PalArch's Journal of Archaeology of Egypt / Egyptology

STATISTICAL ANALYSIS OF FORECASTING PHYSICAL WEAR AND TEAR OF MULTI-FAMILY RESIDENTIAL BUILDINGS

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Asadulla Khotamov, Statistical Analysis Of Forecasting Physical Wear And Tear Of Multi-Family Residential Buildings– Palarch's Journal of Archaeology of Egypt/Egyptology 17(9) ISSN 1567-214X.

KEYWORDS: Multi-apartment buildings (MAB), physical durability, wear intensity, negative natural factors, regional characteristics, assessment of technical condition, forecasting of the remaining service life.

ABSTRACT.

Most of the apartment houses belonging to several "generations", which exist in different regions of the Republic, today have a different level of technical condition. In the exploitation of multi-apartment houses in our republic, a lot of problems related to the maintenance of them have accumulated in the last 30 years.

The purpose of this study is to determine the process of wear and aging of building structures and buildings in multi – apartment buildings in General in order to clarify the durability of residential blocks for subsequent planning of their renovation.

To solve this problem, full-scale surveys of apartment buildings located in different regions of the Republic were conducted. For a full-scale survey, wooden, brick, reinforced concrete panel buildings and buildings made of natural stones with different storeys are accepted.

The results of the study show that the indicator of longevity of multi-family residential buildings in many cases depends on the quality of operation. The actual service life of certain parts of buildings, such as foundations, walls, and coverings, is also set, depending on the location in the region. Significant factors that negatively affect the durability of buildings, such as salinity of the soil, increase in the level of groundwater, are determined.

In conclusion, it is noted that the results of this study are adapted to the effective use of the housing stock for sustainable development from the point of view of safety in the development of a phased renovation program for the future development of cities.

INTRODUCTION.

Our observation and investigation work shows that the negative effects of this factor on the basement part of multi-apartment houses, their effects on the building foundations in some regions, especially in the districts of the Republic of Karakalpakstan, together with soil salinity of moisture, are gaining momentum. To this end, as a result of the specific conditions of the Republic, in particular, dry-hot climate, humidity in some regions, wind, daily, seasonal, annual fluctuations of temperature in large amplitude, rise of the groundwater level to 2.0-2.5 m in some regions in the last 15-20 years, the city has been actively working underground infrastructure [16].

These include: a system of examinations, a breakdown of repair and restoration work, a failure of the management system at the required level, a high level of energy expenditure on the account of physical and spiritual wear and tear of residential buildings, outdated basement and roof components, engineering networks, cases of premature failure of structures and elements, carrying out inventory and passport work, constructive parts of buildings on an arbitrary basis, cases of change of floors, the appearance of facades in different ways, adjacent areas are the elements of landscaping (night lighting, irrigation-water desalination, irrigation system, children's home and farm areas, norms of landscaping, issues of parking lots, Organization of waste, sanitary and safety distances, corridors of fire extinguishers, etc.) failure to meet the requirements of urban norms, the issues of their non-existence in many regions today demand a completely new approach to the sphere in line with the new requirements of the norms and rules of modern urban development.

Analyzing the composition by age of residential buildings in the city of Tashkent, you can qualify as follows:

- residential buildings that are more than 100 years old. They are mostly preserved in the "old town" e, which consist of a wooden structure "Wooden frame". Some of these houses are about 200 years old.

- residential buildings-built in the 30s of the last century, the condition of which is at the stage of "physically and morally obsolete".

- residential buildings built before the Tashkent earthquake (1966), having a kind of architecture with ledges, columns, cornices on the facades, etc. They do not meet the requirements of current design standards, in particular the requirements of seismic resistance of the structure.

- residential buildings built during the period of mass industrial construction (after the Tashkent earthquake). They were built on the basis of the requirements of the design standards of the period, taking into account the requirements of seismic resistance of the structure. However, the monotony of design solutions and architectural appearance of buildings and structures, without taking into account the specific features of the region, requires their modernization. The state of buildings and structures of this generation varies. If we are talking about residential development, the age of residential buildings of the industrial period already exceeds 50 years and the condition of a significant part requires a minimum of major repairs.

