Conclusion

1. Experimentally confirmed the possibility of increasing the corrosion resistance of concrete by treating the surface protective coatings based on oxide and silicate-filled components polimetylfynilsyloksan.

2. Maximum rate adhesion strength (6,2-7,1 MPa) coating for concrete is in its thickness 0.3-0.5 mm.

3. Contact angle sheeting greater than 90 degrees, confirming their high hydrophobicity .

4. Established that protective coatings improve the corrosion resistance of concrete steps d ions Mg^{2+} SO_4^{2-} by 20-35 and 18-21 %, respectively.

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THE METHODS FOR CONDUCTING A SURVEY OF A GROUP OF BUILDINGS OF OLD HOUSING SYSTEM FOR DETERMINING THE INTEGRATED TECHNICAL CONDITION OF THEIR ACTUAL SPATIAL DEFORMATION

The paper presents a method of an advanced integrated assessment of technical condition of brick buildings as a whole as of their deformation of the skeleton of the fixed-engineering-geological conditions of the old building. The research is carried out on the example of a group of buildings of old housing system, located in Lviv at Dzerelna Street.

Key words: survey, technical condition, deformation

Наведено методику випереджаючої інтегральної оцінки технічного стану цегляних будівель загалом за станом деформування їх остову у фіксованих інженерно-геологічних умовах старої забудови. Дослідження виконано на прикладі груп житлових будинків старої забудови, розташованих у м. Львові на вул. Джерельній.

Ключові слова: обстеження, технічний стан, деформації

The analysis of the last research and publications

The plots for new construction located in the area of long-established low-rise residential housing system, are subjected to the inspection under existing regulations [5].

If a group of existing old buildings is placed on the area that according to the scheme directly affects the location of a newly designed building, perhaps with a large hollow of underground floors, the question of a thorough examination of the old building with an evaluation of its basic structural elements and bases under the foundations is of vital importance.

The main elements that typically provide general spatial rigidity of brick apartment buildings, should first of all include: bearing elements of building frame (longitudinal and transversal brick walls, floor), bearing and underlying layers of soil foundations on indicators of its physical and mechanical properties, the construction of foundations and other additional design elements that enhance the rigidity of buildings and installed during the construction, major repairs or reconstruction, including the superstructure.

Virtually all regulations aimed at designing new buildings, without any defects. To compensate the possible deficiencies in the new design solutions of buildings and ensuring their reliable operation, correction factors of different directions are aimed at such as: on the level of responsibility, the purpose, the load, the geometric characteristics, on the physical and mechanical properties of materials and soils, the nature of structural elements, the method of calculation for the two groups of boundary conditions.

When conducting the survey work of residential buildings of old housing system, to the level of determination of at least correction coefficients for the reliability according to loads γf for constant loads, specialized organization should undertake significant work as to the selection of samples of the materials, their testing with statistical analysis of the obtained data [3].

Usually, the obtained meanings for specific weights and reliability factors for permanent loads significantly differ from the standard meanings adopted today under new design. In addition, during the last century new approaches to the design have changed significantly, for both underground and above-ground parts of buildings.

Determination of physical deterioration of bearing elements of residential buildings and their structural elements is proposed by the method [11]. Physical deterioration of building designs in general, refers to the loss of their initial consideration of technical and operational characteristics (strength, sustainability, reliability, and so on.) as a result of climatic, technical factors and human activity.

According to subparagraph 5.1 [11] for determination of physical deterioration value (in percent) of building elements visual inspection using appropriate devices is required. According to the obtained percentage of physical deterioration approximate evaluation of technical condition of building elementsis carried according to such indicators: good, satisfactory, poor, dilapidated, unusable (in the respective ranges: 0-20, 21-40, 41-60, 61-80, 81-100%), with general characteristics of each technical condition (Table 5. 1 [11]).

The use of devices under visual inspection (by subparagraph 5.1 [11]) does not meet the requirements of subparagraph 3.6.2. [7], where the necessary equipment is used only under a detailed inspection.

According to the requirements of [7], the definition of real data for verification of payments for bearing capacity and deformability of bearing structures of existing buildings, taking into account their actual technical condition requires significant additional instrumental inspections and laboratory tests.

It is a long and compulsory way for obtaining final results and recommendations for the necessity of strenghtning of bearing and self-bearing walls of the buildings, their foundations and other substructures.

