SECTION 2. ARCHITECTURE, CONSTRUCTION

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2.1 Application of vertical ribs in walls for strengthening buildings and structures

Everyone knows the use of vertical, outwardly protruding parts of walls during the construction of buildings or structures, which are called buttresses [80]. Buttresses began to be used by the ancient Romans, but they became widespread in Gothic architecture (Fig. 1). During the Renaissance, buttresses almost completely ceased to be used in architectural and construction practice.

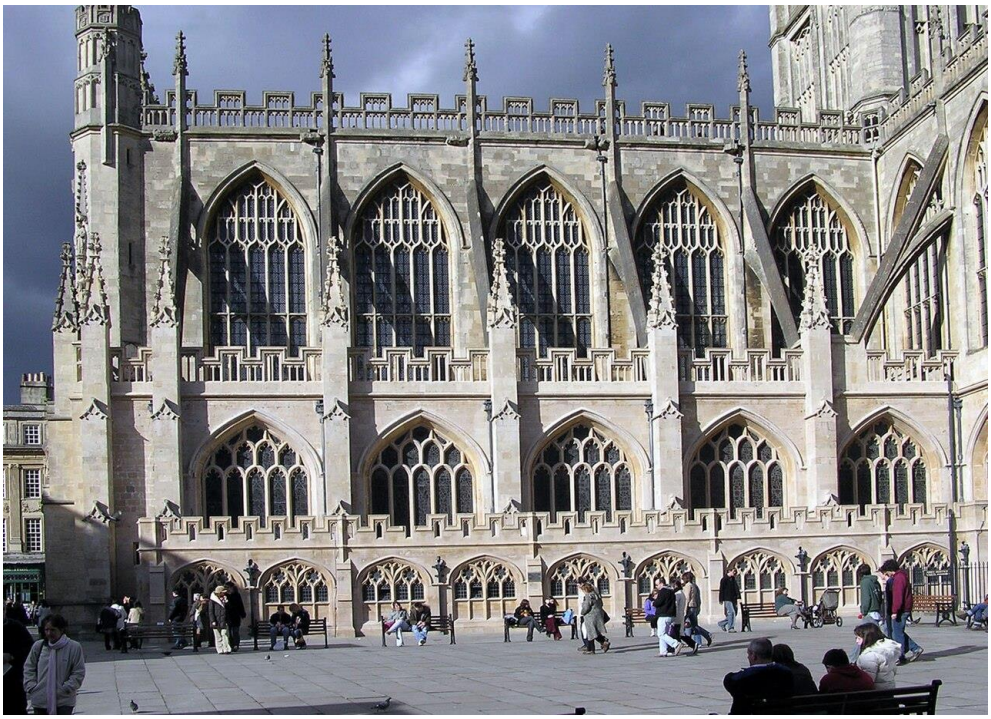


Figure 1. Application of buttresses in the building the Abbey Church of Saint Peter and Saint Paul (16th century)

The main purpose of buttresses is to perceive horizontal forces from the strut (from the French "contre force" - "opposing force"). In some cases, pseudo buttresses were built - vertical elements that did not accept horizontal forces, but served as an architectural decoration of the building.

According to the shape in the plan, these are square, rectangular, semicircular, multifaceted elements, which could be continuous or stepped along their length (thickened downwards).

On the territory of modern Ukraine, it is also possible to note many objects with the use of buttresses. On the example of In Lviv, you can see buildings (Fig. 2) and public buildings (Figs. 3, 4) that contain external protruding vertical ribs. In the era of Soviet architecture of the 70s, during the industrialization of construction, it is possible to single out many typical projects where vertical outwardly protruding elements are located on the facades.

Figure 2. Water towers in Lviv (30s of the 20th century)

Figure 3. The fifth city clinical polyclinic in Lviv (70s of the 20th century)

Figure 4. Center for the provision of administrative services in Lviv (70s of the 20th century)

The authors of this material borrowed the experience of using vertical structural elements - ribs in enclosing structures during reconstruction with reinforcement of

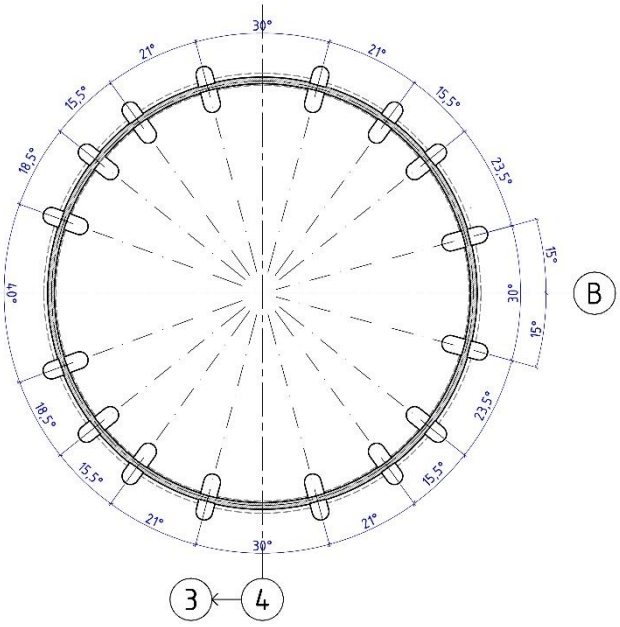
buildings and structures. However, although the proposed ribs look like buttresses, they are intended, in most cases, to absorb vertical forces.

