The value of the intensity of wear to ensure the durability of multi-apartment housing in the renovation of residential areas

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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. 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. 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.

1. 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.

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a high level of energy expenditure on the account of physical and spiritual wear and tear of residential buildings, outdated basement and roof components, engineering networks, cases of premature failure of structures and elements, carrying out inventory and passport work,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 "sincha". 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, T.G. Popov, A.P. Prokopishin, 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, 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.

2. Materials and methods

In nature, all materials are absorbed, become obsolete, the initial quality indicators change. The initial-the word itself is relative, and it is appropriate only if we use it in relation to building materials, g'isht, concrete, metal, etc. To this end, it will be worthwhile if we analyze the intensity of their absorption, then the construction materials will be natural and artificial species.

Now we will describe the results of a natural survey of the intensity of the depreciation of some public buildings, the structures and materials that make up them, carried out from the side.

We analyze the intensity of the general depreciation of some structures, materials and buildings that are used massively in residential buildings as a result of natural observations conducted in residential buildings in different regions of the Republic.

The intensity of physical wear is measured by the ratio of the absorption index to the period of eculatation:

$$\lambda = \frac{F^*}{T_e}$$

where $\lambda$ is the acceleration of absorption of the material (%/year);

$F^*$ – normative physical wear (%);

$T_e$ – is the projected expiration date (year).

Observation and inspection work was carried out in buildings located in different regions of the Republic with different climatic indicators. Their address, number, composition are presented in the table below[1-4]:

Table 1. Structure of buildings conducted a natural experiment.

| №   | Territory         | 2-storey wooden houses | Prefabricated concrete panel *2 | Reinforced panel 5 | Brick *2 | Natural stone 4 | Total |
|-----|-------------------|------------------------|----------------------------------|-------------------|---------|----------------|-------|
| 1   | Tashkent region   | 16                     | 1                                | 10                | 7       | 1              | 3     |
| 2   | Karakalpak AR     | 14                     | 1                                | 23                | 1       | 3              | 3     |
| 3   | Khorezm region    | 1                      | 2                                | 5                 | 1       | 7              | 8     |
| 4   | Bukhara region    | 4                      | 1                                | 6                 | 1       | 7              | 10    |
| 5   | Navoi region      | 4                      | 1                                | 13                | 2       | 3              | 20    |
| 6   | Surkhandarya reg. | 2                      | 1                                | 5                 | 1       | 7              | 8     |
| 7   | Jizzakh region    | 2                      | 17                               | 23                | 4       | 3              | 46    |
| 8   | Fergana region    | 2                      | 17                               | 23                | 4       | 3              | 46    |
| 9   | Namangan region   | 2                      | 1                                | 9                 | 1       | 7              | 12    |
|     | Total             | 41                     | 19                               | 13                | 11      | 2              | 183   |

*Number of floors
Using the formula, tables 2-5 and figures 1-10 show the actual service life, the degree of accumulated wear and tear of buildings, a list of which is given in table 1.

**Figure 1.** Graph of the depreciation of residential buildings with 2-storey wooden construction.

**Figure 2.** Graph of the depreciation of 2-storey residential buildings.

**Figure 3.** Graph of the depreciation of residential buildings with 2-storey prefabricated p/c panels.

**Figure 4.** Graph of the depreciation of residential buildings with 4-storey prefabricated p/c panels.

**Figure 5.** Graph of the depreciation of residential buildings from 2-3-storey natural stone.

Based on the results obtained as a result of the inspections carried out, we will list the work carried out in capital repairs in the buildings, the percentage of reduction in the level of physical degradation in them after capital repairs and the amount of expenses spent on these capital repairs in percentages. For this purpose, the share value of the constructive parts of the buildings in the building was taken according to the "torn indicators of the restoration values of buildings and structures" [1].
3. The results and discussion

Based on the results obtained from the above graphs, below in 2-5 tables we summarize the values of multi-apartment buildings with 2-storey timber, 2-3-storey natural stone, 2, 4-5-storey high-rise and 2.4-storey high-rise reinforced concrete panels located in the districts and cities of the Republic of Uzbekistan and the Republic of Karakalpakstan in terms of royalties were received in accordance with BCR 1.04.03-98 [3].

