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Base connections of single cold-formed steel portal frames

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ABSTRACT

An investigation of the behaviour of base connections, fabricated from cold-formed channels and hot-rolled angle cleats, is presented in this paper. This investigation is part of an extensive research to develop portal frames made out of single cold-formed steel channels. The use of bolted angle cleats allows for a simple connection to be developed, which can result in significant cost savings within the steel construction industry. Stiffer angle cleats are used to prevent premature failing of the base connections. The base connections are subjected to four loading configurations and these are dependent on the eccentricity of the load. In base connections where cold-formed angle cleats were used, failure of the bases was largely caused by premature deformation of the angle cleats. Base connections with hot-rolled angle cleats were so stiff that failure occurred in the column channels instead of the angle cleats. A significant amount of bearing distortion was observed in the heavily loaded flange. A simple formula is suggested to design these bases.

1. Introduction

Base connections are an important part of every structure, not only from the point of view of structural behaviour, but also in relation to the cost of production. The most common base connection in the steel construction industry is an end-plate, welded at the bottom of a column. The end-plate must be designed to transfer all forces from the column to the foundation. These forces include axial and shear forces, and moments from the column. The design and details of this base plate depends on the magnitude and combinations of these forces. When there are high shear forces and moments, such as in a moment frame the design becomes complicated and the base plate and anchor bolts become heavier. In some cases base plate dimensions are not only determined by the forces transferred but by the column dimensions since a base plate dimensions should be sufficient to accommodate the column dimensions. Even if the design requires thin base plates it is common practice to specify thicker base plates in order to avoid fabrication costs as a result of adding stiffener plates.

End-plate base connections can create assembly problems and uncertainties, in terms of workmanship and economy. Weynand, Jaspart and Steenhuis [1] have shown that for a structure of hot-rolled sections about 40% of the total costs are directly or indirectly influenced by the connections of the structure (base connections included). There is no reason to believe that the connections costs will be significantly less for thin-walled structures. Any simplification of the base connections will result in a significant reduction in the cost of the structure. A viable alternative to this connection, especially for portal frames spanning from 5 to 16m, are angle cleat base connections. The main advantage of angle cleat connections is that no welding is required, thus they can be fabricated and assembled with minimum skill. A key factor in erecting a building is the simplicity in which the base connections can be produced. The design and detailing of the connections in a building has a significant effect on costs. The aim of this investigation is to determine the feasibility of using angle cleat connections as column base connections. The results obtained from the experiments are then compared with the ones determined from a theoretical analysis to evaluate whether the connection is sufficient in resisting these loads.

2. Structural forms of the connections

In previous work, portal frames were developed from single cold-formed lipped channels, connected back-to-back at the eaves and apex connections [2,3]. The counterbalancing moments and forces resulting from opposing eccentricities in the two singly symmetric channels, connected together at the eaves were shown to be important in enhancing the lateral buckling strength of the channels. Current investigations are focused on the base connections of these frames. The configuration of the proposed base connection is shown in Fig. 1(a) and is made by connecting the longer leg of the angle cleats to the flanges of the column channels (2 bolts on each side) and the shorter leg to the foundation (1 bolt on each side). This is a relatively simple connection in comparison with other available base connections. The configuration was developed from beam-column connections, in which the top and bottom angles are bolted to the flanges of the beam and column (top and seat angle

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