THE INCREMENTAL COLLAPSE OF DUCTILE STRUCTURES

James Rutherford Lyon

King's College, Cambridge

Abstract

This dissertation describes an investigation into the effects of repeated loading on ductile, frames structures, in relation to the plastic theory of structures. The experimental work is in two parts:

1. The effects of variable repeated loading at 1 and 100 cycles per minute, and
2. The effects of repeated loading and 2 and 100 cycles per minute.

Both point loads and rolling loads are considered.

Under variable repeated loading the structures are shown to fail by incremental collapse, at loads showing excellent correlation with the simple shakedown theorem. The effects of strain-hardening are also studied.

For repeated loading it is found that there is no reduction in the plastic collapse load or any significant change in the deflexions prior to collapse. Above the collapse load the modulus of strain-hardening is shown to be reduced.

It is emphasised that alternating plasticity is possible under unidirectional repeated loading, and that the maximum permissible load in such a case may be reduced by imperfections such as sinking supports, lack of perfect end-fixity etc., which affect the initial yield load. An experimental demonstration showing the effects of alternating plasticity is also given, and the influence of strain-hardening on the alternating plasticity range is discussed.

A graphical model is developed using the equations of equilibrium and compatibility derived by the virtual work method. The model shows the development of the hinge bending moments and rotations in a structure under various types of loading.

Finally, a method is described for calculating deflexions, under variable repeated loading, without calculating any hinge rotations; a simplified approximate solution is also given.