Full Refurbishment of an Office Building in Innsbruck

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ABSTRACT: For the full refurbishment of the AK office building in the center of Innsbruck some new technologies of MBT have been applied very successfully such as slim floors with semi-continuous beam-to-column moment connections and local load introduction from the slabs into the steel-concrete hollow columns by powder actuated nails. During construction work the offices in the upper stories were normally used. The final result with considerable gain of space and improved architectural appearance without soil settling or cracks worth mentioning was highly appreciated by the client.

KEYWORDS: semi-continuous beam-to-column moment connections, local shear introduction into the hollow column by powder-actuated nails and bolts, slim floors

1 INTRODUCTION

The five storey office building of the “Arbeiterkammer” (labour chamber) in Innsbruck dates back to the 19th century. The main construction material was brick with some concrete and steel elements due to previous reconstructions.

Figure 1. AK office building before and after refurbishment

The unsatisfying situation in view of the entrance location, room arrangements, multiple different floor levels, dark corridors and overall architectural appearance led to the demand of a generous refurbishment of the lower levels – ground floor and cellar – whilst the upper four floors should be continuously used as offices with a lot of client contacts.

By lowering the ground level of the cellar for 1,5 m the gained overall room height allowed for the creation of an additional mezzanine. The extension of the cellar walls downwards into the ground was realized with a compaction grouting system. Very stiff, low slump mortar is injected into the soil with very high pressure – displacing and compacting the existing soil in place. This also ensured the foundation capacity in view of the new and increased building loads without considerable additional soil settling.

Beginning in April 2002 the massive brick walls of up to 80 cm thickness where replaced step by step by very slender composite columns and a load transferring beam grid at their top. The load introduction from the concentrated column bases into the existing cellar walls was taken over and spread by a massive concrete basement girder. To fulfill the actual normative requirements especially in view of accidential loads also some remaining floor and wall elements were identified to need strengthening or even had to be replaced.

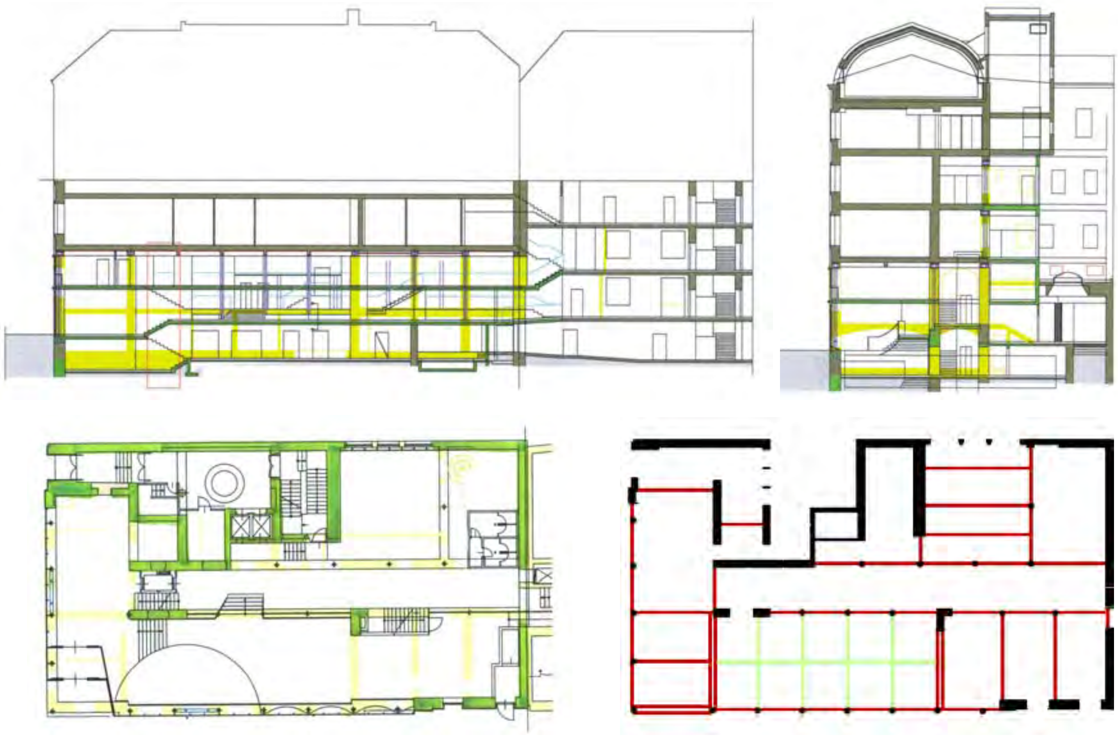

Figure 2. Overview of the refurbishment – replacement of brick walls by a column and beam grid

