Examples of Even Lifting of Structural Elements of Existing Buildings

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Abstract. Two examples of even, vertical lifting of building elements are presented. In the first example, after the raw state of the building was completed, the concept of land development around the building has changed. It involved in particular elevating the ground level by 0.8 m. As a consequence, the entrance to the building would be below the surrounding land. It was decided to lift the above-ground part of the building evenly by 0.80 m in order to avoid this. The lifting of the above-ground part of the building was designed and executed by detaching the building apart at the level of the floor and then lifting it evenly by 0.8 m. For this purpose, eighteen hydraulic jacks were used, installed in the bearing walls in the previously made openings. New technical cellars were additionally constructed as a result of the works. In the second case, the roof truss was raised in the residential building in use. The usable area of the attic was enlarged as a result of the works and the number of posts limiting the freedom of interior design was reduced. In both cases, a system of hydraulic jacks was used to move the structure vertically. With the presented procedure, no damage was caused to both, the building elements that were lifted and those unmoved. In addition, the even lifting of parts of the building allowed to avoid the troublesome dismantling and then restoration in a new location.

1. Introduction
One of the issues occurring in engineering practice is the necessity to change the location of the entire building or part of it. Rectification is carried out in the case of vertically deflected structures. Such works have been carried out, among others, in engineering facilities [1], historic buildings [2] [3] and residential buildings [4]. It is also often necessary to move a historic [5] or residential [6] building or to rectify and stabilise the location of selected elements of the building [7] [8]. If the vertical position of the structure elements must be changed, the decision to dismantle a fragment of the structure and then to rebuild it in a new location is most often made. An alternative to this procedure is even lifting. Such an approach may turn out to be cheaper, and for the buildings in service, it may be the only rational solution. The article presents two such cases. The first concerns raising the above-ground part of the existing building, the second concerns raising the roof of the building in use.

2. Raising the above-ground part of the building
After the raw state of the building was completed (Fig. 1), the concept of land development around of unit building has changed. It involved in particular elevating the ground level by 0.8 m. As a consequence, the entrance to the building would be below the surrounding land (Fig. 2a). It was decided to raise the above-ground part of the building evenly by 0.80 m in order to avoid this.
The structure has a rectangular projection of 14.99 m / 6.99 m (Fig. 2b) and was originally constructed as a single-floor building with a usable attic. The height of the ground floor is 2.5 m and of the attic up to 2.38 m. The building strip foundations, whose base before lifting was 1.27 m below the level of the designed floor, are reinforced concrete with the section (b/h) of 0.60 m / 0.40 m (Fig. 3a). 50 cm thick and 0.87 m high foundation walls were built from concrete blocks on the strip foundations.

External walls of the above-ground floors (walls in axes A, B, 1, 3 - Fig. 2b) are 0.49 m thick and are formed by two layers. The outer one, 0.25 m thick, is made of solid brick and the inner one, 0.24 m thick, is made of ceramic blocks. The inner wall in axis 2 is 0.24 m thick and is made of ceramic blocks. In the place where the chimney is located, the wall is 0.38 m thick and is made of solid brick. The ceiling structure above the ground floor is wooden. The wooden roof truss is characterised by a purlin load-bearing arrangement and is covered with a sheet metal laid on solid formwork.

The lifting of the above-ground part of the building was designed and executed by detaching the building apart at the floor level (level ± 0,00 – Fig. 3a) and then by lifting it evenly by 0.8 m. For this purpose, eighteen hydraulic jacks were used, installed in the bearing walls in the previously made openings. The height of the openings was 0.6 m and the width was about 0.5 m. A reinforcement in the form of 160-type channels running on both sides of the walls was installed on the walls above the openings at the level of + 0.74 (Fig. 3b). These channels were bolted together using M16 bolts spaced every 0.8 m. Then, 20 mm thick steel sheets were installed in the openings where the load was to be transferred from the jacks onto the walls. Grouts from cement mortar were made between the wall of the lifted part of the building and the sheet metal (upper sheet metal) and between the wall of the part remaining in the ground and the sheet metal (lower sheet metal). In addition, the top sheet metal was connected with the channels by welding. Hydraulic jacks were installed in eighteen openings prepared in this way, and the final height of the openings was 0.52 m.
The lifting of the above-ground part of the building consisted in forcing the displacement of pistons of hydraulic jacks. The piston extension range of the jacks was limited to 200 mm; therefore, parallelepiped elements were periodically installed under the jacks. At the end of the lifting process, these elements formed 600 mm high stacks. After the lifting was completed, the jacks were removed and the lifted parts of the structure rested on temporary 800 mm long supports, which consisted of stacks of parallelepiped elements and concrete blocks (Fig. 4). Such temporary supports were the subject of the previously undertaken theoretical analyses [9] and laboratory tests [10].

A monolithic reinforced concrete ceiling was then made, which separated new technical spaces in the cellar floor (Fig. 5a). The ceiling was supported on the external cellar walls, whose height was increased from 0.87 m to 1.69 m, on the internal wall and on two additional walls in axes marked as 1/2 and 2/3 (Fig. 5b). 0.38 m wide strip foundations were made in these axes and 0.25 m thick cellar walls made of concrete blocks were made. The new level of the ground floor was designed in such a way that the height of the rooms on the ground floor remains equal to 2.5 m. With a floor layer thickness of 0.14 m and a ceiling thickness of 0.15 m, the height of the underground technical floor was 1.28 m. This space will be used for providing installations and as storage rooms.
Figure 3. Section A-A, whose location is shown on the Figure 2: a) condition before installation of jacks, b) wall with installed jack, c) condition after lifting and installation of the ceiling: 1 - hydraulic jack, 2 - [ 160, 3 - M16 bolt, 4 - 20 mm sheet metal, 5 - mortar

Figure 4. View of the building during lifting: a) the building after being detached, b) the building after being lifted by 0.8 m
3. Raising the roof

It was necessary to increase the height of the rooms in the attic in a completely cellared one-floor building with a usable attic (Fig. 6).

