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ANALYSIS OF CONCRETE STRUCTURES AFTER INTERFERENCE IN THE SUPPORT SYSTEM OF THE BUILDING – PART 1

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

1. Introduction

A change in the function of the building, resp. changes in the utilization of some parts may lead to radical changes in the static function of an entire bearing structure. In this paper, the complex analysis of the structure after unprofessional interference on a wing of the cellular framed structure is mentioned. The stress and deformation before and after reinforcing and strengthening of the support structure were analyzed. This paper places emphasis on the necessity of a serious diagnosis after a modification to the structure.

2. Actual situation

The building mentioned was constructed in the 1960s. Because of changes of function in certain parts of the building, an assessment of the relevant areas was conducted. Significant deterioration and failures at certain points in the bearing structures were found during the assessment. The bearing system consists of external masonry walls and a longitudinal three-span steel reinforced concrete frame, which supports the classical joist ceiling. The slab of the joist ceiling is continuously supported (Fig. 1).

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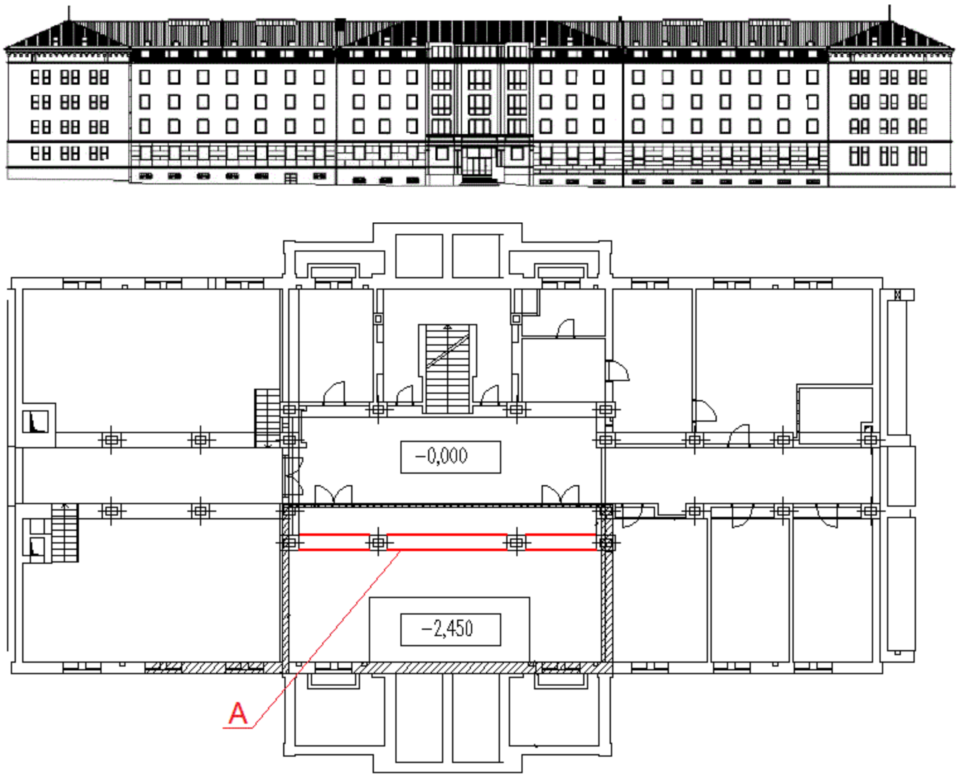