One of these objects was a building - a technological tower for the granulation of ammonium nitrate in the city of Cherkasy (Fig. 5). The tower is made of monolithic reinforced concrete and has a cylindrical outline with an outer diameter of 12,88 m. The reinforced concrete trunk of the tower rests on a reinforced concrete foundation slab with a diameter of 24,0 m and a height of 4,15 m. The barrel of the tower has an internal lining to protect the reinforced concrete from chemical influences. A three-story metal superstructure with a height of 22,8 m is mounted on the upper part of the trunk between the 47,300m and 70,100m marks. In plan, the superstructure is a regular dodecahedron.

Figure 5. General view of the tower before reinforcement

As a result of the examination of the tower trunk, defects and damage were found that reduce its carrying capacity for design loads [81], and a decision was made to strengthen the trunk. The proposed strengthening option [82, 83] consisted in the introduction of vertical ribs protruding outwards and inwards, located along the perimeter of the tower, into the structure of the trunk. The number and total thickness of the reinforcement ribs varied along the height of the tower trunk (Fig. 6).

The repair of the ammonium nitrate granulation tower was carried out in 2020 (Fig. 7). In addition to strengthening the tower trunk, chemical protection of structures was carried out.



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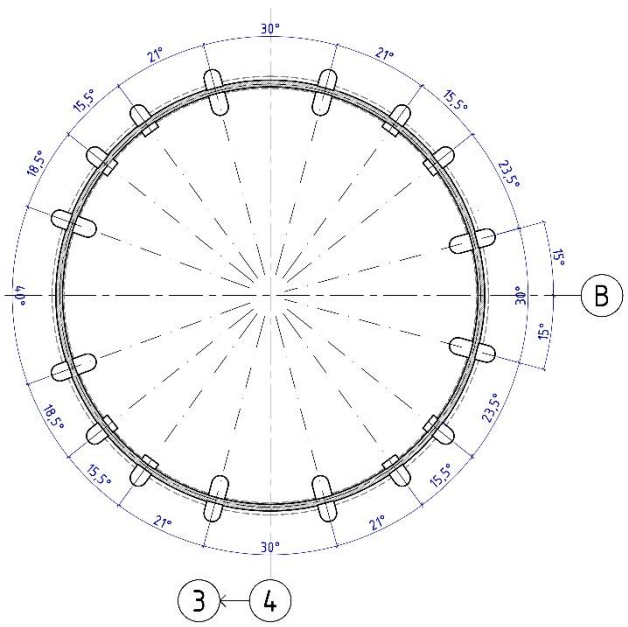

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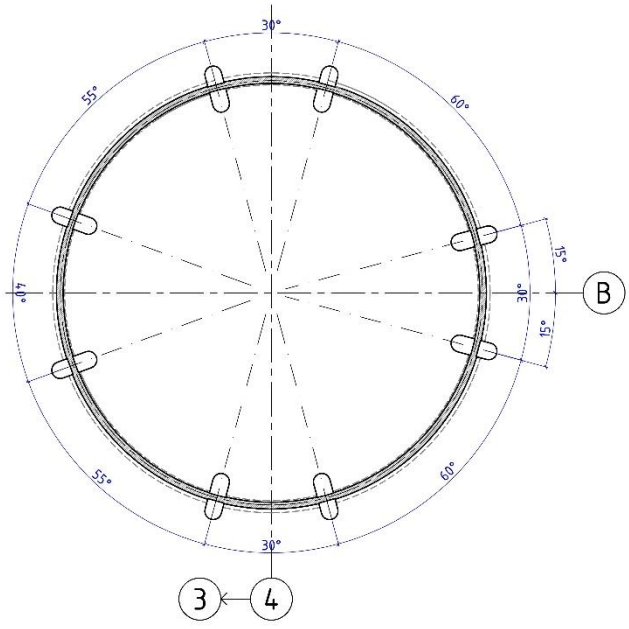

