ZESZYTY NAUKOWE POLITECHNIKI RZESZOWSKIEJ Nr 283
Budownictwo i Inżynieria Środowiska z. 59 (1/12/I) 2012

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ANALYSIS OF CONCRETE STRUCTURES AFTER INTERFERENCE IN THE SUPPORT SYSTEM OF THE BUILDING – PART 2

The paper describes the process of concrete structures after interference in the support system of the building. The material properties, experimental verification, static analysis of the structure and design of its reconstruction are described. Reconstruction of the bearing structures had to be carried out in a very short time.

1. Introduction

In this paper – part 2 (*Analysis of concrete structures after interference in the support system of the building – part 1* [1]), an example of the complex examination of the structure after unprofessional interference in the wing of the cellular framed structure is mentioned. The stress and deformation before and after the reinforcing of the support structure is analyzed. This paper emphasizes on the necessity for a serious diagnosis and restoration of the structure.

The technical solution of the renovation for the continuity reinforcement is showed in Fig. 1 and 2. The continuity of reinforcement was secured and supplemented by consequential welds joining the missing parts of the steel reinforcement bars. It was not possible to weld according to required norms because of poor accessibility to the areas that needed to be welded. The transverse fill was welded at each bar cut-off point and reinforced with an adjoining *L* cross section with dimensions of 35 x 35 x 5 mm.

Those sectional areas are the same as the sectional areas of the reinforcement bars and the length of the welds were designed according to the full original strength in reinforcement. According to the age of the structure and the shape of the bars the reinforcement was identified as E 10 216 with strength 210 MPa.

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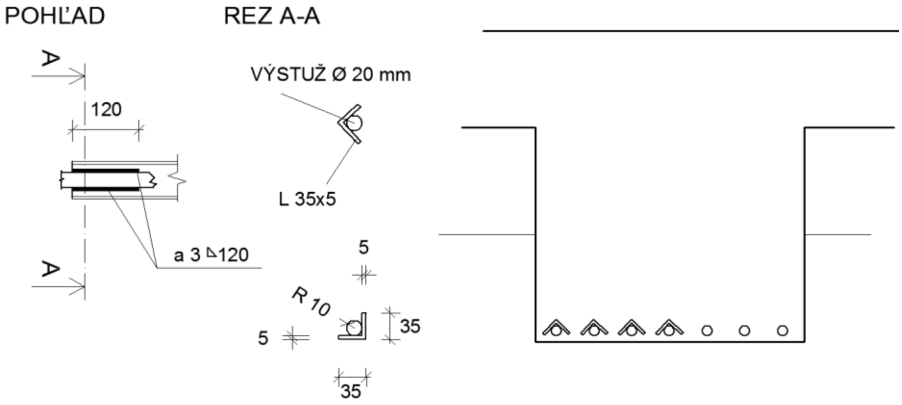

Fig. 1. The technical solution for renovation continuity

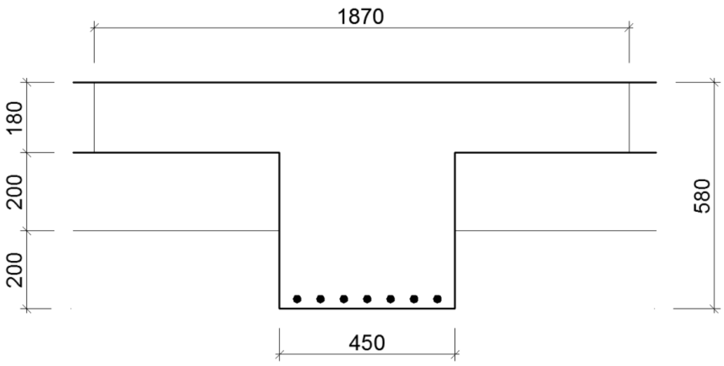

Fig. 2. Shape and dimensions of a section of the transverse beam after renovation in the continuity reinforcement

2. Analysis of the compromised structure, proposal and realization for its final reconstruction

Applying the Schmidt impact hammer, the strength of concrete measured 17,5 MPa which corresponds to concrete class C12/15. The beam is reinforced by 7 bars (20 mm, steel E10 216 with strength 210 MPa. The cover of the reinforcement is 15 mm. The effective width b_w was pinpointed as 1,87 m because this element constitutes a continuous structure, and co-operates with the slab.