Fig. 1. Plan of the underground floor: A-RC frame

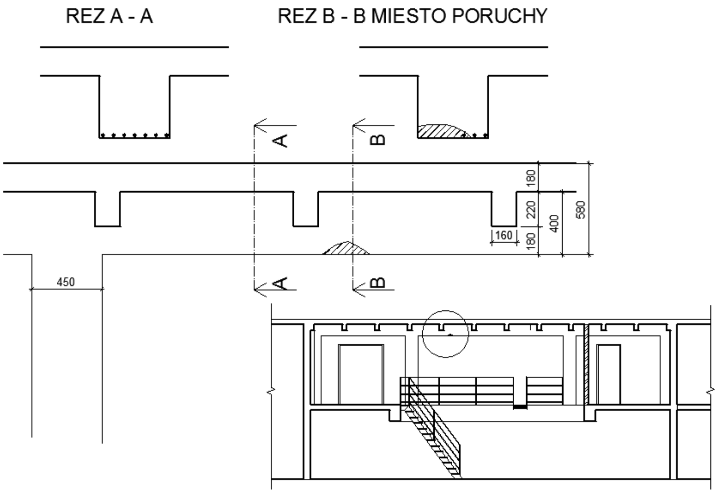

Fig. 2. Detail of part of the construction where interference in the support system occurred

There are four levels situated above the ground and one sublevel. The foundation strips and footings are located under the walls and columns. At the time of inspection, several reconstruction works were already in progress in these areas, removing old technology and preparing the structure for its new function. During the reconstruction many failures of the supporting structures were discovered.

Fig. 3. Illustration of the compromised (cut) reinforcements of the transverse beam

3. Changes of the structural support as a consequence of non-professional interference

By visual inspection alone, damage induced on the reinforced concrete frame was discovered. For example, many cracks in the transverse beam and in the reinforced concrete slab were visibly evident. The transverse beam contained many serious defects (Fig. 2). It was revealed that immediate action was required to prevent catastrophic failure. Part of the bearing reinforcement was cut from the transverse beam which is situated on the lowest floor (length approx. 250 mm) (Fig. 2). From a total number of 7 bars, 4 reinforcement bars were cut (Fig. 3).

This part of the frame is the most exposed, because it supports the entrance and congregating areas. The interference was unprofessional and dangerous. In consequence to cuts in the reinforcement, extension cracks on the bearing elements markedly decreased the rigidity of the structure; effects of which were visible on bearing elements and on their flanking bearing and non–bearing components. Indubitable was the deflection imposed on the transverse beam which was evident on the supported structure’s floor. An indication of the measured increase in the deflection was visible in the ceramic flooring, which responded immediately in the form of continuous surface cracks (Fig. 4).

Fig. 4. Illustration of the cracked floor above a part of the ceiling which was subjected to damage from failure in the transverse beam

4. Diagnostic structure

The defects were so explicit, that there was an immediate need for intervention. It was imperative to make several operative steps, without any additional observation. The transverse beam was propped up by timber columns and all other reconstruction work was stopped (Fig. 5).

Fig. 5. Illustration of the propped up columns supporting the transverse beam

All steps were immediately followed up by a diagnosis of the bearing structure, which documented and measured all cracks that arose: their width, position and inclination. Widths of the cracks were measured using calipers, the positions of the cracks were measured with measuring-tape and their position was drawn and documented according to standards. All activities were photodocumented. Passive cracks were monitored immediately after the location of the damage. A gypsum target was set for the bearing elements that suffered the most damage; the transverse beam, beams and continuous slab respectively (Fig. 6).

Fig. 6. Illustration of the gypsum targets for the transverse beam, beam and continuous slab

In reference to some of the knowledge gained from the measured and documented cracks, it was found that the slab, had repeated lengthwise cracks perpendicular to the primary reinforcement slab. Timber columns were erected in the midrange of the continuous slab. The most damaged areas, contained cracks that were up-to 1 mm wide. Important slanting cracks were found in the beams, at the connections of the transverse beam connected with widths larger than 0.5 mm. An overload of the shearing resistance induced on this element was the second problem that needed urgent attention. Significant perpendicular cracks in the longitudinal axis were found in the transverse beam that suffered unprofessional interference - cuts in parts of its reinforcement. Cracks were located at the transverse beams connection joints, parallel to either side of the beam closest to the fault where unprofessional interference occurred. The cracks were located throughout the height of the transverse beams and continued onto the horizontal cracks of the slab. The cracks separated the transverse beam into quasi-separate blocks joined lengthwise by reinforcement bars. It was a clear expression of overload due to excessive shearing resistance placed on the transverse beam. This unprofessional interference on the bearing structure caused many problems in the building’s ability to function.

