

## **Effect of Support Conditions and Geometrical Imperfections on the Strength of CHS Uniplanar X-Joints**

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### **ABSTRACT**

The main objective of the current study is to investigate the influence of various aspects, such as geometrical imperfections of a joint and the support conditions at the chord ends, on the static strength of uniplanar X-joints, since some experiments recently carried out (Noordhoek et al., 1996) showed unexpected low results.

The results indicate that the joint strength of an uniplanar X-joint subjected to bracing compression could be strongly effected by geometrical imperfections, if the chord ends are not sufficiently restrained to prevent a rotation and a sideways deflection from the chord.

**KEY WORDS:** Static strength, circular hollow sections, uniplanar joints

### **1 INTRODUCTION**

The experiments were carried out in the framework of a programme to study the behaviour of joints in higher strength steels. To investigate the effect of tension and compression on the same type of joints the test programme consists of two series of three specimens of which one series has been tested under an axial tension loading on the braces and the other series has been tested under axial compression loading on the braces. For each series the material used is Steel Grade S 355, S 450 and S 700 with a nominal yield stress of  $f_y = 355 \text{ N/mm}^2$ ,  $450 \text{ N/mm}^2$  and  $700 \text{ N/mm}^2$  respectively (Noordhoek et al., 1996).

The test results were compared with the results of previous investigations (v.d. Vegte, 1995 and Kurobane et al., 1984). The ultimate loads obtained in the tests for the specimens subjected to compressive bracing loads are relatively lower than the results of previous investigations.

To get an insight into the problem a finite element analysis study was carried out. The main objective of this programme was to investigate the influence of various aspects on the static strength of the joints, such as geometrical imperfections and support conditions at the chord ends.

### **2 EXPERIMENTAL OBSERVATIONS**

The configuration and the nominal dimensions of the test specimens subjected to compressive bracing loads are given in table 1. The test specimens X-355c, X-450c and X-700c are made using cold rolled tubes provided with one weld seam. An extra specimen X-355c-res was made using hot rolled seamless tubes with Steel Grade S 355. The brace length is taken as 3.4 times the diameter of the brace, and the chord length is taken as 5.2 times diameter of the chord for the specimens of X-355c, X-450c and X-700c. The X-355c-res was slightly different i.e. the brace length is taken as 3.3 times diameter of the brace, and the chord length is 6.0 times diameter of the chord.

The mean values of the measured dimensions of the test specimens are also given in table 1. The geometrical imperfections, such as the brace out of plane rotation to the chord (hereafter named as BPC) which is equal to  $A - 180^\circ$ , the brace misalignment (hereafter named as BMA) which is equal to  $S_2$  and/or  $S_3$ , are defined in the table.

The specimens were placed in the test rig with the braces in vertical direction. The end of the top brace of the specimen was supported by a ball-joint connected to the test frame. The end of the other brace was supported by a ball-joint installed on the load cell, which was fitted on the jack.

The support conditions at the chord ends used in the tests for the different specimens are shown in figure 1. As indicated, the chord ends were restrained by a steel frame to prevent the chord from a rotation around its axis and a sideways displacement.

The plots of the overall displacement versus the actuator force obtained in the tests are given in figure 2, and the deformation modes observed in the tests are shown in figure 3. The deformation modes for specimens X-355c, X-450c and X-700c are asymmetric, while the deformation mode for specimen of X-350c-res is symmetric

A comparison between the test results and the results of previous investigations is given in table 2 which shows that, except the X-355c-res, the test results for the other specimens are much lower than the results of previous investigations.