Examples of strengthening of main walls in old buildings

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ABSTRACT: In Polish cities, especially in their oldest, monumental parts, there are a lot of historical buildings that in few years must be rebuild and adopted to fulfil new requirements and functions. Their technical state is often very poor, not only because of the lack of proper conservation, but mainly due to their natural deterioration. Examples of brick walls strengthening by two different methods are presented and discussed in a paper. In the first method a self-supporting reinforced jacket covering walls through all the building stories was used. It was also connected to new concrete floor in a cellar and new story massive floors. In the other building there was a need not only to strengthen existing walls, but also to discharged them. The problem was solved by constructing self-supported lateral steel frames that had to carry over new floors.

1 INTRODUCTION

In many Polish cities Old Town is surrounded, among others, by buildings constructed in XVI and XVII centuries. Some of them were built on foundations that belonged even to much older buildings, and all of them were seriously damaged during the second world war. They were entirely rebuilt in years fifties and sixties of the 20th century, but mainly to serve as apartment buildings.

In a lot of cases related to old houses, walls are the only part of them that is left during the process of reconstruction, even they do not have enough strength capacity to carry over new loads. They are treated as shells that will enclose an entirely modern interior. Usually these walls are additionally loaded with solid ceilings or have new constructive solutions, they often need to be strengthen or even replaced with new carrying elements. Calculations are made to determinate their capacity, as well as a capacity of foundations, preceded by proper soil examination. In some cases foundations and soil have enough capacity to carry new loads, but very often there is a need to strengthen brick walls. Generally, the process of load-bearing walls strengthening in existing old buildings is very complicated. A solution of a proper strengthening method needs a well-done surveying of a building structural system, identification of construction material properties, and also a history of its erection.

2 STRENGTHENING OF WALLS USING REINFORCED CONCRETE JACKET

2.1 Description of a building

A strengthening of old brick walls by applying a reinforced concrete jacket clinging to them was conducted in two buildings, placed in the old centre of Jelenia Góra. These buildings are a few hundreds years old, probably built on the turn of the XVI century, staying in a compact street settlement. They have four storeys (a ground floor, two floors and a functional attic) and cellars. A building structural arrangement is transverse with stone and brick vaults over cellars and

wooden ceilings above. In an open pit made in cellars' walls there were found not deeply subsided continuous footings made of loose field stones, founded on weak sandy clays. After forging off pieces of plaster, it appeared that technical condition of load-bearing transverse walls in cellars, on the ground floor and the first floor of both buildings, was very bad. These walls, adequately 80, 65 and 50 cm thick, were made of loosely put bricks and crushed stone, sealed with clay mortar. After uncovering, they resembled a debris rather than a carrying elements. Face and rear walls in the whole height and walls on the second floor and attic were made of full brick on a lime mortar, with few stone inclusions. Technical condition of these walls was satisfactory, probably because they were erected later.

According to obtained information, during one of repairing works, a front and rear façade was reconstructed and the building was heighten by two storeys. The old walls were left inside the