The building was still in use, so it was practically impossible to dismantle the entire roof and then reassemble it in a new position. Therefore, renovation was designed and carried out, consisting in lifting evenly, by 0.8 m, the part of the building located above the ground floor.

The building in which the works were carried out has a projection of 244 m² and can be inscribed into a rectangle with sides of 20.94 m and 15.20 m. The building is placed on a reinforced concrete foundation slab and the ceilings above the cellars and ground floor are reinforced concrete - monolithic. The cellar walls are bricked from concrete blocks and ground floor walls from ceramic blocks.

The wooden roof structure is made as a purlin structure. The pitch of the roof slopes with numerous corners and valleys is 39 degrees. Before the renovation, the wall plate was fixed directly to the ceiling above the ground floor at a level of +3.95 m (Fig. 7a). In addition, there was a significant number of posts in the roof structure to support the purlins (Fig. 28). These posts and the support of rafters on the wall plate at the ceiling level above the ground floor had limited the possibilities of using the rooms in

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**Figure 5.** The building after increasing its height by 0.8 m: a) cross-section, b) plan of technical spaces in the newly created cellar floor
the attic. The aim of the renovation was to raise the entire roof by 0.8 m with the use of jacks and to reconstruct the truss in such a way as to remove as many posts from it as possible.

![Figure 6. View of the building whose height was increased by raising the roof truss](https://via.placeholder.com/150)

**Figure 6.** View of the building whose height was increased by raising the roof truss

![Figure 7. Phases of lifting the roof truss (section A-A position is shown in figures 8 and 11): a) before lifting, b) after installation of jacks, c) after lifting by 0.8 m; 1 - hydraulic jack, 2 - purlin 0.2/0.2 m, 3 - steel frame](https://via.placeholder.com/150)

**Figure 7.** Phases of lifting the roof truss (section A-A position is shown in figures 8 and 11): a) before lifting, b) after installation of jacks, c) after lifting by 0.8 m; 1 - hydraulic jack, 2 - purlin 0.2/0.2 m, 3 - steel frame

Preparatory works were carried out before the lifting. A new wooden purlin with a cross-section of 0.2/0.2 m was mounted first (Fig. 7b). Its location was chosen so that the lower surface of this element is 0.52 m above the floor of the attic ceiling. This enabled to install jacks on the ceiling, directly underneath this purlin. Temporary ties were attached to the purlins (Fig. 8), whose role was to transfer the horizontal tensile forces. These forces occurred in the ties after the screws fixing the wall plate to the ceiling were cut off. In addition, all the roof truss posts were stiffened with struts and the roof was secured against shifting in the horizontal direction by means of guides made of rolled profiles and anchored in tie beams. Twenty-six jacks were placed underneath the newly mounted purlins (Fig. 8, Fig. 9a) and four under selected, previously cut posts. The remaining posts of the roof truss were also cut, but only stacks of parallelepiped elements and wedges were mounted under them. The lifting of the truss consisted in forcing the displacements of the pistons of hydraulic jacks and exerting the forces in the posts, with the use of wedges, where the jacks were not installed. Due to the limited extension of jack pistons to 200 mm, they had to be periodically supported by parallelepiped elements. After lifting, the roof rested on stacks of parallelepiped wooden elements (Fig. 9b).
After lifting the roof structure (Fig. 10a) and placing it on temporary supports, a 0.8 m high knee wall was made (Fig. 10b). The wall, to which the wall plates were attached, consisted of vertical reinforced concrete cores, a tie beam and a filling made of ceramic blocks. In order to increase the functionality of the rooms in the attic, some of the posts were removed and their function were taken over by new steel frames (fig. 11). Such structural changes were associated with an increase in the span
of some of the rafters, hence they were reinforced. The usable area of the attic was enlarged by 48 sq.m. as a result of the renovation. In addition, more flexible arrangement of the rooms in the attic was possible by removing the truss posts.

![Image](image1.png)

**Figure 10.** The lifting process observed from the outside: a) the truss after lifting by 0.8 m, b) the truss after the knee wall was made under it

![Diagram](diagram1.png)

**Figure 11.** Structural changes in the roof truss

- **R** New steel frames
- **R1** Reinforced rafters
- **R2** New wooden purlin 200/200 mm
- **R3** Steel frame pole
4. Summary
Two examples of even, vertical lifting of building elements are presented. In the first one, the above-ground part of the building was moved upwards as it was necessary to raise the area around the building. New technical cellars were additionally constructed as a result of the works. In the second case, the roof truss was raised in the residential building in use. The usable area of the attic was enlarged as a result of the works and the number of posts limiting the freedom of interior design was reduced. In both cases, a system of hydraulic jacks was used to move the structure vertically.

With the presented procedure, no damage was caused to both, the building elements that were lifted and those unmoved. In addition, the even lifting of parts of the building allowed to avoid the troublesome dismantling and then restoration in a new location.

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