Reconstruction of an Office Building, Roosevelt Square, Budapest

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Introduction

The building is located in downtown Budapest and is opposite the Chain Bridge. It has an 'L' shaped form(80 × 60 m) with a yard (15 × 30 m). It is a 7 and 12 storey building first constructed in the mid 1970's on the site of a Second World War bombed ruin and has a total office space of 35 000 m² and a single level parking facility underground.

The flat slab structure was built with three expansion joints and three stiffening cores. The expansion joints were placed at 1/3 distance from the supporting columns. The distance between the columns was 7,50 m and the slab thickness was 21 cm (*l/35,5*). On the main facade side, the slabs had three different protruding dimensions: 0,75 m, 2,25 m and 3,75 m, where the light prefabricated facade elements were hung.

The construction was originally executed using tunnel formwork, the reinforcement in the slab consisted of hand made large diameter wire fabric (Ø16–Ø20/7,5–20 cm, bar distance). The slabs had 3,0–7,0 cm deflection hence screeds were needed to level the floor. The design live load was 2 kN/m². Steel beams or bent reinforcing bars were used against punching.

Reconstruction Work

Originally the facade was dark green in color and it was often referred to as the "Spinach House". Since the building was not very popular, the new owner wanted a reconstruction whereby the building would get a new modern architectural look and create more functional office space.

The winner of the International Architectural Competition gave no consideration to the structure or the existing stiffening core; hence new ideas had to be developed. The new architectural concept lowered the building in one part by three stories and raised the building at another part to fit with the surrounding buildings. The remaining facade was cut back which increased the yard in size allowing more natural light into the office areas and a newly made "cap" gave the impression of a fifth facade to the building when viewed from Castle Hill, which was part of the new concept, as shown in *Fig. 1.*

Structural Consequences

The new architectural concept caused the following structural problems:

- Closing of the existing expansion joints on the slabs.
- Increasing the load bearing capacity of the existing columns and foundations.
- How would the existing thin flat plate structure react to cutting out large openings (5,0 × 6,0 m).
- Construction of a new building part in the existing yard and connection with the old structure.
- Shortening of the protruding cantilever length.
- Rebuilding of the existing cores, because of better operation and to make place for modern building services.
- To increase the height below ground level to increase the possibility of a double-parking system.

The answer to the structural problems was to first re-analyze the existing structure and reinforcement to give a clear starting point, second to use carbon-fibre with fire protection at the cut corners of slabs to strengthen the load bearing capacity and to prevent diagonal cracking. Third, to use confinement of columns with Fiber-reinforced Polymer (FRP) wrapping to increase the load bearing capacity. Fourth, to strengthen the foundations with grouting. Fifth, to give more space at parking level by lowering the floor level and reducing the earth covering on the pad foundations but counterbalancing the load bearing capacity of the foundation with a reinforced floor-plate.

Closing the Existing Expansions Joints on Slabs

The expansion joints divided the original building into three parts; each building part had a stiffening core, as shown in *Fig. 2.* The strength of these cores was reduced by new openings, so the horizontal stability of each part was decreased.

