46th International Scientific Conference EXPERIMENTAL STRESS ANALYSIS 2008
Department of Mechanics of Materials, VŠB - Technical University of Ostrava
June 2 - 5 2008, Horní Bečva, Czech Republic

Henryk KOPECKI*, Przemysław MAZUREK**

EXPERIMENTAL - NUMERICAL ANALYSIS OF RECTANGULAR PLATES WITH CUT-OUT IN THE RANGE OF ELASTIC-PLASTIC DEFORMATION

EXPERIMENTÁLNÍ-NUMERICKÁ ANALÝZA OBDÉLNÍKOVÝCH DESEK S OTVORY V OBLASTI ELASTICKO-PLASTICKÝCH DEFORMACÍ

Abstract

The paper presents the results of experimental researches and numerical FEM calculations of the stress distribution in the rectangular plates, containing different form cut-out. The material of the plate shows elastic-plastic characteristics and optical active properties. An adequate numerical model for nonlinear problem, in the formulation finite elements method was developed on the basis of experimental studies.

Abstrakt

Článek se zabývá výsledky experimentálního výzkumu a numerického řešení (MKP) rozložení napětí v obdélníkových deskách s různými otvory. Materiál desek vykazuje elasticko-plastické chování a optické vlastnosti. Odpovídající numerický model pro řešení nelineárních problémů pomocí MKP byl vytvořen na základě experimentálního výzkumu.

1 INTRODUCTION

Non-linear characteristics of optical active materials are creating the chance to realize of model investigation in the range of elastic - plastic deformation. A special importance has gained examinations of structures with cut-out, being or non-continuities having an influence on the stress and strain distribution. Examinations of this kind are growing peculiarly useful while elaborating numeric models making it possible to make non-linear analyses.

A similar problem was presented at present work on the example of rectangular plates containing centrally located of non-continuities in the form of cut-out: circular and rectangular and crack.

Effects of experimental examinations were posing grounds for elaboration of numerical models in the formulation of finite element method.

2 SUBJECT OF EXAMINATIONS

Examinations were carried out on the transmission polariscope in the monochromatic light.

Using the gravitational system the loading was being realized. Results of examinations in the form of isochromatics were presented on photographs.

* Prof. PhD, DSc – Eng. Eng. Faculty of Mechanical Engineering and Aeronautics, Rzeszów University of Technology, POLAND,tel (48)0178651319, e-mail hkopecki@prz.edu.pl
** PhD – Eng. Faculty of Mechanical Engineering and Aeronautics, Rzeszów University of Technology, POLAND,tel (48)0178651815, e-mail pmazurek@prz.edu.pl

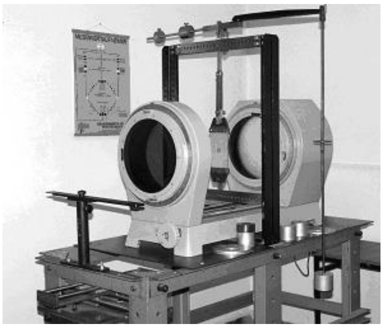


Fig. 1. General view of the station

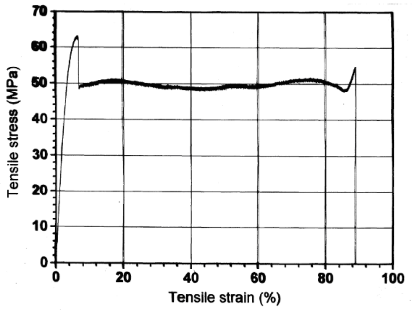
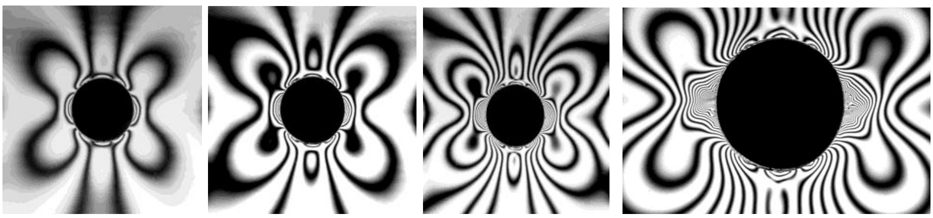


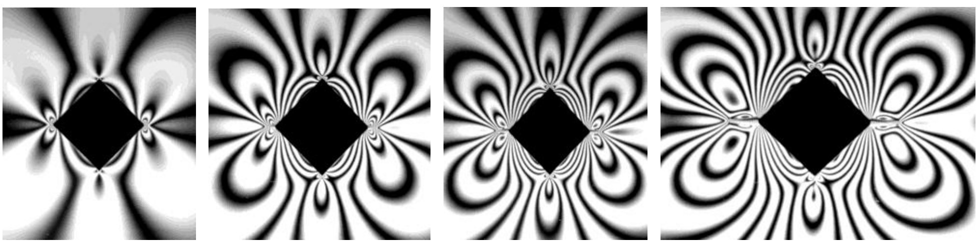
Fig. 2 Characteristic of the material

The material of plates, polycarbonate, shown the following material constants: Young modulus E=30000daN/cm^2 , yelled point - R_e=50000daN/cm^2, model photo elastic constant $\boldsymbol{K}_{\sigma}$ =80 daN/cm^2.



N=96 daN N=160 daN N=224 daN N=320daN

Fig. 3 Isochromatics distribution in the plate with circular cut-out.