This means that after capital repair work in 2-storey wooden building, the level of physical wear on the building can be reduced by 10.43-13.23%, the rate of residual absorption is 33.57-42.77% (table 2).

In 2-storey residential buildings, these indicators could decrease by 8.57-11.31%, while the survival rate was 29.03-38.29% by Regions (table 2). In 4-5-storey residential buildings, these indicators could decrease by 7.27-7.45%, while the survival rate was 26.44-30.74% in the regions (table 3). In residential buildings with 2-4 storey prefabricated reinforced concrete panels, these indicators could decrease by 8.77-10.6%, while the residual absorption rate was 26.44-42.4% by Regions (table 4). And finally, after capital repair work on 2-3-storey natural stone residential buildings, the level of physical wear on the building can be reduced by 9.38-9.75%, the level of residual absorption is 31.22-32.45% (table 5).

Apparently, as a result of the capital repairs carried out, the level of physical wear and tear is maintained around 7.27-13.26%. The depreciation rate, also called base wear, remains around 26.44-42.77%. This information is evidence that capital repairs in multi-apartment residential buildings are not carried out at the required level.

In the pictures 6-10, the residual service life of multi-apartment residential buildings inspected throughout the territory of the region, the intensity of wear and tear, and the relationship between their service life are described by graphs.

![Figure 6](image)

**Figure 6.** The period of actual exploitation, the average depreciation cost and the intensity of depreciation of multi-apartment buildings with 2-storey wooden construction located in the districts and cities of the Republic of Uzbekistan and the Republic of Karakalpakstan.

Complex in buildings the difficulty of carrying out capital repairs is that the structures that make up the premises, the elements, engineering equipment, the elements of external landscaping are very diverse, they are made up of different building materials, the service life of which is different. At the same time, the conduct of capital repairs in the building complex is therefore not economically feasible.

Therefore, in the process of designing buildings, it is desirable to use the standard types of structures, elements, engineering equipment, elements of external improvement, which make up them for the service life. Only then there will be an opportunity to predict even the intensity of their depreciation. This is an important factor in the monitoring of housing stock.
Table 2. Residential buildings with 2 floors of wood and concrete.

| №  | Address of the object | Building number, units | Tav, year | Fav, % | *Fn, % | λav | T, year | Tr, year | Time spent on capital repairs | After capital repair F'av, % | Cost of capital repairs, % | Variability of wear to "T", % |
|----|-----------------------|------------------------|-----------|--------|--------|------|---------|---------|-------------------------------|-----------------------------|-----------------------------|-----------------------------|
| 1  | In Namangan region    |                          | 2         | 60,0   | 44     | 80,0 | 0,00745 | 75       | 23                            | 2019 y                      | 33,57                       | 10,43                       | -36                         |
| 2  | Karakalpak AR         |                          | 14        | 53,3   | 46,8   | 71,1 | 0,00850 | 75       | 11                            | 2019 y                      | 35,70                       | 11,09                       | -24,3                       |
| 3  | In Khorezm region     |                          | 1         | 86,0   | 44     | 100,0| 0,00517 | 75       | 0                             | 2019 y                      | 33,57                       | 10,43                       | -56                         |
| 4  | In Jizzakh region     |                          | 2         | 69,0   | 52     | 92,0 | 0,00760 | 75       | 6                             | 2019 y                      | 39,67                       | 12,32                       | -40                         |
| 5  | In Bukhara region     |                          | 4         | 59,0   | 48,2   | 80,0 | 0,00817 | 75       | 16                            | 2019 y                      | 36,77                       | 11,42                       | -31,8                       |
| 6  | In Navoi region       |                          | 1         | 69,0   | 54,0   | 93,3 | 0,00782 | 75       | 6                             | 2019 y                      | 41,20                       | 12,8                        | -39,3                       |
| 7  | In Surkhandarya region|                          | 2         | 59,0   | 54,0   | 80,0 | 0,00915 | 75       | 16                            | 2019 y                      | 41,20                       | 12,8                        | -26                         |
| 8  | In Tashkent region    |                          | 16        | 68,3   | 56,0   | 91,1 | 0,00818 | 75       | 6,7                           | 2019 y                      | 42,77                       | 13,23                       | -35,1                       |

