AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

# ROTATION CAPACITY REQUIREMENTS FOR ELASTIC-PLASTIC ANALYSIS OF STEEL PORTAL FRAMES

BY

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بسم الله الرحمن الرحيم

## STATEMENT

This dissertation is submitted to Ain Shams University for the degree of M.Sc. in Civil Engineering .

The work included in this thesis was carried out by the author in the Department of Civil Engineering, Ain Shams University, from Nov. 1987 to jan. 1990 .

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution .

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# LIST OF SYMBOLS

The following symbols are used in the present thesis. Other symbols not listed below are defined where they are used.

$A$ = cross sectional area.

$c$ = non-dimensional carry-over factor for fixed end members.

$E$ = Young's modulus of elasticity.

$\sigma_y$ = yield stress.

$I$ = moment of inertia about major axis.

$K$ = $EI/L$ = bending stiffness.

$L$ = unstrained length.

$L_c$ = strained length.

$M$ = bending moment.

$M_p$ = plastic moment.

$M_p'$ = reduced plastic moment.

$M_{ult}$ = ultimate moment capacity.

$M_y$ = yield moment.

$P$ = axial load.

$P_e$ = axial load at first yielded section.

$P_E$ = $(\pi^2 EI)/L^2$ = Euler's buckling load.

$R$ = $\theta/\theta_e$ = rotation capacity ratio.

$S$ = shearing force.

$s$ = non-dimensional stiffness factor for fixed end members.

| | | |
|---|---|---|
| X | = | projected length of member along the x-axis. |
| x | = | deflection along the x-axis. |
| Y | = | projected length of member along y-axis. |
| y | = | deflection along the y-axis. |
| $\alpha$ | = | initial angle of inclination of a member with the x-axis. |
| $\alpha'$ | = | modified value of angle of inclination. |
| $\theta$ | = | angle of rotation with respect to initial direction of member. |
| $\Phi$ | = | angle of sway with respect to initial direction of member. |
| $\lambda$ | = | slenderness ratio. |
| $\rho$ | = | $P/P_E$. |
| $P_J$ | = | load at which a mechanism has just formed. |
| $P_o$ | = | the squash load = $A.\sigma_y$ |

CHAPTER (1)

INTRODUCTION

## 1-1 INTRODUCTION

Behaviour of steel frames is very different from the way assumed by many designers. Elastic design in many cases may hide so much real behaviour that is dangerous. The real factor of safety of a structural element can be much less than the designer thinks. In other cases the real factor of safety may be excessive, and an uneconomical structure will result.

Years ago, research started on the behaviour of structures based on the plastic theory and later plastic method of design was permitted in many countries.

The rapid advance of plastic design is mainly the result of improved structural economy through a better distribution of the used material. This is gained by taking advantage of the reserve of strength of structural steel beyond the elastic limit, by using accurate methods of analysis, and by assuring a uniform factor of safety against failure for all structures.

Plastic analysis of steel structures depends on the ability of members to form plastic hinges and to redistribute moments. In order for redistribution of moment to take place, certain plastic hinges must sustain their plastic moment through some angle of rotation. The amount of rotation required may affect the stability of the structure and therefore, may affect the geometry of the structural shapes. The ability of a structure to rotate near its collapse mechanism is defined as the " rotation capacity ".

The rotation capacity can be thought of as the warning time the structure possesses between the formation of the first plastic hinge and the structure collapse by mechanism. The increase of this value is a good indication that sudden collapse of this structure is not expected.

The objectives of the research presented in this thesis are:-

1- Investigating the non-linear elastic-plastic behaviour of steel portal frames under different factors which affect the rotation capacity of members such as:-

   a- geometry and frame dimensions,

   b- load acting on frame, and

   c- overall buckling of frame.