THE EXPERIMENTAL TESTS OF THE JOINT ASSEMBLY OF THIN WALLED STEEL PROFILES KB

T.F. GĂLĂȚANU[1]   V.V. UNGUREANU[1]

Abstract: *In this paper is presented the experimental tests of the joint assembly of thin walled steel profiles KB and a numerical experiment. It is highlighted a good behaviour of the KB profiles with the joint element by increasing of bearing capacity and reduction of material quantity by optimum usage of the KB profiles.*

Key words: *Thin-Walled Steel Profiles, Steel Bolted Joint Design, Strengthening.*

1. Introduction

The reason of the present study is induced by existence of several lacks noticed at the joints connecting the KB elements used for beams and columns of the structures with several destinations. The joints are usually made by the means of gussets assembled by welded steel plates.

The thin walled cold formed steel profiles used for the joint assemblage are produced by the Kontirom Arcelor Group manufacturer and are so-called the KB profiles; they have a cassette shape and are used as linear elements of the structural resistant frames. A frame element is typically made of two KB profiles positioned back-to-back and fixed together with a thick steel connector.

The carbon steel strip of the profiles is protected by immersion into a zinc bath and they are made of FeE320G as stated in the EN 10147 Product Norm (Euro Norm).

The mechanical properties of material are:

- the yielding strength of the basic material $f_{yb} = f_y = 320$ N/mm^2 ,
- the ultimate strength of the basic material $f_u = 390$ N/mm^2.

2. The Joint Structure

The design of such a joint is performed in order to resist of the maximum stresses that occur when is subjected to the load combinations:

- N axial force,
- Q shear force and
- M beading moment.

By analyzing of the different kinds of elements that are connected and the loads acting on them it was thought like a system that carries on the three efforts separately, each at the level of a separate element of the new joint, not only the bolts, which in turn are acting like usual bolts.

Thus it is advocated the construction of the joint as a box where:

- The axial efforts that are usually of

[1] Faculty of Civil Engineering, *Transilvania* University of Brașov.

compression are carried out by a steel plate placed at lower part (inside) of the box;

- The shear is carried on by the box;
- The bending moment is appears both by the bolts placed on the contour of the KB flanges and a pair of bolt rows fixed on the web, see Figure 1.

On the second stage of the research it has suggested the increasing of the bearing capacity of the element KB using some additional elements at the flange level. These additional elements are made of 5 mm thick S355 cold steel sheet and they are riveted on the profile flange, see Figure 2.

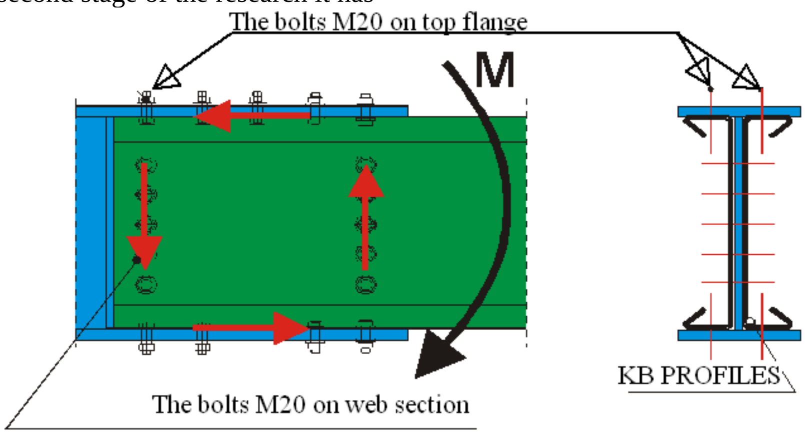

Fig. 1. *The positions of the bolts that carry on the bending moment*

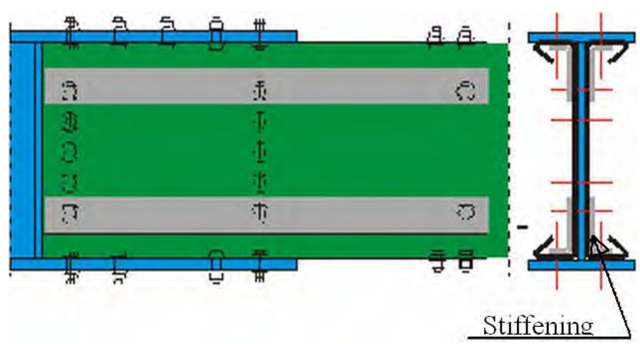

Fig. 2. *The positions of the stiffening elements*

3. The Tests

In order to check the behaviour of the new joint it was proposed the testing of the KB thin-walled steel profiles KB600-5.0 and KB450-3.5. The simply supported beam with a central joint was selected for the experimental model.

