Збірник наукових праць. Галузеве машинобудування, будівництво
Academic journal. Industrial Machine Building, Civil Engineering
http://journals.nupp.edu.ua/znp
https://doi.org/10.26906/znp.2021.57.2585

UDC 692.22:699.82]:721-029.9:9

Moisture protection of structures adjacent to the ground in historic buildings

Semko Oleksandr[1], Filonenko Olena[2], Yurin Oleg [3], Mahas Nataliia[4]*, Rudenko Viktor[5]

[1] National University «Yuri Kondratyuk Poltava Polytechnic» https://orcid.org/0000-0002-2455-752X
[2] National University «Yuri Kondratyuk Poltava Polytechnic» https://orcid.org/0000-0001-8571-9089
[3] National University «Yuri Kondratyuk Poltava Polytechnic» https://orcid.org/0000-0002-9290-9048
[4] National University «Yuri Kondratyuk Poltava Polytechnic» https://orcid.org/0000-0002-4459-3704
[5] National University «Yuri Kondratyuk Poltava Polytechnic» https://orcid.org/0000-0001-7821-8147
*Corresponding author E-mail: mahasnataliia@gmail.com

Vertical and horizontal waterproofing of such underground structures has either been absent since the time of construction, or has already lost its operational characteristics. Moisture from the soil rises through the capillaries of the brickwork, which leads to the destruction of the brick and the finishing layer, the appearance of fungi and mold on the surfaces. Constant wetting of structures bordering the ground leads to a decrease in thermal properties, wear of building structures and a decrease in the standard service life of houses. In most cases, the development of restoration measures involves antiseptic treatment and replacement of wall surface finishes. Such activities carried out repair work in the building of the lyceum in Poltava. The paper emphasizes the introduction of comprehensive measures to restore vertical and horizontal waterproofing on the example of a real object of a gymnasium building in the Poltava region. The damage to the enclosing structures of the basement floor of the gymnasium building and the reasons for their occurrence were analyzed. Measures are proposed to ensure further trouble-free operation of structures adjacent to the ground.

Keywords: foundation, basement floor, moisture, mold

Захист від вологи конструкцій, що межують з ґрунтом, в історичних будівлях

Семко О.В.[1], Філоненко О.І.[2], Юрін О.І.[3], Магас М.[4]*, Руденко В.В.[5]

[1, 2, 3, 4,5] Національний університет «Полтавська політехніка імені Юрія Кондратюка»
*Адреса для листування E-mail: mahasnataliia@gmail.com

Проблема замокання цегляних конструкцій історичних будівель, які межують з ґрунтом, зумовлена поверхневим аналізом причин, які передують. Вертикальна та горизонтальна гідроізоляція підземних конструкцій історичних будівель або була відсутня з часу будівництва або вже втратила експлуатаційні характеристики. Волога з ґрунту піднімається по капілярах цегляної кладки, що призводить до руйнування цегли та оздоблювального шару, виникнення грибків та плісняви на поверхнях. Постійне замокання конструкцій, що межують з ґрунтом, призводить до зниження теплотехнічних властивостей, зношування будівельних конструкцій та зменшення нормативного терміну служби будинків. В більшості випадках розробка заходів з реставраційного ремонту передбачає антисептичну обробку і заміну оздоблення поверхні стін, але ці засоби не дієві і потребують повторного виконання вже через декілька місяців. У роботі наголошено про впровадження комплексних заходів з відновлення вертикальної та горизонтальної гідроізоляції на прикладі реального об'єкту будівлі гімназії у Полтавській області. Було проаналізовано пошкодження огороджувальних конструкцій цокольного поверху будівлі гімназії та причини їх виникнення. Для відновлення горизонтального гідроізоляційного шару усіх несучих цегляних стін рекомендовано ін'єктування в конструкцію гідрофобних розчинів на рівні підлоги першого поверху суцільною смугою. Також передбачалось у місцях де рівень ґрунту перевищує рівень підлоги першого поверху (фасад з двору) виконання перепланування денної поверхні до рівня нижче за рівень підлоги не менше 200 мм. На зовнішній поверхні стіни цоколя відновити вертикальний гідроізоляційний шар з попереднім висушуванням та антисептуванням цегляної кладки. Такі заходи дозволять забезпечити подальшу безаварійну експлуатацію конструкцій, що межують з грунтом.

Ключові слова: фундамент, цокольний поверх, зволоження, пліснява

Introduction

Most of the historical buildings of Poltava and the region, which are 100-200 years old, have brick foundations. Vertical and horizontal waterproofing of such underground structures has either been absent since the time of construction, or has already lost its operational characteristics. Moisture from the soil rises through the capillaries of the brickwork, which leads to the destruction of the brick and the finishing layer, the appearance of fungi and mold on the surfaces. Constant wetting of structures bordering the ground leads to a decrease in thermal properties, wear of building structures and a decrease in the standard service life of houses.