2 COMPOSITE COLUMNS

The existing walls between the level of 0,0 and 6,9 m where replaced by steel-concrete hollow columns with a diameter of 22 or 25 cm. The load introduction at the bottom and at the top was realized with simple top/bottom plates. The introduction of the floor loads docking to these columns takes place in the following way. The slim floor steel beams are supported by steel brackets welded to the column tubes. The further load transfer from the steel tube to the interior chamber concrete is ensured by nails which are placed powder actuated in the shop or on site.

As already well-tried at the floor connections of the Millennium Tower in Vienna the Hilti fasteners X-HVN32P10 have been applied. These are nails which are also used for conventional fastening purposes.

According to Eurocode 4 shear connectors have to provide sufficient resistance against uplift; in the actual application case of a chambered concrete such uplift is automatically prevented and though the nails can be applied without further measures. Despite of high strength steel material of the nails they proved to behave very ductile due to the chamber effect within the hollow steel section and therefore could be classified as ductile connectors.

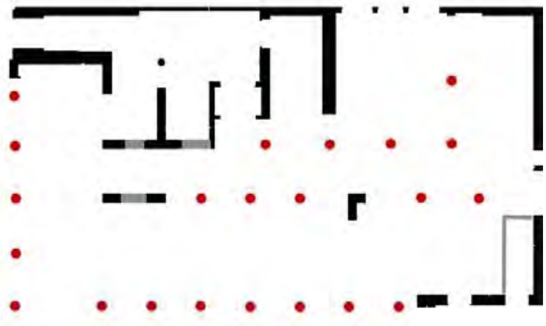

Figure 3. Column grid replacing the old brick walls

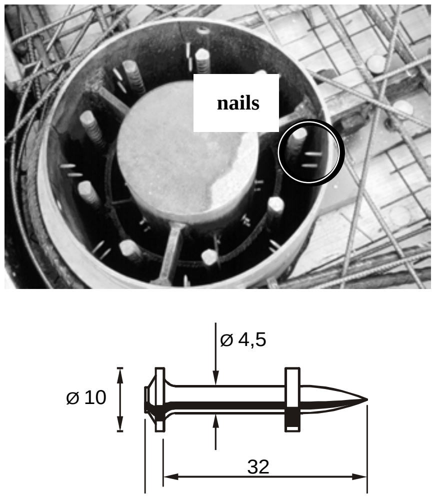

Figure 4. Powder-actuated fasteners (nails) for shear transfer (foto Millennium Tower)

Figure 5. Replacement of external and internal brick walls

3 COMPOSITE SLIM FLOORS

The demand for an additional mezzanine floor led to a very limited construction height for the ground and mezzanine floor of at maximum 17,5 cm in combination with a very localized vertical load transfer from the slabs into the slender column tubes. Additionally the main span between the column axes amounts considerable 7,2 m and furthermore the concreting of these floors should be enabled without temporary supports leading down to the basement, where already screed work should start at this time.

From these demands a slim floor construction with T-shaped, cambered steel beams in a transverse distance of 3,4 m proved to be most suitable. Trapezoidal steel sheeting was placed on the lower flanges of these beams and served for an immediate working platform. Hilti shear connectors were fixed in every knuckle of the steel sheeting with powder actuated nails going through the steel sheeting into the beam flange. This provided both – end anchorage of the composite slabs and partial shear transfer in longitudinal direction of the slim floor T-beams resulting in a bi-directional composite action of these slabs.