A 300.000daN hydraulic press was used for testing. In the Figure 3 it is presented how the transducers are mounted on the specimens and the complementary elements used in the experiments.

At this testing stage it was proposed the following instrumentation of specimens:

- two displacement transducers mounted on the central joint from the midspan (D0, D1);
- two displacement transducers mounted at the joint edge (D2, D4 – D3, D5);
- two displacement transducers mounted on

the KB profile at the joint vicinity (D6, D8 – D7, D9);

• One force transducer to accomplish the automatic load recording.

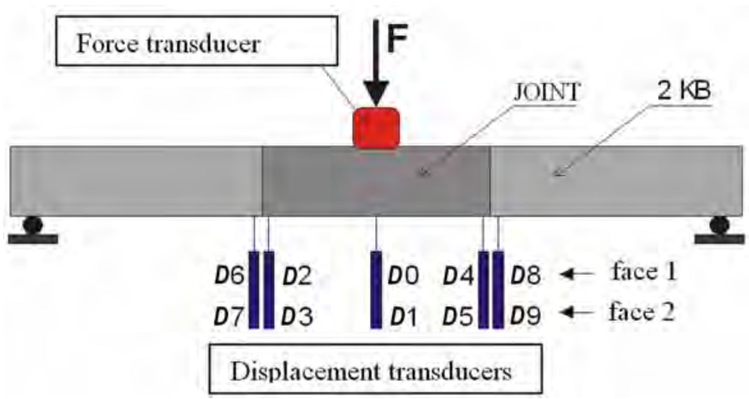

Fig. 3. *The transducer positions on the two sides of beams*

In order to avoid the lateral buckling of the beams was thought a driving system and it was mounted at middle and edge of each specimen(see Figure 4).

The signals received from all the transducers were amplified and introduced into an analog–digital converter system and processed numerically.

The experiment was accomplished in monotonic loading paths up to the levels of 100 kN, 200 kN, 300 kN and 350 kN. The last value corresponds to a stress of 290 N/mm^2, i.e. the design strength.

Fig. 4. *The driving elements mounted to prevent the lateral buckling.*

4. The Test Results

The tested girders names were the following:

- N-KB600-5.0
- R-KB600-5.0
- N-KB450-3.5
- R-KB450-3.5

where "N" means a joining without stiffeners and "R" a strengthened joint.

After the analysis of the force–displacement relationship in the case of this type of beam it cannot be noticed a significant increase of the element stiffness. Unlike the previous tests, this time the element was tested till the failure

Thus, it comes out that element ceased due to the local buckling at the boundary of the strengthening elements.

The bearing capacity of the element is significantly increased, the buckling occurred at a force level of 485,200 N presented for Figure 9.