Residential buildings with 2 floors brick construction

| №  | Address of the object | Building number, units | Tav, year | Fav, % | *Fn, % | λav | T, year | Tr, year | Time spent on capital repairs | After capital repair F'av, % | Cost of capital repairs, % | Variability of wear to "T", % |
|----|-----------------------|------------------------|-----------|--------|--------|------|---------|---------|-------------------------------|-----------------------------|-----------------------------|-----------------------------|
| 1  | In Namangan region    |                          | 7         | 45,7   | 48,3   | 36,6 | 0,01060 | 125      | 79                           | 2019 y                      | 37,29                       | 11,01                       | 11,7                        |
| 2  | In Fergana region     |                          | 3         | 58,0   | 45,6   | 46,4 | 0,00803 | 125      | 67                           | 2019 y                      | 35,20                       | 10,40                       | -0,8                        |
| 3  | Karakalpak AR         |                          | 23        | 43,2   | 49,6   | 34,6 | 0,01158 | 125      | 81                           | 2019 y                      | 38,29                       | 11,31                       | 15                          |
| 4  | In Khorezm region     |                          | 5         | 46,0   | 40,4   | 36,8 | 0,00902 | 125      | 79                           | 2019 y                      | 31,37                       | 9,21                        | 3,6                         |
| 5  | In Jizzakh region     |                          | 23        | 39,9   | 37,6   | 31,9 | 0,00950 | 125      | 85                           | 2019 y                      | 29,03                       | 8,57                        | 5,7                         |
| 6  | In Bukhara region     |                          | 6         | 47,5   | 40,0   | 38,0 | 0,00869 | 125      | 77,5                         | 2019 y                      | 30,88                       | 9,12                        | 2                           |
| 7  | In Navoi region       |                          | 5         | 40,0   | 44,8   | 32,0 | 0,01120 | 125      | 85                           | 2019 y                      | 34,59                       | 10,21                       | 12,8                        |
| 8  | In Tashkent region    |                          | 7         | 49,8   | 42,5   | 39,8 | 0,00881 | 125      | 75                           | 2019 y                      | 32,81                       | 9,69                        | 2,7                         |

*Fav- normative wear;  
**Frav- residual wear and physical wear rate after capital repairs.

Table 3. 4-5 storey residential buildings.

| №  | Address of the object | Building number, units | Tav, year | Fav, % | *Fn, % | λav | T, year | Tr, year | Time spent on capital repairs | Capital repair-after lash **Frav, % | Cost of capital repairs, % | Variability of wear to "T", % |
|----|-----------------------|------------------------|-----------|--------|--------|------|---------|---------|-------------------------------|-----------------------------|-----------------------------|-----------------------------|
| 1  | Residential building No. 44, floor 3-microdistrict, Chirchik         |                          | 1         | 40     | 37,0   | 33,3 | 0,00925 | 120      | 80                           | 2019 y                      | 26,44                       | 7,29                        | 3,7                         |
### Table 4. Residential buildings with 2-4-storey prefabricated reinforced concrete panels.

| №  | Address of the object | Building number, units | $T_e$, year | $F_{av}$, % | $*F_{nh}$, % | $\lambda_{av}$, % | $T_r$, year | $Tr$, year | Time spent on capital repairs | Capital repair-after lash** $F'_{av}$, % | Cost of capital repairs, % | Variability of wear to "T", % |
|----|-----------------------|------------------------|--------------|--------------|----------------|------------------|------------|------------|-------------------------------|---------------------------------|-------------------------------|-------------------------------|
| 1  | In Jizzakh region     | 1                      | 17           | 46.1         | 50.2           | 38.4             | 0.01096    | 120        | 73.9                         | 2019                            | 40.16                          | 10.04                          | 11.78                          |
| 2  | Surkhandarya region   | 1                      | 40.0         | 48.0         | 33.3           | 0.01200         | 120        | 80.0       | 80.0                         | 2019                            | 38.4                           | 9.6                           | 14.70                          |
| 3  | In Tashkent region    | 1                      | 40.0         | 53.0         | 33.3           | 0.01325         | 120        | 80.0       | 80.0                         | 2019                            | 42.4                           | 10.6                           | 19.70                          |

* $F_{nh}$ - normative wear;
** $F'_{av}$ - residual wear and physical wear rate after capital repairs.

