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EXPERIMENTAL STUDIES OF A SERIES OF HIGH STRENGTH FRICTION GRIP BOLTED JOINTS

BY

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The performed tests intended to establish the necessary conditions for the surfaces of the assemblage elements in contact with the KB, so as, by connecting them using the HSFG (High Strength Friction Grip) bolts, to ensure the necessary frictional resistance.

The tests have been performed using 2.5 mm thickness KB250 thin-walled profiles. This minimum thickness is often used for structural elements in this constructive system. The KONTIBEAM system is primarily made of two galvanized sheet profiles so denominated as "KB", which are joined by the means of steel sheets, (usually of 10 mm thickness), placed in-between them. Connecting this assembly (KB's and connectors) is done by using M20 bolts put in ⌀22 holes, which work in friction with two contact planes.

The tested joints are connected by the means of 8.8 class HSFG bolts.

The connecting elements for the tested KB's have been manufactured with two types of prepared surfaces: (i) rough (sandblasted) and (ii) covered with a zincamid film.

The main conclusions of the tests are that the bearing capacity of the connections with sandblasted surface joining elements observes the norms while the bearing capacity of connections with painted-surface joining elements does not observes the norms.

1. Introduction

The aim of this research is the behavior of the high strength friction grip bolted joints, used for the assemblage of the KONTIBEAM thin-walled systems. The tested HSFG (High Strength Friction Grip) bolts are of 8.8 class. In the Fig. 1 it is presented the M20 bolt, the corresponding washer and nut that were tested.

The tests have been performed using 2.5 mm thickness KB250 thin-walled profiles. This minimum thickness is often used for structural elements in this constructive system. The KONTIBEAM elements are made of cold-formed galvanized sheets. They are formed from the FeE320G carbon steel sheet, according to EN10147 Norm and has the following mechanical characteristics:

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.

The KONTIBEAM elements have connections in which the bolts are subjected to shear, due to the adopted constructive systems. Therefore it is advantageous to use the HSFG bolts, as long as the bearing capacity is ensured by friction between the adjacent elements.

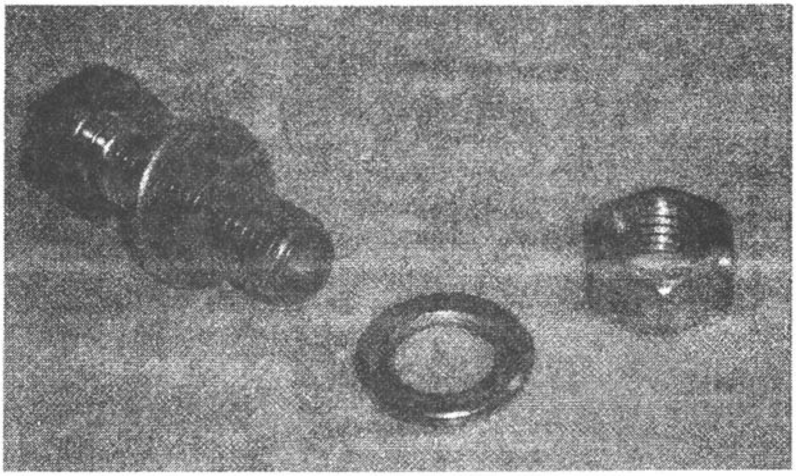

Fig. 1.- The M20 bolt, washer and nut.

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

The performed tests intended to establish the necessary conditions for the surfaces of the assemblage elements in contact with the KB, so as, by connecting them, using the HSFG bolts, to ensure the necessary frictional resistance. For this purpose there were used some connectors (load transferring elements) with two types of surfaces: (i) rough (sandblasted) and (ii) with a zincamid film.

2. The Testing Environment

A complex specimen was conceived in order to assure the loading of a KONTIBEAM system at the bolted connection level. Therefore, the two KB250 elements are fixed by the means of two load transferring elements using bolts. The specimen was manufactured and compressed in a testing device. Under these circumstances the tested area is at the upper part of the sample, where the connection is realized by means of a pair of HSFG bolts only.