Traditionally, to assess the technical condition of buildings according to the statutory documentation professionals are operating the Ukrainian rules of the survey [7], the technical evaluation and the certification of the production buildings. During inspection the specialized organization must obtain qualitative and quantitative indicators of operational capability of the building, its parts and structures by visual inspection, instrumental measurements in nature and laboratory determinations.

Of the total list of surveys presented in [7], for residential buildings of old buildings it is sufficiently to carry out two types of surveys which are preliminary and detailed:

- A preliminary survey is the type of examination according to which expert analysis of technical documentation and external inspection of buildings and their parts followed are the main methods forthe determination of operational capability. A visual inspection is determined mainly qualitative indicators serviceability;

- A detailed examination is the type of examination, for which the basic method is the determination of operational capability indicators; the instrumental tests of designs and materials of buildings are used for that.

Preliminary examination contains (sub 3.6.1. [7]):

- collection and analysis of technical documentation;

- the general overview with the assessment of the state of structures and identification of the most poor and emergency structures;

- making up a technical task for performing the examination;

Detailed examination includes (sub 3.6.2. [7]):

- specification by measurements of cross sections of elements, design scheme loads, definition by devices of the actual physical and mechanical properties of materials (strength, elastic modulus, density, thermal conductivity, etc..)

-- Identification, measurement, sketching of defects and damage of structures (deformation, declivities, concavity, convexity, etc..)

-determination of the deformation of joints and seams, width of opening and depth of cracks, cross sections reinforcement, the thickness of the protective layer of concrete;

- analysis of the previous and instrumental inspections;

Under specific circumstances, depending on the buildings usage and their condition, some stages of surveys may not be conducted.

Subparagraph 3.9 of [7] can be used to highlight the main outcomes of the survey of buildings and analysis of the results, which shall be made as a report of a specialized organization that performed the inspection.

According to subparagraph 4.3 of [7] for a complete diagnosis of the technical state of buildings it is expedient along with full-scale surveys and laboratory determinations to plan and carry out a series of diagnostic procedures.

The latest diagnostic procedure in subparagraph 4.3 [7] is to evaluation of the technical condition of the building as a whole, which should be regarded as a result of the survey.

The technical condition of the separate structures is determined by joint analysis of defects and damage, and the results of verifying calculations. By bearing capacity and operational properties of the design it is recommended according to subparagraph4.13 [7] to refer to one of the following states: I - normal, II - satisfactory; III - unusable for operation; IV - emergency.

It is recommended according to paragraph 4.14 [7] that the buildings as a whole, depending on the condition of bearing and protecting designs, should be enlisted to one of the above mentioned conditions.

As to the paragraph4.15 [7], with appropriate justification, carrying out surveys and the evaluation of technical condition of certain parts of the building that can be distinguished by functional and structural characteristics is possible.

The aim and tasks of the research

The aim of the research is to develop a methodology of integrated assessment of technical condition of the brick buildings in general, as to the state of deformation of it's skeleton in fixed engineering and geological conditions of the old building.

This methodology should be used at the beginning of the inspection of separate buildings or groups of adjacent buildings due to the fact that firstly we are interested in the integral state of deformation of building skeletons, because if it is in unusable technical condition for exploitation, the technical condition of other construction elements are secondary importance.

The task of researches is to obtain the experimental results, which characterize the deformation state of buildings, and a search of approaches according to which by the experimental data we can estimate the actual deformated state of spatial frameworks of brick buildings and identify the main parameters according to which the necessity for amplification can by determined. The authors performed the study on a group of residential buildings № 30, 32,34 of old construction located in Lviv on Dzherel'na Street (Fig. 1).

Fig. 1. A group of three residential buildings № 34, 32, 30 (from left - to right) on Dzherel'na street in Lviv

The main material

For a speedy integrated determination of the actual deformations of spatial skeletons of buildings, which fix the joint deformation of their longitudinal and transverse walls with the bases for the period of inspection, the authors of research offer to start an inspection using a geodesic method [4].

The evaluation of technical conditions of buildings skeletons should be performed as their individual part, which can be identified according to the main functional and structural characteristics (p.4.15 [7]).

For example, let consider only the determination of the parameters of the actual deformation of the main facade walls of the residential buildings (Fig. 1) using the geodesic method.

