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EXPERIMENTAL STUDIES OF A NEW JOINT SYSTEM FOR THIN-WALLED STEEL PROFILES

BY
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The results and conclusions regarding the experimental tests of the joint assembly of thin walled steel profiles with and without strengthening elements (stiffeners) are presented.

The entire test series have been performed using the 5 mm thick KB600 thin-walled profiles and 3.5 mm thick KB450. In the paper will be presented the analysis of the joints connecting the KB600-5.0 steel profiles.

The KONTIBEAM system is primarily made of two galvanized sheet profiles so denominated as KB, which are joined by means of steel sheets (usually of 10 mm thickness), placed in-between them. Connecting of this assembly (KB's and connectors) is realized by using M20 bolts put in $\phi 22$ holes, which work in friction with two contact planes.

The tested joints are connected by the means of 8.8 class HSFG bolts (High Strength Friction Grip).

The main conclusions of the tests are that the contour bolted connections assure a good behavior between the KB profiles and the joint element. Due to their position the strengthening elements lead to an increase of the bearing capacity up to 30...35% with respect to the yield limit of the KB material. The use of such strengthening elements allows the optimum use of the KB profiles, thus leading to the reduction of the material consumption.

1. Introduction

The aim of this paper is to present the experimental tests obtained at the joint assembly of thin walled steel profiles KB600-5.0 with and without strengthening elements.

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. Usually the joints are made by the means of gussets assembled of welded steel plates.

Under these circumstances it was advocated a new type of joint connected with normal joints, based on the bolt strength when working in shear and compression on the hole.

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

The mechanical properties of material are:

a) The yield stress, $f_y = 320$ N/mm^2=3,200 daN/cm^2,

b) The ultimate strength, $f_u = 390$ N/mm^2=3,900 daN/cm^2.

Ratio $f_u/f_y = 390/320 = 1.22 > 1.2$.

2. The Philosophy of the Joint

The design of such a joint is performed in order to undertake the maximum stresses that occur when is subjected to load combinations namely: N - axial force, V - shear and M - bending moment.

By analysing the different kinds of elements that are connected and the loads acting on them it was thought 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 their turn are acting like usual bolts. Thus it is advocated the construction of the joint as a box (Fig. 1), where:

a) the axial efforts, usually of compression, are carried out by a steel plate placed at lower part (inside) of the box (Fig. 2);

b) the shear is carried on by the box;

c) the bending moment is undertaken both by the bolts placed on the contour of the KB flanges and a pair of bolt rows fixed on the web (Fig. 3);

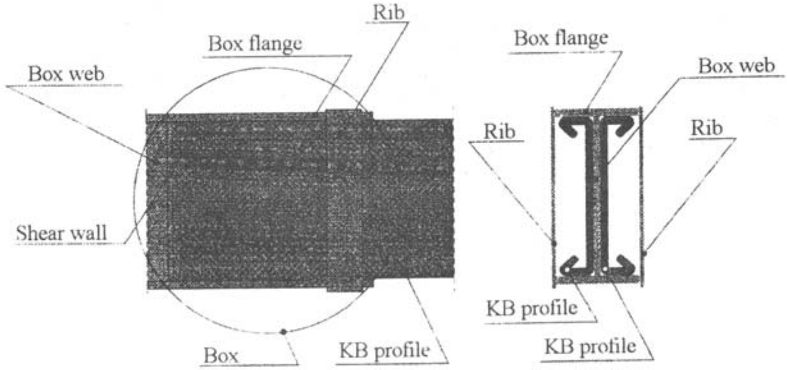

Fig. 1.- Box-type joint.

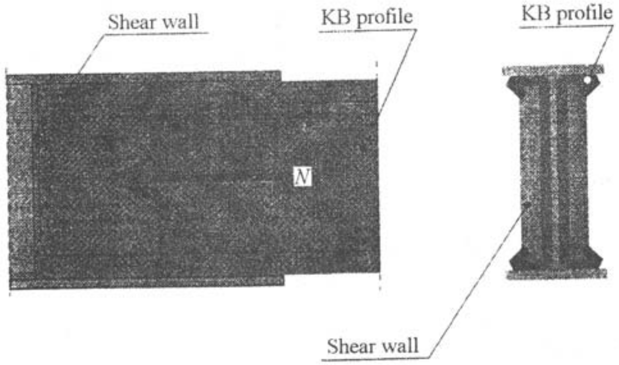

Fig. 2.- Steel plate to undertake the axial force.

