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Radim ČAJKA [1], Vít KŘIVÝ[2], David SEKANINA[3]

DESIGN AND DEVELOPMENT OF A TESTING DEVICE FOR EXPERIMENTAL MEASUREMENTS OF FOUNDATION SLABS ON THE SUBSOIL

NÁVRH A VÝVOJ ZKUŠEBNÍHO ZAŘÍZENÍ PRO EXPERIMENTÁLNÍ MĚŘENÍ ZÁKLADOVÝCH DESEK NA PODLOŽÍ

Abstract

The paper deals with technical solutions and construction of a testing stand designed for experimental measurements of deformations and state of stress of foundation structures placed on the subsoil. The designed structural system, the analysis of internal forces and the range of maximal loading during experiments are described in detail. The testing stand was constructed in 2010 at the Faculty of Civil Engineering, VSB-TU Ostrava. The testing stand was ready for start of experiments at the end of 2010.

Keywords

Test Equipment, Interaction, Subsoil, Foundation, Static Load Test.

Abstrakt

Článek pojednává o technickém řešení a výstavbě zkušebního zařízení, tzv. standu, pro experimentální měření přetvoření a napjatosti základových konstrukcí na podloží. Podrobně je popsán navržený konstrukční systém, analýza vnitřních sil a rozsah možného zatížení při experimentálních zkouškách. Výstavba zkušebního standu v areálu Fakulty stavební VŠB-TU Ostrava byla realizována v roce 2010 a v závěru roku bylo zařízení připraveno k zahájení experimentálních zkoušek.

Klíčová slova

Zkušební zařízení, interakce, podloží, základ, statická zatěžovací zkouška.

1 INTRODUCTION

The paper describes the new testing stand which will be used not only for the static loading stress of the subsoil in accordance with ČSN 73 6190 but also for other experiments which investigate stress-strain conditions in the boundary between the foundation and subsoil. The testing stand should be sufficiently flexible because the planned experiments and tests will be variable quite a lot.

[1] Prof. Ing. Radim Čajka, CSc., Department of Structures, Faculty of Civil Engineering, Technical University of Ostrava, L. Podéště 1875/17, 708 33 Ostrava - Poruba, phone: (+420) 597 321 344, e-mail: radim.cajka@vsb.cz.

[2] Ing. Vít Křivý, Ph.D., Department of Structures, Faculty of Civil Engineering, Technical University of Ostrava, L. Podéště 1875/17, 708 33 Ostrava - Poruba, phone: (+420) 597 321 363, e-mail: vit.krivy@vsb.cz.

[3] Ing. David Sekanina, Ph.D., Department of Structures, Faculty of Civil Engineering, Technical University of Ostrava, L. Podéště 1875/17, 708 33 Ostrava - Poruba, phone: (+420) 597 321 363, e-mail: david.sekanina@vsb.cz.

The key requirement for the testing stand is to create sufficiently rigid supports with sufficient load-carrying capacity for the press which will compress the samples. The testing stand should be also able to compress the test body in any point(s) of the test area. The design takes also into account the extreme limit load when it is required to create the contact stress up to 150 kPa under reinforced concrete foundation with maximum dimensions of 2,500 x 2,500 mm. See Fig. 5. Such a stress is typically reached in building practice in foundation bottoms of the buildings. In order to reach the necessary stress in the subsoil contact, hydraulic presses should produce the force of F_k = 940 kN (94 t). The steel structure, anchoring elements as well as continuous strip footing incl. micropiles should be rated at this forces in most critical positions of the test area. The designing process was in line with European standards which are in force for building structure designing processes.

2 DESCRIPTION OF THE STRUCTURE

The structure of the testing stand consists of two main frames, see Fig. 1. On the bottom of the frames there are cross beams which can be adjusted in order to be able to change the location of the loading presses variably. The frame is anchored by means of T-head anchoring bolts into a steel grate placed in the continuous strip foundation made from reinforced concrete. Because of the size of the continuous strip footing, it is impossible to create a sufficient balance weight for the measurement. The total weight of the continuous strip footing is about 216 kN (21.6 t) and that of the steel structure is 69 kN (6,9 t), this being cca. 30 % out of the total required reaction. Because the own weight of the structure is not sufficient, the assembly needs to be anchored into the subsoil. It was decided to anchor the assembly using a system of micropiles with the planned length of the root being 4 m. The micropiles were welded onto the anchoring grate because tensile stress was too high and could not have been transferred using the concrete reinforcement.