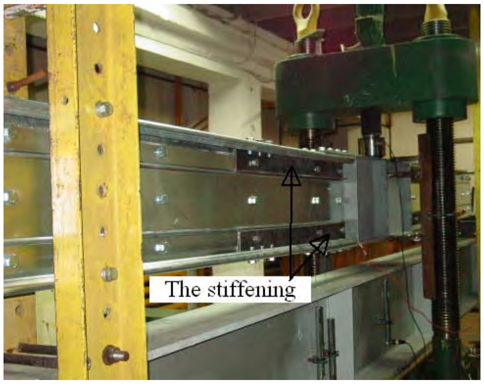

Fig. 5. *The positions of the strengthening elements R-KB 450-3.5.*

Fig. 7. *The local buckling of the KB element for the R-KB450-3.5 beam*

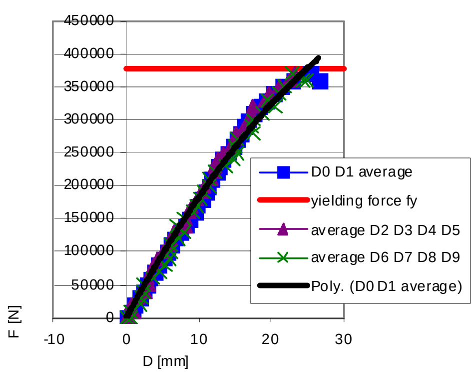

Fig. 6. *The force – deflection relationship for the KB600-5.0 beam*

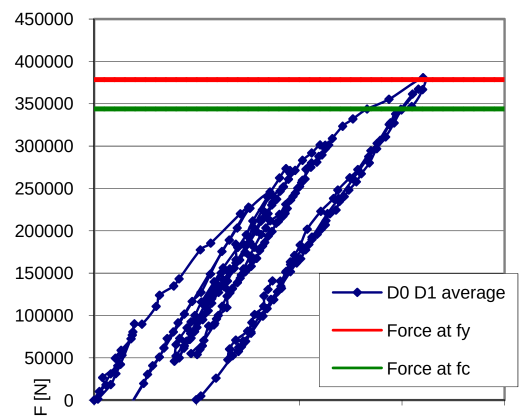

Fig. 8. *The force – deflection relationship at the midspan of the N-KB600-5.0*

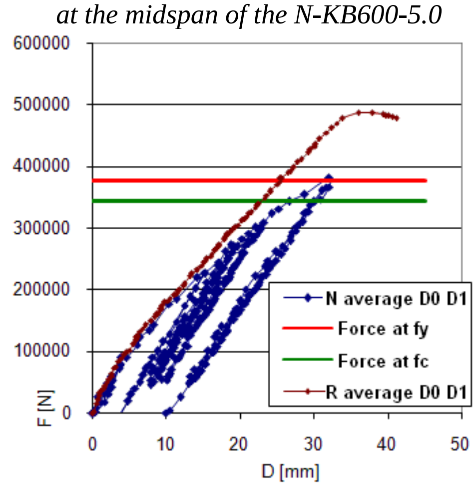

Fig. 9. *The force – deflection relationship for the N and R KB600-5.0 beams*

Under these circumstances it results a force level increase greater than 22% when compared to the yielding level of the KB basic material.

The beams made of the KB450-3.5 profiles were tested under the same conditions as those consisting of pairs of KB600-5.0 the behaviour of the N-KB450-3.5 beam until it reaches the yield limit stress.

The beam failure occurred by the local buckling of the flange of one KB profile at the boundary area of the "strengthening" elements. The bearing capacity of the beam with strengthening elements is increased by approx. 35%.

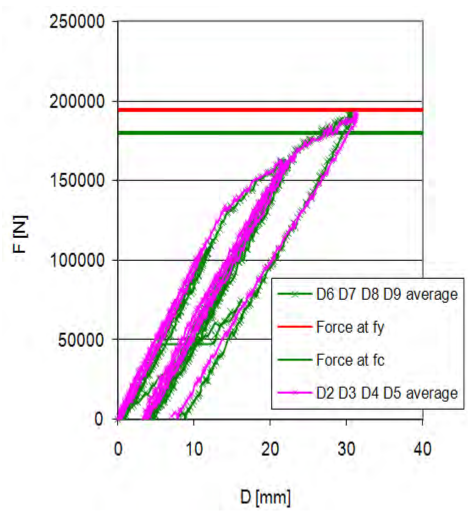

Fig. 10. *The force – deflection relationship at the joint ends for the N-KB450-3.5 beam*

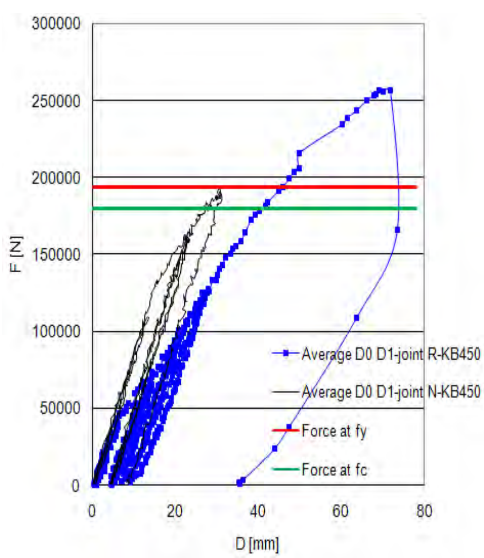

Fig. 11. *The force – deflection relationship (D0-D1 average) for the N-KB450-3.5 and R-KB450-3.5 beams*

5. The Numerical Experiments

The joint assembly of thin walled steel profiles KB for the KB450-3.5 beam was numerical analysed using ANSYS software.