The tests were performed by the means of a machine that applies statically compression, which can develop forces up to 30,000 kN. Besides the testing device there were used in the experimental measurement chain the following equipment (Fig. 2):

a) the force transducer (1 pc.);

b) the displacement transducer (2 pc.).

The two types of equipment allowed the data acquisition, *i.e.* the applied forces of the testing device and the relative displacements between the KB250 profiles and the joining plate (connector) at the level of the connection bolts. The displacement transducers were mounted on the connection element between the KONTIBEAM profiles, by drilling a hole in the KB250 element, matching the position of the bolts (Fig. 2). The support of the inductive displacement transducer was connected to the joining element by means of a M10 bolt. The contact strap is made of a thin plate and it ensures the connection of the transducer rod to the KB250 profile at the level of the pair of HSFG bolts. The strap was glued to the KB specimen.

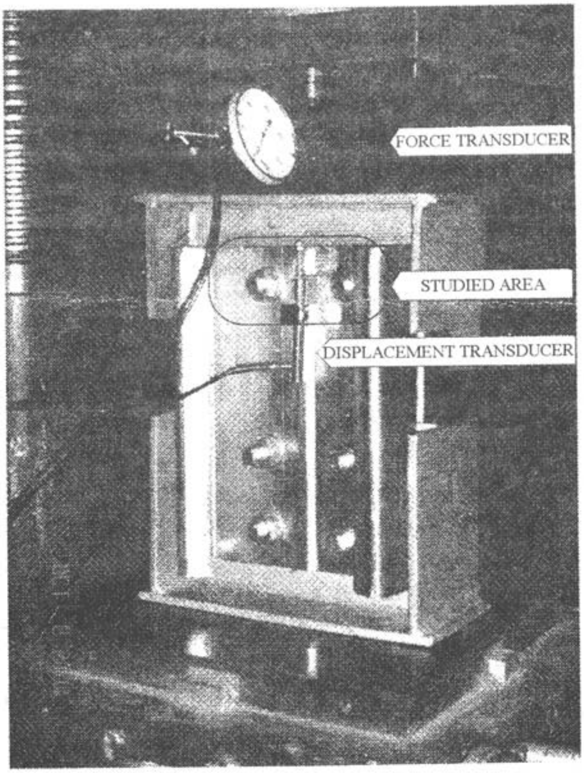

Fig. 2.– Setup of the specimen.

For every specimen type three pieces were made and they were denominated as follows: ES-1...3 – for the sandblasted surfaces; EV-1...3 – for the zincamid cover surfaces. The tightening of the bolts was done by means of a handle wrench with torque indicator adjusted to a torque of 50 daNm, according to the provisions of C 133-82 Code.

The strength capacity (in friction) of one HSFG bolt in contact with a surface is of 4,170 daN, as stated in the C 133-82 Code. Under these circumstances the strength capacity of a connection with a pair of M20 bolts (with two slipping surfaces) is of $4{,}170 \times 4 = 16{,}680$ daN.

3. The Test Tesults

The testing results, expressed in the form of force *vs.* average displacement relationship for the specimens with the connectors having sand-blasted surface, are presented in the Figs. 3,...,5. The average displacement is the mean value of the recordings performed by the displacement transducers on both sides of the specimen.

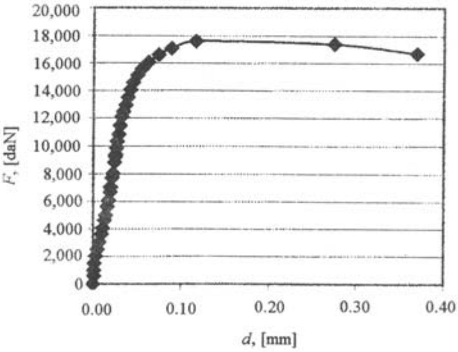

Fig. 3.- The force *vs.* average displacement relationship - transducer ES-1.