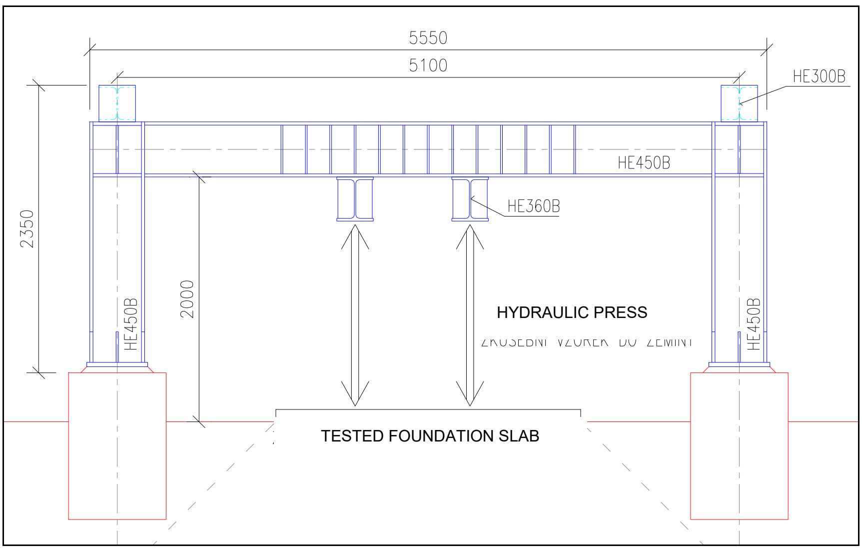

Fig. 1. Testing stand cross-section

Because the foundation should be deep enough, an area without any buried utilities was chosen. The facility will be located 2.2 m from a timber air-drying plant and 2.4 m from the edge of the park place. Fig. 2 shows the location within the site where the Faculty of Civil Engineering, Technical University of Ostrava, is based.

2.1 Geology

Source documents included the final report entitled OSTRAVA PUSTKOVEC – an additional building for FAST TU VŠB (K-GEO, s.r.o., Ing. Luděk Kovář, Ph.D., 03/2006). The final report says that layers there are almost horizontal with simple structure.

Pre-quaternary subsoil consists of loess loan mostly of solid consistence (F6 CI (CL) class) with the thickness up to 5.0 m. Then, there is a cca. 2.0 m thick layer of solid drift loam (F6 CI (CL) class)) which covers a cca. 3.0 m thick dense drift sand (S3 (S-F) class) and a cca. 5.0 m thick layer of dense mixture of gravel and sand (G3 class). Under a gravel layer, there is compact sand (S2 class).

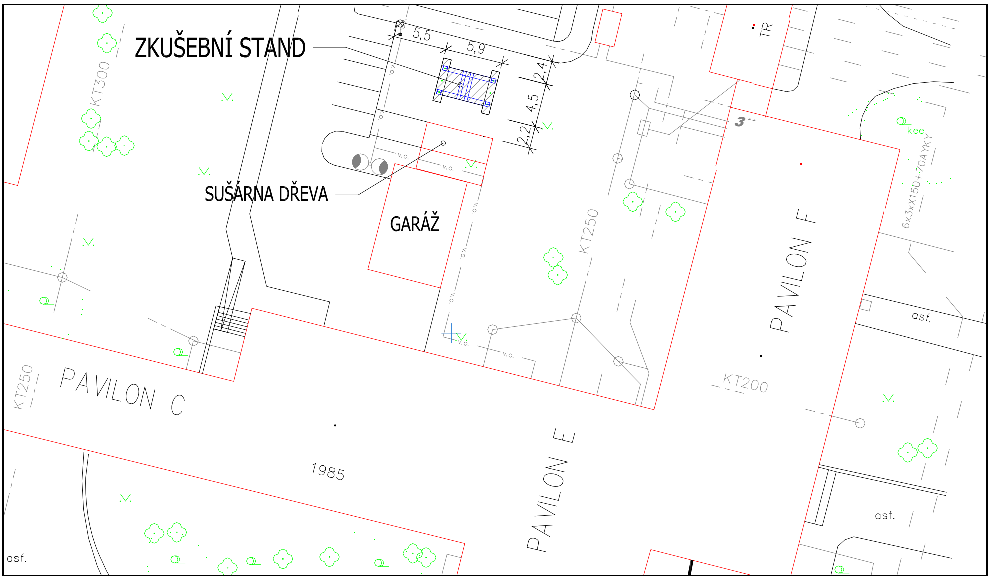

Fig. 2: Location proposed for the testing stand

2.2 Foundation structures and micropile anchoring into the subsoil

Because of the aforementioned tensile force, it was necessary to anchor the construction into the subsoil. In ditches excavated for the continuous strip footing, a drill rig drilled bores for the micropiles with the length of about 5 m. A steel pipe, 89/10 mm, was installed into the drill bores as reinforcement for the micropiles. Fig. 3 shows position of the micropiles. The steel structure was anchored using a steel grate made from U140 sections. Anchoring details are shown in Fig. 3 and Fig. 4.

