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PERCEPTION, EVALUATION AND PREDICTION OF THE SHOPPING MALL BUILDING ASSESSMENT

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Abstract. *The change in the condition of a building over time in the technical terms can be seen as a deteriorating process of aging of the building elements and the loss of original technical performance. In the economic terms, it is the process of changing the value of the facility and new investments in the maintenance of the facility, as well as servicing the system of equipment and installations, during the service life. The technical dilapidation of the building, or of its elements, can lead to unwanted consequences of endangering the lives and property of people, and of the disruption of functional and aesthetic values of the building, which is very important for the fate of shopping malls. With the exhaustion of the technical life of the building, questions and decisions about the revitalization or demolition of the building necessarily arise. The value of the facility decreases over time, and the costs of maintenance and repairs increase. Over time, regardless of the actual condition, the facility and equipment systems become obsolete when the first needs for modernization arise, which entails new costs. The ratio of maintenance costs is constantly growing, until the moment when the level of profitability of further investment in the renovation of the facility and the system is reached, i.e. until the moment of exhaustion of the economic life of the facility. The paper presents the relationship between preventive, reactive and predictive maintenance costs as well as methods of monitoring, prediction and evaluation of the durability condition of shopping mall facilities.*

Key words: *perception, evaluation, prediction, building condition, shopping malls*

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1. INTRODUCTION

Building Condition Assessment (BSC) is based on monitoring the economic performance of the building, on the formation of a database on investments over time based on the procedures of asset management AM, where the strategy of investments and risks and the way of further functioning of operational work on the maintenance of the facility is being conceived. In shopping malls, both the proper technical condition of the facility and the flawless functioning of the equipment and installation systems are very important, along with the regular maintenance of the level of aesthetic characteristics and comfort, which requires increased costs. Remodeling is a way to restore and improve the technical, functional, aesthetic and economic performance of a building. The economic life of shopping mall buildings can be shorter than the technical service life in conditions of changes in market conditions, changes in supply and demand, competition, unemployment and declining purchasing power, so possible solutions are: remodeling, conversion or sale regardless of technical condition of the buildings. In the architectural sense, the disruption of the functional and aesthetic values of the building, outdated forms and shapes is of great importance in the remodeling of shopping malls. This includes changes in the state of functioning of devices and equipment of the facility, their obsolescence and maintenance. The modeling of deterioration and the calculation of the service life of buildings is based on theoretical models of deteriorating changes that occur in the aging process or caused by physical, mechanical and chemical actions of the environment over time. Models contain relevant parameters important for describing changes in the performance of an object or some of its elements over time.

Predicting the future condition of the facility is based on collecting and forming a database on the current condition and behavior of the facility, on the basis of which probabilistic prediction models are developed. From an economic point of view, it is necessary to monitor the costs of operation, which in practice are often the decisive factor in deciding on further financing or termination of the facility, its demolition or conversion. In shopping malls, from the architectural aspect, it is especially important to maintain visual, functional and aesthetic values at every moment of the life cycle of the observed building.

2. MONITORING, EVALUATION AND PREDICTION OF THE DURABILITY CONDITION OF SHOPPING MALL BUILDINGS

Condition prediction methods can be traditional, which are based on the empirical data (experience), methods of condition monitoring and integrated methods. Condition monitoring method can be an expert report (Fig. 1a), when it comes to the material condition of the building or a report obtained by a survey (Fig. 1b), especially when it comes to the non-material features such as: functionality of the building, esthetics, features related to entertainment, sport, cultural and other social events. Building condition assessment can be also based on:

1. Information of event data about the building behavior over time or
2. Information of the building condition monitoring data - measurements.