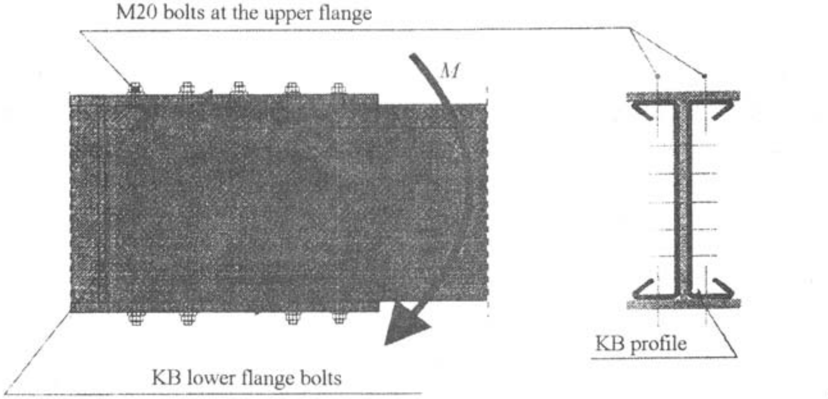

Fig. 3.– The positions of the bolts that carry on the bending moment.

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 (Fig. 5). These additional elements are made of 5 mm thick OL 52 cold steel sheet and they are riveted on the profile flange, as is presented in Fig. 4.

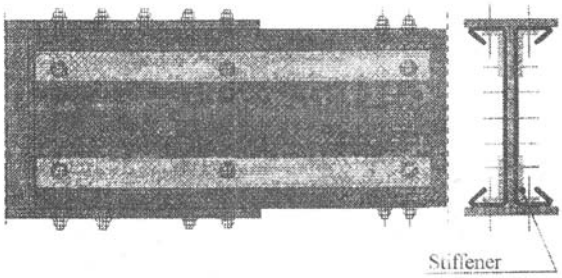

Fig. 4.– The positions of the stiffening elements.

In order to check the behavior of the new joint it was proposed the testing of the KB600-5.0 thin-walled steel profiles. The simply supported beam with a central joint was selected for the experimental model (Fig. 5).

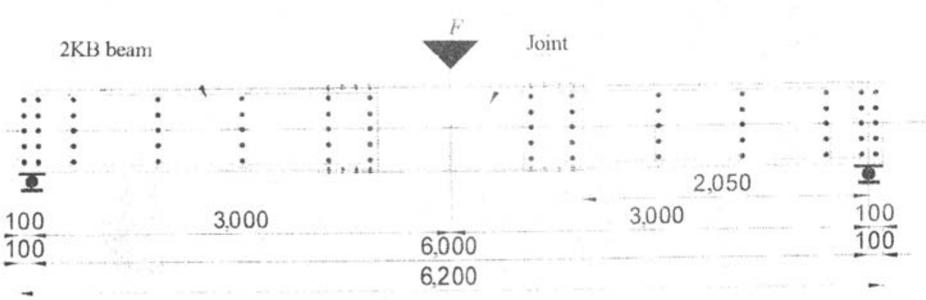

Fig. 5.– The dimensions of the proposed specimens.

3. The Tests

A 300,000 daN hydraulic press was used for testing. In the Fig. 6 it is presented how the transducers are placed on the specimens and the complementary elements used in the experiments.

