AD-A072 836 OAKLAND UNIV ROCHESTER MICH SCHOOL OF ENGINEERING F/G 14/2
DEVELOPMENT AND APPLICATION OF METHODS OF EXPERIMENTAL MECHANIC--ETC(U)
AUG 79 A J DURELLI, J D HOVANESIAN, Y Y HUNG N00014-76-C-0487

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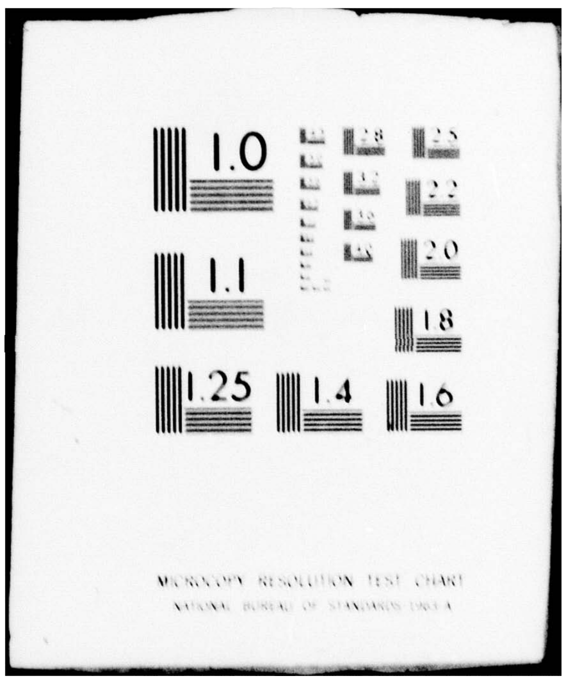
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ANNUAL REPORT TO ONR, AUGUST 1979

1. TITLE OF THE RESEARCH EFFORT: Development and Application of Methods of Experimental Mechanics

PRINCIPAL INVESTIGATORS: A. J. Durelli, J. D. Hovanesian and Y. Y. Hung

Task No. : Contract No. P00003, N00014-76-C-0487

2. KEY WORDS:

a) Moiré
Gratings
Speckle
Experimental Stress Analysis
Fourier Filtering
Optimization
Stress Concentrations
Photoelastic Coatings

b) Technical Objective:

The general objective of the research program is to develop methods in experimental mechanics, with particular emphasis on stress analysis. The following phases have been dealt with: 1) new methods in three-dimensional photoelasticity, 2) viscoelasticity, 3) strains in actual solid propellant for rockets, 4) shrinkage stresses, 5) transient thermal stresses, 6) gravitational stress, 7) composite materials, 8) dynamic holography and photoelasticity, 9) interference phenomena, 10) two- and three-dimensional finite strains and stresses, 11) cables, 12) evaluation of relative merits and limitations of different experimental stress analysis methods, 13) elastostatics of boxes subjected to pressure and concentrated loads, 14) optimization of shapes, 15) speckle methods, 16) photoelastic coatings.

3. RESEARCH CURRENTLY UNDERWAY

At present, work is being conducted under three items: a) optimization of structures subjected to in-plane loading; b) improvements on birefringent coating techniques and evaluation; c) optical strain-gage rosette. The work on item a) is well advanced and some important results have already been obtained. Several manuscripts are in process of publication. The work on item b) is also well advanced and some verifications of the precision obtained are being conducted. The work on item c) has started.

4. (a) SCIENTIFIC RESULTS

It is believed that in the reports submitted recently, some important scientific developments have been made: 1) the introduction of the concept of "coefficient of efficiency", associated to the concept of stress concentration factor, as a means of evaluating the merit of the shape of a discontinuity in a field of stress, and indicating the possible degree of improvement by optimization procedures. Several structural shapes have been optimized, among them holes, in finite and in infinite plates, and holes in circular rings. Uniaxial and biaxial loadings have been considered; 2)a multiple image-shearing camera has been built, which is very simple, consisting only in the addition of a thin glass plate located in front of the lens of an ordinary camera. The importance is that surface-displacement derivatives with respect to three different directions can be measured simultaneously. As well known, these derivatives are the important quantities to be determined in the analysis; 3) photoelastic coatings have been limited in their application by the fact that only in-plane maximum shears could practically be determined. The introduction of very small holes in the coating permits now a much wider application of the method, and in many cases, permits the correct interpretation of the patterns obtained.

4. (b) PREVIOUS ACCOMPLISHMENTS ON ONR CONTRACTS

1) Development of experimental methods to determine stresses in two- and three-dimensional bodies (including composite material bodies) subjected to both mechanical and restrained shrinkage loads (applications in solid propellant grain design, and structures in general).

