Torsional buckling strengthening in cruciform columns

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Abstract

Flanged cruciform steel columns are often used in heavy-duty industrial buildings, with high axial loads and buckling length, to effectively eliminate weak-axis flexural buckling. Consequently, torsional buckling often becomes the governing failure mode under compression. While the effectiveness of twisting and warping restraints has been extensively studied for lateral torsional buckling, much less research is available on torsional buckling restraints in cruciform members.

For this study various FEM-assisted linear elastic buckling analyses have been performed to assess the increase in torsional buckling resistance due to typical end connections as compared to ideal fork end conditions. Furthermore, it is shown that adding intermediate warping restraints is an effective means against torsional buckling. Finally, a simple design criterion is presented for their spacing and dimensions to effectively eliminate torsional buckling.

Keywords: cruciform columns, torsional buckling, warping restraint, industrial buildings, tall buildings.

1 Introduction

Flanged cruciform steel columns are often used in heavy-duty industrial buildings with high axial loads and storey heights. In these conditions, they seem the natural evolution from conventional wide flange columns. Simply welding together two (rolled) members at their web mid-height (Figure 1) effectively eliminates weak-axis flexural buckling under compression, also referred to as Euler buckling.

However, increasing resistance to flexural buckling brings along that torsional buckling often becomes the governing failure mode.

Whereas flexural buckling resistance is increased by restraint to member deflection, torsional buckling is controlled by twisting and warping restraints. The effect of the latter two on the bending resistance of I-section beams has been studied extensively, but much less attention has been paid to their effect on cruciform columns under compression.

The research needs for this paper arose during the structural design of steel preheater towers in cement plants located in areas with high wind and/or seismic loads. The main load bearing structure is typically composed of a multi-storey braced frame with typical storey heights between 10 m and 20 m and columns subjected to design axial forces between 15 MN and 30 MN.

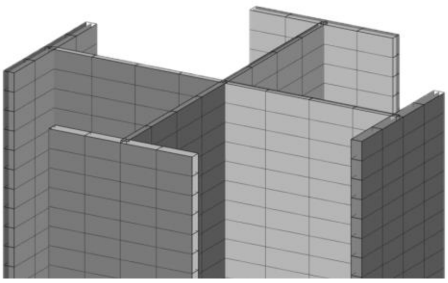

Figure 1. Detail of a cruciform section.