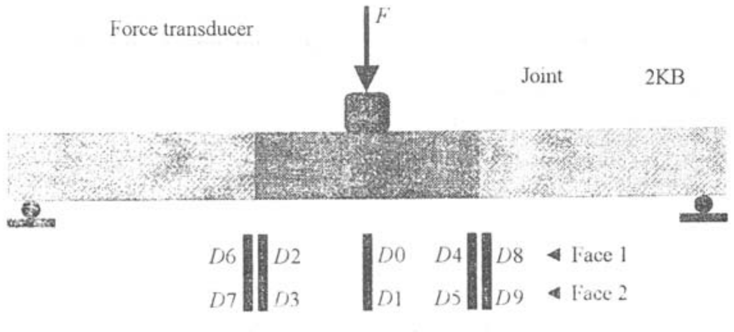

Fig. 6.– The transducer positions on the two sides of beams.

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

a) two displacement transducers placed on the central joint from the midspan ($D0$, $D1$);

b) two displacement transducers placed at the joint edge ($D2$, $D4$-$D3$, $D5$);

c) two displacement transducers placed on the KB profile at the joint vicinity ($D6$, $D8$-$D7$, $D9$);

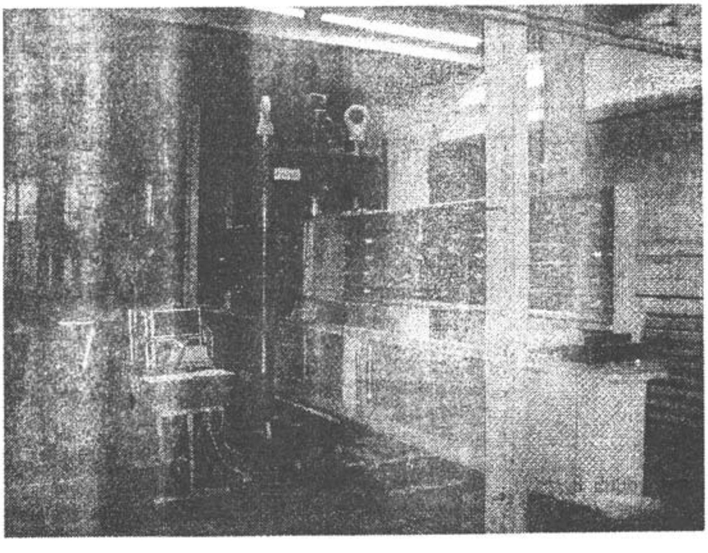

Fig. 7.– The driving elements placed to prevent the lateral buckling (KB600-5.0).

d) one force transducer to accomplish the automatic load record.

In order to avoid the lateral buckling of the beams a driving system was thought and placed at middle and each specimen edge, as depicted in Fig. 7.

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

The tested girders names were N-KB600-5.0 and R-KB600-5.0, where N means a joining without stiffeners and R – a strengthened joint.

4. Test Results for N-KB600-5.0

In the Figs. 10 and 11 there are presented the force *vs.* displacement dependence for the N-KB600-5 girder. During the tests, the specimens were loaded over the yielding limit. At this time it can be noticed the plastic yield of the joint. Under these circumstances the experimental 2006 Testing Program made in for the thin walled steel profiles KB600-5.0 was accomplished with joints without stiffeners.

Figs. 8,...,12 depict the force *vs.* displacement dependence for the N-KB600-5 beam.

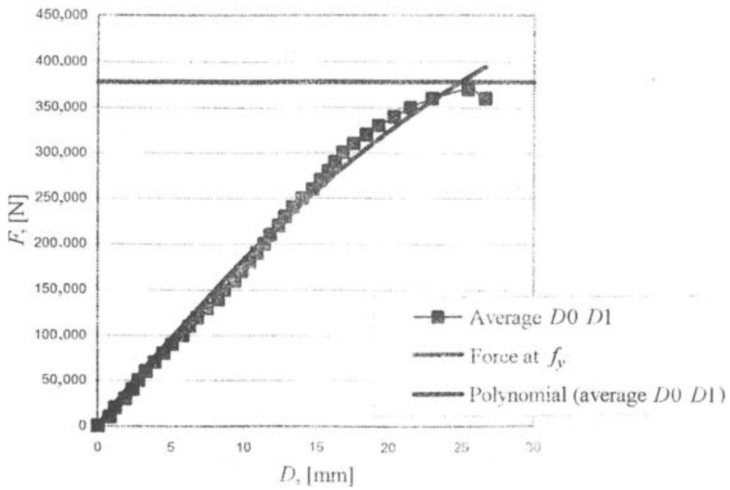

Fig. 8.– The force *vs.* deflection dependence at the midspan of the KB600-5.0 beam (2005).