The method based on event data information involves the study of the interaction between different data such as: data on the building, the environment, the characteristics of the building from the existing documentation, interventions on the building, etc. In addition to these data, the condition monitoring method and integrated methods require data obtained from visual

inspections, laboratory or in situ testing data. The first step in data collection is to assess the condition of the building by routine visual inspection, based on which it is decided to plan a more detailed research if necessary. The second step involves detailed research - special testing of materials and analysis of deterioration processes to assess safety, durability and identification, detection and prediction of corrosion processes and the degree of damage. If necessary, the third step is the examination of structures (testing the response of the structure) and research related to the analysis of actual effects, determining the bearing capacity and safety assessment. The prediction of the remaining service life of the facility, while ensuring safety, serviceability and functionality, is based on data on the condition of the facilities of the considered stock. On the basis of the database, further decisions are made on the type and manner of maintenance of facilities and priorities for repairs, rehabilitation, reinforcement of facilities, for the same or increased effects in further service are determined.

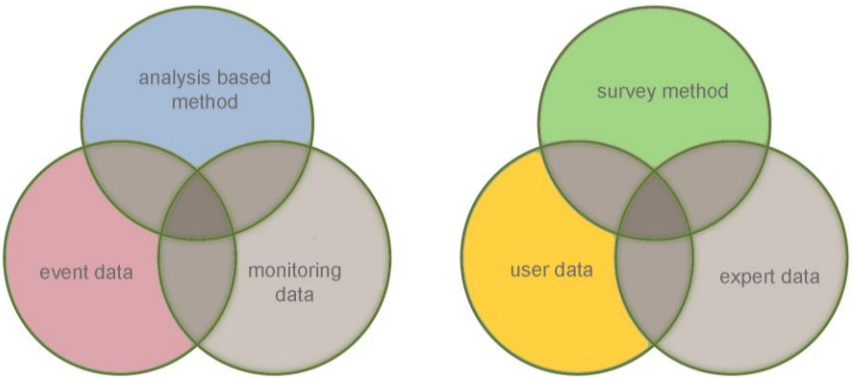

Fig. 1 Methods of monitoring and prediction of the condition a) based on the expert report, b) based on the survey

2.1. Monitoring

Sustainable architecture is based on the application of new design concepts, the introduction of new materials, the application of more complex systems, monitoring the condition of the building for a certain period of time (service life of the building). The architectural concept of the building should anticipate possible changes during the operation, i.e. to predict the possibility of remodeling in terms of changing the function, expansion of the building and replacement of individual elements. The building conditioning method can entail monitoring. Monitoring is a systematic, continuous and incessant process of monitoring of the building condition during a certain time period in respect to the planned investments, activities and outcomes. Monitoring is a routing collection of information on the building, i.e. incessant, systematic and purposeful monitoring, observation, recording and assessment of the building condition with a goal of forming a database.

2.2. Building durability curve according to Schroeder

The performance of a building or of its elements changes over time. When it comes to the aging process, then these are values that are constantly declining over time. The decline in value over time can be defined in several ways. The state of a building according to Schröder is defined by the degree of state W which is mathematically expressed by a function:

$$W=1-\text{ŧ}^a \quad \text{where:}$$
$$W\leq 1,$$
$$0\leq \text{ŧ} \leq 1$$

Whereby ŧ does not represent the real time but it is given in the function of the unit service life. The value W is given in relation to 1, but it can be presented in percents in relation to 100. The maximum value of the time is the service life which is also expressed in units. The modified method, by introducing the real time and the building duration time – technical service life T, can be presented by the expression: $W = 1 - \text{ŧ}^a$, whereby $W \leq 1$, is the value depending on the current time t and technical service life T.

$$\text{ŧ} = t/T \text{ , whereby:}$$
$$0 \leq \text{ŧ} \leq 1, \text{ i.e. } 0 \leq t/T \leq 1, \text{ ili } 0 \leq t \leq T$$

Element condition change over time, in a favorable environment is represented with the square function, i.e. with the exponent a=2

$$W = 1 - t/T)^2$$

Element condition change over time in a medium favorable environment is represented with the linear function, i.e. with the exponent a = 1

$$W = 1 - t/T)^2$$

Element condition change over time in an unfavorable – aggressive environment is represented with the function, i.e. exponent a = 0,5

$$W = 1 - \sqrt{((t/T))}$$

Technical life of the building elements T is defined depending on the type of building elements and material they are made of. (Simon, 1991)