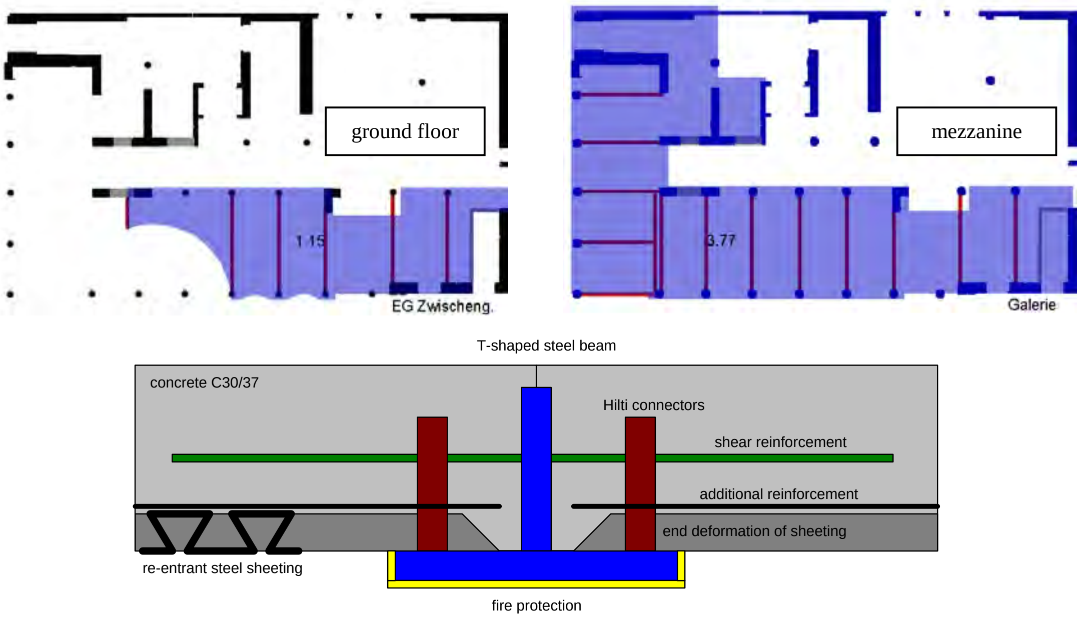

Figure 6. Ground and mezzanine floor with slim floor construction

Figure 7. Composite slim floors at the ground and mezzanine level

4 BEAM-TO-COLUMN MOMENT CONNECTIONS

For improvement of the ultimate and serviceability limit state (deflections and vibrations) these composite slim floor beams spanning between the composite tube columns should not only be used single span. Moment resisting and semi-rigid beam-to-column connections at both ends transferred the single span beams into semi-continuous ones. This semi-continuity at the beam ends was already applied very successfully at the Millennium Tower in Vienna with more than 50 storeys. The beam end restraint was realized by a horizontal force couple. The lower compression forces are introduced via the lower beam flange into the column bracket. There the gap due to construction tolerances is closed with shim plates. The upper tension forces are activated by reinforcement loops going around the columns.

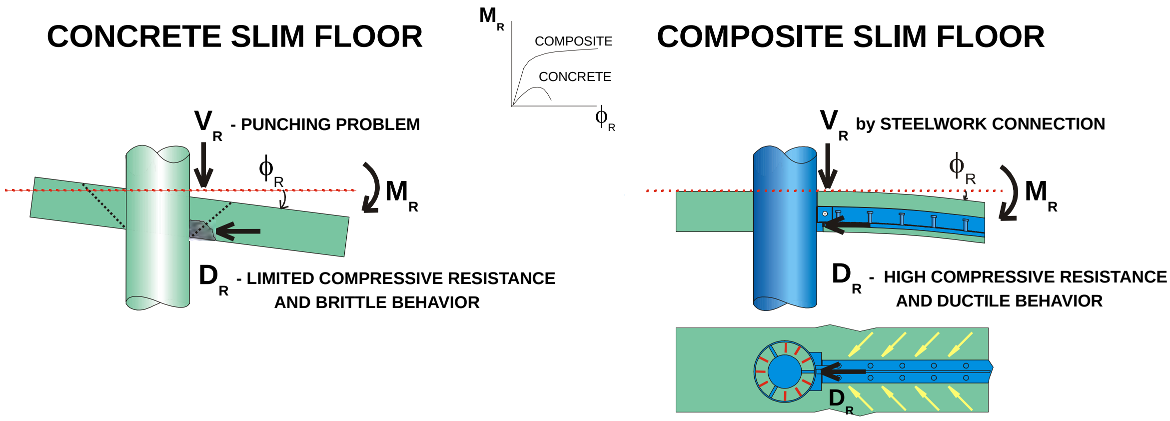

Figure 8. Comparison between conventional concrete and innovative composite slim floors

The resulting additional bending moments in the columns proved to be not so significant than the high normal compression forces. This multiple frame effect between the external columns, the slim floors and the internal columns was also used as a contribution to the overall horizontal building stabilization in view of wind and earthquake loads.

