Prognostication of relations between the buildings age and deterioration of construction

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Abstract. The untimely reconstruction of the building can lead to its liquidation, despite the intrinsic value. Such measures can be prevented if a competent program for organizing reconstruction is present. To create an organizational and technological model of reconstruction, it is necessary to know the parametric dependencies of the characteristics of the studied buildings. To analyze the data on the conditions of existing houses, a mathematical model is used, built in the 3d table curve software. 55 houses were selected, 11 buildings in 5 districts of St. Petersburg. Using of the equations obtained, it is possible to predict the deterioration of structural elements in the future using the described method. The most important thing is the organization of timely actions on the basis of projected data: planned repair and reconstruction.

1 Introduction

The untimely reconstruction of the building can lead to its liquidation, despite the intrinsic value. As an example, the house of merchant Rogov located in St. Petersburg near with Vladimirskaya subway station, at the intersection of Zagorodny Prospekt and Shcherbakov Lane. The house was a rare example of urban development of Pushkin's time. Demolition, the legality of which is still in question, was made because of the danger of collapse due to an emergency condition. Such measures can be prevented if a competent program for organizing reconstruction is present [1]. Accelerated destruction of buildings can lead to spontaneous causes, technological disruptions and inadequate operating conditions [2]

To create an organizational - technological model, it is necessary to analyze the parametric dependencies of the characteristics of the buildings under study, since the reliability of the entire building system depends on the reliability of its constituent elements [3]. Creating such a model will also help to optimize costs, because there is a certain optimum of a parity of expenses for construction and operation costs. [4]

2 Methods

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To study the dependencies, it was decided to use 5 districts of St. Petersburg in order, to assess how much belonging to a certain area of the city affects the technical behavior of the structural elements in time. Data on the technical conditions of the buildings are provided by the State Construction Committee and are summarized in Table 1. Issues of operation and inspection of buildings are widely described in the works of N.V. Braille

Table 1. Depreciation of constructive elements in Vasileostrovskiy district

No	Total age	House area, m^2	Depreciation of foundations, %	Depreciation of walls, %	Depreciation of ceiling,%
1	128	13670	50	42	43
2	102	4502	23	36	30
3	101	2218	36	45	42
4	102	2295,6	42	42	42
5	113	1926	43	42	44
6	103	6190	38	42	40
7	101	3938	46	46	47
8	101	3507	37	38	39
9	36	7422	27	29	29
10	119	5831	18	31	24
11	105	2404	37	41	39

Table 2. Depreciation of constructive elements in Vyborgskiy district

No	Total age	House area, m^2	Depreciation of foundations, %	Depreciation of walls, %	Depreciation of ceiling,%
1	51	5214,7	32	35	34
2	101	1369,9	45	36	32
3	101	1752,3	46	35	32
4	78	4000	51	28	32
5	101	1700,1	53	38	38
6	136	5090	37	39	37
7	119	3161	55	35	35
8	82	4051,8	52	39	37
9	62	6 630,60	42	38	37
10	106	1685,4	47	44	44
11	81	9797	52	28	27

Table 3. Depreciation of constructive elements in Kalininskiy district

No	Total age	House area, m2	Depreciation of foundations, %	Depreciation of walls, %	Depreciation of ceiling,%
1	101	11230,1	47	43	41
2	64	10 948,30	43	30	38
3	118	2224	49	41	41
4	57	2777,2	35	36	36
5	36	6 490,70	22	21	13
6	48	4877	39	40	44
7	66	2 929,60	44	36	34
8	55	4 951,80	34	30	24
9	57	2856,7	36	38	43
10	37	11 722,70	22	28	27
11	58	2888,97	36	32	38

Table 4. Depreciation of constructive elements in Petrogradskiy district

No	Total age	House area, m2	Depreciation of foundations, %	Depreciation of walls, %	Depreciation of ceiling,%
1	107	8133	47	40	39
2	82	1835	52	36	35
3	107	7485	20	35	29
4	115	2804	48	41	42
5	107	6013	28	19	10
6	115	10644	48	48	51
7	141	5652	53	44	42
8	106	8706	46	45	50
9	117	3706	48	44	45
10	113	7441	48	42	41
11	122	891	37	36	35

Table 5. Depreciation of constructive elements in Centralniy district

No	Total age	House area, m2	Depreciation of foundations, %	Depreciation of walls, %	Depreciation of ceiling,%
1	176	2228	38	41	1
2	183	2473	36	32	2
3	104	2690	38	41	3
4	103	3200	38	41	4
5	184	1883	45	44	5
6	142	5633	25	19	6
7	108	6792	39	42	7
8	123	11410	42	41	8
9	117	20905	44	43	9
10	102	4980	31	30	10
11	102	4279	37	37	11

Based on the tables, the relationship between structural deterioration and the year of construction of the buildings was made. For the analysis, the 3D Table Curve software is used, in which there is a large mathematical functionality for analysis, selection of functions and their visualization, allowing to quickly process any types of data [3]. Using that software surfaces are created that visualize the relationships between the obtained deterioration parameters of the structures. X-axis - deterioration of the floor, Y-axis - deterioration of the foundation, Z-axis - total age of the building in years. Figure 1 shows an example of the surface created in the 3D Table Curve software for the "age-ceiling-wall" parameters for the building located at Petrogradsky district. Similar surfaces were created for all other studied areas.

