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Plastic Analysis of Simply-Supported Grillage under a Point Load

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ABSTRACT

Grillage is common types of structures in marine and land-based structural system. The plastic collapse modes of those structures are dependent on the loads, which are lateral, in plane or combination of those directions as well as boundary conditions. In this paper, a plastic analysis method is applied to grillages or grids under a single concentrated load to find the worst load point. The worst load point would be either at the central intersection or on the point of between intersections. In the present paper, general formulae for plastic collapse for the grillages with simply-supported boundaries are derived.

INTRODUCTION

A rational design procedure requires a sound and scientific background in the following key areas:

- Accurate load prediction
- Definition of safety margins and designs criteria
- Response analysis methods
- Synthesis and optimization

In certain structural systems such as grillages in ships and ocean structural systems, it is possible to predict the accurate limiting condition by applying plastic analysis method (Baker, 1951-52; Boufounos, 1975; Kim, 1983; Kim and Park, 1995).

In grillage design, the central intersection point load may be used as a worst-case loading condition, especially with a larger number of beams in each direction as long as local collapse is prevented. But a point load may often move around on the grid system. In such a case, the worst load point would not necessarily be at the central point. In this case, the worst load point is located between intersections.

To find the plastic collapse equations, the upper bound theorem or mechanism method is applied to the square grillages with simply supported boundaries.

VIRTUAL WORK METHOD

The principle of virtual work is very simple, and we can get results from its use. If a body in equilibrium is given a set of small displacement, then the work done by the external loads is equal to the work done by the internal forces. A typical load p will do work that is accomplished by moving through a certain distance δ; the magnitude of the work done is $\sum p\delta$, where the summation extends over all loads on the frame. This work done by the external loads absorbed in the rotating plastic hinges is $\sum Mp\theta$, so that:

$$\sum p\delta = \sum M\theta$$

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KEY WORDS: Grillages, grids, mechanism method, plastic hinge, virtual work.

As an example, the collapse of a simply supported beam is considered here for carrying a central point load.

If a beam has a deformation d, the hinge rotation at the center is $4\delta/L$. Then the collapse load can be found as follows:

$$P\delta = M_P \frac{4\delta}{L} \tag{1}$$

$$M_P = \frac{PL}{4} \tag{2}$$

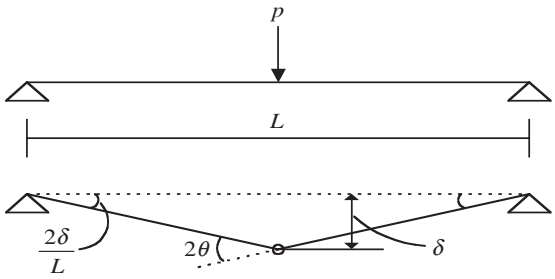

Fig. 1 Plastic collapse of simply supported beam

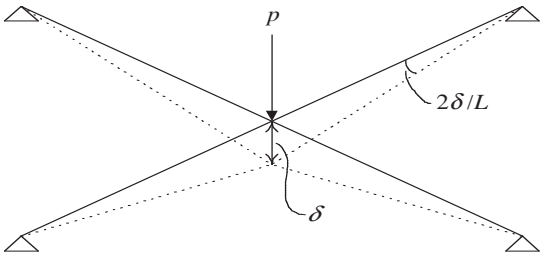

Fig. 2 Plastic collapse of 1 x 1 grid