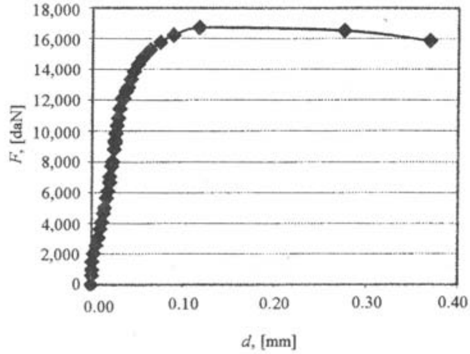

Fig. 4.- The force *vs.* average displacement relationship - transducer ES-2.

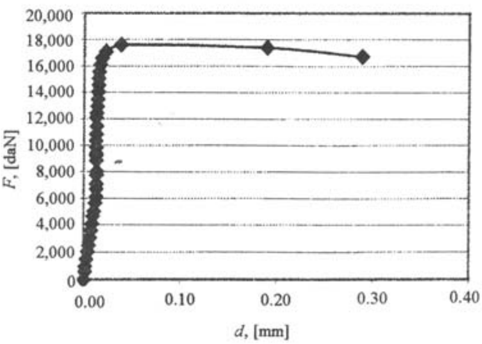

Fig. 5.- The force *vs.* average displacement relationship - - transducer ES-3.

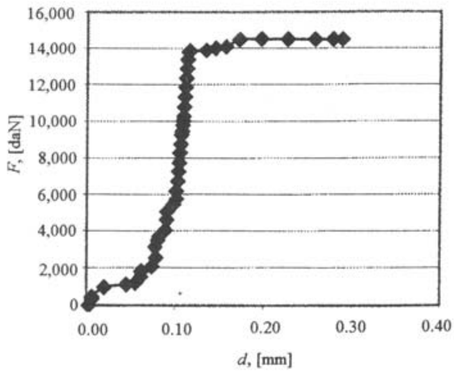

Fig. 6.- The force *vs.* average displacement relationship - - transducer ESR-4.

All the samples with sandblasted surfaces had the bearing capacity greater than the value stated in Codes (16,680 daN). The increase of the testing values compared to the theoretical ones is between 1 and 5%. The resulting curves have similar shapes for all three samples. Thus, after a nearly straight-line range the force *vs.* displacement diagram becomes curved and the slip occurs. Slip occurs continuously, without reverse tendencies, excepting the moment when the bolts start working together with the specimen components.

One can notice that after the test the sandblasted connector is crushed, as a consequence of the loading of the connection beyond the strength capacity to slip.

Besides the testing of the three samples presented above, one of the sandblasted specimens was tested again, after replacing the bolts and tightening them. The force *vs.* mean displacement diagram for this sample (namely, ESR-4) shows a decrease of the bearing capacity of the connection, at about 83% from the computed one. The shape of the diagram shows an initial displacement that can be explained by the decrease of the surface roughness after the first test (Fig. 6).

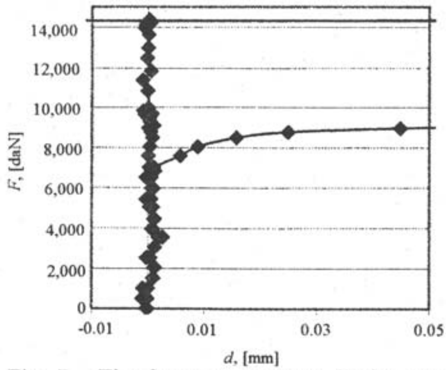

Fig. 7.- The force *vs.* average displacement relationship - transducer EV-1.

