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The Strength of 100% Overlapped Multiplanar KK-Joints of Square Hollow Sections

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ABSTRACT

The strength of multiplanar overlap KK-joints in square hollow sections (RHS) and their counterpart uniplanar overlap K-joints are studied in more detail in order to determine the multiplanar effect. In this study the RHS sections are square.

This paper deals with 100% overlapped multiplanar overlap KK-joints in RHS. In this FE study a basic KK-overlap joint with $\beta = 0.4$ and $2\gamma = 15$, 25 and 35, has been considered.

Based on this study the relationship between the strength of multiplanar overlap KK-joints and uniplanar overlap K-joints has been determined. Further comparisons are made with existing design recommendations.

Key Words: Static strength, hollow sections, multiplanar joint.

Nomenclature:

N_i	applied axial force in member i (i = 0, 1, 2)
N_{0p}	chord "preload" (additional axial force in the chord member at a connection which is not necessary to resist the horizontal components of the brace member forces)
$N_{1u,C}$	design resistance of the joints predicted by the CIDECT Design Guide
$N_{1u,N}$	numerically determined resistance of the joints
O_v	overlap, $O_v = q/p \times 100\%$
b_i	external width of a brace i (i = 1and 2)
b_0	external width of a chord
f_{yi}	design yield strength of a brace i (i = 1 and 2)
f_{y0}	design yield strength of a chord
p	length of projected contact area between overlapping brace and chord without presence of the overlapped brace
q	projected length of overlap between braces of a K- or N-joint, at the chord face
t_i	wall thickness of a brace i (i = 1 and 2)
t_0	wall thickness of a chord
β	width ratio between braces and chord: $\beta = (b_1+b_2)/(2b_0)$
γ	half width to thickness ratio of the chord, $\gamma = b_0/2t_0$
θ_i	acute angle between brace member i (i = 1 and 2) and chord

INTRODUCTION

Compared to connections between CHS less attention has been devoted to multiplanar connections between RHS (see Fig. 1). Because of a lack of sufficient experimental and numerical evidence there is no sufficient information available for such connections. Based on some initial tests in the CIDECT Design Guides (Packer et al. 1992) a reduction factor of 0.9 is applied to the joint strength calculated using the relevant uniplanar joint formula for multiplanar joints. This factor is similar as that used for circular hollow section KK-joints.

To address this deficiency, ECSC and CIDECT funded research programmes were carried out to investigate the effect of the multiplanar interactions on the static strength of RHS KK-joints (O'Connor 1995, Yeomans 1993). The experimental results of the multiplanar KK-joints indicated for the joints with lower brace to chord width ratios β a significant multiplanar effect in comparison with existing uniplanar design formula.

Before this research some indications for the multiplanar effect of gap KK-joints were already given based on the CIDECT programmes 5W (Redwood et al. 1981) and 5W/2 (Bauer et al. 1984), however the parameter range was limited.

In CIDECT programme 5BG (Yu, 1997), all influencing parameters have been investigated for XX- and TT- joints. The results provide a good basis for design rules for XX- and TT- joints. Furthermore, a deformation limit of 3% has been defined (Lu et al. 1994). Logically, the next step is thus to provide the required information for KK- joints.

This project sponsored by CIDECT concerns a numerical analysis of the static strength of multiplanar KK-joints in square hollow sections. The objective is to provide sufficient data to define design recommendations for multiplanar KK-joints in square hollow sections.

The first part of this study deals with the influence of the support conditions on the strength of joints (Liu et al. 1998a, b). The main part concerns a parametric study for joints with gap and/or overlap for various values of β (brace to chord width ratio), γ (half width to thickness ratio of chord) and θ (included angle between brace and chord).