ELASTIC-PLASTIC BENDING: THE CALCULATION OF DEFLEXIONS IN FRAMES

John Henderson Percy

Clare College and the University of New Zealand

Abstract

The dissertation is concerned with the problem of estimating deflexions in framed structures when the deformation is primarily due to flexure. The aim throughout is the development of straight forward methods which are sufficiently accurate for use in real cases.

It is shown that for most design calculations elastic methods will suffice, since the variation of material properties and secondary effects on frame behaviour in service influences deflexions to such an extent that at design loadings a careful elastic-plastic analysis is unlikely to give a more reliable estimate than an elastic calculation.

There are occasions, particularly in research into structural behaviour, where more subtle methods are requires, but again limits of accuracy are imposed by material properties and testing methods. Consideration is therefore given to the relationship between bending moment and curvature for as-received steel sections, supported by evidence obtained from a series of tests in bending on 3 in. by $1\frac{1}{2}$ in. joist section.

A simple laboratory test to determine the flexural properties of I section is described, and a method is developed for estimating the effect of axial load from the results of such a test. A systematic method is set out for finding the relationship between bending moment and curvature from the stress-strain relationship for steel when such a procedure is necessary.

Existing methods for determining the deflexions of determinate structures and for analysing redundant frames are summarised. Further methods are developed, using an arbitrary relationship between bending moment and curvature as a starting point. The methods thus apply to all steels, whether they exhibit a definite yield plateau or not, and to non-ferrous materials. In particular it is shown that the behaviour of a member subjected to

end moments only can be calculated readily if certain parameters have previously been determined. Alternatively the equations describing the behaviour can be set out in the form of a chart which gives the deformed shape immediately. For indeterminate frames a relaxation procedure is developed which uses such a chart to solve the equations arising from member behaviour.