After concreting the T-beams - except the lower flanges – are fully integrated into the slab depth. Summarising the advantages were slim floors with a high serviceability quality, a fast construction progress, considerable pre-fabrication standard and a reduced noise disturbance.

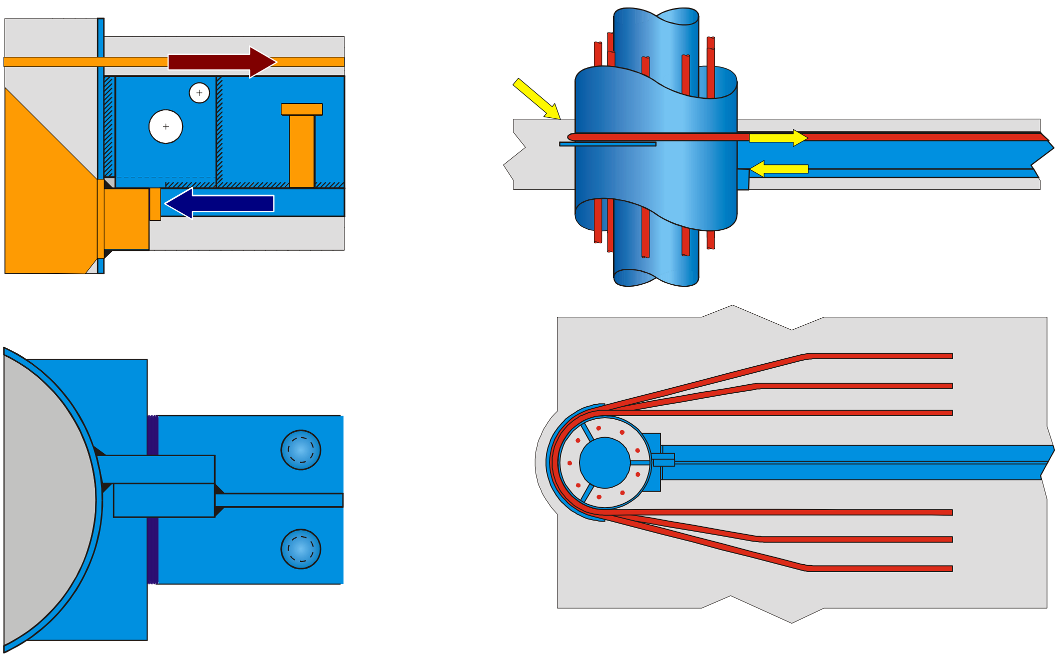

Figure 9. Semi-continuous moment connection between the slim floors and the column tubes

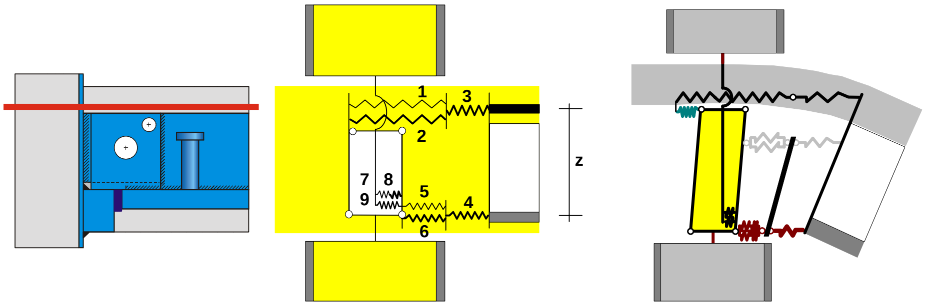

Figure 10. Connection characterization and modeling

5 CONCLUSIONS

The complete refurbishment of a 19th century brick-concrete office building in Innsbruck was very successfully realized with new MBT technologies. Compaction grouting to extend the existing foundation walls into the ground, local shear transfer from the steel column tubes into the chamber concrete with powder actuated nails and slim floors with partial shear connection and semi-continuous end moment connections to the columns.

Figure 11. AK office building during and after refurbishment

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