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strengthening solutions

case study

FROM THE PLANNING ENGINEER'S POINT OF VIEW

Addition of punching shear reinforcement with re-bar 16

Project:	Shopping center
Location:	Winterthur ZH, Switzerland
Engineering office:	Knapkiewicz + Braunschweiler AG
Contractor:	Hans Stutz AG, Winterthur
Year:	2024

Overview

A large retailer opens a new branch in a shopping centre in Winterthur. Part of the retail space was built in 1977 and has a ceiling slab made of reinforced concrete.

Problem

Due to the new client's demand for higher working loads in the sales area, the ceiling had to be structurally reinforced.

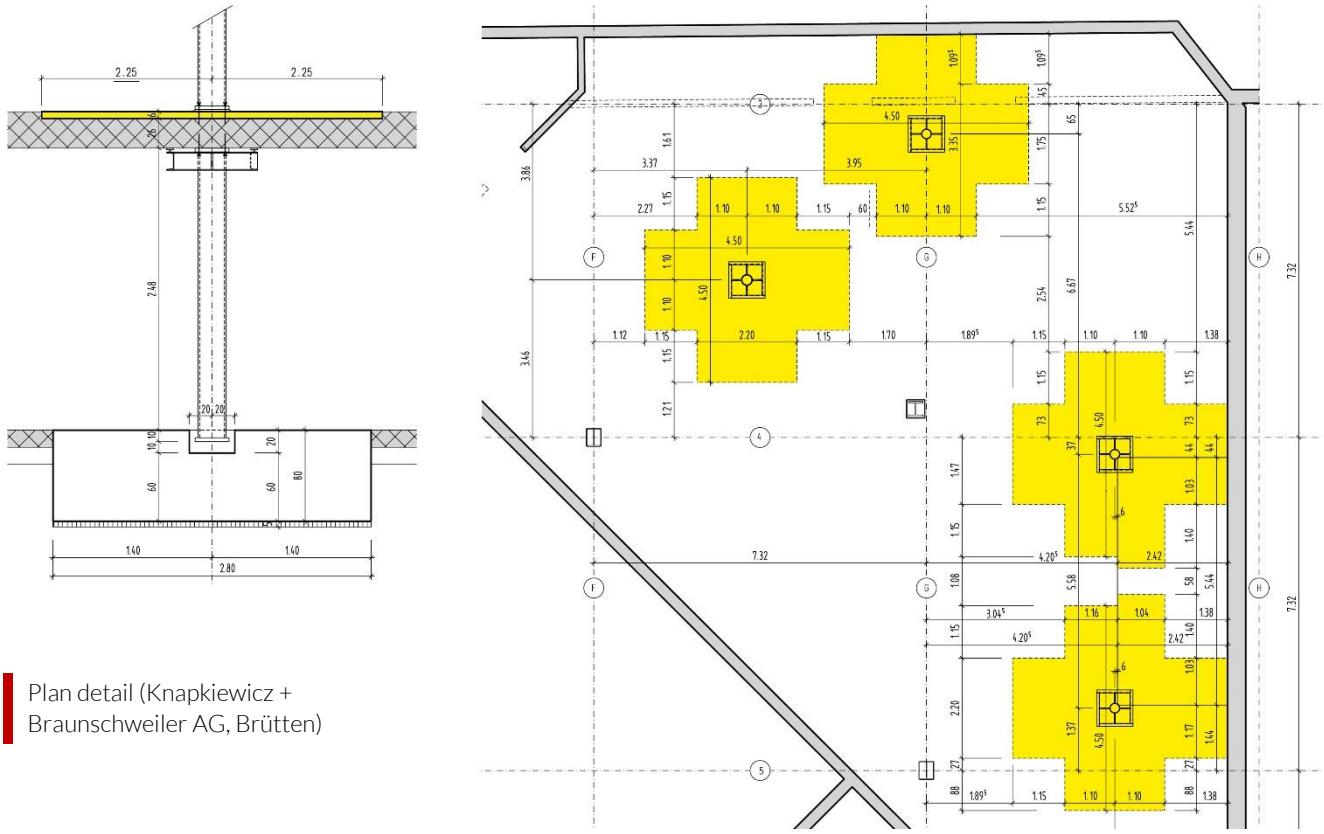
Four additional columns were required in the basement to absorb the increased loads and relieve the ceiling accordingly.

Old stair openings in the ceiling had to be filled with concrete. In the area of the new columns, the upper bending reinforcement was therefore completely missing or too weak. There were deficits in the bending reinforcement - both on the underside of the ceiling and above the supports.

Solution

Additional CFRP laminates on the bottom of the ceiling cover the increased positive bending moments.

The four new columns in the basement were placed on individual foundations, which were embedded in the



Plan detail (Knapkiewicz + Braunschweiler AG, Brütten)

existing concrete floor. The column heads were fitted with external steel mushrooms. On the top of the ceiling, 16 bars were installed in these areas as prestressed bending reinforcement. In combination with the steel mushrooms of the column heads, this achieves the required punching shear resistance. At the same time, the newly arising negative bending moments are also covered.