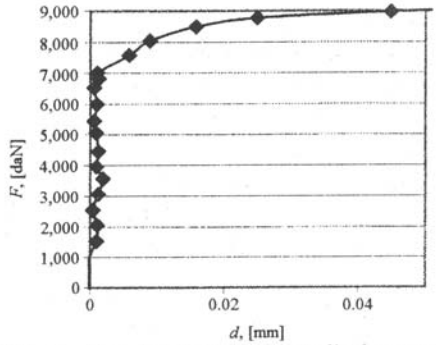

Fig. 8.- The force *vs.* average displacement relationship - transducer EV-2.

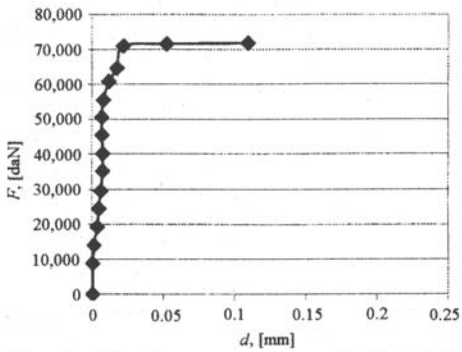

Fig. 9.- The force *vs.* average displacement relationship - transducer EV-3.

In the Figs. 7,...,9 there are presented the test results for the samples with the load transmitting element covered with a zincamid film, expressed as a force *vs.*

average displacement diagram.

The specimens with zincamid-covered surfaces had the bearing capacity much lower than the theoretical value. Furthermore, different slipping occurred on the two surfaces, which induced even the buckling of the KB250 profile.

Based on the EV specimens testing one can notice some dispersion of the results that doesn't allow the definition of a certain limit of the bearing capacity of the joint, in comparison to the computed (theoretical) values. The bearing capacity may be considered approximately of 40...50% from the computed one.

4. Conclusions

At the request of S.C. KONTIROM S.A. Bucharest it was performed the experimental analysis of the behavior of the HSFG bolted connections, specific to the KONTIBEAM structural systems.

The aim of the performed tests was to determine the necessary conditions for the surfaces of the connecting elements adjacent to the KB's, so that, by joining them with the HSFG bolts, the necessary strength capacity (by friction) be ensured.

The connecting elements for the tested KB s have been manufactured with two types of prepared surfaces: (i) rough (sandblasted) and (ii) covered with a zincamid film.

The bearing capacity of the connections with sandblasted surface joining elements observes the norms.

The bearing capacity of connections with painted-surface joining elements does not observe the norms.

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STUDII EXPERIMENTALE ASUPRA UNOR ÎMBINĂRI CU ŞURUBURI DE ÎNALTĂ REZISTENŢĂ, PRETENSIONATE

(Rezumat)

Testele efectuate au avut drept scop stabilirea condiţiilor necesare pentru pregătirea suprafeţelor elementelor de asamblare a elementelor metalice tip „KB" astfel încât prin asamblarea cu şuruburi de înaltă rezistenţă pretensionate să fie asigurată capacitatea portantă prin frecare.

Testele au fost realizate pe elemente metalice tip „KB" realizate din profile cu pereţi subţiri de 2,5 mm grosime. Sistemul constructiv KONTIBEAM este alcătuit, în principal, dintr-o pereche de profile galvanizate, denumite „KB", ce sunt conectate prin intermediul unor fururi metalice (de obicei de 10 mm grosime) amplasate între elemente. Solidarizarea acestui sistem (KB şi fururi) se realizează cu şuruburi M20 în găuri de Ø22 ce lucrează prin frecare cu două planuri de contact.

Şuruburile testate fac parte din clasa IP, grupa 8.8.

Fururile pentru KB-uri au fost realizate prin două moduri de tratare a suprafeţelor: (i) aspră (prin sablare) şi (ii) acoperite cu peliculă de zincamid.

Principalele concluzii rezultate în urma testelor efectuate indică faptul că în timp ce la fururile tratate prin sablare este asigurată capacitatea portantă prin frecare, conform prevederilor din normele autohtone, la fururile acoperite cu peliculă de zincamid nu mai este asigurată această capacitate portantă (nu se înscrie în prevederile normelor).