2) Application and justification of the immersion analogy for the experimental analysis of gravity stresses in two- and in three-dimensional bodies and in composite material studies (application to solid propellant grain design, dams, etc.)

3) The general development of photoelasticity and moiré methods to permit the efficient three-dimensional analysis of rocket motors subjected to pressure or to restrained shrinkage loads. Development of a systematic photoelastic method to determine the optimum shape of a slot in a loaded grain (application in machine design).

4) Combination of dynamic photoelasticity with other methods to determine all the stresses in the interior of a body in a simpler and more efficient way than used previously (applications in experimental stress analysis).

5) Method to analyze bodies vibrating in liquids (application in underwater technology).

6) Method to determine strains and stresses in bodies subjected to large deformations.

7) Method to evaluate finite strains experimentally obtained in industrial applications.

8) Development of a new material to be used "frozen" in three-dimensional stress analyses. This material has a Poisson's ratio of about 0.4 which permits the complete solution of problems using photoelasticity, moiré, mechanical gages, or combinations of them.

9) Complete elastostatic solution of hollow boxes subjected to hydrostatic pressure and to concentrated loads.

10) Use of time-averaged photoelasticity and moiré to study vibrations and interpretation of the results obtained.

5. ABSTRACT OF 4(a), PROGRESS MADE SINCE LAST SUMMARY

Optimum shapes of holes and fillets in plates and disks have been obtained (the plates may be subjected to uniaxial or biaxial loading). Photoelastic coatings have been made useful by the introduction of very small holes. A multiple image shearing camera has been built to determine simultaneously three-strain components in speckle interferometry.

6. TECHNOLOGICAL RELEVANCE OF RESEARCH UNDERWAY

The Navy is faced continuously with hundreds of design problems, many requiring stress analyses of vibrating components or structures. The use of speckle methods, and the proposed camera, permits a simpler and more precise determination of the strains and stresses in particular when components are subjected to vibrations.

The optimization of holes, filets and notches permits the design of stronger and lighter structures, in particular, because it is usually at those discontinuity that failure starts.

Photoelastic coatings are frequently used to stress analyzed structural components, but the operator often interprets the results as if maximum shears in space were really obtained, when actually only shears in the plane tangent to the surface are obtained. The suggested development permits a correct interpretation.

7. (a) TECHNICAL REPORTS DISTRIBUTED (in Report Period)

A. J. Durelli and K. Rajaiah, "Quasi-Square Hole With Optimum Shape in an Infinite Plate Subjected to In-Plane Loading," Technical Report No. 49, January 1979.

A. J. Durelli and K. Rajaiah, "Optimum Hole Shapes in Finite Plates Under Uniaxial Load," Technical Report No. 50, February 1979.

A. J. Durelli and K. Rajaiah, "Determination of Strains in Photoelastic Coatings," Technical Report No. 51, May 1979.

A. J. Durelli and K. Rajaiah, "Optimized Inner Boundary Shapes in Circular Rings Under Diametral Compression," Technical Report No. 52, June 1979.

7. (b) JOURNAL ARTICLES PUBLISHED (in Report Period)

C. Y. Liang, Y. Y. Hung, A. J. Durelli and J. D. Hovanesian, "Direct Determination of Flexural Strains in Plates Using Projected Gratings," VDI-Berichte Nr. 313, pp. 401-405, 1978.

J. D. Hovanesian, Y. Y. Hung and A. J. Durelli, "New Optical Method to Determine Vibration-Induced Strains with Variable Sensitivity After Recording," Experimentalna Analyza NApati, Smolenice 16-18.10, Czechoslovakia, 1978

C. Y. Liang, Y. Y. Hung and A. J. Durelli, "Time-averaged Moiré Method for In-plane Vibrational Analysis", J. of Sound Vibration, Vol. 62, No. 2, pp. 267-275, 1979.

(The three papers mentioned above are respectively ONR reports nos. 45, 47 and 39)

A. J. Durelli, K. Rajaiah, J. D. Hovanesian and Y. Y. Hung, "General Method to Directly Design Stress-wise Optimum Two-dimensional Structures", Mechanics Research Communications, Vol. 6 (3), 159-165, 1979.

8. OTHER GRANTS AND CONTRACTS OF PRINCIPAL INVESTIGATOR

A National Science Foundation grant to develop optical method started December 1976

9. NAMES AND STATUS OF PERSONNEL CONTRIBUTING TECHNICALLY TO THIS TASK

A. J. Durelli, Professor
J. D. Hovanesian, Professor
Y. Y. Hung, Assistant Professor
K. Rajaiah, Post-Doctoral Fellow
M. Erickson, Adjunct Professor
S. Nygren, Machinist