To install the re-bar reinforcement, the concrete surface in the area of the negative bending zone was hydromechanically removed in advance and the bars were then positioned. The end areas for the anchoring over a length of approx. 1.00 m were then filled with SikaGrout®-314. A small mortar bed was made as formwork and a suitable timber formwork was mounted on top of it.

Once the anchoring zones had hardened sufficiently, the bars were heated to a temperature of 300°C using a gas burner in order to create the shape memory effect and thus the prestressing. Finally, the free length between the anchoring zones was also filled with cement to create a system that was fully bonded with the concrete.

Hydromechanical removal

Reinforcement areas, waste disposal

System benefits

HIGH DUCTILITY OF RE-BAR: This allows the ceiling in this area to undergo the necessary deformations to properly utilise the load-bearing structure. The existing reinforcement and any steel stiffeners or punching dowels can be sufficiently activated.

ACTIVE RE-BAR REINFORCEMENT: From the start, the reinforcement is at a comparable stress level to the existing reinforcement. There are no additional deformations and associated concrete cracks (serviceability). There is also no need, for example, to relieve the concrete slab with hydraulic presses beforehand.

SIMPLICITY OF THE SYSTEM: The reinforcement can be installed and prestressed without hydraulic presses. There is also a very high degree of situational adaptability; the bars can also be fitted with end hooks to transfer forces even more robustly into the core concrete.

NOTE: CFRP laminates are unsuitable for these purposes in accordance with the SIA 166 standard and are only permitted under very special conditions. The reason for this is that their load-bearing behaviour is too brittle, and the peaks of the bending moments cannot be redistributed.

Preparation of formwork

Mortar bed and wooden formwork

Grouting the anchoring areas

Grouting with SikaGrout®-314 N

Hardened anchoring areas

Activation of re-bar with gas and temperature control

Notes on planning

The quality of the substrate is crucial for concrete repairs. Care must be taken to ensure clean substrate preparation. The best results are achieved using ultra-high-pressure water jetting (HPW). The concrete can be removed cleanly without causing microcracks or other damage to the substrate. As an alternative, manual 'peeling' using a pointed hammer would also be conceivable. In this case, however, subsequent sandblasting is necessary for a clean and crack-free surface. Furthermore, the substrate must be pre-wetted until capillary water saturation (for at least 24 hours).

The SIA 262 standard can be used as a guide for concrete coverings. However, the crossing points of re-bars must be considered (sometimes with screw couplers). Small unevennesses and distances between the bars and the substrate (for sufficient mortar covering) must also be taken into account.

re-fer can provide assistance for anchoring the re-bars. The minimum required adhesive tension strength of the substrate (1.5 N/mm^2) can be used as a guide. As an alternative, end hooks can also be used on re-bar. The anchoring is carried out in the core concrete by drilling holes and using the anchor adhesive Sika AnchorFix®-3030.

Caution: No third-party products (construction foam, polystyrene and other chemical and chlorine-based components) may be used. Otherwise, decomposition products such as chloride will remain in the concrete or on the iron after the heating process.

If the existing reinforcement is visible after HPW removal, electric heating is recommended to avoid heating this reinforcement.

Rough cost estimation (Switzerland)

For an initial project study, it is helpful to carry out a rough cost analysis. re-fer is happy to help with this. Such information should always be treated with caution! The contractor's capacity utilisation, current product or energy costs and the size of the project have a noticeable influence on prices. In the case of this project, this was as follows for the most important positions:

HPW-Removal: Total approx. 4 x 15 m^2 with a depth of 60 mm = 3.6 m^3 → One worker with a hand spray lance removes around 0.5 m^3 per day and costs around 1'600 CHF → total costs **approx. 11'500 CHF**

Demolition disposal: This produces around 3.6 m^3 of rubble → approx. 600 CHF/m^3 → **approx. 2'100 CHF**

re-bar 16 Stäbe Delivery and installation: Total approx. 470 m → approx. 235 CHF/m for material, installation and activation → total costs **approx. 110'500 CHF**

Wooden formwork: Total approx. 35 m → around 35 CHF/m → total costs **approx. 1'200 CHF**

Mortaring: Total around 3.6 m^3 → approx. 1'700 CHF/m^3 → total costs **approx. 6'100 CHF**

Site installation: For HPW-removal and mortarin, approx. 10% site installation is added → total **approx. 1'700 CHF**

Contingencies: additional surcharge of 10% on the total sum → **approx. 13'300 CHF**

In total, this results in approximate rough costs of **approx. 146'400 CHF**. (Check: the actual construction costs in this case were around 9% lower).

Additional work such as the removal of flooring etc. and other strengthening work (columns, CFRP laminates) are not included in this estimation.

> *A complete system that is totally convincing.*
>
> Urs Braunschweiler, Knapkiewicz + Braunschweiler AG