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THE POST-BUCKLED FAILURE OF STEEL PLATE SHEAR WEBS WITH CENTRALLY LOCATED CIRCULAR CUT-OUTS

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Abstract. This paper examines the response of steel plate shear webs when subjected to in-plane shear loading in the form of applied in-plane shear displacements. The buckling and post-buckling failure capabilities of thin plates subjected to in-plane shear can be substantially eroded through the introduction of openings or cut-outs which can contribute, significantly, towards a less stable structural system. The paper details appropriate suitable finite element modelling strategies and solution procedures to enable the determination of the post-buckled failure response of steel plate shear webs with cut-outs. The results presented in the paper give a detailed account of the complete loading history of the shear webs, illustrating the significant degrading influence on structural performance of the cut-outs and highlighting the importance of the in-plane boundary conditions at the plate edges on the mechanics of structural failure.

1 INTRODUCTION

Thin plate shear webs are structural elements, which are utilised in several engineering fields including civil, mechanical, and aeronautical engineering. Shear webs often have cut-outs for light weighting or for more practical reasons such as the passage of systems within the structural framework such as electric cabling and hydraulics.

The presence of openings in shear webs changes the stress distribution within the web by developing high stress levels around the cut-outs. This results in a significant reduction of the elastic buckling capability and ultimate shear capacity of the webs.

Many researchers have investigated the influence of perforations on the stress distribution and the ultimate strength of thin plate structural systems when subjected to in-plane shear or compressive loading.

Narayanan and Rockey [1] discussed the failure mechanisms of plate girders with webs containing circular cut-outs and determined the ultimate strength by carrying out experimental tests. Parameters, including the web slenderness, size of hole and flange thickness, which influence the ultimate strength, were varied to note their effect. The presence of large holes, in particular, were found to affect the inclination and width of the diagonal tension field in the plate girder webs and stiff girder flanges were found to increase the post-buckling capacity of the plate girders significantly.

Shanmugam and Narayanan [2] gave details of approximate formulae, using the finite element method, to determine the elastic buckling of perforated square plates for various loading and edge conditions. Their work covered the behaviour of square steel plates with circular and square cut-outs and dealt with the loading cases of bi-axial compression and shear.