Research in the field of housing maintenance shows that untimely scheduled preventive repairs accelerate the physical deterioration of building structures. The experience of many years of research by the authors shows that permanent basic building structures get wear and tear of the basic nature (structural changes in strength, rigidity of building materials), which can not be restored or is not economically feasible. The change of environment, sanitary and hygienic environment, in particular, the increase in groundwater level due to the mismatch of irrigation systems of the city and also because of the destruction of the natural ravines in land improvement without drainage was the catalyst to the intensity of physical deterioration of structures below zero housing. This is clearly seen in the state of the city's underground engineering infrastructure. In addition, the daily increase in the concentration of salts, alkalis and acidity in the composition of groundwater has become an aggressive influence on the main Fund of the city economy. Widespread flooding of residential areas, streets and other functional areas with atmospheric and other surface water, lack of irrigation systems in the city, incorrect design decisions or errors in the construction and improvement of territories when performing vertical planning is the main source of groundwater increase.

Today, proper operation of the main Fund of urban development is important. Research on the development of the theory of wear, aging, and operational reliability and safety of the urban construction Fund is relevant.

Issues related to operational reliability of residential buildings devoted to the work: V.V. Anisimov, S.K., Balashov, I. Borovkov, M.D. Boyko, L. Burak, A.A. Soderman, N.E. Simionova[13],T.G. Popov, A.P. Prokopishin [14], E.V. Polyakov, G.P. Poryvai, A.G. Roitman, V.A. Rogonsky, N.G. Smolenskaya, B.M. Kolotilkin, A. V. Kolomeits, A.I. Kostrits, G. Kruglyakov, V.N. Kutukova, N.N. Milovidova, N.I. Nechaev [15], R. Ribicki, G. Ruffert, M.S. Shumilov, I.A. Fisdel, V. V. Fursov, etc.However, the operational reliability of residential buildings, taking into account regional characteristics, is little studied and requires further research.

To reduce the negative impact of the above problems, ensuring and improving the durability and safety of the urban construction Fund requires a comprehensive approach to the study of this problem, in particular, the study, analysis and assessment of the state, determining the remaining life, durability and reliable operation. And on the basis of the obtained results, it is important to forecast the residual resource of construction Fund city services for scientific substantiation of technical and economic indicators on the feasibility and operation of buildings and structures, sequence reconstruction, renovation subject to multivariate analysis.

This circumstance causes an urgent need to develop new, effective approaches to planning, organization and technologies for capital repairs and reconstruction of buildings and structures that contribute to more effective use of budget funds allocated for the restoration of fixed assets of the city economy.

MATERIALS AND METHODS. Analyzing the results of the work on natural observation and inspection, we determined the intensity of the wear of the foundation structures of AB (apartment building) with 2-4 storey prefabricated reinforced concrete panels in different regions of the Republic [7,9].

Most of the results of the natural survey were conducted in unsatisfactory exported residential buildings, and the results obtained, that is, the depreciation values did not correspond to any of the formulas analyzed. The closest to the indicator of the depreciation of buildings in our regions was the A-formula recommended by V.A.Srokovsky in the error 15-20%. We analyzed the statistics of the buildings on the size of depreciation and we developed a new model of forecasting the depreciation taking into account the conditions of our republic.

Table 1.
Data on statistical processing of observation-examination results [17]

N	x,year	y ,%	x^2	y^2	xy	ŷ	(ŷ-y)^2	(y-Yav)^2
1	30	13	900	169	390	14,46	2,1316	63,3616
2	35	15	1225	225	525	15,81	0,6561	35,5216
3	40	18	1600	324	720	17,16	0,7056	8,7616
4	44	19	1936	361	836	18,24	0,5776	3,8416
5	45	19	2025	361	855	18,51	0,2401	3,8416
6	50	21	2500	441	1050	19,86	1,2996	0,0016
7	55	22	3025	484	1210	21,21	0,6241	1,0816
8	60	22,5	3600	506,25	1350	22,56	0,0036	2,3716
9	65	23	4225	529	1495	23,91	0,8281	4,1616

