AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

ULTIMATE STRENGTH OF COLD FORMED STEEL BEAMS

By

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بسم الله الرحمن الرحيم

سبحانك لا علم لنا الا ما علمتنا

صدق الله العظيم

بسم الله الرحمن الرحيم

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STATEMENT

The dissertation is submitted to Faculty of Engineering, Ain Shams University for the degree of MASTER OF SCIENCE in Structural Engineering.

The work included in this thesis was carried out by the author in the Department of Structural Engineering, Faculty of Engineering, Ain Shams University , from December 1991 to May 1995.

No part of this thesis has been submitted for a degree or a qualification to any other university or institution.

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TO MY PARENTS

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LIST OF SYMBOLS

The following symbols are used in this thesis:

A_1 to A_8 = constants depending on the shape of the cross section and are given by eqns.(4-41), (4-42), (4-43), (4-44), (4-76), (4-77), (4- 78), and (4-79) respectively ,

b_c = width of compression flange ,

b_t = width of tension flange ,

b_e = effective width of compression flange ,

C = constant of the rotation capacity ,

d = depth of cross section ,

E = Young's momdulus ,

f_y = yield stress ,

I_x = moment of inertia ,

H = length of the plastic hinge ,

k = the ratio between the ultimate moments of the two stressed sections,

L = span of the beam ,

M_p = the plastic moment of the cross section ,

M_u = the ultimate moment of the cross section ,

M_y = the yield moment of the cross section ,

P_u = the ultimate load of the beam ,

P_y = the yield load of the beam ,

t = thickness of the cross section ,

w = flat width of the compression flange ,

x = distance from support to the maximum positive moment on the beam ,

Y_{ce} = distance from neutral axis to compression flange at elastic stage ,

Y_{te} = distance from neutral axis to tension flange at elastic stage ,

Y_c = distance from neutral axis to compression flange at ultimate stage ,

Y_{cp} = the depth of yielded compression part of the cross section ,

Y_p = distance from the neutral axis to the first yield point of the cross section at ultimate stage ,

Y_t = distance from neutral axis to tension flange at ultimate stage ,

Y_{tp} = the depth of yielded tension part of the cross section ,

$\alpha = \varepsilon_{cu} / \varepsilon_y$,

$\beta_1 = b_t / d$,

$\beta_2 = (b_t - b_c) / d$,

ε_{cu} = ultimate compressive strain on the cross section at failure stage ,

ε_y = yield strian ,

θ_a = actual rotation of the beam ,

θ_p = rotation capacity ,

ϕ_u = the curvatre of the beam at ultimate stage ,and

ϕ_y = the curvature of the beam at yield.

ABSTRACT

To develop a limit states design method for cold formed steel beams, two basic items must be considered. The first item is to determine the ultimate strength of cold formed steel sections. The second item is to determine the post-yielding strength of redundant cold formed steel beams, due to moment redistribution. The amount of moment redistribution in redundant beams depends on the rotation capacity of the first formed plastic hinge. The rotation capacity of plastic hinges in cold formed steel beams depends on the shape of cross section as well as the length of the plastic hinge formed or in other words the shape of the bending moment at the ultimate stage.

The method of determining the ultimate strength of cold formed steel sections is similar to the method developed for reinforced concrete sections, since the failure in cold formed steel sections is defined in terms of the strain capacity of the compression flange.

Formulae to compute the ultimate moment capacities of commonly used cold formed steel shapes are derived for design and analysis aids. In addition, the ratio of the ultimate moment to yield moment is derived taking into account the inelastic reserve capacity due to stress

redistribution for different cross sectional shapes. This ratio represents the gain in section design due to ultimate design method.

Formulae for calculating the rotation capacity for different shapes of cross sections are introduced in terms of the cross section parameters and the length of plastic hinge.

Based on the previous results, the distribution of bending moments and the ultimate loads in redundant beams are estimated for different types of beams as well as for different cases of loading. It is obvious that the use of the proposed limit state design method results in considerable savings, due to both stress and moment redistribution.

Additionally the availability of reliable methods to predict the behaviour beyond the initiation of yielding would help to provide realistic safety factors against complete failure.

CHAPTER (1)

INTRODUCTION