FAILURE LOAD OF PITCHED ROOF PORTAL FRAMES

A Thesis

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By

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بسم الله الرحمن الرحيم

COMPUTER PROGRAM

CHAPTER III

ELASTIC STABILITY BASED ON SMALL DEFLECTION THEORY

CHAPTER IV

ELASTIC CRITICAL LOAD OF MULTI-BAY PORTAL FRAMES

CHAPTER V

ELASTIC CRITICAL LOAD OF MULTI-BAY GABLE FRAMES

CHAPTER VI

MULTI-BAY GABLE FRAMES WITH VARIABLE INERTIA OF COLUMN

CHAPTER VII

GABLE-FRAMES WITH CRANE LOADS

CHAPTER VIII

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INTRODUCTION

For a long time all calculations of structures were based on Hooke's law. The nonlinear analysis of structural frames is receiving considerable attention in the present research work. The rigid plastic theory because of its simplicity has become to be a rational method of design although the stability of the structure is overlooked.

The natural growth of design methods has led to comparing the behaviour of columns in structures with that of isolated columns. In building codes of design it is assumed that the effective length is a constant fraction of the column length due to the stiffness of the beam to column connections. These methods of design are very empirical of unknown accuracy. The reason is that the effective lengthes are dependent on the stiffness of the members which in turn is dependent on the axial load they carry and is not constant. The columns should be designed as a part of a structure and not by analogy with the behaviour of isolated columns.

The object of this thesis is to introduce a study on the elastic critical load of portal and gable frames and to put before hand to the designer the curves and tables which give accurate data about the stability of these frames. Thus enabling the designer to carry out his design on conceptual basis.

A brief summary of the theory of failure of structural frames and description of electronic digital computers are introduced in Chapter I.

Chapter II is devoted for the linear analysis of structures by digital computer. The program has been further developed in Chapter III to include the effects of the instability caused by axial loads.

Chapter IV is concerned with the elastic sway critical load of multi-bay portal frames.

In Chapter V, VI, & VII or thorough study is introduced on the sway critical load of gable frames. The influence of the number of bays, the variable inertia of columns, the relative stiffness of the rafter to the column and the effect of the crane loads on the sway critical load are investigated.

A study on the optimum slope of the rafter of the gable frames is given in Chapter VIII.

The results are summarized in the conclusions.

CHAPTER I

REVIEW OF PREVIOUS WORK

1.1 The First Yield Theory.

The considered starting point was almost Hook's law. The first yield load is that corresponding to straining actions, distributions for which the most highly stressed fibers are subjected to the yield stresses, Fig. 1.1a .

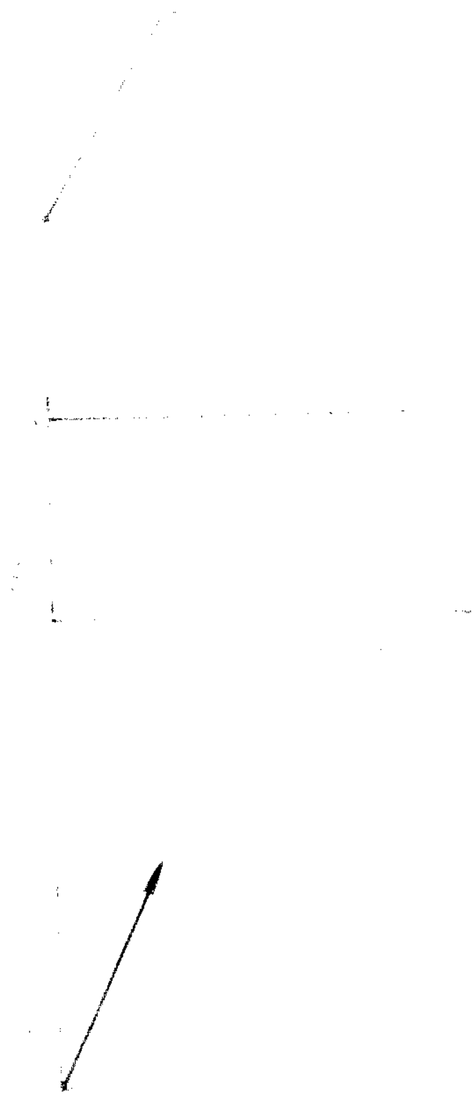
Apart from Euler's work on the buckling of columns, the early investigations in this field were concerned predominantly with the distribution of stresses of structures in the absence of buckling effects.

In fact since the results of elastic analysis cease to be applicable when the yield stress is attained at the most highly stressed cross-section, elastic design methods are of necessity based on the assumption that a frame will become unsafe when yield first occurs and a margin of safety is insured by specifying a working stress which is well below the yield limit.

It has long been known that an indeterminate steel frame has a greater load-carrying capacity than indicated by the allowable-stress concept. Such frames are able to carry increased loads above the yield value because structural steel has the capacity to yield. Thus the allowable - stress concept has overremphasized the importance of stress rather than strength as a guide in engineering design.

1.2 The Rigid Plastic Load.

The plastic methods of structural analysis have been developed for the purpose of calculating the plastic collapse load for frames, with the ultimate objective of establishing a rotational and economical design procedure. It might be thought that any attempt to evaluate the plastic collapse load for a given frame would require an investigation of the complete behaviour of the frame between the first yielding and its ultimate collapse. However, it is a remarkable fact that if buckling effects are absent it is possible to calculate the collapse



(b)

(c)

load directly by the plastic methods without considering the intervening elastic-plastic range. When the rigid plastic load is just attained the frame becomes a mechanism. For such method of calculation the stress strain relation is a straight line indicating the yield stress at zero strain, Fig. 1.1b .

1.3 The Elastic Critical Load.

It is the load at which the stiffness of the structure as a whole comes to zero. Herein the stress-strain curve is assumed to be completely elastic, Fig. 1.1c . There are several methods to obtain the elastic critical load of a structure such as the mathematical analysis, the dynamic and the experimental methods. A simplified method has been introduced to obtain the elastic critical loads for rectangular multi-story frameworks by Merchant (1955), Chandler (1955). It was later generalized to include pitched roof frames by Merchant-Saafan (1962).

1.4 Rankine-Merchant Load.

The failure load P_F is lower than either the Euler load P_E or the plastic limit load P_p. Hence $P_F/P_E < 1.0$ and $P_F/P_p < 1.0$. This may be expressed by stating that the solution of any practical strut must lie within the area OABC in Fig. 1.2-a. The straight line AC gives the following relationship.

$$\frac{1}{P_F} = \frac{1}{P_E} + \frac{1}{P_p} \qquad \ldots\ldots \quad (1.1a)$$

$$\frac{P_F}{A} = \frac{\sigma_y}{1.0 + \dfrac{\sigma_y}{\pi^2 E}\left(\dfrac{\ell}{r}\right)^2} \qquad \ldots\ldots \quad (1.1b)$$

where :

P = Failure load of structure;

P_p = Load obtained from plastic theory;

P_E = Euler load of stanshion;

A = Cross-sectional area for stanshion;

ℓ = Length;

r = slenderness ratio.