joint experiences non-uniform contact, which is difficult to incorporate accurately into a computer model. Idealised models therefore tend to underestimate the actual maximum stress concentration at the root of the thread. Photoelasticity therefore remains a major tool in modern stress analysis.

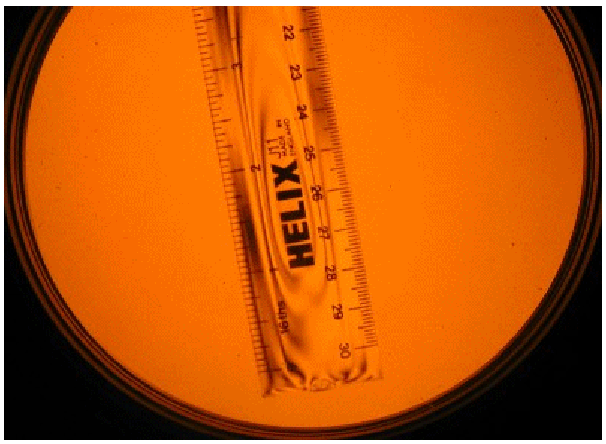
Introduction:

The photoelastic effect (alternatively called the piezo-optical effect) is the change of refractive index caused by stress. Applications of photoelasticity involve applying a given stress state to a model and utilising the induced birefringence of the material to examine the stress distribution within the model. The magnitude and direction of stresses at any point can be determined by examination of the fringe pattern, and related to the studied structure.

Two different types of fringes can be observed in photoelasticity: isochromatic and isoclinic fringes. Isochromatic fringes are lines of constant principal stress difference, (σP - σQ). If the source light is monochromatic these appear as dark and light fringes, whereas with white light illumination coloured fringes are observed. The difference in principal stresses is related to the birefringence and hence the fringe colour through the Stress-Optic Law.

Isoclinic fringes occur whenever either principal stress direction coincides with the axis of polarisation of the polariser. Isoclinic fringes therefore provide information about the directions of the principal stresses in the model. When combined with the values of (σP - σQ) from the photoelectric stress pattern, isoclinic fringes provide the necessary information for the complete solution of a two-dimensional stress problem.
A standard plane polariscope shows both isochromatic and isoclinic fringes, and this makes quantitative stress analysis difficult.

Isoclinic fringes can be removed by using a circular polariser. Image capturing and digital processing techniques also allow for the separation of the isoclinic and isochromatic fringe patterns. Isoclinic fringes can be observed by reducing the number of isochromatic fringes through either applying a smaller load or by using a material with a high material fringe constant. The two types of fringes can be distinguished by rotating the specimen in a plane polariscope. Isoclinic fringes will vary in intensity during rotation whereas isochromatic fringes will be invariant to the orientation of the specimen with respect to the polariser and analyser.



Plain polariscope images of the same ruler in different orientations. Note the varying intensity of the isoclinic fringes.

Source : http://www.doitpoms.ac.uk/tlplib/photoelasticity/intro.php