

EXPERIMENTAL ANALYSIS OF “T”- JOINTS COMPOSED OF RHS, CHS AND HEA SECTIONS

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Зосереджено увагу на порівнянні результатів вимірювання, одержаних в лабораторних експериментах на з'єднаннях прямокутних і дугових порожніх секцій. Експериментальні результати порівнюються з результатами, одержаними від теоретичних моделей і обчислень. Особливу увагу звернено на Т-з'єднаннях, які складаються з єдиних членів акорду і дужки. Процедура оцінки контролює опори і деформації таких з'єднань.

Ключові слова: з'єднання, прямокутна пустотна секція, дугова пустотна секція, відкрита секція, експериментальний аналіз.

The article presented focuses on the comparison of the measurement results obtained in laboratory experiments on joints composed of rectangular and circular hollow sections. The experimental results are compared with the results obtained from theoretical models and calculations. Special attention is paid to T-joints that consist of single chord and brace members. The evaluation procedure monitors the resistances and deformations of such joints.

Key words: joints, rectangular hollow section, circular hollow section, open section, experimental analysis.

Introduction. The gradual increase in the production range of hollow sections has resulted in their more common application in various areas and types of construction. This type of section can find a number of applications in the construction industry, especially in structures where attractive general appearance of the whole structure is required.

From the point of view of a structural designer, the application of hollow section joints presents relatively effective utilisation of the material. The distribution of the material and its mass in hollow section joints brings several advantages for various kinds of load. Their application is one of the best design solutions in members under compression, with respect to their buckling, as well as in members loaded in bending, with respect to their lateral-torsional buckling as well.

As far as strain is concerned, joints present the most exposed areas in structures composed of such types of section. Joints composed of rectangular hollow sections have recently received quite close attention [3], [6], [7]. Our experimental research programme concerns the hollow-section joints combined with other kinds of section.

The paper presents the results of the experimental programme that has been carried out at the Faculty of Civil Engineering of the Technical University in Košice.

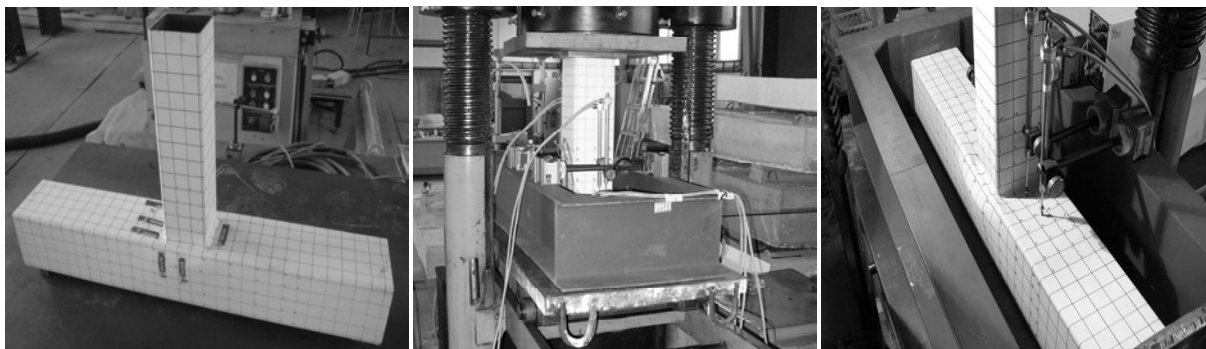


Figure 1. Arrangement of the diagnostic apparatus on the specimens under observation

Attention is paid to the joints composed of rectangular and circular hollow sections, and HEA-type open sections. These are all T-joints where the continuous chord member is made of a rectangular hollow section in each type of specimen. The brace members vary in section in terms of their type and dimensions. Due to a large variety of combinations of sections in terms of their type and dimensions, the authors of the paper are planning to extend the research and supplement the results gradually by using some other combinations and types of section in the future [1], [2], [4].

Preparation of the experiment and performed laboratory measurements. It is essential for the design of a joint to take into account a lot of factors that influence the stiffness of the joint, such as its geometry, the material used, stress application, etc [5].

As regards the geometry of the joints, three different types of joint were compared. In the first type of joint, both the chord and brace members were composed of rectangular hollow sections. In the second type of joint, the chord member was composed of a rectangular hollow section as in the first case; however, the brace member was made of a circular hollow section. In the third type, the brace member was composed of an open HEA-type rolled section while the chord member remained the same as in the other two types.