Fig. 1: The office building before and after reconstruction

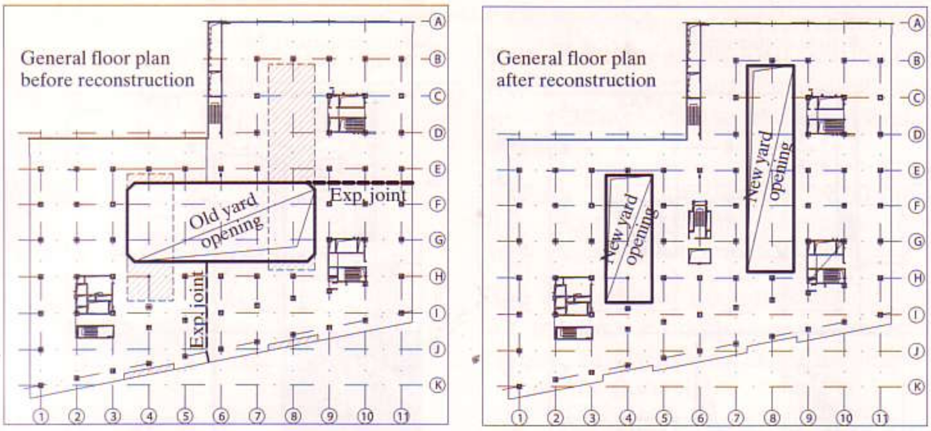

Fig. 2: Reconstruction of general slab

The existing expansion joints "crossed the new building section" which was designed in the middle of the old yard, and so it was not possible to keep the expansion joints in the same place. To make new expansion joints would cause instability of the structures. But by closing the expansion joints, global stability of the building could be increased. Therefore, it was decided to close the existing expansion joints by cutting back a part of the old concrete slab and by putting additional reinforcement in, before new concrete was laid. The design philosophy was that the largest movement had been coming from shrinkage and this was over the past 30 years. Within the finished building which measures 70 × 80 m the movement from temperature is very small, and can be absorbed by the structure.

Increasing the Load Bearing Capacity of Existing Foundations and Columns

Originally one part of the building was lower than the other so it was heightened, and during rebuilding the live load capacity was increased from 2 kN/m² to 3,5 kN/m² to provide more flexibility for use as an office area.

Because of these modifications, it was necessary to strengthen some of the foundations by injection grouting and strengthening the columns using the FRP wrap system. "Jet-grouting columns" were designed with a diameter of 80 cm and with a length of 5,0 m. The control measurements for the soil strength showed 5000 kN/m², and 1,5 mm settlement (*Fig. 3*).

The number of FRP wrap sheets varied from one to four layers. The design increase of maximum load bearing capacity depended on required increased loading. The maximum increase of the

