THE COLLAPSE LOAD OF ELASTIC-PLASTIC STRUCTURES

S.T. Ariaratnam

Abstract

The investigation is concerned with the overall stability and collapse behaviour of elastic-plastic structures. The discussions are restricted to plane rigid-jointed frames loaded in their plane.

Fundamental ideas put forward intuitively by previous investigators and verified by them using specific numerical examples, are proved rigorously for structures in general. It is shown that the elastic critical loads play a significantly part in determining the stability of elastic-plastic structures. The critical loads are defined as eigenvalues in terms of a variational problem. Using this definition some useful results concerning critical loads are established for structures generally.

The “Southwell Method” for predicting critical loads of struts from experimental observations, is extended to the problem of plane frameworks which buckle within and out of their plane. A proof of Hoff’s Convergence Criterion for stability of elastic frameworks is presented as an appendix to the main body of the analysis.

The collapse behaviour of elastic-plastic structures which fail through frame instability is explained in mathematical terms. The general procedure adopted is the study of the equilibrium problem of the response of a structure to proportional loading in relation to the associated eigenvalue buckling problem, the solutions being obtained as series in the buckling modes using the Theorem of Minimum Potential Energy. The special case of the collapse of frames, in which the external loading does not excite in the deflexions a component in the first buckling mode, is discussed by considering the problem of the slender symmetrically loaded symmetrical frame.

Equations for the stability analysis of elastic-plastic structures are developed in a form suitable for evaluation on a digital computer. Empirical methods for predicting collapse loads are reviewed and suggestions for possible improvements made where necessary.

The result of an experimental investigation on frame instability in the plastic range is presented. The programme consists of tests on a series of model multi-story frames of rectangular and tubular members under the action of vertical and horizontal loading in the plane of the frames.