The remaining service life is the time

$$t' = (T - t)$$

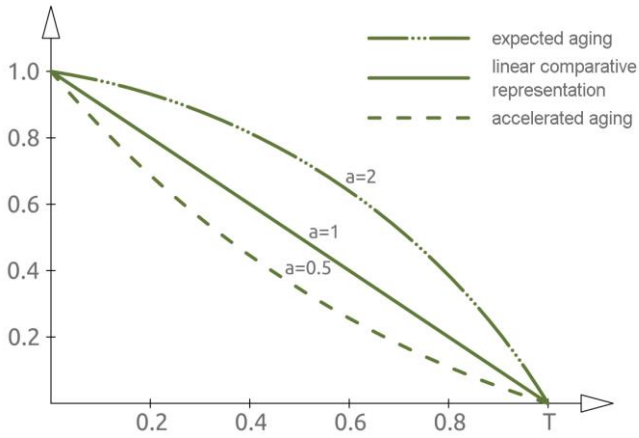

Fig 2. Element condition change over time t up to the value T

2.3. Monitoring and prediction of the maintenance condition of shopping mall buildings

Building maintenance can be realized either through the momentary intervention with a goal of removing the malfunctioning of the building or as Time-Based Maintenance (TBM) according to the plan or as Predictive Maintenance (PM) according to the building condition CBM (Condition Based Maintenance), which is based on the expert monitoring of the evaluation of the condition, maintenance, and predicted potential interventions over time, in order to avoid unforeseen material damage of the building or consequences of the risk to the property and lives of people. Building maintenance can be: reactive RM (Reactive Maintenance), where the intervention is undertaken at the moment of malfunction or failure of some building element of equipment; preventive PM (Preventive Maintenance), where it is intervened for the purpose of regular maintenance according to the time plane or service life, and predictive PdM (Predictive Maintenance) which is based on monitoring and prediction of building condition, where it is intervened according to the actual condition of the building and equipment (on whose basis the maintenance priorities are determined). For redistribution and reduction of maintenance cost are used modern computer systems such as BMS (Building Management Systems), where the predictive maintenance is given advantage over reactive maintenance. According to the research data from USA (Sullivan, Melendez, Pugh, & Hunt, 2010) reactive maintenance of buildings RM is 55% of all maintenance cost, while preventive maintenance PM is 31% and predictive PdM maintenance 12%, and other 2%.

Table 1 Share of individual types of maintenance

RM *(Reactive Maintenance)*	55%
PM *(Preventive Maintenance*)	31%
PdM *(Predictive Maintenance*)	12%
Other	2%

Total cost of building maintenance include the cost of Maintenance 35%, Utilities 37% and Janitorial 28%. (IFMA, http://www.ifma.org/, 2009)

Table 2 Distribution of building maintenance cost

Maintenance	35%
Utilities	37%
Janitorial	28%

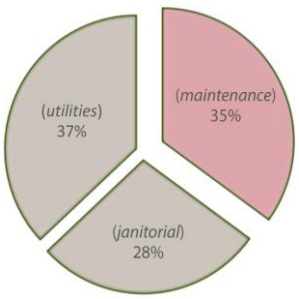

Fig. 3 Distribution of building maintenance cost

Preventive maintenance, against reactive maintenance can save 12-18%, and predictive maintenance against preventive maintenance can save 8-12% of total maintenance cost. Based on the conducted further research, a ratio of these types of maintenance is proposed:

$$RM : PM : PdM = 1 : 5 : 10$$

Predictive maintenance is based on the collection of expert data, measurement or periodic reviews, monitoring, as well as processing of this data in order to make conclusions and decisions about maintenance. The cost of maintaining a facility, over time until the final exhaustion of its service life, exceeds the investment value of the facility (Kriegesmann, 2002). After only 7 years, the maintenance costs of the facility reach the investment value of the facility, and after 40 years, they reach five times the value of the facility. Maintenance costs are a relevant factor in determining the economic service life of a facility (Figure 4).