### Table 5. Residential buildings with 2-3 floors of natural stone.

| №  | Address of the object | Building number, units | $T_e$, year | $F_{av}$, % | $*F_{nh}$, % | $\lambda_{av}$, % | $T_r$, year | $Tr$, year | Time spent on capital repairs | Capital repair-after lash** $F'_{av}$, % | Cost of capital repairs, % | Variability of wear to "T", % |
|----|-----------------------|------------------------|--------------|--------------|----------------|------------------|------------|------------|-------------------------------|---------------------------------|-------------------------------|-------------------------------|
| 1  | In Navoi region       | 1                      | 14           | 63.5         | 40.6           | 63.5             | 0.00597    | 100        | 36.5                         | 2019                            | 31.22                          | 9.38                           | -22.9                          |
| 2  | Jizzakh city          | 4                      | 40.0         | 42.2         | 40.0           | 0.01056         | 100        | 60.0       | 60.0                         | 2019                            | 32.45                          | 9.75                           | 2.2                            |
Figure 7. The period of actual exploitation of 2-storey apartment buildings located in the districts and cities of the Republic of Uzbekistan and the Republic of Karakalpakstan, the average depreciation cost and the intensity of depreciation.

Figure 8. The period of actual exploitation of 4-5-storey multi-apartment buildings located in Chirchik city of Tashkent region, the average depreciation cost and the intensity of depreciation.

Figure 9. The actual periods of exploitation, average depreciation and intensity of depreciation of multi-apartment buildings with 2.4-storey high-rise reinforced concrete panels located in Chirchik city, Tashkent region.

Figure 10. Actual periods of exploitation, average depreciation and intensity of depreciation of 2-3-storey natural stone multi-apartment buildings located in Navoi and Jizzakh regions.
4. The results and discussion

Based on the results obtained from the above graphs, below in 2-5 tables we summarize the values of multi-apartment buildings with 2-storey timber, 2-3-storey natural stone, 2, 4-5-storey high-rise and 2.4-storey high-rise reinforced concrete panels located in the districts and cities of the Republic of Uzbekistan and the Republic of Karakalpakstan in terms of land royalties were received in accordance with BCR 1.04.03-98 [3].

This means that after capital repair work in 2-storey wooden building, the level of physical wear on the building can be reduced by 10.43-13.23%, the rate of residual absorption is 33.57-42.77% (table 2). In 2-storey residential buildings, these indicators could decrease by 8.57-11.31%, while the survival rate was 29.03-38.29% by Regions (table 2). In 4-5-storey residential buildings, these indicators could decrease by 7.27-7.45%, while the survival rate was 26.44-30.74% in the regions (table 3).

In residential buildings with 2-4 storey prefabricated reinforced concrete panels, these indicators could decrease by 8.77-10.6%, while the residual absorption rate was 26.44-42.4% by Regions (table 4). And finally, after capital repair work on 2-3-storey natural stone residential buildings, the level of physical wear on the building can be reduced by 9.38-9.75%, the level of residual absorption is 31.22-32.45% (table 5). 

Apparently, as a result of the capital repairs carried out, the level of physical wear and tear is maintained around 7.27-13.26%. The depreciation rate, also called base wear, remains around 26.44-42.77%.