A cement mixture (c:w = 2:1) was grouted under low pressure into the reinforced bores for the micropiles. The cement used there was Portland blast-furnace slag cement, 32.5R. Once the cement grout set and hardened, the same cement mixture was grouted under high pressure (2.5 MPa).

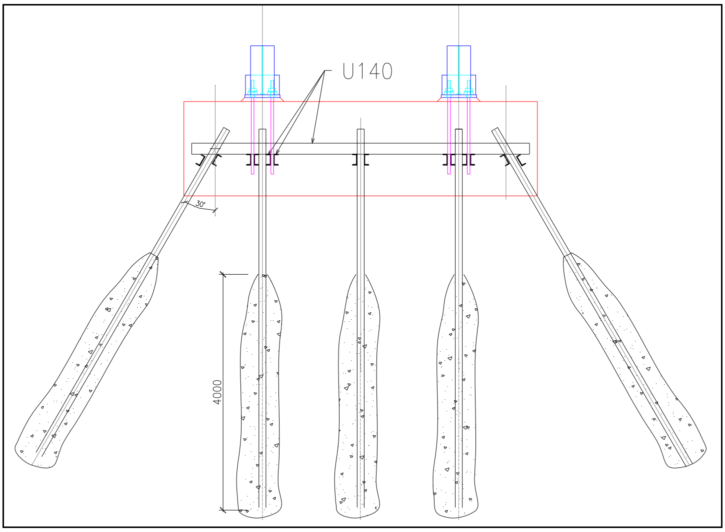

Fig. 3 Continuous strip footing with the micropiles and anchoring grate

Fig. 4: Detail of the continuous strip footing, anchoring grate and micropiles

2.3 Steel structure

The load-carrying steel structure consists of two hinged frames (height and bar length: 1,825 mm and 5,100 mm, respectively (the axial distances). The distance between the frames is 2,500 mm. See Fig. 5. The frame columns and frame cross beams are made from HE450B sections. Frame bracing protect the frame against buckling out of the plane. The frame bracing is created by the frame columns and bracing beams made from HE300B. The bracing beams are moment-attached to the frame corners by means of high-strength bolts. It was decided not to use simple latticed wind bracing so that the testing stand could be accessed in the test area from any site.

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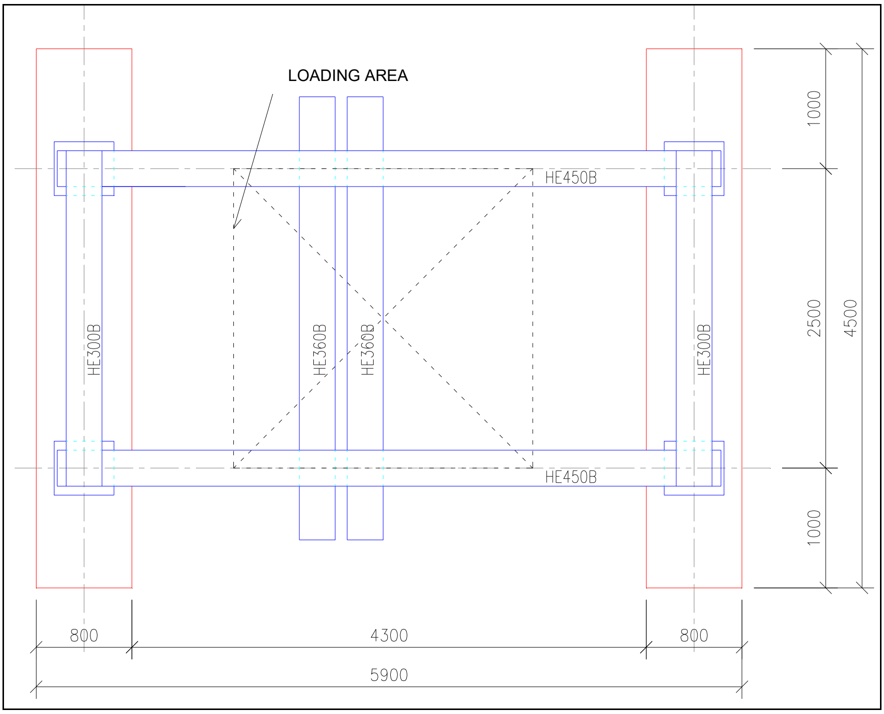

Fig. 5: Ground plan of the testing stand

When the hydraulic press produces the load, it is supported by a cross beam made from HE360B. The cross beam is bolted to the lower flange plates of the frame bars. Because the cross beam is loaded with an extensive local load and by load applied from the frame bars, it is essential to reinforce the elements by means of cross braces. The distance between the cross braces is 200 mm. In these spans, it is possible to choose the application point for the hydraulic press in the loading area of 2,500 x 2,500 mm.