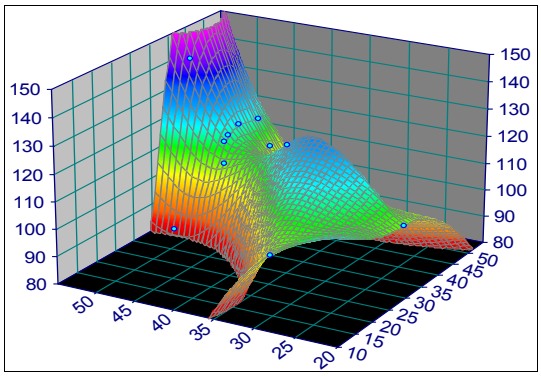

Fig. 1. The surface, describing the relation of Depreciation and age of the building in Petrogradskiy district

3 Results

After creating of the surfaces it is needed to choice the equations which describe the received surface. In this particular case, the program offers to choose one of 378 equations with different degrees of correlation. Then closer this index is to zero, the less suitable this equation for our case, and then it is closer to 1, the more suitable the equation is. The chosen equation (1) with correlation coefficient ~ 0.92 corresponds to the surface shown on figure 2. The value of each parameter is shown in table 6.

Table 6. Variables and the values of equation (1)

Variable	Value
A	-4553.88035
B	42.9285749
C	-0.46918896
D	676840.9249
E	4.3659e+07
F	1.16772e+09
G	1.0696e+10

$$z=a+bx+cx^2+d/y+e/y^2+f/y^3+g/y^4 \quad (1)$$

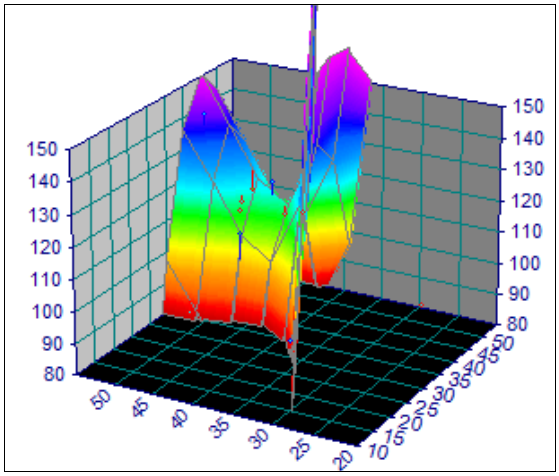

Fig. 2. The surface, describing the relation in equation (1)

On the figure 2 we can see the points that "drop out" of the chart. The less amount of such points, the higher the correlation coefficient.
After a careful selection of the proposed equations, we select one for each region. It is important that there be a high correlation coefficient and some of the equations have visual similarities. Table 7 represents result of the selection.

Table 7. The resulting equations and correlation coefficients for each district.

District	Correlation coefficients	Equations
Vasilevskiy	0.9111	$z=(a+bx+clny)/(1+dx+ex^2+flny)$
Vyborgskiy	0.9101	$z=(a+bx+clny+d(lny)^2)/(1+ex+fx^2+glny)$
Centralniy	0.9101	$z=a+blnx+cy+d(lnx)^2+ey^2+fylnx$
Petrogradskiy	0.9167	$z=a+bx+cx^2+d/y+e/y^2+f/y^3+g/y^4$
Kalininskiy	0.9189	$z=a+by^2lny+ce^{y/wy}$

4 Discussion

The obtained data can be used to predict the deterioration of the building in the future. The following methods can be used:

1. Determine the period of the forecasting. Let it be 5 years.
2. The percentage of deterioration for 1 year is calculated through a simple proportion: current deterioration of buildings / building age. For example, 20/100 = 0.2% per year.
3. Obtained proportion is multiplied by the age of the building + 5 years. Thus we get the expected deterioration. For example, 0.2 * (100 + 5) = 21%.
4. The same for the second deterioration parameter. So we have forecasted deterioration in 5 years for two types of structures.
5. By substituting the obtained age and deterioration data from table 7 into equation, we can obtain a forecast for the second constructive element, which will be true with a probability of 90% - this is achieved due to the high correlation coefficient of the equations.

5 Conclusions

The described forecasting technique based on the use of the mathematical calculation software “3D Table Curve” opens big opportunities for organizing the order of reconstruction of buildings and structures. Analyzing large amount of the data, it is possible to determine the necessary order of reconstruction, repair and maintenance of buildings which will positively affect the condition of the housing stock of the city and the productivity of the service organizations.

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