10	70	25	4900	625	1750	25,26	0,0676	16,3216
11	75	26	5625	676	1950	26,61	0,3721	25,4016
12	80	28	6400	784	2240	27,96	0,0016	49,5616
Amount	**649**	**251,5**	**37961**	**5485**	**14371**	**251,6**	**7,508**	**214,229**
Average	**54,08**	**20,96**	**3163**	**457,1**	**1198**	**20,96**	**0,626**	**17,8524**

The results of the conducted examination are presented in Table 1, we obtained the following in the statistical processing method of the results. Table 1 illustrates the average values F = y of the wear of AB foundations with (2-4) storey prefabricated reinforced concrete panels in the range of $30 \leq T \leq 80$.
Here, x = T - the average value of the period of operation of the foundation of the building, year; y = F-the average amount of depreciation of the foundation of the building, %.
Based on the results determined in Table 1, we will analyze the correlation of y to x based on the linear relationship.
To do this, it will be necessary to find the following statistical finite details:
Medium values,

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i = \frac{649}{12} = 54,08$$

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i = \frac{251,5}{12} = 20,96$$

$$\overline{x^2} = \frac{1}{n}\sum_{i=1}^{n} x_i^2 = \frac{37961}{12} = 3163.42$$

$$\overline{y^2} = \frac{1}{n}\sum_{i=1}^{n} y_i^2 = \frac{5485,25}{12} = 457.104$$

$$\overline{xy} = \frac{1}{n}\sum_{i=1}^{n} x_i y_i = \frac{14371}{12} \approx 1198$$

Here n is a sample size, and n=12.
link y= Φ to x= T

$$\hat{y} = ax + b$$

We find the linear regression equation. In this we determine the values of coefficients a and b by the method ‘the smallest squares’:
To do this, we draw up the following system of normal equations [4].

$$\begin{cases} a \cdot \sum_{i=1}^{n} x_i^2 + b \cdot \sum_{i=1}^{n} x_i = \sum_{i=1}^{n} x_i\, y_i \\ a \cdot \sum_{i=1}^{n} x_i + nb = \sum_{i=1}^{n} y_i \end{cases}$$

We use the values calculated in Table 1:

$$\begin{Bmatrix} 316{,}42a + 54{,}08\, b = 1197{,}58 \\ 54{,}08a + 12\, b = 20{,}96 \end{Bmatrix}$$

$$a = \frac{n\sum xy - \sum x - \sum y}{n\sum x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2} = \frac{12 \cdot 1197{,}58 - 54{,}08 \cdot 20{,}96}{12 \cdot 3163{,}42 - 54{,}08^2} = 0{,}27$$

$$\mathrm{b} = \frac{\left(\sum_{i=1}^{n} y_i - a \cdot \sum_{i=1}^{n} x_i\right)}{n} = \frac{20{,}96 - 0{,}27 \cdot 54{,}08}{12} = 6{,}42.$$

So, the equation of dependence of the depreciation on time was as follows for these foundations:

$$\hat{y} = 0{,}27x + 6{,}42$$

We check the adequacy of the Found model:
We calculate the following finite details using the values calculated in Table 1:
Coefficient of correlation:

$$r_{xy} = \frac{\sum (y_i - \bar{y})\ (x_i - \bar{x})}{(n-1)\, S_x \cdot S_y}$$

Average squared deviation:
$S_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}}$=15,44