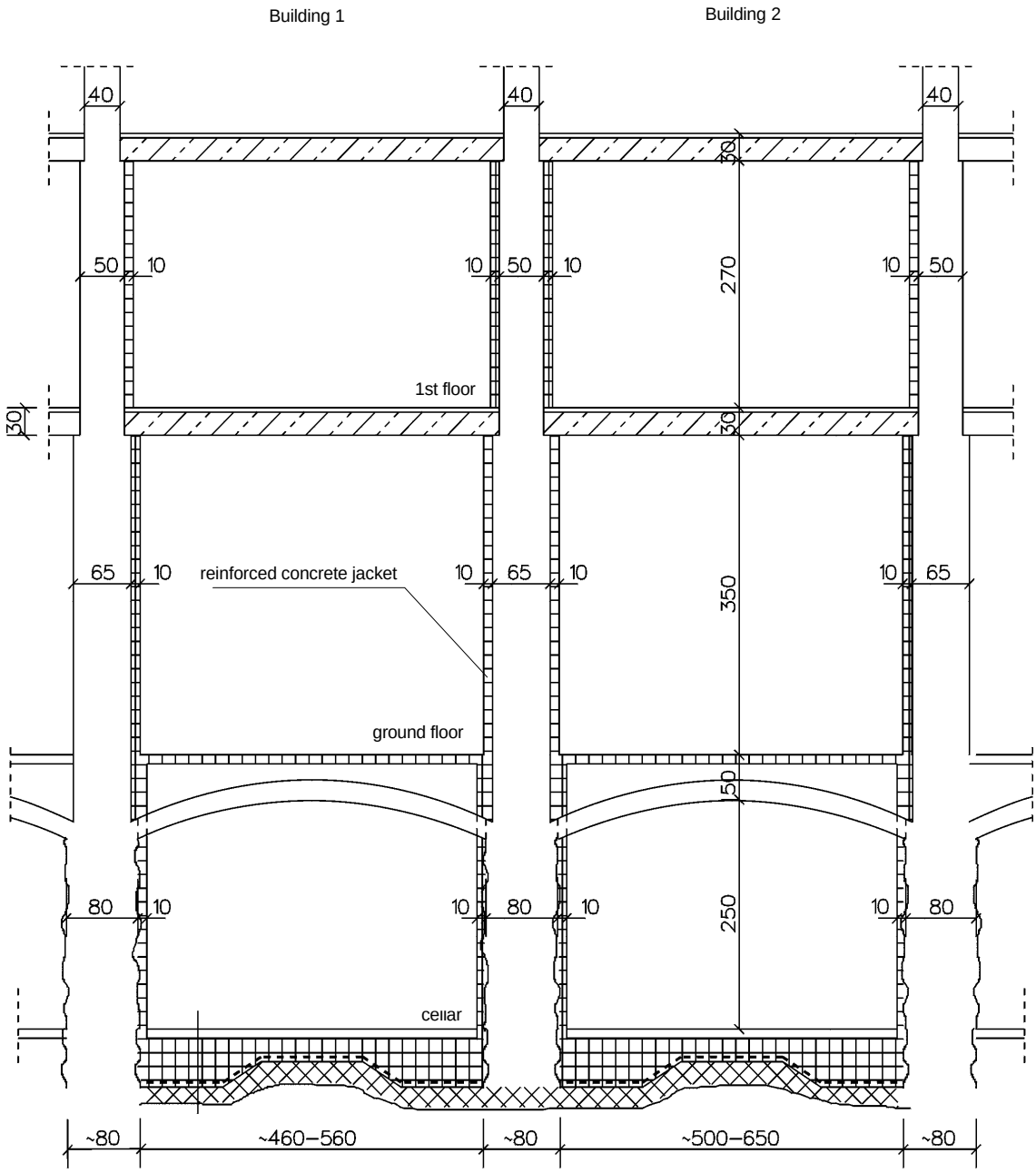

Figure 1 : Strengthening of walls by applying a reinforced concrete jacket.

building. Structural analysis showed that after a planned additional loading walls with new, solid ceilings of small prefabricated slabs, a width of existing foundations will not be sufficient to transfer design loads.

2.2 Description of a strengthening method

In both described buildings, transverse walls foundations and the walls in cellars, on the ground floor and the first floor did not have a proper load capacity to transfer designed loads. A surface of walls made of bricks and stones was very irregular. There were found many losses from a few to a dozen cm big. That is why the decision was to reinforce these walls by applying a double-sided, self-supporting reinforced concrete jacket clinging to them. A sketch of an applied strengthening is shown in a Fig. 1.

In reality, a building structural arrangement of both buildings was more complicated and in a presented sketch there is only shown a pictorial diagram of an applied reinforcement. While designing, it was assumed that it should provide a proper load capacity for foundation walls. That is why a reinforced concrete jacket of cellar walls was connected with a thickened, reinforced cellar floor, counted like a foundation plate on an elastic foundation. Additionally, every 1.80 m a reinforced concrete wall from cellars was passed through holes forged in vaults. The whole was fastened together with a curb-plate and a reinforced concrete floor of the ground floor. Reinforced concrete jackets of building walls and the floor of cellars as well as the ground floor were made of concrete B20 and reinforced with steel 34GS. Because of a very porous walls structure there were no additional connectors between reinforced walls and reinforced concrete jackets, which were at least 10 cm thick, because of a necessity of a proper concrete condensation. A reinforcement of the wall on the ground and first floors were made simultaneously with an exchange of ceiling over these floors. A unity of wall structures was ensured by irregularities created after clearing old walls.