Another variable that can characterise the above-mentioned joints is a β parameter. It is the ratio of the mean diameter or width of the brace members to that of the chord. Our effort was to cover as wide a range of β parameters as possible. To this end, the constant section of RHS 140x140x4 was selected as the chord. Rectangular hollow sections of RHS 60x60x3, RHS 100x100x3 and RHS 140x140x4 were used as the brace members in the first type of section, circular tubes of CHS 60x3, CHS 100x3 and CHS 140x3 in the second type of joint, and, in the third open type of joint, HEA 100, HEA 120 and HEA 140 sections were used. The β parameter for all types of section ranged from 0.42 to 1.00.

All models were made of steel S235 and a specimen of each model was taken to analyse its material characteristics. The yield strength in all specimens did not exceed the one declared by the steel manufacturer and it varied between 290 and 320 MPa.

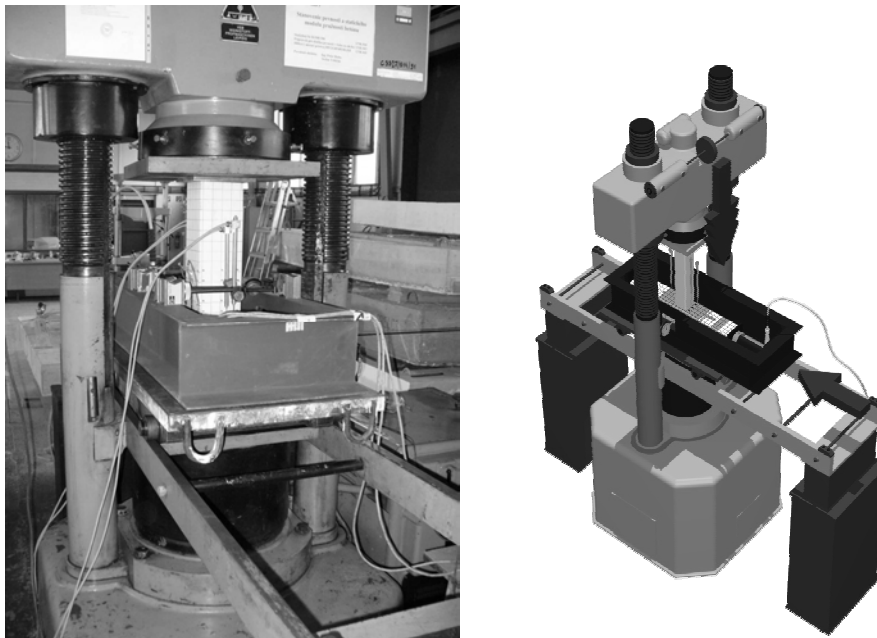


Figure 2. The loading test assembly

In order to simulate the real behaviour of the joint in a lattice structure, the chord member was assumed to act in horizontal compression, while the brace members were compressed in a vertical direction. Horizontal compression was actuated by means of an additional frame and pneumatic hand press. The numerical value of horizontal load remained constant during the whole loading period. Each specimen type was tested at three horizontal force levels: 68 kN, 115 kN and 192 kN.

Vertical load imposed on the specimens by the main hydraulic press was gradually increased until the total failure of the specimen. With respect to the complexity of the task, the length of the brace member was designed so as to prevent buckling of the member.

Measurement points were then selected on the individual specimens. Strain gauges were used to measure stress in the specimens and inductive sensors to determine horizontal and vertical deformations in the specimens.

Obtained results. The types of joints selected were observed for both stress and deformation. In the following section of the paper, the attention will be directed to the deformation of the joints.

As can be seen from the figure below, deformation was measured mainly in the chord members, namely in the upper horizontal and vertical walls of the chord member section.

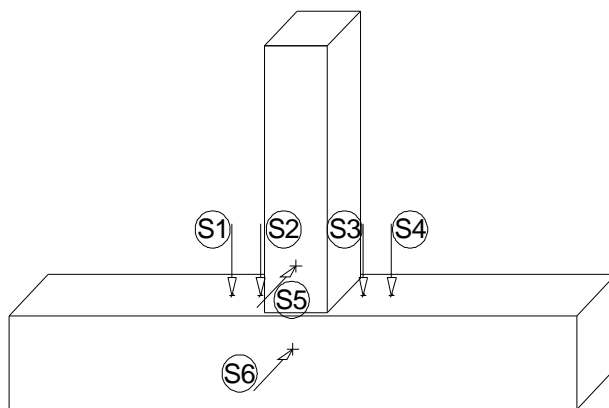


Figure 3. The geometrical arrangement of inductive sensors

The behaviour of the individual joints and their deformation in both horizontal and vertical directions are shown in the following graphs.