$$S_y = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}} = 4{,}22$$

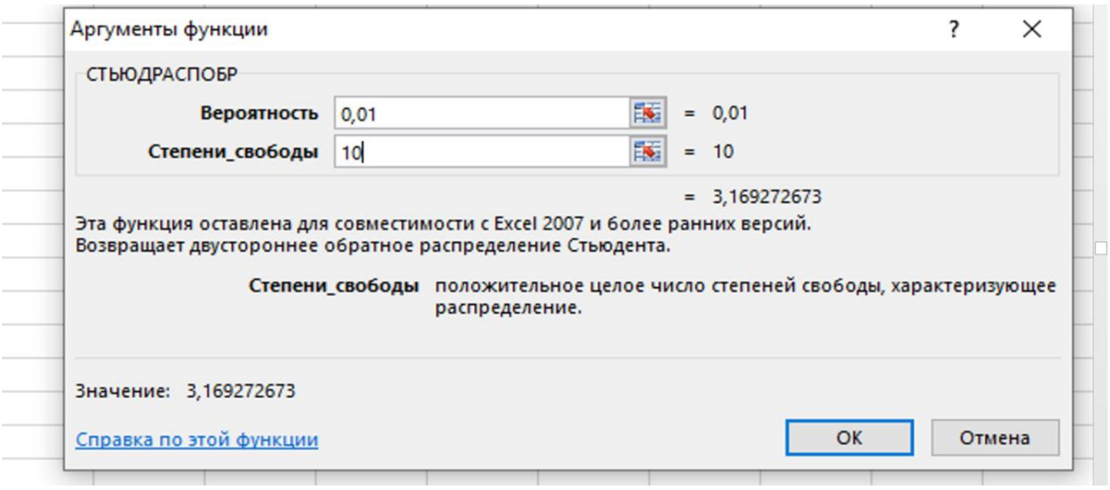
$$r = \frac{\sum (y_i - \bar{y})\ (x_i - \bar{x})}{(n-1)\, S_x \cdot S_y} = 0{,}98$$

$$\begin{Bmatrix} \text{if} \quad \mathrm{r} < 0{,}3, \quad \text{there is no link} \\ \text{if} \ 0{,}3 \le \mathrm{r} \le 0{,}7, \quad \text{there is weak link} \\ \text{if } 0{,}7 < r \le 1, \text{there is strong(functional) link} \end{Bmatrix}$$

Now we evaluate the correlation coefficient, that is, we check the adequacy of$\boldsymbol{r_{xy}}$. To do this We use the t – sign of Styudent. We find the empirical $\boldsymbol{t_r}$ and critical $\boldsymbol{t_{crit}}$ values of t:

$$\boldsymbol{t}_{э} = \frac{r_{xy}}{\sqrt{\frac{1-r_{xy}^2}{n-2}}} = \frac{0{,}98}{\sqrt{\frac{1-0{,}96}{12-2}}} = 15{,}49$$

α = 0.01 at the value level k = n-2 = 12-2 =10 when the degree of freedom is equal to 10 we find the value of t_{crit} from the MS Excel NORMSTOBR function [17] (Picture 1):



Picture 1.Determining the value of t_{crit}in MS Excel.

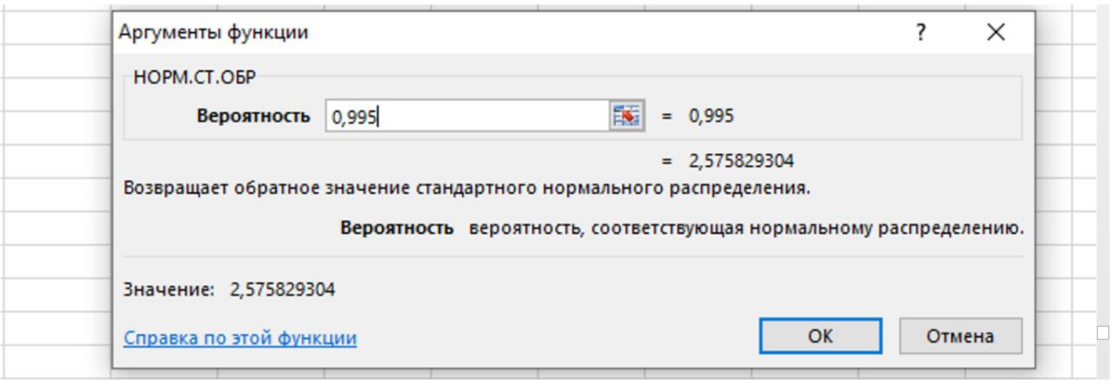
$t_{crit} = t_{1-\alpha,\ n-2} = t_{0.99,\ 10} = 3{,}17$

$t_{эм} > t_{crit}$(15,49 > 3.17)

So, r_{xy} is static adequate.
We find a reliable interval of the correlation coefficient.We use Fisher's Z-replacement:

$$Z = \frac{1}{2} ln \frac{1 + r_{xy}}{1 - r_{xy}} = \frac{1}{2} ln \frac{1 + 0.98}{1 - 0.98} = 2{,}3$$

