SHAKEDOWN OF STEEL FRAMES

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Abstract

This thesis is a study of the elastic-plastic behaviour of mild steel frames under the action of a number of loads whose intensities vary arbitrarily with time. Statically indeterminate plane frames are considered, whose members are one-dimensional and resist load primarily by bending. The loads, which act in the plane of the frame, are applied sufficiently slowly and infrequently as to cause neither fatigue nor dynamic effects.

The static and incremental collapse loads are defined for a general frame under the action of any set of independent loading systems. A simple relationship is found between the upper bounds on these two loads associated with any one and the same mechanism. From this a new method of shakedown analysis is evolved, which in most cases shortens the amount of labour entailed in finding the shakedown load, particularly if a static analysis has already been preformed.

The effect on the incremental collapse load of taking into account the change of geometry under load is found to be less than the static collapse load. The reduction of incremental collapse and alternating plasticity loads due to varying axial loads are also investigated. A survey of a number of frames shows that the reductions in carrying capacity due to repeated loading of between 10 and 30% of the static capacity can normally be expected.

The process of shaking down is studied with reference to change of residual moments within the frame. A hypo-thesis is made that the final state of the structure after shaking down will generally be independent of the loading history. On this is based a new method for estimating the permanent deflexions incurred whilst shaking down, which avoids the necessity for performing a step-by-step analysis. A similar method is used for estimating the deflexions per cycle during incremental collapse.

The new methods for calculating shakedown loads and deflexions are illustrated by applying them to a 4-storey 2-bay frame which is plastically designed. A more rigorous

shakedown analysis of the frame is made with the aid of a computer programme, which shows that the effects of geometry change on the value of the static and incremental collapse loads are 26 and 7% respectively.

A series of static and cyclic loading tests on 26 miniature portal frames, 2- and 3-span continuous beams and 4-storey 2 bay frames are described. Complete load ultimate deflexion curves are obtained for each frame. The cyclic loading tests, which required over 2,500 hours of testing time, were performed automatically by a machine designed especially for the purpose. The results show that the incremental collapse load makes an important point in the loading history, and that it can be accurately predicted by available theory. The deflexions in the plastic range can also be predicted, but with a lower degree of accuracy, using the methods described earlier.