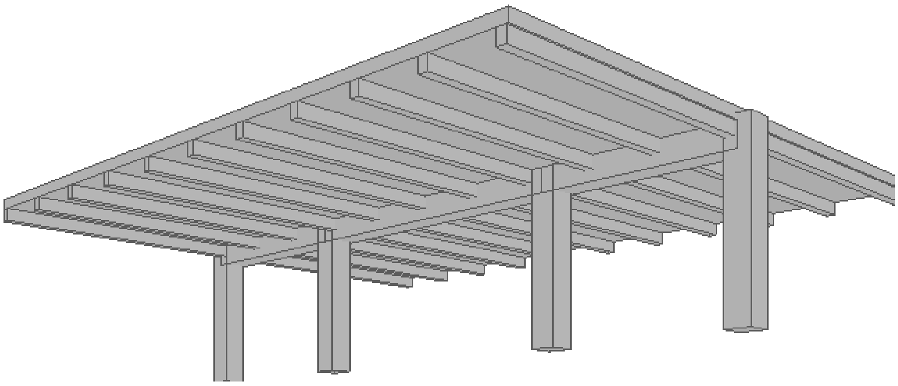

Fig. 3. Model of original structure

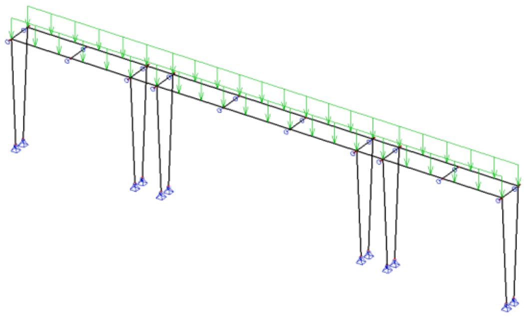

Fig. 4. Computing model utilizing a slanting column at the internal span of the frame

The bending resistance was measured at M_{Rd} = 217,5 kNm. The value of the load (including the constant and variable load), which was applied to the structure measured, is f_d = 29 kN/m^{-1}. After renovation to restore the bearing structure it was decided to strengthen the existing support using a steel support structure because of the impossibility of knowing the exact material characteristics, supplementary reinforcement and quality of the welds. The new steel support was designed to transmit 50% of the existing load valued at f_d = 14,5 kNm^{-1}, and the linear load on one beam assessed at f_d = 75 kNm^{-1}. The models of the construction and the calculation of the sectional forces were designed using the program SCIA ESA 2010 (Fig. 3 and 4).

The structure was modeled without any damage in order to find the most exact maximum loads (Fig. 5). The resistance of the *T* cross-section of the transverse beam was considered. From analyses the results signified, that the structure needed to be strengthened because of the damage and marked redistribution of the sectional forces. This information complied with our previous assumptions. The steel structure was designed to respect the demands of the client. The demands adhered to the underpass minimum height and the

