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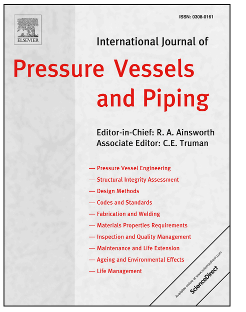

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J. Błachut

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Bifurcation, plastic and plastic instability loads for cones subjected to combined pressure and axial force

J. Błachut
The University of Liverpool, Mechanical Engineering, Liverpool, L69 3GH, U.K.

Abstract:
The paper discusses load carrying capacity of steel cones subjected to combined loading by simultaneously acting uniform pressure and axial load. The following combinations of loads are considered: external/internal pressure plus axial tension. Depending on the load combination various modes of failure are studied. These includes bifurcation buckling, plastic load and plastic instability load.
For the case of internal pressure/axial tension: envelopes of the first-yield, plastic load and plastic instability load are computed. All of these domains are convex and closed. This is not true for the case of external pressure and axial tension where bifurcation buckling becomes an active mode of failure.
Due to substantial plastic straining, numerical results are based on true stress-strain modelling of material beyond necking and for up to fracture.

1. Introduction

Structural integrity of conical shells has been the subject of intense research in the past due to their usage in a wide range of applications. Large portion of the research effort has been confined to their elastic behaviour, Ref. [1]. Thicker metallic shells, where plasticity is likely to be important, on the other hand, have not been subject of a wide research effort. It is shown, for example, in Ref. [2] that plastic bifurcation or other mechanisms of structural failure associated with plastic behaviour have been examined very rarely. Combined stability of cones within elastic-plastic regime, until recently, has not been studied at all, Ref. [2]. The current paper examines conical shells subject to different combinations of two simultaneously, and independently, acting loads. These are pressure and axial load applied at the top of truncated cone. Hence there are four possible scenarios depending whether pressure is internal or external, and axial load is compressive or tensile.
The case of externally pressurised cones has been explored over the years, with recent additions covering post-yield behaviour. In the latter case, one of prime concerns under incremental loading was the possibility of buckling/collapse, Refs [2-6]. The case of internally pressurised cones, on the other hand, is less obvious in terms of structural failure under incremental internal pressure within the elastic-plastic regime. The choice of an appropriate failure criterion on which a safe design could be based and the development of an efficient numerical algorithm for predicting failure is not straightforward even for the case of a single load case, e.g., internally pressurised domed ends onto cylindrical vessels. In the past, this subject related to conical shells has not been addressed to any large extend. One obvious approach to a cone's safe performance would be to follow the strategy developed earlier for domes. This would mean finding the magnitude of plastic instability and then to use a knock-down factor. Another approach would be to adopt the concept of plastic load as an indicator of safe performance. However in the latter case there have been different approaches to the definition of plastic loads, and they appear to depend on the type of pressure vessel and on mechanisms of its loading. A brief discussion regarding these issues is given later on in the paper.