On the selected points of the elements of buildings facades where renovation repairs are possible during the exploitation did not change the original image of facades and could not change dramatically the increase of the repair materials, the actual relative vertical displacement should be measured, which accompanied the old building houses from time of the construction to time of the detailed inspection ie, 80 ÷ 90 years of exploitation.

The fixed deformed scheme of skeleton integrally takes into account the deformation properties of soils, both in terms of buildings, and the nature of it’s bedding in the base under the foundations. The fixed horizontal bindings of points on the geometry of the elements of the facades buildings groups, where the actual vertical displacements (as to the horizontal) were measured, which appeared in homes from the time of construction, allow to define all necessary data for the analysis of spatial deformation of separate walls and skeletons in general considered residential brick buildings after their construction and approximation in the Microsoft Excel.

The actual recorded parameter values of actual deformation of the considered group of residential buildings are shown in Fig. 2.

The analysis of the obtained characteristic geometric parameters of buildings (slopes, curvature of the walls in the vertical and horizontal planes, subsidence, deviations from the vertical, differences of subsidence, deflections, bending) indicates that the stiffness of supporting and self-supporting walls and therefore the spatial stiffness of the very building decreases during long-term exploitation.

№34	№32	№30
Inclination: i=161.5/26790=0.00603; curve: f =114mm; Radius of curvature: R=0,716km	Inclination: i=121.5/15630=0.0078; curve: f = 89mm; Radius of curvature: R=0,331km	Inclination: i=119/15200=0.007829; curve: f =19,2 mm; Radius of curvature: R=1,507km

Fig. 2. Picture of crack formation on the main façade of a group of residential buildings and characteristic geometric parameters of deformation

It may be noted that the obtained actual meanings of the façade slopes of the buildings in their planes exceed the limit value i = 0.005 and is registered in the regulatory documents [1, 2, 5-10].

According to the obtained geometric parameters of buildings, the nature and consequences of the transfer of loads from the buildings on the base; the schemes of actual deformation development of the basis for the testing period considering the additional deformations of base on existing objects from the effects of adjacent sequentially adjoined and semi-detached groups of buildings (unit 11.3 [5]).

But there is a question, how we can analyze the condition of buildings, foundations and reasoning for a need in strengthening of building on that effort according to the obtained characteristic geometric parameters and the results of approximation of experimental data (Fig. 2).

The analysis of regulatory documents showed that this can be done according to the rules [10, 1] which are applied to the designing of buildings and structures which are built on areas meant for underground works.

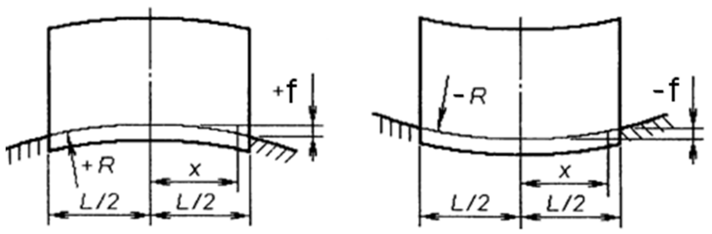
To use of approaches [10, 1] to the analysis of the actual state of the buildings and foundations as to the received parameters from testing, the following scheme of buildings deformation and "deformation of the earth's surface" should be considered (Fig. 3, 4).

If, under the unit 1.7.10 [5], to use the approaches to the calculations of foundations as systems "base-foundation" or "base-foundation-building" as to deformations of bases, than we propose to use the term "deformation bases foundations" as a more local action of distribution and redistribution of stresses from building foundations at the bases, instead of the term "the deformations of the earth's surface".

The effects of uneven basis deformations in the form of dislocations and deformations of soil mass in calculation schemes operate in three orthogonal directions X, Y, Z. The directions of axes X and Y are taken as those, which coincide with the directions of the main axes of the building foundation[1].

During the smooth deformations of basis, the calculation schemes can be used for quick analysis of residential buildings (subparagraph 10.1.4 [5]).