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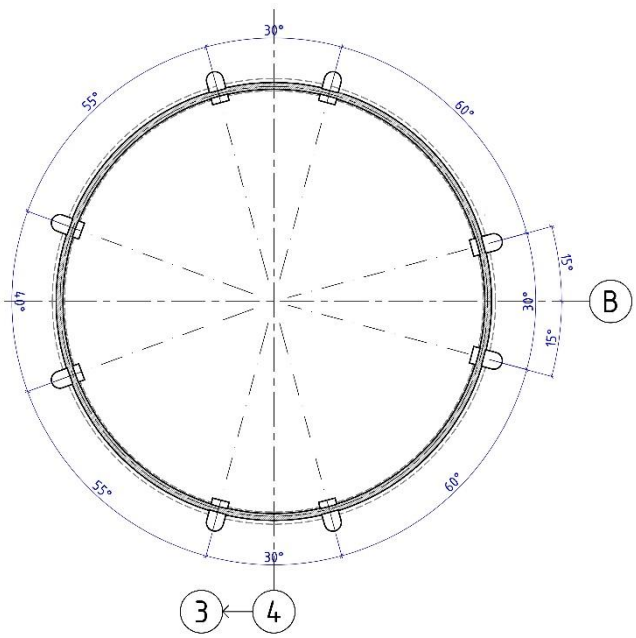

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Figure 6. Location of reinforcement ribs along the height of the tower trunk

The four-year operation period of the tower after strengthening and repair (Fig. 8) showed the correctness of the decision.

Figure 7. In the process of performing amplification

Figure 8. General appearance of the tower after strengthening and repair

The second object was an industrial building in Lviv (Fig. 9) [84], which provided for the change of functional purpose to a public purpose with the addition of floors.

The existing three-story building is a combined structural system, with brick walls on the outside and reinforced concrete columns on the inside, is an insert building between other industrial and public buildings. The length of the building in axes is 45,415 m, the width is 20,34 m. The height of the 1st floor is 4,7 m, the 2nd – 5,7 m, the 3rd – 6,0 m. Under the part of the building there is a basement with a height of 4,2 m. Flooring – monolithic ribbed reinforced concrete slabs.

As a result of the survey and verification calculations, the insufficient bearing capacity of the brick blocks, on which the reinforced concrete monolithic beams of the

floor rest, was revealed, so a decision was made to strengthen them. The proposed strengthening option consisted in the introduction of outward and inward vertical reinforced concrete hugs-ribs into the structure of the external walls (Fig. 10, 11).