We find the ordinal standard normal distribution quantum from MS Excel NORMSTOBR function [17] (Picture 2):



Picture 2. Determining the value of $t_{1-\alpha/2}$ in MS Excel using the NORMSTOBR function

$t_{1-\alpha/2} = t_{0.995}$ = NORMSTOBR (0,995) = 2,57
Now

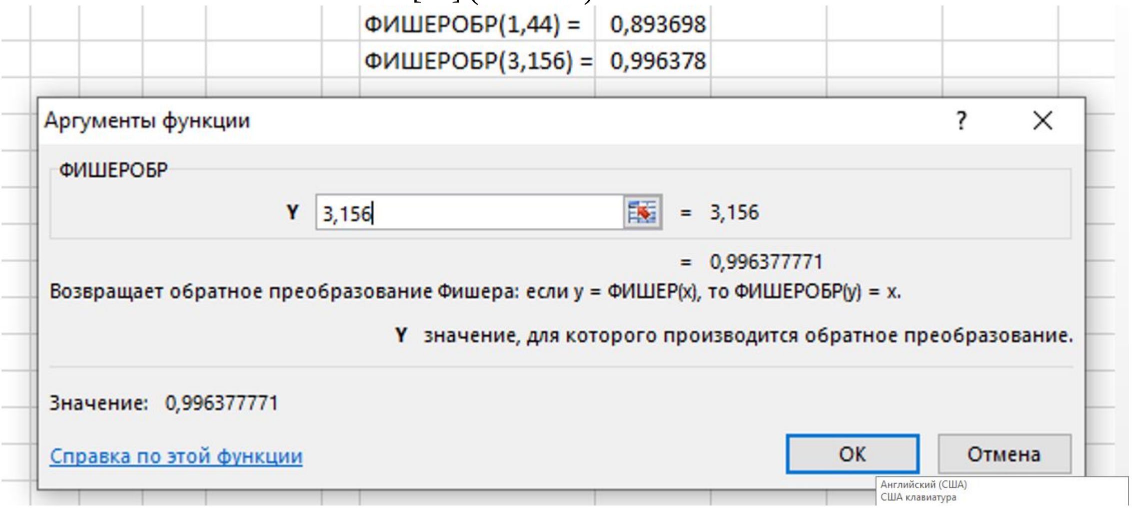
$$t_{1-\frac{\alpha}{2}} \cdot \sqrt{\frac{1}{n-3}} = 2{,}57 \cdot \sqrt{\frac{1}{12-3}} = 0{,}856$$

$(Z^- ; Z^+)$ we find a reliable interval:

$$Z^- = Z^1 - t_{1-\frac{\alpha}{2}} \cdot \sqrt{\frac{1}{n-3}} = 2{,}3 - 0{,}856 = 1{,}44$$

$Z^{+} = 2{,}3+0{,}856 = 3{,}156$

$(r^{-}; r^{+})$ values of reliable interval limits
we use $r = Z^{-1}(r)$as the statistical function of MS Excel FISHEROBRS [17] (Picture 3):



Picture 3. r^{-}, r^{+} - to determine the values of reliable interval limits using MS Excel FISHEROBRS statistical function.

$$r^{-} = Z^{-1}(1{,}44) = 0{,}89$$
$$r^{+} = Z^{-1}(3{,}156) = 0{,}99$$

Reliable interval (0,89; 0,99).
Result:
The law on the wear and tear of the foundation of residential buildings

$\Phi(T)=0{,}27\cdot T + 6{,}42$
found a linear model.
The correlation coefficient is found in $r = 0{,}98$ value.
Through Styudent's criteria – t,t_r= 15,49,

$t_{crit} = t_{0.99,\,10} = 3{,}17$, $t_r > t_{crit.}$

α= 0.01, p = 0,99 with probability to$r$ (0,89; 0,99) found a reliable interval.