When passing under the brick foundations of emergency engineering networks of water supply or sanitation, frost destruction of the basement brick is observed due to constant wetting. Restoration measures usually involve only replacing the destroyed plaster layer and impregnating the brick walls with antiseptics. Such a repair lasts for several months and mold again forms.

Review of the research sources and publications

The issues of rising moisture in historical buildings are considered in [1-5]. The impact of moisture on building structures and the issues of protecting structures from moisture are discussed in [6-9]. The issues of warming the near-foundation zone and its temperature and humidity regime were considered in [10-12]. In [13], the authors considered a method for protecting the foundation zone from water by introducing a compacted clay barer; three materials with low hydraulic conductivity were analyzed.

Definition of unsolved aspects of the problem

The problem of blockage of brick structures of historical buildings bordering on the ground is due to a superficial analysis of the previous causes. In most cases, the development of restoration measures involves antiseptic treatment and replacement of wall surface finishes. These measures are not effective and require repeated implementation after a few months. The paper notes the introduction of comprehensive measures to restore vertical and horizontal waterproofing on examples of real objects.

Problem statement

The purpose of the work is to develop constructive solutions for the restoration of the waterproofing layer of brick structures adjacent to the ground and their implementation at specific construction sites.

Basic material and results

The building of the lyceum in Poltava wall structural system. The walls of the first floor - load-bearing internal and external - brick with a variable thickness of 900-1000 mm. Outside, the walls are finished with cement-sand plaster. Interior finish - plaster layer with painting or ceramic tiles. The floor of the first floor is continuous on the ground.

The depth of laying the foundations of the old part of the building (based on the results of geological surveys in 2017) from the current planning level is about 2.5 m. The width of its sole corresponds to the wall thickness and is about 1 m. Horizontal waterproofing of foundations not detected. There is no concrete preparation under the foundation. The brickwork of the foundations and walls of the basement is in a wet state.

Repair and restoration works of the lyceum building were carried out in 2017-2018. Works on the complete replacement of the internal and external finishing layers of the walls were completed. Before restoring the plaster layer, the wall surface was hydrophobized. A year later, when the authors of the article examined the load-bearing walls of the premises on the first floor, 80% of the perimeter of the surfaces of the inner and outer walls revealed detachment of the plaster layer and the impression of a fungus. On the new plaster layer, efflorescence and traces of wetting are observed (Fig. 1).

Figure 1 – Destruction of the plaster layer due to capillary moistening of foundations

Considering that the institution building was built more than 200 years ago, the horizontal layer of waterproofing has exhausted its normative service life since the time of construction. The increase in the cultural layer of soil around the house has led to the fact that the level of the floor (from the yard) is lower than the level of the daily surface of the soil. In both cases, this leads to the moistening of the brickwork of the foundations, the basement, and the walls of the first floor due to the pulling of capillary moisture from the soil.

The historical building of the gymnasium in the Poltava region is more than 110 years old. The building foundations were explored from several pits. In particular, it was found that the foundations of the building's load-bearing walls were built on a natural basis, brickwork strip foundations, 880 mm wide. Under the foundations of concrete preparation is not fixed.

Soaking of basement walls observed. Frost destruction was recorded in places where once damaged spillways were installed and in the basement, soaked as a result of the formation of drainless areas around the building.

At the same time, both the foundations themselves and the building as a whole are not adapted to the conditions of subsiding soils (there is no reinforcement of foundations, monolithic reinforced concrete belts, reinforcement of load-bearing walls, etc.). The building also cannot be considered rigid as a whole.

A blind area around the building in a condition unsuitable for normal use (it cannot perform its function).

The planning of the internal territory contributes to the accumulation of atmospheric waters there and their local penetration into the base of the foundations (the so-called drainless platform was formed).

Around the building there are external engineering networks and unused wells. Their technical condition leads to the accumulation of water in them. Soil erosion is observed and, as a result, subsidence of the asphalt pavement around the building.

Figure 2 – Destruction of the inner surface of the walls of the basement room due to the rise of capillary moisture

To restore the horizontal waterproofing layer of all load-bearing brick walls, it is recommended to inject hydrophobic solutions into the structure at the floor level of the first floor in a continuous strip.