Figure 9. General appearance of the facade of the building during the survey

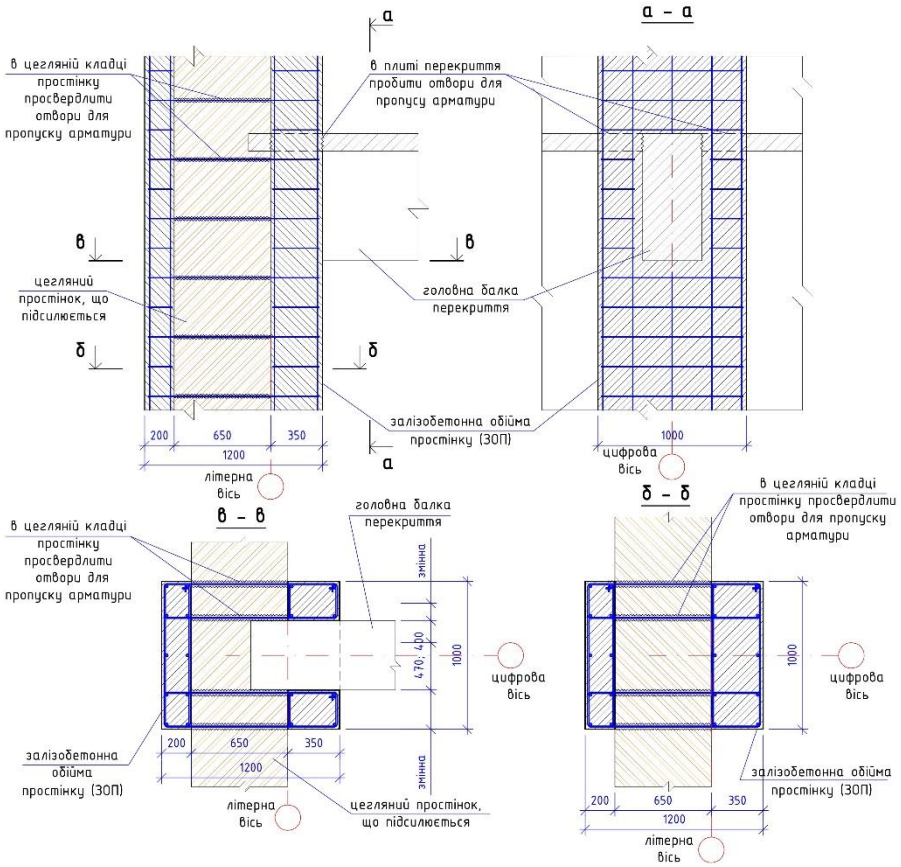

Figure 10. The general principle of strengthening the walls

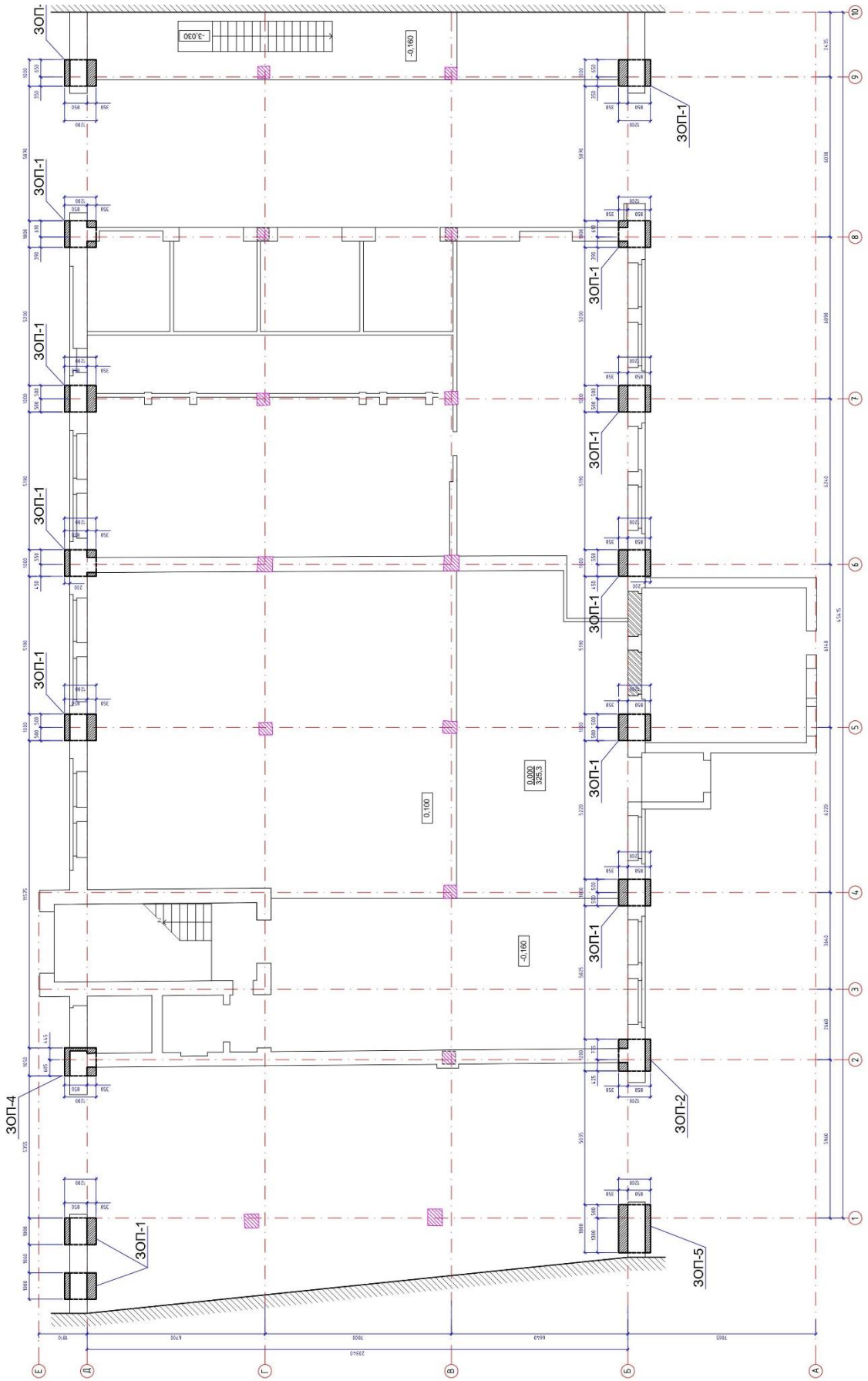

Figure 11. The general principle of strengthening the walls

Reconstruction of the building began in 2021. In addition to the strengthening of the walls, work was carried out to strengthen the foundations [84] and columns. Currently, all works have been completed except for the addition of floors (Fig. 12).

The proposed options for the use of vertical ribs in the wall enclosure for strengthening the objects in question have proven themselves well and can be used in the reconstruction and repair of other buildings and structures.

Figure 12. General appearance of the facade after reinforcement (at the stage without adding floors)