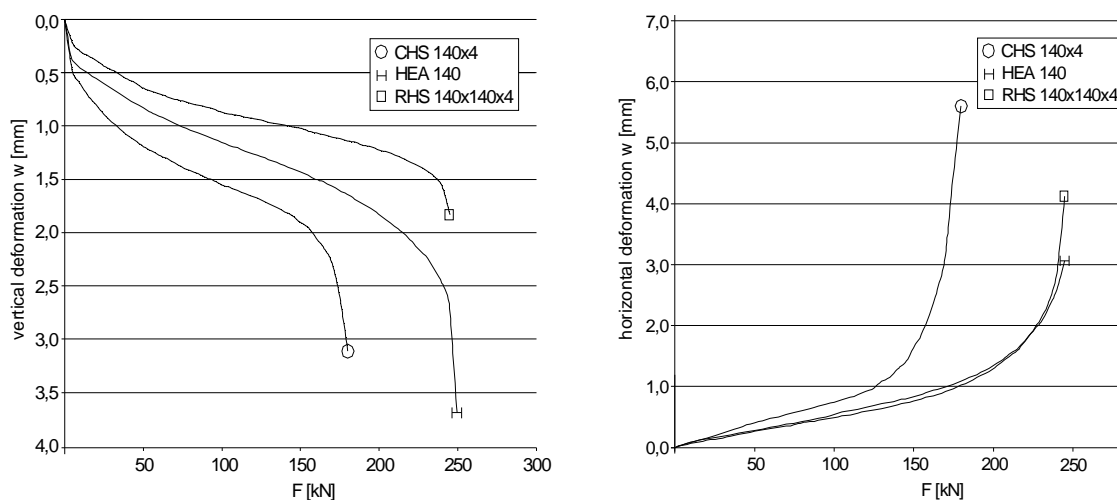


Figure 4. Vertical and horizontal deformation of the T-joint with $\beta=1.00$ depending on the type of the brace member used

In the first type of joint ($\beta=1$), the stability of the chord web (wall) was crucial for the overall resistance of the joint. Graph 1 presents the distribution of values of vertical and horizontal deformation. Great deformation of the vertical chord web (wall) occurred even under a relatively light vertical load. The joint collapsed completely with the gradual increase in load due to the buckling of the vertical web (wall) of the horizontal chord member.

When the resistance of rectangular, circular and open sections was compared, the rectangular sections proved to be the stiffest.

The effect of the buckling of the chord web (wall) on the overall resistance of the joint can be observed also in the joints with $\beta=0.714$, The overall resistance of the joint was influenced by the loss of stability of the vertical web (wall), although the difference between the vertical and horizontal deformation was not as significant as it was in the first case.

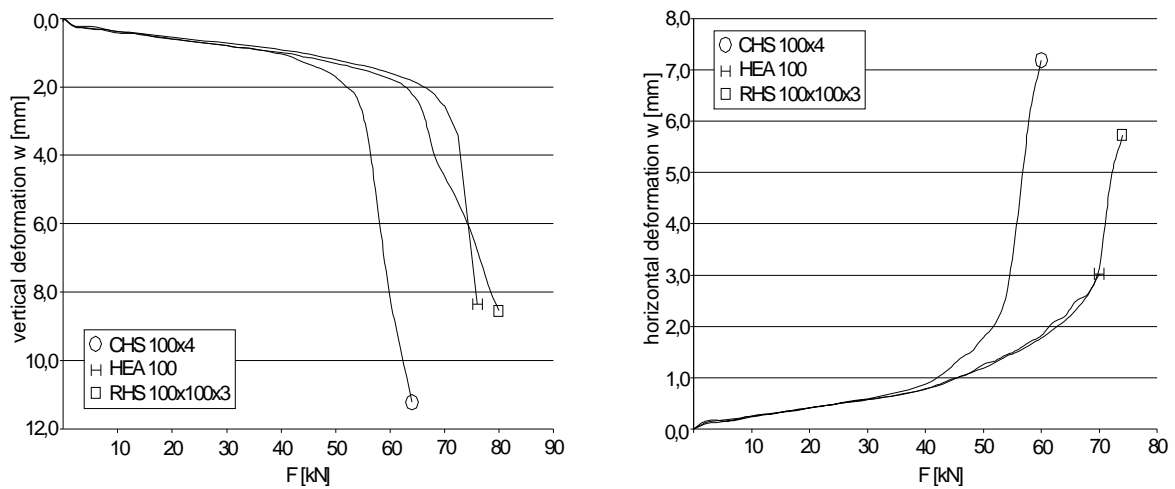


Figure 5. Vertical and horizontal deformation of the T-joint with $\beta=0,714$ depending on the type of the brace member used

When comparing the types of the brace member used, the rectangular section appeared to be the most resistant of all again, although the difference between the rectangular and open HEA-section was minimal as far as their vertical and horizontal deformation is concerned.