5. Results

All diagnostic processes had to be conducted post haste. Increased attention was paid to following the deformation of the gypsum target, measuring the real dimension elements and strength characteristics of the concrete and reinforcement. The dimension elements of the frame structure and elements of the timber ceiling were checked using measuring-tape (Fig. 7).

Fig. 7. Measuring the dimensions of particular structural elements of reinforced concrete frame

The client did not provide any original building documentation for the bearing system. It was therefore necessary to prepare the relevant background papers for examination of the bearing structure. Consequently an additional task was to find out the strength characteristics of the concrete that had to be inspected using non–destructive methods - Schmidt impact hammer type N (Fig. 8). Homogeneity of the concrete was checked by means of an ultrasound apparatus.

Fig. 8. Non-destructive method of determining concrete strength by means of Schmidt impact hammer tests

Particular attention was addressed to documentation of the reinforcement. The position and number of the reinforcing bars were detected using non-destructive methods by applying a magnetic indicator known as a Profometer. The diameters of the bars were determined by measuring the diameters of the uncovered reinforcement at critical cross-sections areas. A rusted reinforcement bar was cleansed before measuring its diameter. Diameter of the reinforcement was measured using a slide caliper (Fig. 9).

Fig. 9. Cleaning of reinforcement and consequent measurement of its diameter using a slide caliper

The diameter of the reinforcement was determined and the position of the reinforcement was drawn under the slab (Fig. 10). The same methods were used to find the diameter of the reinforcement in the transverse beam and slabs (Fig. 11).

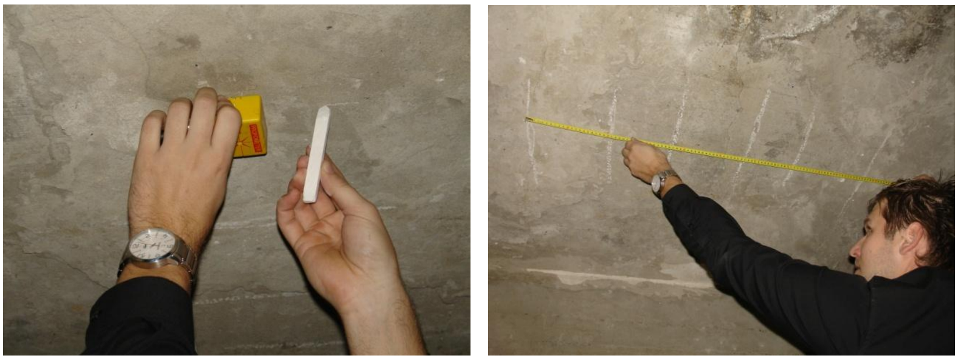

Fig. 10. Position and marking of the reinforcement on the flooring plate of the ceiling using a magnetic indicator – Profometer

Fig. 11. Position and marking of the reinforcement in the frame and in the transverse beam using a magnetic indicator – Profometer

6. Stabilizing the bearing structure and a consecutive analyses

After the defects were found, an effort was made to stop the process of infringement on the bearing structure. The load bearing capacity of the cut-off reinforcement was restored post haste. In parallel the gypsum target was monitored. In the course of three days from the moment of interference all targets were damaged. It was a clear signal of an infringement in the structure. Renovation of the bearing structure was secured and missing reinforcement was supplemented and welded to restore the load bearing capacity. (Fig. 12).

Fig. 12. Restoring the load bearing capacity of the beam by welding and rejoining the cut reinforcement

7. Conclusion

A „small interference in the bearing structure of a building” by inexperienced workers can cause major local damage and cause negative global consequences. A follow up paper will focus on the needs for a diagnosis and reconstruction plan and realization of the damaged structure.

References

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