According to 2.1 [1], when analyzing the condition of buildings and foundations, the actual "deformations of the foundation bases" should be considered; they are divided into the following types (Fig. 3, 4): subsidence *S*, mm; subsidence difference *ΔS*, mm inclination *i*, mm/m; the curvature (convexity, concavity) *p*, 1/km, the radius of curvature R= 1/*p*, km.



a *b*

Fig. 3. Schemes of vertical displacements of bases under the foundations during the formation of the corresponding radiuses of curvature ± R:a - sign "+" - convexity (curve); b - sign "-" -

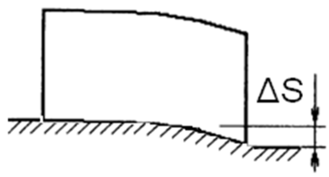


Fig. 4. Vertical dislocations of base under the foundations, which cause the difference of subsidence ΔS of end walls in the facade plane

The scheme of vertical displacements of the base of foundations in uneven subsidence of base in the form of a parabolic cylinder with radius at the top, equal to the radius of curvature ***R*** (Fig. 3).

The dislocation of any point of the basis "*y*" relatively the axis of the building or it's compartment can be defined by the formula:

$$y = \frac{\tilde{o}^2}{2 \times R} , \qquad (1)$$

where *x* - the distance from the point to the central axis of the building (Fig. 3). At $x = L/2$, $y_{max} = f$ - deflection (-) or bend (+) of the building.

$$y_{max} = f = \frac{L / 2^2}{2 \times R} . \qquad (2)$$

The difference of displacements Δy of two points of the basis under the foundations of the building, which is the result of curvature of system “basis-building”is determined by the formula:

$$Dy = \frac{x_2^2 - x_1^2}{2 \times R}, \tag{3}$$

where x_1, x_2– the distance from point of the basis to the corresponding central axis of the building.

The difference of displacements DS of two points of the basis (fig.4) that occurs in the result of uniform inclination i of the basis under the foundations of the building is determined by the formula:

$$DS = S_2 - S_1, \tag{3}$$

Where S_1, S_2 - settlings of basis under the foundations in the extreme points of the walls of the building’s facades.

The angle of inclination at any point of the basis i_p, which is a result of deformation of bases und foundations is determined by the formula:

$$i_p = \frac{x}{R}. \tag{4}$$

The lurch of foundations i (walls of the building) in its plane is determined by the formula:

$$i = \frac{DS}{R} L. \tag{5}$$

The results of measurements of vertical deformations of the main facades of buildings and the main indicators of deformations are shown in Fig. 2.

The formed radiuses of the curvature R of the walls of buildings on the level of performed measurements correspond to radiuses R_o of the curvature of bases on the level of soles of foundations of these walls. The radiuses R_o of the curvature of bases on the level of soles of foundations can be determined by the formula:

$$R_o = R - h, \tag{6}$$

where h – the distance from the level of measurement of relative vertical displacements on the facade to the level of bases of foundations. For the general analysis of the determination of meaning R_o is not obligatory, as the ratio h/R can be can be attributed to the infinitely small value. For example, for the building №34 (fig. 2) R_o=R–h=716-7,1=708,4m, ratio R_o/R =708,4/716=0,99 –the difference is ≈1%.

The determined radiuses of the curvature of buildings R together with geometric dimensions of these walls (height H and length L), by the methodology [10] allow in a graphical form to identify the integral need for strengthening or not strengthening of buildings on the effect of bending moments M and transverse forces Q, which function in planes of the walls.

According to the recommendations [10], for the determination of the necessity of strengthening of buildings with rigid constructive scheme on M and Q from the effect of formed curvature of the basis under the soles of foundations *Ro,* or R (depending on the thoroughness of the analysis), the graphics presented [10] for a significant range of radiuses of curvature R from 1000 m to 15000 m should have put the geometric data of the very buildings, their height H and length L.

In Fig. 5-7 there are the graphics for each examined building and the analysis of the necessity for it’s strengthening on M and Q.

Conclusions

1. After receiving the basic parameters according to which the general technical condition of stone buildings with bearing and self-supporting walls can be estimated, we should extend the further study of geological data and other searching to be able to more deeply analyze the condition

of building and theoretically highlight the contribution of different influence factors on their actual received deformed pattern.

2. Identified under real conditions by geodesic method, the components of relative vertical dislocations of façade elements can be regarded as the actual consequences of compatible vertical deformations as to the system "base-foundation-structure" on the basis of which the recorded parameters can be analyzed or use them for the analysis of linear and nonlinear models of deformation of soil of foundation as a system.

