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Behavior and resistance of beam-column structural elements

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A B S T R A C T

Most of the structural elements in a steel structure are subjected to bending moment and axial force simultaneously. In some elements, one of the two components is relatively small compared to the other. Yet, the smaller component cannot be ignored due to the interactive behavior of the two components. Therefore, it is not adequate to design the beam-column element as a beam or a column by ignoring one of the two load components even if the ignored component is relatively small.

Most of the design codes use empirical interaction equations that are based on semi-experimental semi-analytical results. Most of the design formulae adopted by the design codes do not explicitly account for the geometrical imperfection.

This research aims at investigating the buckling behavior of steel beam-column elements for the sake of developing an analytical model to calculate their ultimate resistance under axial compression and bending moment. The analytical model will be based on Perry-type formulation, and it will account for the effect of initial imperfection. The model will be validated by comparing its results with those obtained by the Finite Element Non-Linear Elasto-Plastic analysis using ANSYS 5.4 program.

Finally, a simple but rational design method based on the model, will be introduced. This method can be applied using a simple mathematical expression or charts and tables. The results of the developed design method will be compared with the design method of the international codes of practice for design of steel structures. On light of these comparisons, design recommendations are introduced.

1. Introduction

Resistance and interactive buckling behavior attracted the attention of many researchers over the last four decades, however, due to its importance and complexity, this subject is still receiving the researchers' interest.

In 1977, Kanachalani [14] investigated the in-elastic behavior of 82 steel beam-column. He developed the well-known bilinear interaction equation that is being utilized by many international design codes. The AISC (LRFD) design manual [2] is adopting this bilinear interaction equation. Also, the Egyptian Code of Practice for Steel Design (LRFD) [10] is utilizing this equation.

In 1985, Trahair [15] investigated the accuracy and applicability of the design formulae utilized by the Canadian Standard. He developed a simple computational procedure for estimating the in-plane strength, which generally leads to more accurate prediction than that of the code. He also developed two alternatives for estimating the out-of-plane strength of beam-column.

In 1989, Geng-Shu and Shao-Fan [12] established an interactive buckling theory for built-up beam columns which can be used to determine the ultimate strength of the member taking account of various adverse influences of imperfections (residual stress, member's and chords' initial deflections and load eccentricity). They verified the applicability of the proposed theory by the finite integral method.

In 2004, Aminmansour [3] introduced design aids including charts and tables to facilitate the application of the AISC (LRFD) [2] interaction equation. The proposed approach avoids the application of the iterative technique followed to select the most appropriate steel section. Several design examples have been given to explain the application of the proposed design approach.

In 2004, Gonçalves and Camotim [13], examined the beam-column design approach adopted by the Eurocode (EC3) [11], using the finite element non-linear analysis utilizing ABAQUS program. They compared the code design approach to the finite element analysis for different loading and boundary conditions. They highlighted the sensitivity of the code estimated strength to the C_m value compared to the FE analysis. They concluded that the EC3 strength estimate is excellent for the in-plane strength of members with arbitrary boundary conditions. For low axial force, they concluded that the EC3 strength estimate is quite conservative.

This research aims at investigating the interactive buckling behavior in beam-column. Two types of interaction will be studied; the elastic linear interaction and the non-linear interaction. The first type affects the critical buckling modes and the critical buckling loads. The second type affects the beam-column resistance. Mathematical models will be developed to predict both the interactive buckling stress and the

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