A New Approach to Evaluation of Measurement in Dynamic Photoelasticity

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Summary

In this paper there is presented a new method combining theoretical and experimental approaches for the solution of impact state of stress in two-dimensional elastic configurations. The used theoretical model is based on finite difference equations and describes the behaviour of investigated two-dimensional configurations. From the experimentally obtained boundary conditions and dynamic isochromatic pattern the model allows to determine all the values of stresses, displacements and strains and was satisfactorily verified on the solution of state of stress in the three-point-bending specimen.

Problems dealing with quickly varying state of stress in solid bodies begin to play the paramount role in the last time, especially in connection with present ever increasing requirements of useful life-time and reliability of machines.

The purely theoretical or purely experimental solutions of these problems cannot be usually satisfactorily provided due to their inherent complexity and difficulty.

The development of presented combined theoretical and experimental method was stimulated by the necessity to obtain a practical and reliable tool allowing the description of mentioned phenomena both in pure research and in machine design analysis. In the present state of development we are satisfied with a semi-empiric character of the method which allows to overcome a certain ambiguity of boundary conditions, our approximate knowledge of material constants, etc. The method employs advantages of more exact representation of an actual machine by a physical model with advantages of easy computer modelling of a theoretical model.

The presented so called hybrid or complex method is ba-
sed on dynamic photoelasticity and on a computing system for the solution of dynamic equations of two-dimensional continuum by finite difference method. We are thus using the possibility of comparatively simple registering of isochromatic pattern in the whole area of the investigated physical model and simultaneously the easy finite-difference calculations of all the kinematic and stress quantities determining the non stationary state of stress of the theoretical model for the boundary conditions previously determined by physical-model experiment.

The developed approach is schematically illustrated in Fig.1. The left part depicts the physical modelling while on the right side there is described the theoretical one. The part of the whole solution illustrating the presented hybrid method is accentuated by heavy solid lines.

The whole procedure consists of the following partial tasks:

1) determination of material mechanical properties - density $\rho$, Poisson ratio $\nu$ and Young modulus $E_d$,
2) determination of boundary conditions by experimental ascertaining of the time dependent values of loading forces and support reactions,
3) registering the isochromatic pattern in the whole area of model for various values of time and photoelectrical measurement of time dependent values of birefringence at its certain points,
4) calculation of stress distributions in the whole investigated area for various values of time and determination of the stress distributions (if necessary the differences of principal stresses) at certain points as a function of time,
5) determination of optical sensitivity,
6) for checking purposes the calculated isochromatic pattern is plotted, then an "area of satisfactory agreement" (both in time and space) is determined and areas with greater differences between experimental and calculated values are discussed, verified and judged,
7) eventual correction of computing model by more exact representation of boundary conditions, by more accurate ma-