For the building of the lyceum, the repair project assumed that in places where the ground level exceeds the floor level of the first floor (facade from the courtyard), the redevelopment of the day surface to a level below the floor level of at least 200 mm. The pits are designed to be 1200 mm wide with a waterproof coating (eg 150 mm compacted clay and 80 mm concrete layer) and culverts. On the outer surface of the basement wall, restore the vertical waterproofing layer with preliminary drying and antiseptic treatment of the brickwork.

If the work to lower the soil level according to the above recommendations is not carried out, it is necessary to inject hydrophobic solutions into the structure to a height from the floor level to a level 200 mm above the daytime surface of the soil outside the wall.

After beating the plaster on the load-bearing walls, a hole should be drilled through the walls with a diameter of not more than 20 mm in order to determine the size of the cavity between the layers of the wall. After determining the width of the cavity from the inside on the outer walls and on one of the most damaged side of the inner load-bearing walls, holes with a diameter of 20 mm are drilled at an angle of about 30 ° so that it does not reach the opposite side by 5-10 cm. The distance between the holes is 12-15 cm horizontally.

A packer is mounted into the hole and a cement slurry with a water-cement ratio of 0.5 is injected. The packer is taken out and a plastic probe is mounted in the hole so that it reaches the end of the hole. The next day, the probe must be removed and the packer re-inserted into the hole. A hose from a high-pressure boiler is connected to the packer and a water-repellent liquid of the type (for example, AQUAMAT-F) is pumped using a compressor. The injection is carried out until the wall is saturated with liquid.

The injection of liquid into the walls should be carried out along the entire horizontal section of the external and internal load-bearing walls on grips up to 2 m.

If it is necessary to inject hydrophobic solutions into the structure to a height from floor level to a level 200 mm above the daytime surface of the soil outside the wall, holes are drilled every 200 mm in a checkerboard pattern.

Repair work to restore the operational properties of the walls of the basement floor of the gymnasium building in the Poltava region was carried out according to fig. 3.

