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NEW APPROACHES TO ASSESSMENT OF STRESS AND STRAIN FIELDS WITH APPLICATION OF PHOTOSTRESS METHOD

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Abstract: *Isoclinic and isochromatic fringes provide qualitative and quantitative information in experimental method PhotoStress. They are the source of data on directions and magnitudes of principal strain and principal normal stress on the surface of analysed objects with photoelastic coating. The article reviews methodology of autonomous assessment of magnitudes and directions of stress fields and strains as carried out by the authors of the article by means of PhotoStress method.*

Keywords: ***Linear and circular polarization, isoclinics, isostatics, singular points, isochromatics.***

1. Introduction

Experimental method PhotoStress is based on temporary birefringence that appears in photoelastic coating applied to a tested object subjected to loads. When photoelastic coating applied to the tested object under load is illuminated with polarized light, two types of photoelastic entities can be observed: isoclinic and isochromatic fringes. These photoelastic entities allow us to perform qualitative (visual) and quantitative analysis of principal strain and principal normal stress directions and magnitudes on the surface of the object subjected to load. Quantitative analysis of principal strain and stress directions and magnitudes is performed manually at a point and hence is time-consuming when it comes to strain and stress determination at more points on the analysed surface. For the above-mentioned reasons, the authors of the article developed a PhotoStress software application that enables automatic determination of parameters of isoclinics and isochromatics from their images. From these parameters we can determine directions and magnitudes of principal strains and principal normal stresses at all points of tested surfaces.

2. Photoelastic entities

Isoclinic fringes are used in PhotoStress method in order to determine parameters of principal strains and principal normal stresses. They are dark lines or areas which are defined as geometrical points in which directions of principal stresses are parallel to intersected polarization planes of the polarizer and analyzer. Isoclinic fringes appear in a plane-polarized beam of light. When examining isoclinic fringes, the axes of polarizer and analyzer are perpendicular to one another. When intersected polaroids rotate synchronically, the isoclinics viewed under reflection polariscope are continuously changing from the isoclinics with parameter 0° up to the isoclinics with parameter 90°. Isoclinics are distributed through the whole tested surface of an object under minimum load with respect to the changing directions of principal strains or stresses. Only one isoclinic with a particular parameter can intersect a particular point of a photoelastically coated test surface since in that point there is only one principal stress direction, i.e. α or $\alpha+\pi/2$. However, isoclinics of all parameters intersect points in which both principal stresses have the same magnitude and in which these stresses are principal in all directions. Such points are called singular points. Singular points have qualitative value for the behaviour analysis of isostatics and isochromatics. Singular point belongs to the zero order. The material is at this point in the state of hydrostatic pressure ($\sigma_1 < 0$), tension ($\sigma_1 > 0$) or is in a stress-

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free state ($\sigma_1 = 0$). Isostatics are other typical photoelastic lines. Isostatic lines can be defined as stress trajectories. These are the sources of information about the directions of principal normal stresses σ_1 and σ_2 along the whole tested surface. Quantitative information about strain and stress magnitudes at particular points of the photoelastically coated surface of a tested object can be derived from another type of photoelastic lines, i.e. isochromatic fringes. Isochromatics are connection lines of points along which the difference between principal normal stresses $\sigma_1 - \sigma_2$ is constant. They occur in a circle-polarized light. When illuminated with polarized light from reflection polariscope, deformations in the coating reveal optical effects which appear as colourful isochromatic fringes or areas of the same (iso) colour (chromos).

3. Conclusions

As it is evident from the article, software application PhotoStress makes the analysis of principal strain and principal normal stress directions and magnitudes on photoelastically coated objects faster. The foundations of this improvement lie in automatic processing of photoelastic entities such as isoclinic fringes, singular points and isochromatic fringes. The application is currently subjected to some improvements regarding little imperfections that arise during automatic projection of isostatic curves and recognition of colourful isochromatic fringes or surfaces. Amendments and other additions to the software application will be discussed in future articles.

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