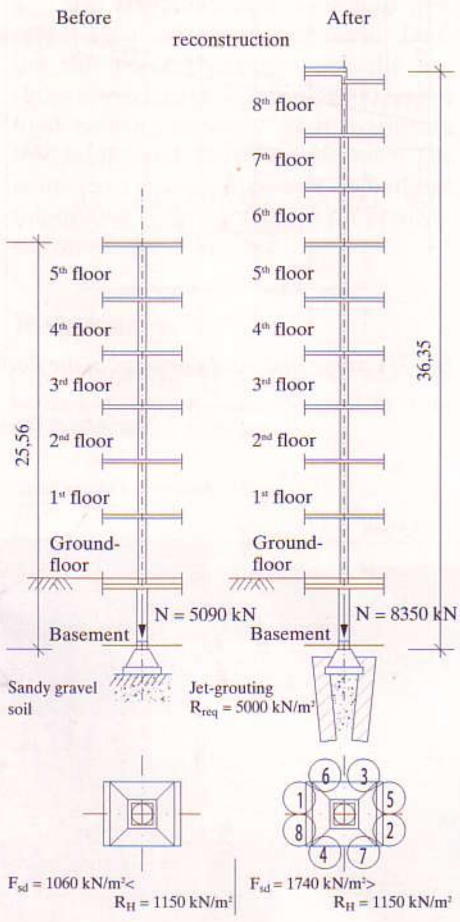

Fig. 3: Increasing the load bearing capacity of existing foundations

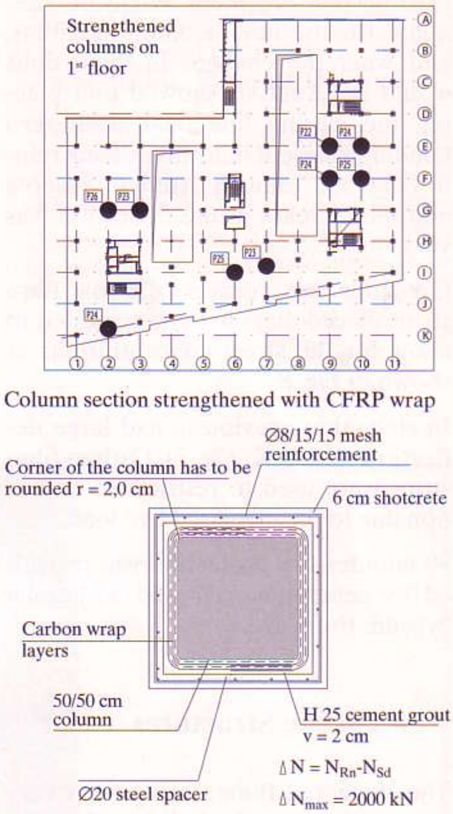

Fig. 4: Increasing the load bearing capacity of existing columns

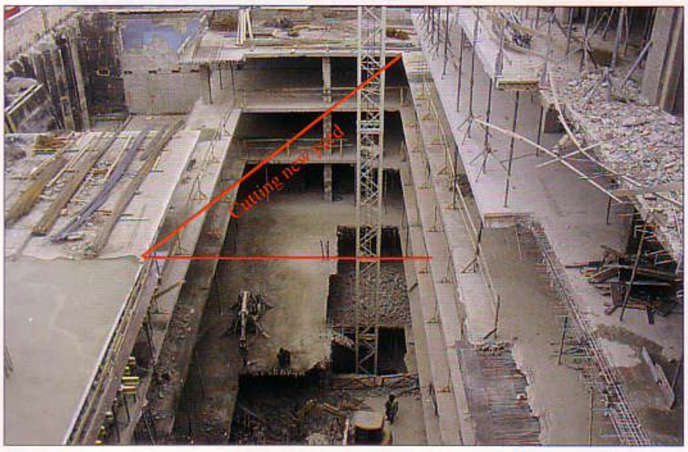

Fig. 5: Cutting new yards openings on the floor slabs

Fig. 6: Reinforcement in existing slab at cutting edge

load bearing capacity was 2000 kN for one column with a 50 × 50 cm cross-section and C20 concrete strength originally. The FRP was given 6 cm thick fire protection from shotcrete, as shown in *Fig. 4*.

Cutting New Yard Openings in Floor Slabs

To achieve a more functional building the architect proposed to close the old yard and make two new yards by cutting through the existing floor slabs, as shown in *Figs. 5, 6, 7*. These "simple geometrical transformations" resulted in new boundary conditions for the slabs. The question was, whether the existing reinforcement would be adequate for the new bending moments, and what the changes in deflections would be. Analysis showed that placing the cutting line near to a zero bending moment line, the existing reinforcing had enough strength reserve and the increase in the deflection was very small.

On some cut corners, Carbon fibre strips placed diagonally were added to allow for the stress concentrations as shown in *Fig. 8*.

In slabs that previously had large deflections (1-2/J-K, *Fig. 7*), Carbon fibre strips were used to restrict the deflection due to the increased live load.

90 minutes fire protection was provided by cement mortar and additional gypsum fireboard.

New Facade Structures

The staggered floor slabs gave a very unusual look to the building. (*Fig. 1*). The maximum protrusion of the 21 cm thick floor slab was 3,75 m (*375/21 = 17,8*).

To follow the architectural concept of the new facade on the upper floor slabs it was necessary to reduce the overhang of the slabs, and at lower floor slabs to extend them, as shown in *Fig. 9*.

To improve heat insulation and to be able to build a modern facade a new concrete wall was designed, which was supported on the foundation of an earlier building which existed before the Second World War, and until now had been covered by the pavement. This new reinforced concrete (RC) wall gives support to the floor slabs.