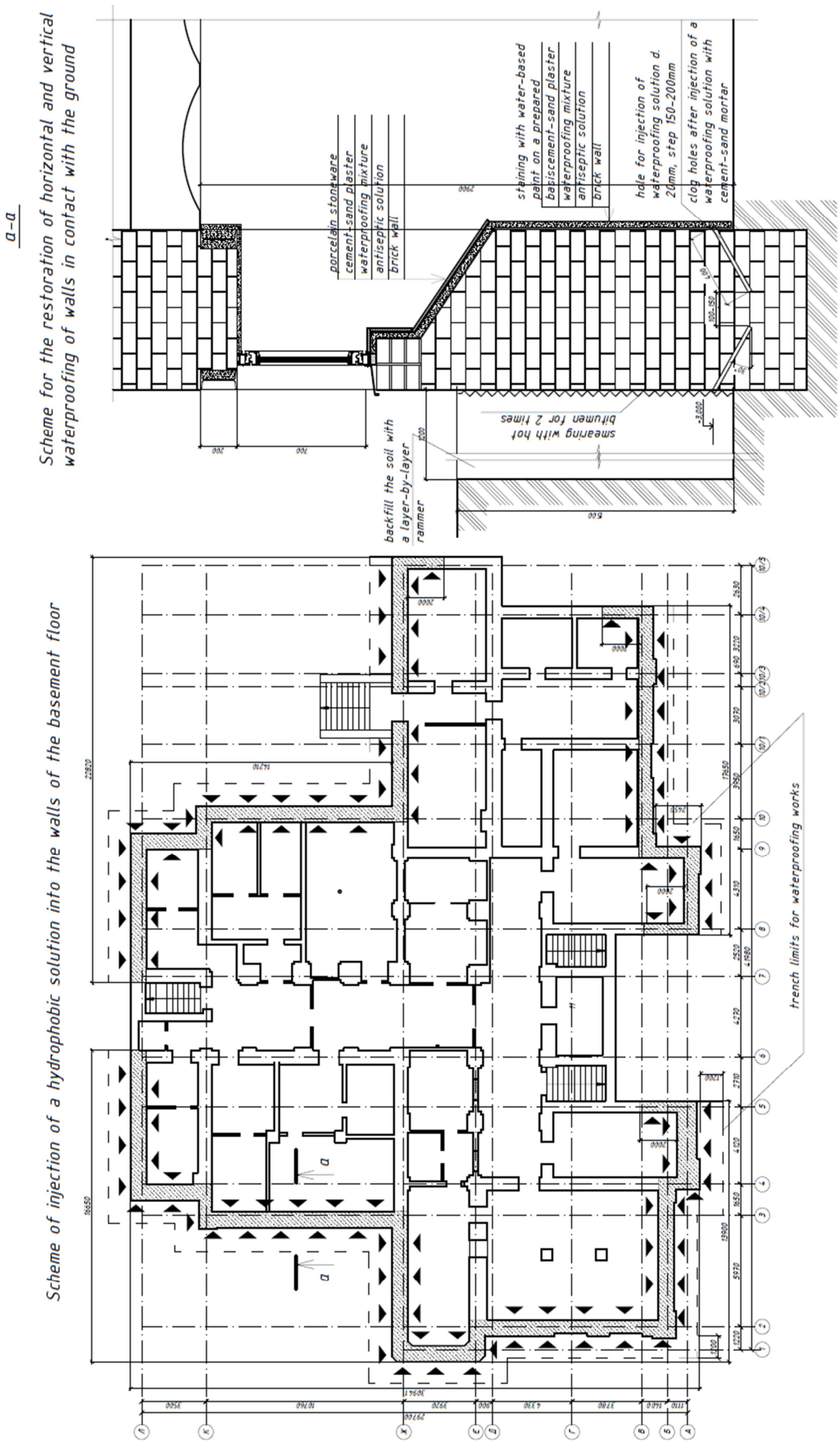

Figure 3 – Scheme of restoration of horizontal and vertical waterproofing of the basement floor walls of a gymnasium building in the Poltava region

The works included in the estimate had the following sequence:

1. Dismantling of asphalt / concrete blind area, 50 mm
2. Trench along the wall 1500 mm deep and 1200 mm wide.
3. Cleaning the wall from dust, dirt, and bumps
4. Jointing masonry joints made of bricks with cement-sand mortar (eliminating masonry cracks)
5. Horizontal waterproofing device by injection of a hydrophobic solution:

– the length of the waterproofing layer - 118 m.
– number of holes 1080, their length is 400 mm, diameter 20 mm (number of packers 2160 pcs)
– the area of the horizontal section of the repaired walls - 102 sq.m.
– the volume of the wall that is being impregnated is 51 cubic meters.

6. Filling holes with cement-sand mortar
7. Vertical waterproofing device - coating with hot bitumen for 2 times
8. Backfilling with soil with layer-by-layer compaction.

For further trouble-free operation of the gymnasium building, it is necessary to revise the old engineering networks within a radius of 30 m from the building. Dismantle emergency engineering networks and carry out landscaping of the adjacent territory.

Conclusions

When developing measures for the restoration repair of historical buildings with brick foundations, it is necessary to conduct a detailed technical examination of the relevant structures, foundation soils and underground engineering networks around the house in order to establish the causes of structural defects. Restoration should include work to eliminate them, and not just hide the consequences of permanent wetting.

References

1. Bakolas A., Biscontin G., Moropoulou A., Zendri E. (1996). Salt impact on brickwork along the canals of Venice. *Mater Struct*, 29(1), 47-55 https://doi.org/10.1007/BF02486006
2. Bowley M. (1975). *Desalination of stone: a case study. Building Research Establishment*, Watford, England, Paper CP46/75
3. Lopez-Arce P., Doehne E., Greenshields J. et al. (2009). Treatment of rising damp and salt decay: the historic masonry buildings of Adelaide, South Australia. *Materials and Structures*, 42, 827-848 https://doi.org/10.1617/s11527-008-9427-1
4. Schmidt H. (1999). Historische Bauwerksabdichtungen - Traditionelle und neuzeitliche Maßnahmen zum Schutz gegen Bodenfeuchtigkeit und zur Trockenlegung feuchter Wände. *Bautechnik*, 76, 581-598 https://doi.org/10.1002/bate.199903790
5. Torres M.I.M., Peixoto De Freitas V. (2003). *Research in Building Physics*. CRC Press http://dx.doi.org/10.1201/9781003078852-53
6. Yurin O., Mahas N., Zyhun A., Musiienko O. (2020). Aspects of calculation of resistance vapor penetration of enclosing structures. *Academic Journal Industrial Machine Building*, *Civil Engineering*, 2(55), 96-101 https://doi.org/https://doi.org/10.26906/znp.2020.55.2350
7. Філоненко О.І., Юрін О.І. (2018). *Енергетична ефективність будинків*. Полтава: Астрая http://dx.doi.org/10.13140/RG.2.2.17366.16961
8. Černý R., Podêbradská J., Drchalová J. (2002) Water and Water Vapor Penetration Through Coatings. *Journal of Building Physics,* 26(2), 165-177 https://doi.org/10.1177/0075424202026002975
9. Jerman M., Černý R. (2012). Effect of moisture content on heat and moisture transport and storage properties of thermal insulation materials. *Energy and Buildings*, 53, 39-46 http://dx.doi.org/10.1016/j.enbuild.2012.07.002