Fig. 12. *The joint assembly of thin walled steel profiles KB for the KB450-3.5 beam*

The numerical analysis showed the decrease of deformations for the beam with strengthening elements (see Figure 13).

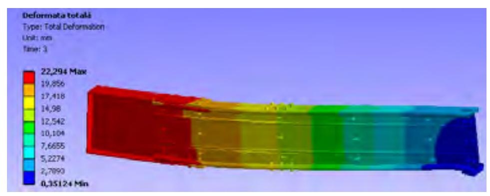

Fig. 13. *The maximum total deformation of joint assembly with strengthening elements for the KB450-3.5 beam*

Also, it showed the appearance of local buckling near the ends of strengthening elements due to the local increasing of stresses and modifications of stiffness in this area of beam (see Figure 14).
The numerical computations have not taken into account the geometric imperfections.

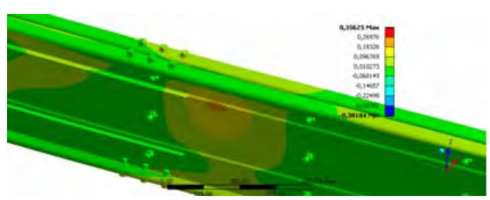

Fig. 14. *The local buckling of the KB element for the R-KB450-3.5 beam - side view*

6. Conclusion

The boundary bolted connections assure a good behaviour between the KB profiles and the joint element.
The mounting of the strengthening

elements leads to an increase of the bearing capacity up to 30. . .35% with respect to the yield limit of the KB material.

The use of the strengthening elements leads to a safer cross-section of the compound KB profile when the bending moments may lead to the local buckling.

The presence of a too big tolerance between the joint carcasse and the KB profile allows the rotation of the profile until all the bolts start working – these phenomena are consumed at repeated cycles.

The usage of these stiffeners allows the optimum use of the KB profiles, thus leading to the material quantity reduction.

The results of numerical simulations are in a good agreement with experimental tests.

Acknowledgements

The authors wish to thank prof. dr. eng. Ioan Petru Ciongradi and prof. dr. eng. Mihai Budescu for our help in test data analyses.

The authors greatly appreciate the skilful work of the technical staff of the Laboratory of the Department of Structural Mechanics of the University "Gh. Asachi" of Iasi for assistance during the tests.

References

1. Budescu M., Ciongradi I.P., et al.: *Experimental tests of a new class of steel joints.* In: Intersections (2005), Vol. 2, No. 1, p.64-72.
2. Gălățanu T.F. In: Ph.D. Thesis: *Comportarea îmbinărilor elementelor structurale realizate din profile din oțel cu pereți subțiri laminate la rece(Behavior of connections between structural elements made of cold formed steel thin gauge sections),* Iași, Romania, 2009.
3. Gălățanu T.F., Ciongradi I.P., et al.: *Experimental studies of the back-to-back connected cold formed steel profile bolted joints.* In: The Bulletin of the Polytechnic Institute of Iasi (2009), Construction. Architecture Section, LV (LIX), f.1, pp. 17-28.
4. *Studiu privind îmbunătățirea îımbinărilor dintre elementele structurale tip KONTI***.** Technical Report K077145, 2005, VESPER SRL Iași, INCERC Iași.
5. Wei-Wen Y.: *Cold-Formed Steel Design*. 3rd Ed., Wiley & Sons, Inc., NY, 2000.
6. ****Cold Formed Steel Design Manual*. AISI, Washington D. C., 1996, p. 1-621.
7. ****Normativ pentru calculul elementelor din oțel cu pereți subțiri formate la rece*. NP 012-1997.
8. *** SR EN 1993-1-3:2007: *Eurocod 3: Proiectarea structurilor de otel. Partea 1-3: Reguli generale -Reguli suplimenare pentru elemente structurale şi table formate la rece.*