In the third type of joint with the most slender brace members, the overall resistance of the joint was in large measure affected by the stiffness of the horizontal chord web (wall). The difference between the horizontal and vertical deformation in this type of joint is the biggest and the vertical deformation the greatest.

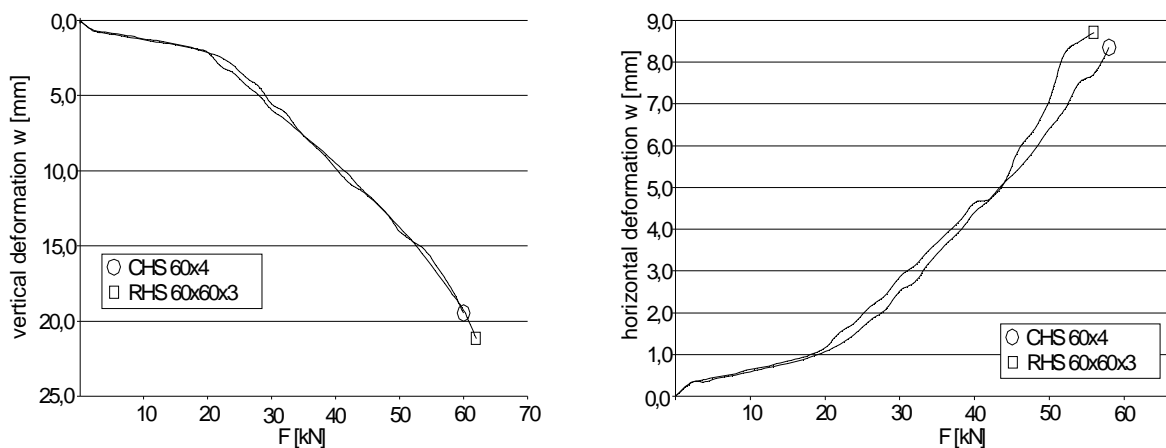


Figure 6. Vertical and horizontal deformation of the T-joint with $\beta=0,428$ depending on the type of the brace member used

The influence of the type of the brace member used on the overall resistance of such joints is virtually negligible. Due to the limited possibilities of the HEA rolling programme, only circular and rectangular hollow sections were compared. For $\beta= 0.714$ the behavior of open sections was identical to that of rectangular sections and, obviously, it does not change for lower β parameters.

On the grounds of the results obtained, it is possible to create a picture of the behaviour of T-joints with respect to the geometry and type of section. It can be concluded that the resistance of such a type of joint with $\beta=1.00$ is greatly influenced by the type of brace member. This influence sharply diminishes

with the decreasing value of a β parameter. With very low β parameters, the influence of the type of brace member becomes virtually negligible and unimportant.

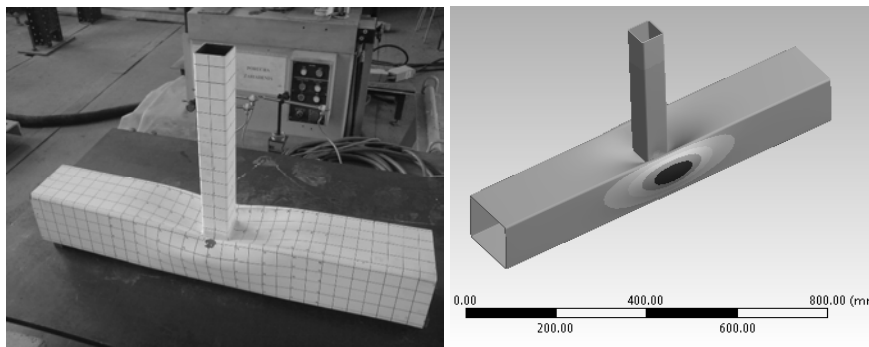


Figure 7. Comparison of the actual deformation of the specimen and the deformation modelled using the finite element method

Conclusion. The conclusions presented in this paper are only part of a number of results obtained in the experiments. The authors of the paper would like to continue in the analysis of such joints, while the main emphasis should be placed on the verification of the obtained results using an appropriate finite model for the joints in question.

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