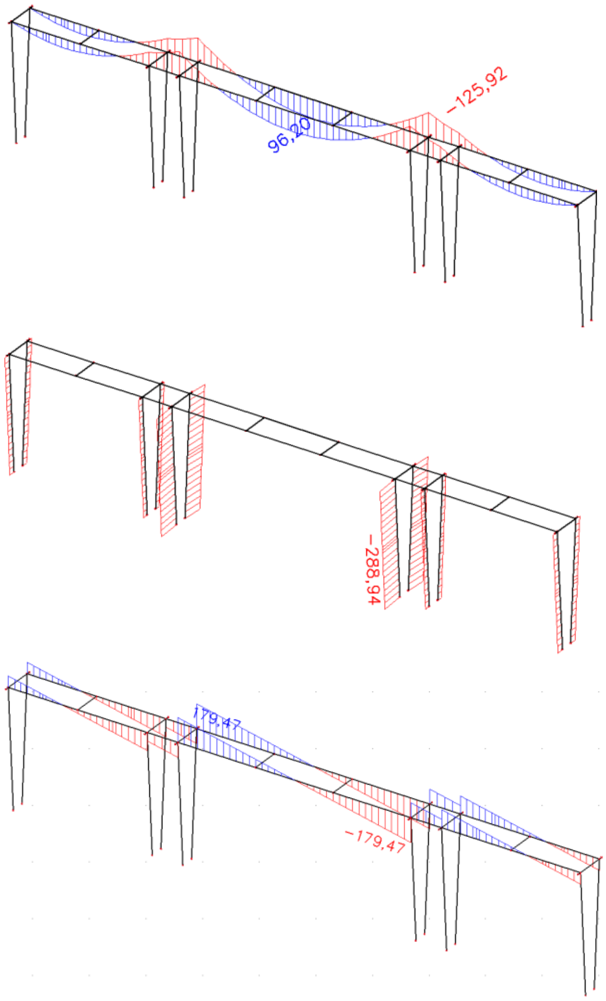

Fig. 5. Sectional forces acting on the model of the support structure

size of the edge spans of the reinforced concrete frame. The support of the structure below which consists of girders which are supported by a cross-beam frame was deemed the optimal solution (design) for the reconstruction.

The height of the steel sections was modified using a differential value between the height of the transverse beam and the height of the beams in Fig. 2 and 10. Supports were designed from steel pipes (Fig. 6-10).

Proposed cross-section elements of the steel construction were necessary to maximize the underpass height in the central span. Therefore a higher steel grade S 355 for the cross section 2 x U 200 was used. For other elements, steel grade S 235 (Fig. 10) was used.

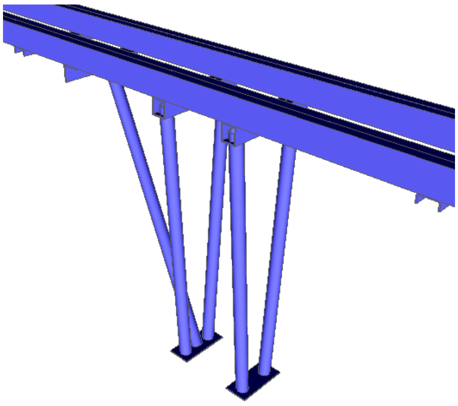

Fig. 6. Visualization of the steel structure with slanting columns

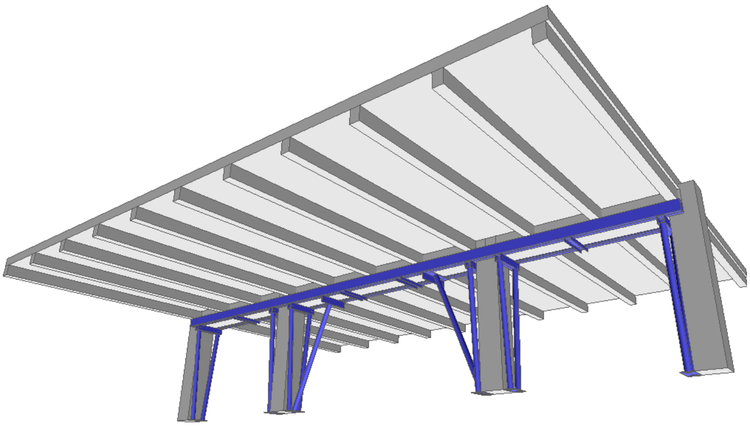

Fig. 7. Model of the support structure with slanting columns

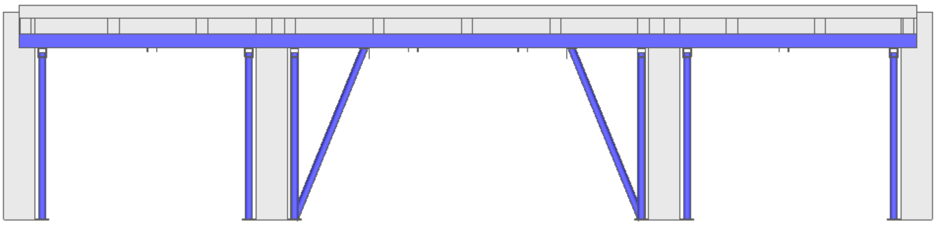

Fig. 8. Primary form of the plate, and below a three – dimensional model of the structure