The following model of the general law of depreciation of the foundation of the naturally inspected AB was found:

$$\hat{y} = \begin{cases} 3{,}78\ln(x+1) \text{ if}, & x < 30 \\ 0{,}27x + 6{,}42 & \text{if}, 30 \le x \le 80 \\ 13{,}6e^{0{,}009x} \text{ if}, & 80 < x < 135 \end{cases}$$

The correlation coefficient is found in $r = 0{,}998$value.
Through Styudent's criteria – t, t_r= 15,49,

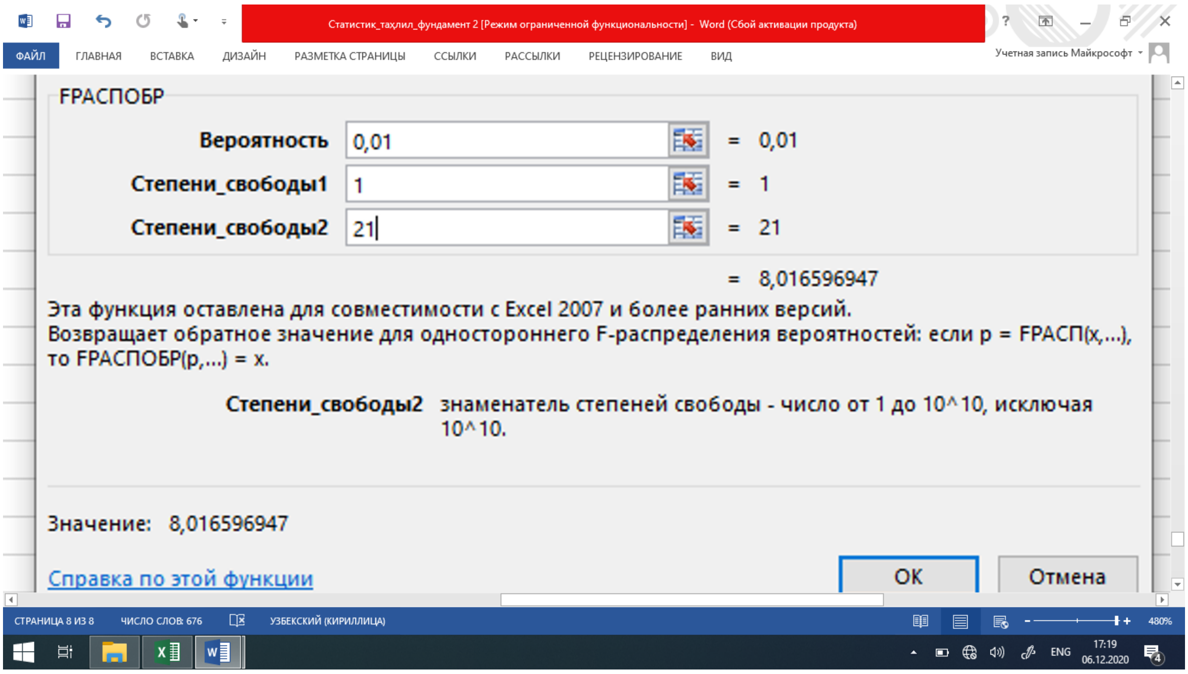
$t_{crit} = t_{0.99,\,21} = 3{,}17$, $t_r > t_{crit.}$

α = 0.01, p = 0,99 with probability to r(0,89; 0,99)a reliable interval is found.

We check the R-correlation index. To do this, we use Fisher's F sign:
R = 0,99

$$F_R = \frac{R^2}{1-R^2}(n-2) = \frac{0.99^2}{1-0.99^2}(23-2) = 1034{,}2$$

To find the critical F_{crit}, we use MS Excel FRASPOBR [17] (Picture 4):α= 0,01, $k_1 = 1$, $k_2 = n-2 = 21$.



Picture 4.To find out the $F_{крит}$ using the statistical function FRASPOBR in MS Excel

$F_{crit} = F_{распобр}$ (0.01; 1; 10) = 8,01
All in all, $\mathbf{F_R}$ = 242,5 >8,01 = $F_{crit.}$
This means that the model found can be considered adequate with an 99% warranty.

THE RESULTS AND DISCUSSION.

