ANAYLSIS OF BLADE STRESS AND MECHANICS OF DIGGING WITH A MANUALLY OPERATED SPADE

By

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A Thesis submitted
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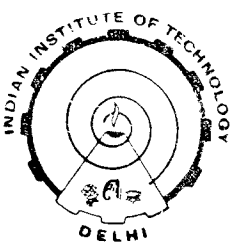

to the

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DEDICATED TO

MY PARENTS

CERTIFICATE

This is to certify that the thesis entitled "ANALYSIS OF BLADE STRESS AND MECHANICS OF DIGGING WITH A MANUALLY OPERATED SPADE" being submitted by Mr. Praveen Kumar Sharma to the Indian Institute of Technology, Delhi for the award of degree of Doctor of Philosophy, is a record of bonafide research work carried out by him. He has worked under our guidance and supervision and has fulfilled the requirements for the submission of the thesis which, to our knowledge, has reached the requisite standard.

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

A manually operated spade is a multipurpose implement used extensively by thousands of farm workers and other users in this country. An actual field survey showed that some of the problems confronting farmers with the hand implements were the frequent blunting of the cutting edge, uncomfortable posture of the operator while operating with the implement and corrosion of the blade material. Visual examination of the cutting edges and blades of numerous spades revealed that problem of blunting of the cutting edge was caused not only by normal wear and tear but quite frequently by permanent deformation of the blades due to compressive as well as bending stresses caused by encounters with buried obstacles. However very little published research work exists on any of the above aspects. As a first step it was considered desirable to formulate and verify analytical models for the analysis of blade stresses and reaction forces during digging with a spade. In the present work, a total of six analytical models have been developed. The first is the so called half plane model for the analysis of stress in the blade when it is subjected to a concentrated line load or a uniformly distributed stress over a small portion near the middle of the cutting edge. The second model is called the quarter-plane model and it deals with the analysis of stress in the blade due to distributed in-plane normal and tangential stress acting on a portion of the cutting

edge of the blade near a corner. The third model has been based on the boundary element technique for solving the problem of stress analysis in the body of the blade when subjected to an arbitrary distribution of external inplane loads. The problem of bending of the blade caused by out of plane loads has been tackled by using a finite element model. The fifth model is for the study of the buckling phenomenon in the blade. The last model has been formulated for the analysis of the mechanics of the spade action. It considers the spade as a moving rigid body which is subject to time dependent force in the form of resistance offered by the soil to its penetration by the striking blade. Experimental work was also undertaken for evaluating the validity of the above analytical models. The rigid body model for the analysis of digging forces was treated with the help of a rig specially designed and fabricated for simulating the digging action. Full size spades can be attached to the loading arm of the rig and any given soil sample can be used for the tests. The predicted results of the model and the experimental results from the rig were found to agree well with one another. Compression buckling tests were performed on blade specimens in order to find the actual buckling loads and compare them with those of the analytical model. Fair agreement was found between the two sets of buckling loads. Photoelastic experiments were carried out on blade models in order to verify the validity of the proposed models for stress analysis of the blade subject to inplane loads. The predictions of boundary element model were found to be very realistic.

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