

NUMERICAL AND EXPERIMENTAL ANALYSIS OF DEFORMATION OF A LUG

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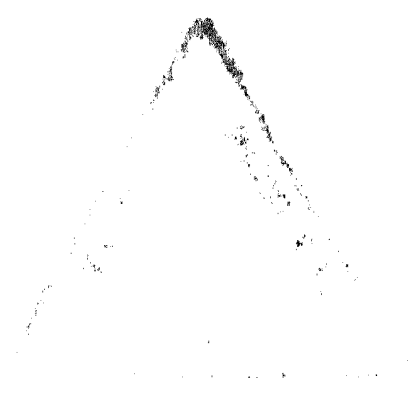
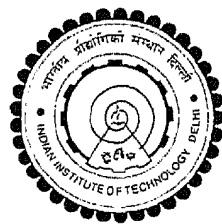
ASLAM

Department of Applied Mechanics

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Doctor of Philosophy

to the

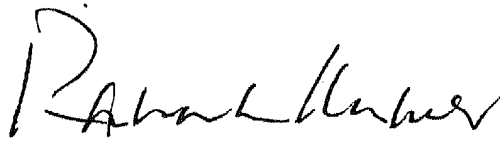


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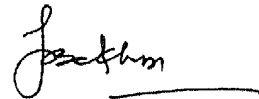
CERTIFICATE

This is to certify that the thesis entitled '*Numerical and Experimental Analysis of Deformation of a Lug*' being submitted by Mr. Aslam to the Indian Institute of Technology, Delhi for the award of the Degree of Doctor of Philosophy is a record of bonafide research work carried by him under our supervision and guidance. The thesis work, in our opinion, has reached the requisite standard for the Doctor of Philosophy Degree.

The results contained in this thesis have not been submitted in part or full, to any other university or Institute for the award of any degree or diploma.



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ABSTRACT

The lug is the subject matter of the present study. It is used in structures, load lifting and load carrying systems and machinery items because it is also used in aircraft structures, its study has attracted serious and often classified research attention. Increasingly sophisticated methods are being employed for investigating the distributions of stress, strain and displacement in the body of the lug both in elastic and elasto-plastic range of deformation. The present work is focussed on the analysis of stress and measurement of strain in a lug. It deals with the development of an approximate boundary element model for the engineering analysis of elastic deformation of the lug, a finite element model for the analysis of its plastic deformation and an experimental procedure based upon the moiré fringe technique for the measurement of strain in the lug.

The boundary element method has been chosen to analyze the elastic deformation of the lug because it offers distinct advantages over the finite element method. The proposed boundary element method is based upon the so-called fictitious stress formulation. While the ligament is considered as elastic, the pin is taken as rigid. The governing equations are solved by means of gaussian elimination. A Fortran program called as BEM2D has been developed for solving the model. The model is capable of providing useful results on stress and strain distributions in the lug under a variety of loading

and frictional conditions. It can assist the designer explore alternative lug designs and assess the reliability of a cracked lug.

A rigid-plastic finite element model has been proposed for approximate engineering analysis of permanent deformation of the lug caused by overloading resulting from misuse or accident. The lug material has been idealized as rigid-workhardening. A flow formulation has been adopted for driving the system equations and the incompressibility condition is enforced through a penalty approach. A special purpose finite element code, developed by an earlier scholar at IIT Delhi, was suitably modified and enlarged to suit the requirements of the proposed model. This program automatically generates triangular as well as quadrilateral meshes. The program regenerates a mesh whenever the previous mesh gets overly distorted. The total deformation of the lug is divided into a large number of increments. The lug geometry is adopted at the end of each increment. Computational results on the process of deformation, changing distributions of stress and strain and the variation of the pin load with pin displacement have been obtained. It is expected that the proposed model will help the analyst estimate damage accumulation and evaluate joint safety under abnormal loading conditions.

The moiré fringe method has been used to measure actual strain distribution in the lug. Procedures have been developed for preparing specimens and reproducing gratings on their surface. A loading rig has been designed and fabricated for imparting deformations to the specimens.

Aluminum, araldite and brass have been used as the specimen materials. Gratings of 1000 lines per inch (40 lines per mm) were photographed on the models. The mismatch method was used to improve the sensitivity of the method. A master grating of 990 lines per inch (39 line per mm) was also prepared. It was oriented in two orthogonal directions in order to produce the u-moiré and v-moiré fringe patterns. The fringe patterns were photographed and analyzed to obtain the distribution of normal and shear strains in the lug. The measured strains were used to study the distribution of strain in the lug and also to test the validity of the proposed boundary element and finite element models for stress analysis of the lug.

The results of the present investigation show that the proposed boundary element and finite element models are computationally efficient and robust, and yield satisfactory results. Also the experimental procedures developed for measuring strains in the lug are reliable and provide good whole field moiré solutions to the lug problem.

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