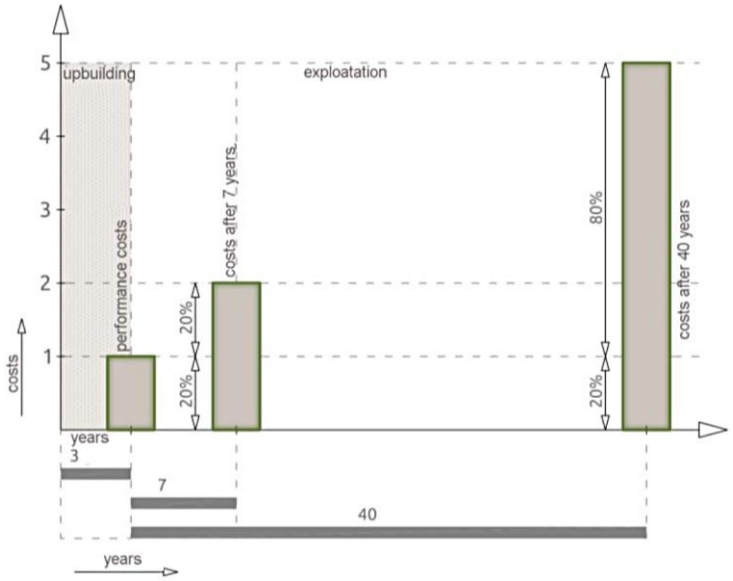

Fig. 4 Maintenance costs as a relevant factor in determining the economic service life of a facility

3. METHODS AND TECHNIQUES IN THE REALIZATION OF THE GOALS OF SHOPPING MALLS REMODELING

3.1. Prediction Method

The strategic goals of remodeling the facility in the technical sense are to obtain: safe, usable, durable, functional, attractive, environmentally friendly and healthy facility. In the sense of energy, it is getting a more efficient facility in terms of energy consumption, and in the economic sense, getting an increase in sales levels and levels of visits to the SM, as well as reducing maintenance costs. Decision-making in order to realize the goals

in revitalization planning, i.e. remodeling, is based on research methods. The most well-known research methods used today are: SWOT, portfolio, benchmarking and prediction methods, (Table 5.3)

Table 3 Distribution of building maintenance cost

RESEARCH METHODS			
SWOT	Portfolio	Benchmarking	**Prediction Methods**

Further research will use prediction methods based on the building condition, in technical, functional and aesthetic terms, which are variable over time. A stochastic analysis will be used to predict the future condition of the building (Table 5.4). With this method, which is based on the irreversible process of aging of the building, it is possible to determine the time in which a decision must be made on the further fate of the building (revitalization, conversion or demolition).

Table 4 Methods of building condition prediction

PREDICTION METODS		
Mathematical methods:	Qualitative methods:	Explorative methods
Stochastic analysis	Brainstorming	Scenario Method
Method of the trend	Delfi method	Modeling and simulations
Correlation and regression analysis	Expert analysis	Morphologic analysis
Sensitivity analysis	Interview Method	

Further research in this paper employ the mathematical probabilistic method – "Markov", based on random, i.e. stochastic variables.

3.2. Methods of building condition evaluation

Evaluation is a systematic analysis of the process in relation to the planned outcomes, with the application of previously established criteria, in order to improve efficiency. (Detels, Holland, Mc Ewan 2004), (AEA, 2005) In previous research, as well as in the current technical regulations, the assessment of the condition of buildings is related to irreversible aging processes of materials. In the technical sense, it is related to the change of the structure of the material and the change of its characteristics, the change of appearance and the change of mechanical, physical and chemical properties, and in the economic sense to the increase in the value of maintenance costs and the decline of the building value over time. Maintaining a high level of comfort - maintaining cleanliness, maintaining temperature and humidity with the requirement that there is no sense of difference in air quality in any part of the indoor space, which is a common requirement in shopping malls. It is necessary to sustain the light levels and sound insulation, which requires constant monitoring of the equipment system condition and require additional costs. Much attention is paid to this part of the functioning of the system, equipment, maintenance of the facility and related costs in the SM, because these costs during the service life of the facility are very high and quickly exceed the cost of the facility itself.