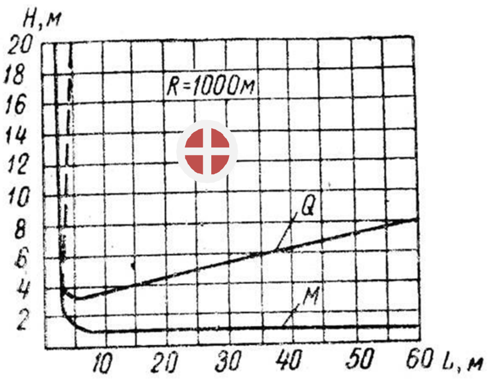


Fig. 5. Schedule R = 1000 m [10]is used to determine the need for strengthening the building at 34 Dzherelna Str.

At the inspection it is recorded: the radius of curvature of the building R = 716 m, height H = 13.2 m, length L = 27,26 m. According to these data, the façade wall of the building should be strengthened on the M and Q in the longitudinal direction

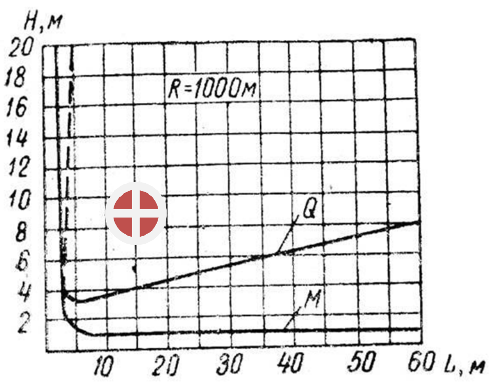


Fig. 6. Schedule R = 1000 m [10]is used to determine the necessity for strengthening the building at 32 Dzherelna Str.

At the inspection it is recorded: the radius of curvature of building R = 331 m, height H = 8.3 m, length L = 15,6 m.According to these data façade wall of the building should be strengthened on the M and Q in the longitudinal direction

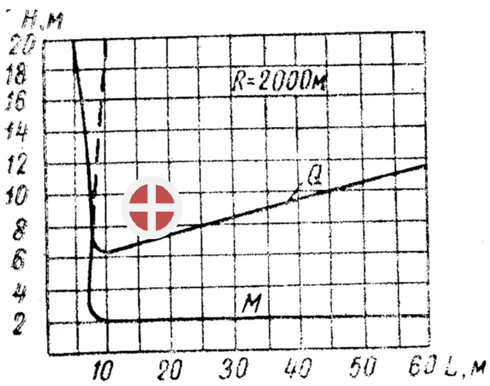


Fig. 7. Schedule R = 2000 m [10] is used to determine the necessity for strengthening the building at 30 Dzherelna Str.,

At the inspection it is recorded: the radius of curvature of the building R = 1507,73 m, height H = 8.7 m, length L = 15,2 m. According to these data the facade wall of the building should be strengthened on the M and Q in the longitudinal direction

3. The experience of the survey of residential buildings of old buildings shows that the design scheme super fundamental structures and their foundations are not always taken into consideration according to the analysis of deformation characteristics of bases for making well-grounded rigid spatial brick frames.

4. Brick buildings of old housing system with longitudinal and transverse bearing and self-supporting walls are not adapted to the perception of uneven deformation of bases and the redistribution of tensions under foundations of adjacent walls. Due to uneven deformation of building skeletons, for the

long term of operation, rigid frames of buildings converted into a "combined" spatial systems with low stiffness, which work is complicated by significant vertical and inclined cracking.

5. Aboveground part of residential buildings should be designed, usually with a rigid structural scheme, which can perceive the efforts of the loads acting on it, and the effect of efforts arising from uneven deformation of the spatial frame of building.

6. According to the minimum obtained figures of foundation deformations under the foundations of buildings - the radius of curvature R and the inclination i, according to Table 1 [1]the classification of the conditions for the construction of four groups of territories can be evaluated. Thus, the analysis should use unprofitable values: smaller for R, larger for i. Relative horizontal values of strain ε or compression of the base for foundations (Table 1 [1]), which are taken into account at buildings calculation as load factors, can be defined as a result from the calculation in which the actual geometry of deformation of buildings, physical and mechanical characteristics of the soil foundation and the actual rigidness of the spatial frame should be considered.

7. The dimensions of spatial deformation that of considered buildings walls together with the base excess of the limit values for objects that are not adapted to the perception of uneven deformation of the base.

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