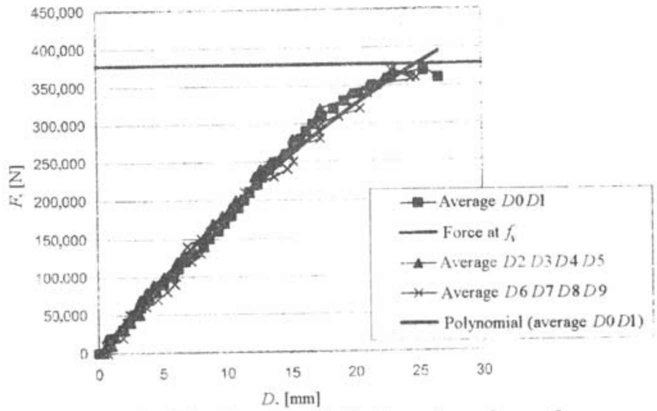

Fig. 9.- The force *vs.* deflection dependence for the KB600-5.0 beam (2005).

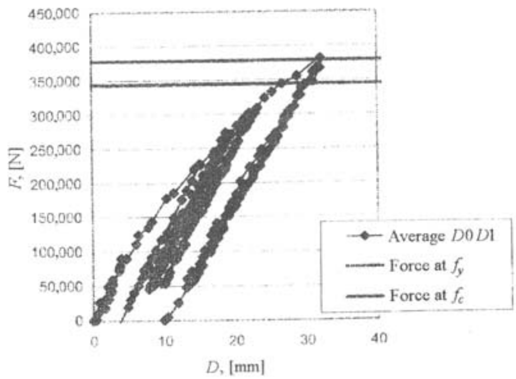

Fig. 10.- The force *vs.* deflection dependence at the midspan of the N-KB600-5.0.

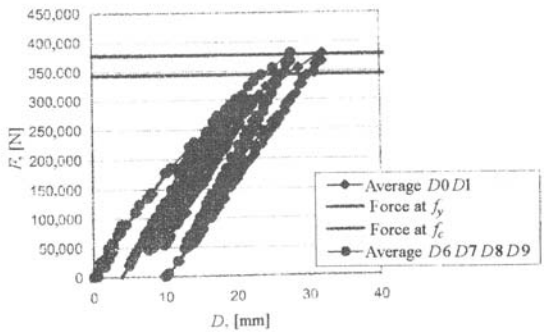

Fig. 11.- The force *vs.* deflection dependence for the N-KB600-5.0.

5. Test Results for R-KB600-5.0

The strengthening elements (of 1,100 mm length) were disposed on both sides of the girder, as presented in the Fig. 12.

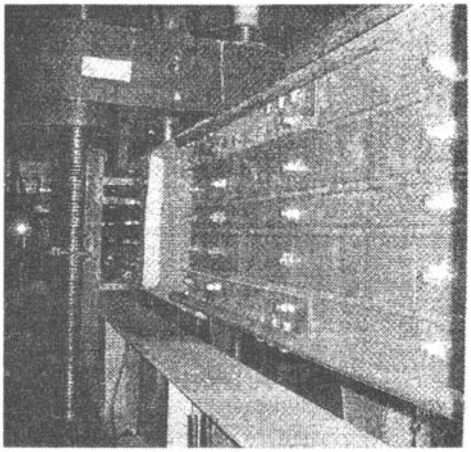

Fig. 12.- The positions of the strengthening elements R-KB600-5.0.

After the analysis of the force *vs.* displacement dependence in the case of this type of beam it can be noticed an insignificant increase of the element stiffness (Fig. 13).