3 STRENGTHENING OF WALLS BY STEEL SELF-SUPPORTING FRAMES

3.1 Description of a building

A reinforcement of old brick walls by applying steel self-supporting frames was conducted inone of buildings placed in a compact settlement of the East frontage of Wroclaw Town Square. The building was many times reconstructed, and finally shaped at the end of the 19th century. It was destroyed during war fights and rebuilt after the 2nd World War in a baroque form.

The building has got six storeys including cellars and a functional attic. A building structural arrangement is transverse. Side load bearing walls are common with neighbouring buildings. Foundations are made of boulders and bricks, above there are brick walls made of full bricks on a lime mortar. An interval floor above the cellar is on steel beams, higher there are wooden floors with a sound boarding. The whole width of the building in the inside diameter between side walls is of 5.70 m. In an open pit made on foundation walls it was found that the building was founded on fine sands with a good degree of density.

Because of functional assumptions it was planned to exchange existing wooden floors with new solid ones on steel beams. It was also assumed that the floors will base only on side walls without any additional indirect supports. A similar assumption was made by designers of neighbouring buildings which were repaired earlier. It caused an overload of existing walls.

Structural analysis showed that even with the wooden floors these walls do not have an adequate analytical load capacity. Additionally, after forging off pieces of plaster it appeared that bricks in these walls were laid many times and big pieces of walls do not have an adequate lacing with the rest of a masonry. That is why it was decided to reinforce and unload these walls.

3.2 Description of a reinforcement method

Because of a small width of the building and its designed gastronomic and hotel functions, an investor did not agree to apply continuous reinforcements of the walls such as a reinforced concrete jacket. An additional difficulty in applying this reinforcement was a fact that offsets

making walls thinner were in the walls on every storey. Applying a reinforced concrete jackets on upper storeys would just unload the wall. That is why it was decided to apply transverse, self-supporting steel frames along the building walls, which would transfer a weight of new floors. A scheme of the reinforcement is shown in Fig. 2.