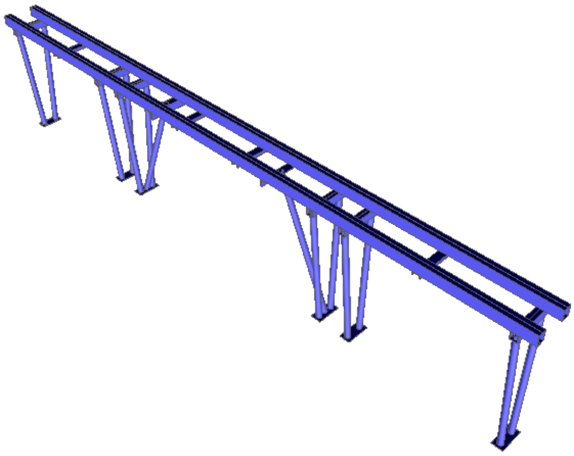

Fig. 9. Character and arrangement of particular elements for the additional steel support structure

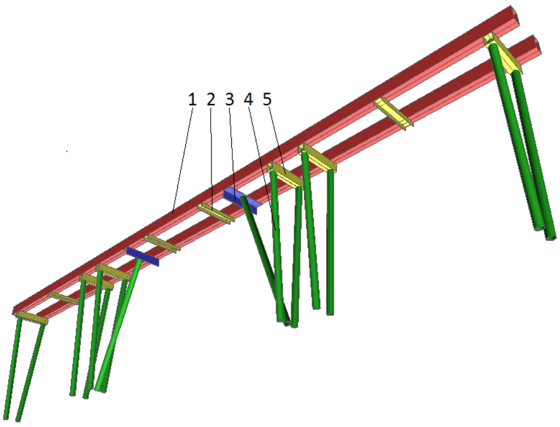

Fig. 10. Character and arrangement of particular elements of the steel structure model for additional steel structure – description in the table

In Figure 10 the cross-sections are color coded and numerical specified. Overall, 1952 kg of steel was required, 1228,5 kg thereof, S 355 grade steel and 723,5 kg is S 235 grade of steel (Tab. 1). The process for establishing the individual parts of the support construction was very simple. The lifting elements of the steel structure, used threaded bars as is documented in Fig. 11.

Table 1. Description of the steel elements

Number	**Type of cross-section**	**Steel grades**
1	2 x U 200	S 355
2	U 140	S 235
3	L 150 x 12	S 235
4	CFCHS 101,6 x 6,3	S 235
5	2 x U 140	S 235

Fig. 11. Process of installing the steel construction

Figure 12 illustrates the reconstructed view of the bearing structure. The continuous steel frame has an internal span with slanting. After the installation of all elements the construction was painted with an anticorrosive coating.

Fig. 12. Illustration of the load bearing structure reinforced by a steel frame

3. References

Despite almost immediate intervention and realization for strengthening the structure, long-term monitoring of the real behavior of the bearing structure, verified that the correct proposal for reconstruction was undertaken which eliminated any doubt of hidden damage and defects.

4. Conclusion

Sometimes „a small interference in the bearing structure of a building" by inexperienced workers can cause local failure that could result in very troublesome global consequences. We can conclude that the diagnosis must be made by experts. All responsible members must apply the correct analysis procedures and employ it for each particular proposal's specific conditions.

We can conclude that even small interventions in the building's support system must always be confirmed by an expert – designer, structural engineer.

References

[1] Priganc S., Kušnír Š., Sabol P.: Analysis of concrete structures after an interference in the support system of the building, XIII International Scientific Conference, Slovakia, Košice 2011.