N=96 daN N=208 daN N=256 daN N=304daN

Fig. 4 Isochromatics distribution in the plate with rectangular cut-out.

3 NON-LINEAR FEM ANALYSIS

Algorithms of non-linear analysis are based, mainly, on iterative and incremental - iterative procedures. The stiffness matrix **K** is treated in every solution stage as a constant and it is experiencing the increase as far, as **λ** stage control parameter grows. Newton - Raphson algorithm constitutes the basic iterative method. Lack of the chance to obtain the solution convergence is the method defect. It is bound up with the appearance of the limit of bifurcation points on the equilibrium path. In such situations the arc length method is applied, which makes possible to determine the balance of the system.

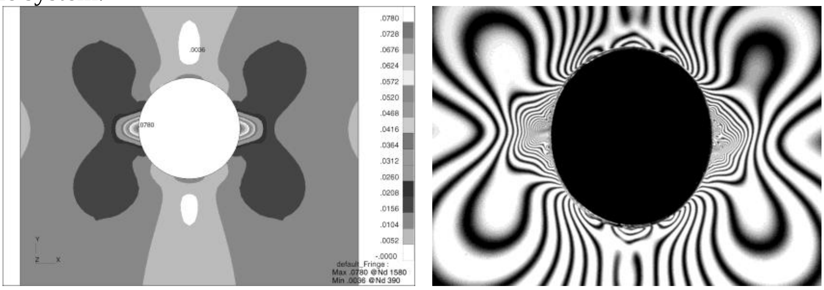


Fig. 5 Effective strain distribution obtained by FEM and photo-elasticity

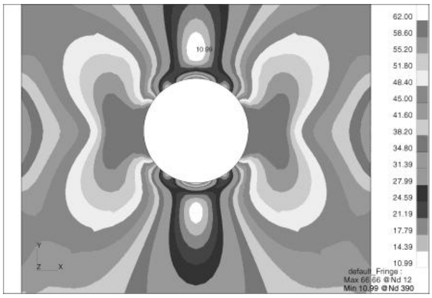


Fig. 6 Effective stress distribution according to Huber – Misses – Hencky criterion obtained on the basis of FEM analysis

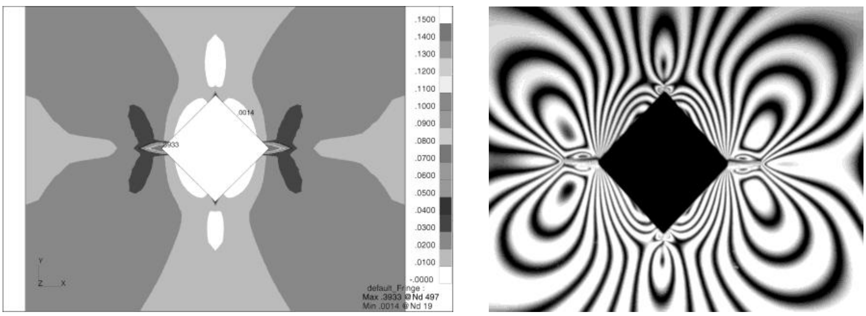


Fig. 7 Effective strain distribution obtained by FEM and photo-elasticity

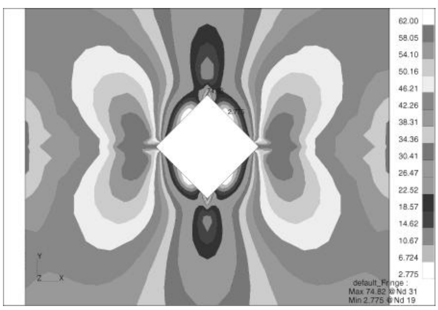


Fig. 8 Effective stress distribution according to Huber – Misses – Hencky criterion obtained on the basis of FEM analysis

In considered problem, applying MSC MARC 2007 programme, non-linear numerical analyses were made. This programme is creating the chance of the user's meaning intervention in the issue of the iteration parameters selection.

3 CONCLUDING REMARKS

On the basis of numerical and experimental results some statements could be formulated, essential for engineering practice.

Comparing effects of numerical calculations to results of experimental studies easily to notice satisfying convergence of the form of deformation. On this base it is possible to formulate statement, that assumed strategy of solution of physically non-linear problem was corrected.

REFERENCES

[1] ARBOCZ J. *Shell stability analysis: theory and practice. Collapse, the buckling of structures in theory and practice.* In Thompson J.M., Hunt G.W. (editors), Cambridge University Press, 1983.

[2] BATHE K.J. *Finite Element Procedures*. Prentice Hall, Upper Saddle River, New Jersey, 1996.

[3] ABACUS Analysis User's Manual, version 6.3

[4] CRISFIELD, M.A. *A faster modified Newton-Raphson iteration*. Comp Meth Appl Mech Engrg 20, 267-278 (1979).

[5] CRISFIELD, M.A. *Incremental/iterative solution procedure for nonlinear structural analysis in numerical method for nonlinear problems*. Vol.1, (eds. C. Taylor, E. Hinton and D.R.J. Owen).

[6] CRISFIELD, M.A. *An arc-length method including line Searches and accelerations*. Int J Num Meth Engrg 19, 1269-1289 (1983).

[7] KOPECKI, T. & ZACHARZEWSKI, J. *Fatigue life and stress state analysis of cracked thin-walled plate under cycles axial tension*. Maintenance and reliability, Nr.3 (31)/2006, Polish Maintenance Society (Warsaw)

Reviewer: MSc. Radim Halama, Ph.D., VŠB-TU Ostrava