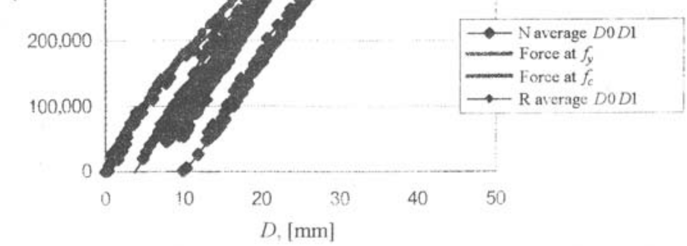

Fig. 13.- The force *vs.* deflection dependence for the N-KB600-5.0 and R-KB600-5.0 beams.

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 (Fig. 14).

The bearing capacity of the element is significantly increased, the buckling occurred at a force level of 485,200 N. Under these circumstances it results a force level increase greater than 22% with respect to the yielding level of the KB base material.

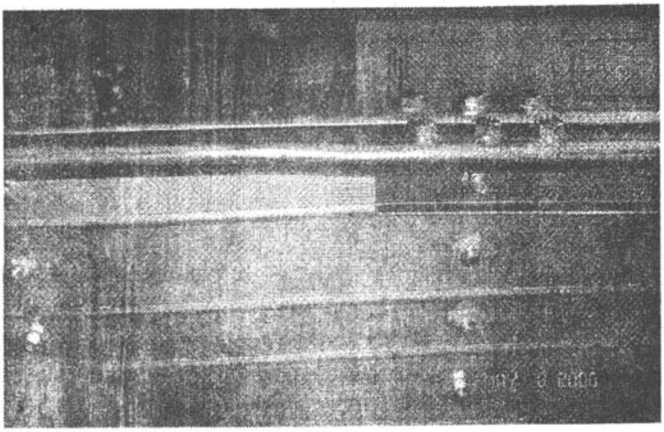

Fig. 14 – The local buckling of the KB element of the R-KB600-5.0 beam.

6. Conclusions

The experimental tests carried on during the program lead to the following conclusions:

1. The contour bolted connections assure a good behavior between the KB profiles and the joint element.

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

3. Due to their position the strengthening elements lead to an increase of the bearing capacity up to 30... 35% with respect to the yield limit of the KB material.

4. By the use of some strengthening elements one makes safe the cross-sections of the KB profiles where the bending moments may lead to local buckling.

5. The use of such strengthening elements allows the optimum use of the KB profiles, thus leading to the reduction of the consumptions.

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STUDII EXPERIMENTALE ASUPRA UNUI TIP NOU DE NOD DE CONECTARE A PROFILELOR METALICE CU PEREŢI SUBŢIRI

(Rezumat)

Se prezintă rezultatele obţinute şi concluziile stabilite cu privire la testele unor noi tipuri de îmbinări pentru profilele metalice cu pereţi subţiri. Aceste noduri pot fi prevăzute cu anumite elemente de rigidizare.

Programul experimental a fost realizat pe grinzi KB600 de 5 mm grosime şi grinzi KB450 de 3.5 mm grosime. În lucrare se prezintă rezultatele pentru grinzile realizate din profile KB600-5.0.

Sistemul constructiv KONTIBEAM este constituit, în principiu, din două profile metalice realizate din oţel galvanizat, denumite KB, unite prin eclise din oţel (de obicei de 10 mm grosime), plasate la mijloc. Întregul ansamblu (profil–eclisă–profil) este prins cu şuruburi M20 care trec prin găuri cu diametrul de 22 mm.

Nodurile testate au elementele din tole metalice iar prinderile se efectuează cu şuruburi de înaltă rezistenţă din grupa 8.8.

Concluziile rezultate în urma efectuării cercetărilor experimentale au arătat că aceste noduri cu şuruburi pe contur asigură o mai bună comportare nod–profile KB. Dacă se prevăd şi elementele de rigidizare, atunci se obţine o creştere a capacităţii portante cu peste 30... 35% în raport cu limita de curgere a materialului din profile. Prevederea constructivă a unor astfel de elemente de rigidizare conduce la o utilizare eficientă a profilelor metalice şi, în final, la o scădere pe ansamblul structurii a consumului de material.