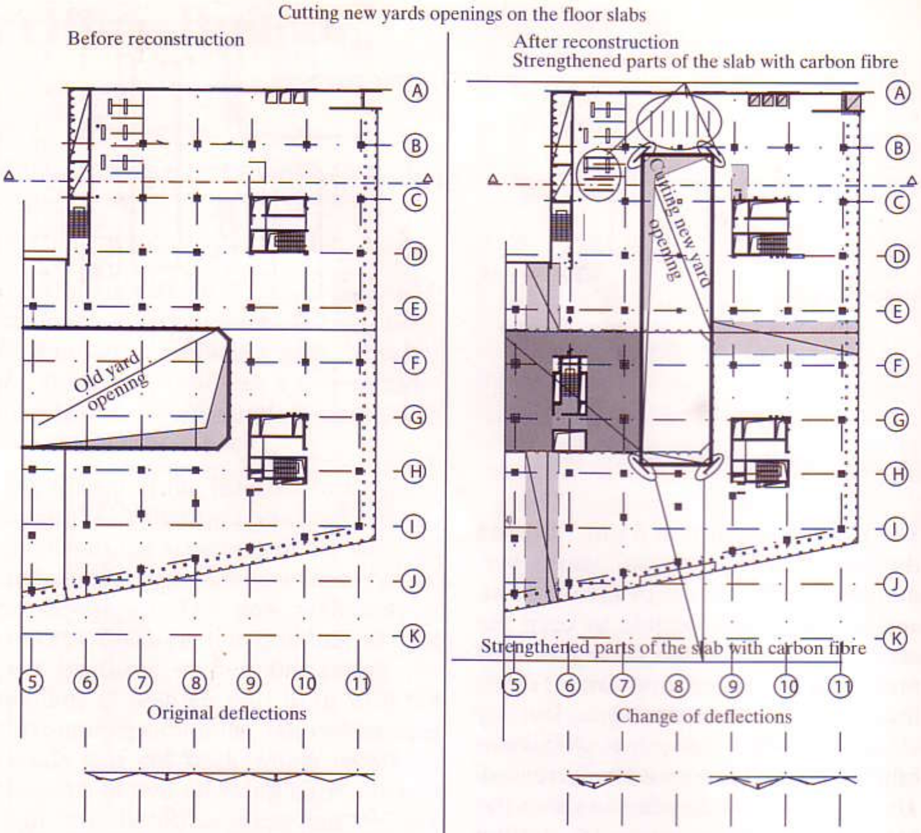

Fig. 7: Cutting new yard openings in the floor slab

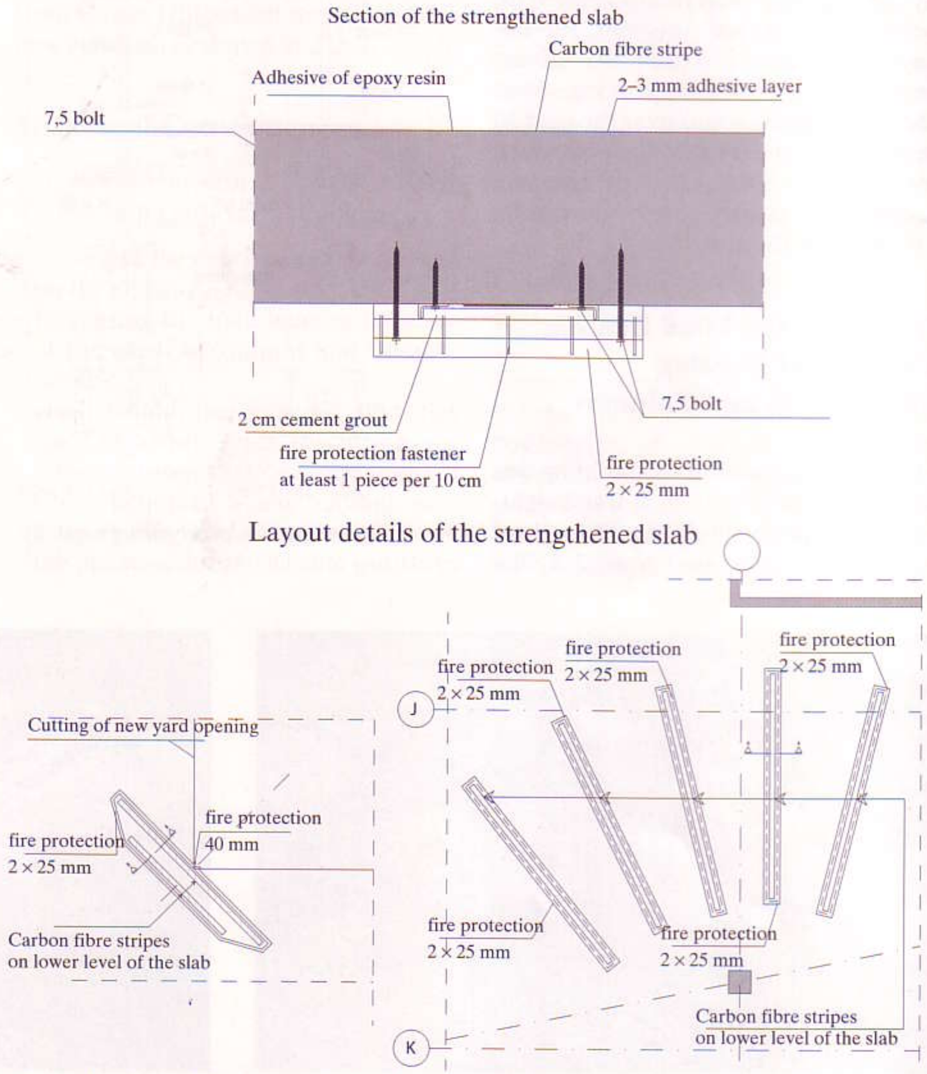

Fig. 8: Details of slab strengthened with carbon fibre stripes

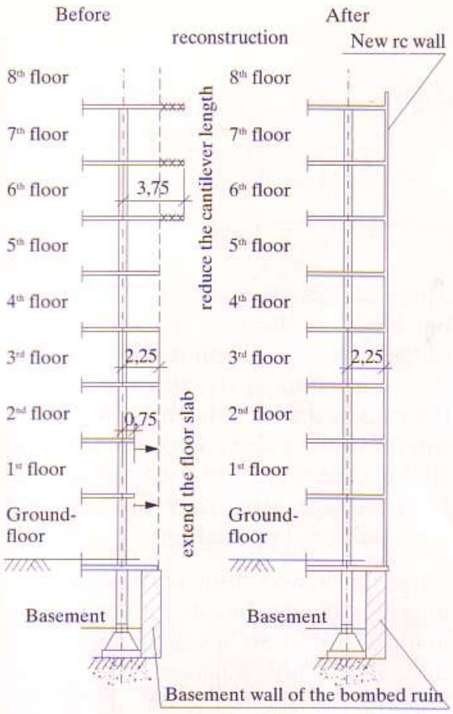

Fig. 9: The old and new facade structure

Conclusions

The reconstruction work was finished in 2005. There were no problems (cracks) from closing expansion joints after one year. The increase in load bearing capacity of some existing foundations was successful according to settlement measurements.

It is the first time that FRP wrapping has been used in Hungary for strengthening columns and slabs.

The changing of boundary conditions for the slabs by cutting new openings caused hardly any measurable deflection at the floor slabs.

The rebuilding of the structure was finished without any major problems, and the structural solutions and new materials used, were successful. During the reconstruction work the authors experienced the kind of "reserve load bearing capacity" that existed in the integrated structure because the contractor on many occasions had not taken care of the temporary propping as shown on the drawings.

References

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[2] FIB TASK GROUP 9.3 FRP REINFORCEMENT FOR CONCRETE STRUCTURES. Externally bonded FRP reinforcement for RC structures, July 2001, pp. 130.

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SEI Data Block

Owner:
Bayerische Hausbau, München, Germany

Structural design:
Cronauer Almasi Eng. Consulting Kft., Budapest, Hungary

Contractors:
Architekton Rt. Godollo, Hungary

Office area (m²):	35 000
Cost of structural reconstruction (EUR millions):	4,10