The technical condition of residential buildings with 2-storey timber construction, although their resource over time was exhausted, the coefficient of physical wear rate relative to the normative wear was 1.3-1.56 (Table 2). Such a coefficient indicates that the Houses of this type of construction are more likely to be exploited in practice than the normative service life. Absorption intensity $\lambda_{av}=0.00517-0.00915$;

In the technical situation of 2-storey residential buildings, this was observed. The coefficient of physical wear rate relative to normative wear by Regions was 0.85-1.02 (Table 2). This is evidenced by the fact that the premises of this type are out of work ahead of schedule. The intensity of absorption is $\lambda_{av}=0.00803-0.01158$, the maximum indicator belongs to KKR;

The coefficient of physical wear rate of 4-5-storey residential buildings in relation to the normative wear was 0.964-1.057 (Table 3). This is an indication that the wear in buildings of this type is uniform. Absorption intensity $\lambda_{av}=0.00803-0.01158$, the maximum indicator belongs to KKR; In other respects, the examination was conducted only in the city of Chirchik. Absorption intensity $\lambda_{av}=0.00760-0.00975$;

The coefficient of physical wear rate of 2-4 storey prefabricated reinforced concrete panel residential buildings over 3 provinces was 0.951-0.803 compared to the normative wear rate (Table 4). Burst intensity $\lambda_{av}=0.00955-0.01225$, the maximum indicator belongs to Tashkent region;

The coefficient of physical wear rate of 2-3-storey natural stone residential buildings in Navoi and Jizzakh regions in relation to normative wear was 0.978-1.229 (Table 5). These types of construction houses, like yohoch buildings, are more likely to be exploited in practice than the normative service periods. The intensity of absorption is $\lambda_{av}=0.00597-0.01056$, the maximum indicator belongs to the Jizzakh region;

From the results of the analysis, it is known that the intensity of absorption was observed in residential buildings with 2-storey brick and reinforced concrete panels ($\lambda_{av}=0.01158-0.01225$);

The intensity of the depreciation of houses in relation to the normative service life in average wooden houses $\lambda_{av}=0.00716$, in natural stone houses $\lambda_{av}=0.00826$, in 2-storey buildings $\lambda_{av}=0.00980$, in 4-5-storey houses $\lambda_{av}=0.0086$ and the largest indicator in houses with reinforced concrete panels $\lambda_{av}=0.0114$;

5. Conclusion.

The results of the conducted examination confirm that the actual service life of the building, its designations and materials does not always correspond to the normative service life established in the
norms for them. During the period of the design of buildings for the proper use of housing stock in urban planning, it is necessary to take into account the specific details of the territory in the selection of construction materials used in the construction industry, their capital groups, their life expectancy indicators, their function in the network of the economy. As a result of the analysis of natural observation and inspection works carried out in different regions of the Republic, the following can be cited in terms of multi-apartment houses in the exploitation:

- This information is evidence that capital repairs in multi-apartment residential buildings are not carried out at the required level.
- Complex in buildings the difficulty of carrying out capital repairs is that the structures that make up the premises, the elements, engineering equipment, the elements of external landscaping are very diverse, they are made up of different building materials, the service life of which is different. At the same time, the conduct of capital repairs in the building complex is therefore not economically feasible.
- Therefore, in the process of designing buildings, it is desirable to use the standard types of structures, elements, engineering equipment, elements of external improvement, which make up the service life. Only then there will be an opportunity to predict even the intensity of their depreciation. This is an important factor in the monitoring of housing stock.
- There is an opportunity to predict their actual service life according to these indicators;
- As a result of the observations, there is an accelerated depreciation of relatively new buildings, and over time, a decrease in the intensity, which in this way provides an opportunity to create a graph of physical wear from the climatic conditions of the Republic and the Capital Group of buildings;
- The intensity of wear and tear of structures and materials indicates that according to BSR 1.04.03-98, capital repairs in relation to the function of buildings and the operating environment are planned to be carried out every 8-20 years, according to the 2-3 application of this document, some structures and materials do not fully fulfill their service life and;
- With the help of the obtained results, there will be an opportunity to make corrections to BSR 1.04.03-98 on the normative service life of materials, constructive parts and completely the building (lifetime), to forecast their residual service life;
- Once again, the factors known to us in the growth of the intensity of the general wear of the material, constructive parts and the building the quality of the exploitation, in addition to the quality of the project, preparation and construction have proved to be an autonomous factor.

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