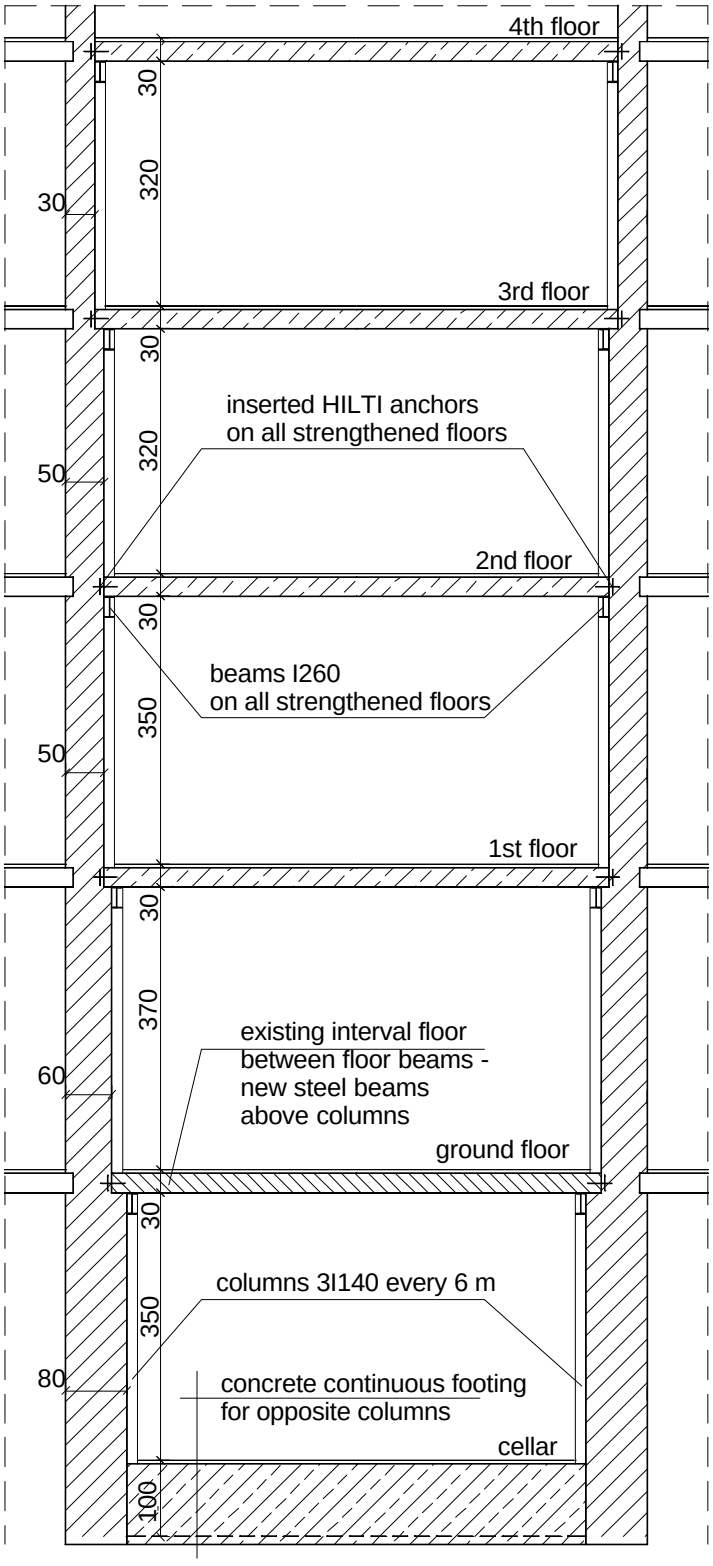

Figure 2 : A reinforcement of building walls with self-supporting steel frames.

Columns of steel frames were placed along building walls every 6 m and based on concrete boards, common for both columns of the same frame. Steel binders with I260 were placed on pillars, along the building wall. The floor on steel beams was made on binders. Beams were condensed above the columns. On the overhanging floor beams, laid above the columns of the lower storey, there were placed columns of the higher storey, pushing them as close as possible to the brick walls. The whole structural arrangement of the building was repeated up to the 3rd floor, above which the floor was based on the building walls. Additionally, on every storey, on which the strengthening was applied, the walls were braced to the floors with inserted anchors of HILTI type. The reinforcement itself, after applying it in the building, is shown in Figs. 3-4.

Figure 3 : View of a reinforcement - cellar.

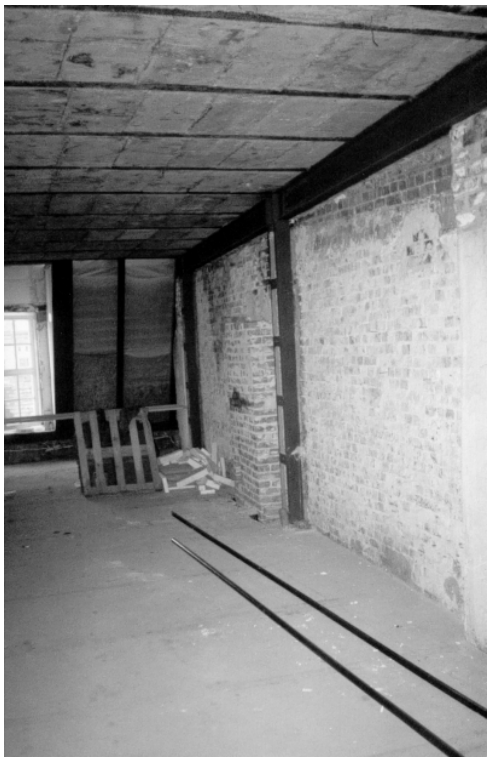

Figure 4 : View of a reinforcement - ground floor.

4 CONCLUSIONS

Nowadays, while repairing old buildings, more and more often there is a necessity to reinforce their carrying walls. This process is very complicated and a choice of the proper method requires a detailed recognition of a structural arrangement of the whole building and making proper agreements with the investor. In this paper two of many possible methods of reinforcing have been presented. Both of them were applied in existing buildings. With such a reinforcement there must be provided the same deformation ability of the old and new structure and a fire-control of steel elements.