The calculation of the physical decay of a building by the method of service life can be used in the mass technical inventory of the housing stock (for example: in the classification of buildings of the same type, in the planning of mass scheduled repairs, etc.). This method is based on the analysis of statistical data collected during the technical operation of residential buildings, and in this approach, several methods and formulas are proposed.The formulas proposed by the architects Ross [1-2] and V. Srokovsky are quite convenient, with the help of which the account of normal, average and unsatisfactory operation is kept in the fall. The calculation method proposed by S.K. Balashov [1-2] is also more accurate in assessing the technical condition of buildings in average operation.However, buildings differ by mutual capital groups and, accordingly, the service life is determined by the same indicator. In order to take this factor into account, the calculation formulas co-authored by V.V. Anisimov and V.E. Nikolaytsev and recommended by Litver are noteworthy.

Determining costs by calculation - the method of estimation and V.S. Bashkatov [1], A.V. In the method recommended by Belyx [2], the degree of depreciation is determined by the estimated value of the costs incurred to eliminate the physical decay. The correct approach to determining the breakdown when taken logically.But in order to use the method, the operation of the system of scheduled repairs of residential buildings, all the information on the work performed must be preserved. All of the methods analyzed have their own disadvantages and advantages. These methods are used to determine the initial, probable level of physical deterioration (wear) of buildings. It is also used to predict the level of physical decay that may occur over a long period of exploitation.However, these methods come in handy when planning routine preventive maintenance of a building. The accuracy and reliability of the calculations are not high, but these methods can be used in planning the solution of the above problems. However, these methods cannot be used to determine the true technical condition of a building.

Thus, the normative-service life methods are convenient in the inventory and certification of buildings, mass assessment, and for the satisfactory, average and unsatisfactory conditions of operation of buildings proposed by architects Ross and V. Srokovsky. .Recommended by Anisimov-V.E. Nikolaytsev and Litver. While the first of the above takes into account the operating conditions, the second stems from the capital group of the building. Their main drawback is that they cannot accurately determine the real technical condition of the buildings.In particular, the formula proposed by S.K. Balashov can give good results only in some cases. The method proposed by V.K. Sokolov can be very effective in determining the normal physical erosion for brick walls with capital class 1A, 1,2,3. A method that allows to predict the collapse of the building under consideration in the first 10 and 20 years is recommended by N.V. Nechaev [15].

The next method is a method of determining the physical wear and tear of the object, taking into account the age of the object and the capital repairs carried out, which can reflect a much more real situation. However, this formula is important only if the building has undergone a major overhaul. Simultaneous complete overhaul of MAB is very rare. Obsolescence of materials is not fully taken into account in the current norms and methods in the country [3, 5-6, 8, 10-12].

Methods related to the normative service life are useful in the development of programs for the renovation of residential quarters, their typology, the decision to make mass capital repairs, reconstruction or demolition, depending on age. In addition, based on our many years of experience in real estate appraisal, the formula of S.K. Balashov can be recommended for appraisal specialists in the appraisal of real estate.

Qualimetric methodology for assessing the technical condition of a building is also a method used to assess the condition of damage to building structures. Here, of course, the use of the method requires a high level of expertise in the theory of obsolescence of buildings and structures.

CONCLUSION.

None of the methods discussed above can give a complete result in determining the wear of a building. In addition, they do not have the opportunity to take into account the specific territorial factors of the territorial zones of Uzbekistan. Therefore, our study of the causes of physical decay, based on the characteristics of the territorial zones of the republic, was conducted using the results of in-kind observations.

The obtained results were statistically analyzed and the rate of deterioration of MAB, their foundations and walls in different regions of Uzbekistan was studied. As a result, in contrast to the methods recommended by the above scientists, a model of obsolescence of MAB, which is typical for our country, was created. Based on it, it is possible to predict the obsolescence of MAB in operation, their residual service life and longevity.

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17. SP MS Excel-2007: NORMSTOBR,FISHEROBRS, FRASPOBR.

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STATISTICAL ANALYSIS OF FORECASTING PHYSICAL WEAR AND TEAR OF MULTI-FAMILY RESIDENTIAL BUILDINGS
Кўп квартирали уйларни жисмоний эскиришини прогноз қилишнинг статистик таҳлили
Статистический анализ прогнозирования физического износа многоквартирных жилых домов