Because the length of the cross beam is 3,700 mm and the HE360B weight is about 640 kg, it would be very difficult and potentially hazardous for operators to handle such a heavy element, so a simple facility was created to handle the cross beam easily. See Fig. 6. To facilitate the handling, two removable brackets made from the HE120A sections are used. The brackets are moment-attached on the upper flange plate of the cross beam. In the projected part of the brackets, there are wheels that would move on the upper flange plates of the frame bars. The removable brackets weigh 27 kg.

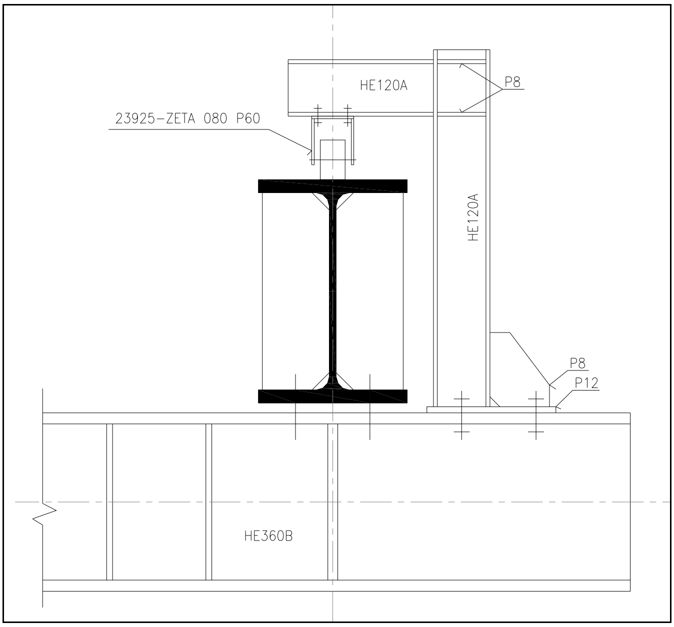

Fig. 6: Frame corner in the fitting of the reinforcing cross bar

The anchoring of the construction into the concrete foundation is rated at the designed tensile force in the column being 937 kN. A joint footing with four anchoring bolts, M36x3, made from the steel S355 is used there. At the end of each bolt, there is a T head which leans against a steel grate which is a part of the continuous strip foundations. The reinforcing footing plate is 35mm thick and the grout height is 50 mm. Tolerance for fitting the anchoring bolts into holes in the footing plate is ± 10 mm (it is assumed that the bolts will be fitted accurately before the concrete is poured, as they will be welded onto the anchoring grate). The bolts are protected over the footing plate by means of bolt caps.

The total weight of the steel structure (without the foundation grate) is 6,434 kg. All steel elements are made from the S355J0 steel. Zinc-coated bolts are made from the material with the 8.8 strength class. The construction is painted in accordance with ČSN EN ISO 12944-3 for the C3 corrosion aggressiveness. The steel structure resists explosion in accordance with EXC2 pursuant to ČSN EN 1090-2. Fig. 7 shows the construction design.

3 CONCEPT OF THE EXPERIMENTS

The testing stand was originally intended for static load tests with the maximum press load of 37 kN. After modifications, it is now possible to apply as much as 1 MN. The testing stand is flexible enough for various tests and testing positions. Using the testing stand, it will be possible to test models of the footings, strips, slabs.... The size of the models of the foundation structures will be limited by the cross dimension of the testing stand and size of the steel structure subject to the loading.

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Fig. 7: Completed structure of the testing stand in FAST VŠB-TU Ostrava

4 CONCLUSION

The paper discussed technical aspects of the testing stand used for experimental analyses of the subsoil-foundation structure interaction. Using the testing stand, it is possible to investigate into various models of the foundation structures which are in interaction with the subsoil, such as strips or slabs. It is also possible to replace subsoil layers which are being investigated.

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Reviewers:

Prof. Ing. Josef Vičan, CSc., Žilina University in Žilina, Faculty of Civil Engineering.

doc. Ing. Zora Hroncová, CSc., Žilina University in Žilina, Faculty of Civil Engineering.