1. Bakolas A., Biscontin G., Moropoulou A., Zendri E. (1996). Salt impact on brickwork along the canals of Venice. *Mater Struct*, 29(1), 47-55 https://doi.org/10.1007/BF02486006
2. Bowley M. (1975). *Desalination of stone: a case study. Building Research Establishment*, Watford, England, Paper CP46/75
3. Lopez-Arce P., Doehne E., Greenshields J. et al. (2009). Treatment of rising damp and salt decay: the historic masonry buildings of Adelaide, South Australia. *Materials and Structures*, 42, 827-848 https://doi.org/10.1617/s11527-008-9427-1
4. Schmidt H. (1999). Historische Bauwerksabdichtungen - Traditionelle und neuzeitliche Maßnahmen zum Schutz gegen Bodenfeuchtigkeit und zur Trockenlegung feuchter Wände. *Bautechnik*, 76, 581-598 https://doi.org/10.1002/bate.199903790
5. Torres M.I.M., Peixoto De Freitas V. (2003). *Research in Building Physics*. CRC Press http://dx.doi.org/10.1201/9781003078852-53
6. Yurin O., Mahas N., Zyhun A., Musiienko O. (2020). Aspects of calculation of resistance vapor penetration of enclosing structures. *Academic Journal Industrial Machine Building*, *Civil Engineering*, 2(55), 96-101 https://doi.org/https://doi.org/10.26906/znp.2020.55.2350

7. Filonenko O.I., Yurin O.I. (2018). *Energy efficiency of buildings*. Poltava: Astraya http://dx.doi.org/10.13140/RG.2.2.17366.16961

8. Černý R., Podêbradská J., Drchalová J. (2002) Water and Water Vapor Penetration Through Coatings. *Journal of Building Physics,* 26(2), 165-177 https://doi.org/10.1177/0075424202026002975
9. Jerman M., Černý R. (2012). Effect of moisture content on heat and moisture transport and storage properties of thermal insulation materials. *Energy and Buildings*, 53, 39-46 http://dx.doi.org/10.1016/j.enbuild.2012.07.002

10. Filonenko O. (2018). Definition of the parameters of thermal insulation in the zone of building foundation according to the ground freezing depth. *Energy Efficiency*, 11(3), 603-626
http://dx.doi.org/10.1007/s12053-017-9600-x
11. Філоненко О.І. (2011). Вологісний режим фундаментної зони при термомодернізації забудови. *Містобудування та територіальне планування*, 39, 402-407.
12. Семко О.В., Чернявський В.В., Філоненко О.І. (2013). Вплив теплозахисних заходів на тепловий режим фундаментів та підлоги на грунті. *Коммунальное хозяйство городов*, (86), 19-22
https://khg.kname.edu.ua/index.php/khg/article/view/1634
13. Michette M., Lorenz R., Ziegert C. (2017). Clay barriers for protecting historic buildings from ground moisture intrusion. *Heritage Science,* 5, 31
https://doi.org/10.1186/s40494-017-0144-3
14. ДСТУ-Н Б В.2.6-192:2013 *Настанова з розрахункової оцінки тепловологісного стану огороджувальних конструкцій.* (2014). Київ: Мінрегонбуд України

15. ДБН В.2.6-31:2016. *Теплова ізоляція будівель*. (2016). Київ: Мінрегонбуд України

10. Filonenko O. (2018). Definition of the parameters of thermal insulation in the zone of building foundation according to the ground freezing depth. *Energy Efficiency*, 11(3), 603-626
http://dx.doi.org/10.1007/s12053-017-9600-x
11. Filonenko, O.I. (2011). Humidity regime of the foundation zone during thermal modernization of buildings. *Urban planning and territorial planning*, 39, 402-407.

12. Semko O.V., Cherniavskyi V.V., Filonenko O.I. (2013). Impact on events thermal barrier thermal regime basement and on the ground floor. *Municipal Economy of Cities*, (86), 19-22
https://khg.kname.edu.ua/index.php/khg/article/view/1634

13. Michette, M., Lorenz, R., Ziegert, C. (2017). Clay barriers for protecting historic buildings from ground moisture intrusion. *Herit Sci* 5, 31
https://doi.org/10.1186/s40494-017-0144-3
14. DSTU-N B V.2.6-192:2013. *Guidelines for the computational assessment of the thermal and moisture state of enclosing structures.* (2014). Kyiv: Ministry of Regional Development of Ukraine
15. DBN B.2.6-31:2016. *Thermal insulation of buildings*. (2016). Kyiv: Ministry of Regional Development of Ukraine