There are no uniform criteria for assessing the condition of a building. Evaluation of the condition of the building is most often based on the assessment of the level of the condition (assessment of the condition) or on the indices of damage. Condition evaluation can be based on technically or economically relevant parameters. In practice, damage indices or building condition indices are used, which technically represent the ratio of the condition of the condition of the damaged and of the new building, or economically speaking, the cost of repairing the damage in relation to the value of the building. The contemporary approach to this problem is based on the formation of priority condition matrices, age condition matrices and energy state matrices, on the basis of which the Facility Condition Index (FCI) is determined (IFMA, http://www.ifma.org/, 2009). Evaluating the condition of a building in some methods comes down to determining the class or code of the condition of the building. The procedure for determining the assessment of the condition and maintenance of the facility is based on direct and indirect methods.

Direct methods are based on the standard of direct determination - by measuring and forming a database of damage and on the basis of permissible tolerances of elements in high-rise buildings, their condition is determined according to German standard DIN 18202:2005-10, so that each element of the building is able to meet the requirements facility, with the required security.

Indirect methods relate to the determination of the characteristics of the building condition in terms of the quality properties of the building function and purpose, in all as stipulated in the standard EN 15341:2005-10

4. CONCLUSION

The paper presents the interrelationships of preventive, reactive and predictive maintenance costs, as well as methods of monitoring, predicting and evaluating the durability condition of shopping center facilities. These methods and techniques are presented in the function of realizing the goals of remodeling of shopping malls. The need for remodeling of shopping malls arises during the operation of the facility. Usually, the first interventions on the building are aimed at its modernization, improvement of functional or other characteristics. Each stakeholder has its own role and sphere of interest, the reciprocity of which results in overall quality. Shopping malls in terms of quality depend on the fulfillment of three basic requirements, in terms of technical characteristics of buildings and equipment, building management and architectural qualities.

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PERCEPCIJA, EVALUACIJA I PREDIKCIJA STANJA OBJEKATA TRŽNIH CENTARA

Promena stanja objekta tokom vremena u tehničkom smislu, može se posmatrati kao deteriorativni proces dotrajavanja (starenja) elemenata objekta i gubitka prvobitnih tehničkih performansi. U ekonomskom smislu to je proces promene vrednosti objekta i novih ulaganja u održavanje objekta, kao i servisiranje sistema opreme i instalacija, tokom upotrebnog životnog veka. Tehnička dotrajalost objekta, ili njenih elemenata, može da dovede do neželjenih posledica ugrožavanja života i imovine ljudi, do poremećaja funkcionalnih i estetskih vrednosti objekta, što je za sudbinu tržnih centara veoma važno. Icsrpljenjem tehničkog veka trajanja objekta, nužno se nameću pitanja i odluke o revitalizaciji ili rušenju objekta. Vrednost objekta vremenom opada, a troškovi održavanja i popravki rastu. Vremenom, bez obzira na faktičko stanje, objekat i sistem oprema zastarevaju, kada dolazi do prvih potreba za modernizacijom, što povlači nove troškove. Odnos troškova održavanja stalno raste, sve do trenutka kad bude dostignut nivo isplativosti daljeg ulaganja u obnovu objekta i sistema, odnosno do trenutka icrpljenja ekonomskog veka objekta. U radu je prikazan međusobni odnos preventivnih, reaktivnih i prediktivnih troškova održavanja kao i metode praćeanja, predikcije i evaluacije stanja trajnosti objekata tržnih centara.

Ključne reči: *percepcija*, *evaluacija*, *predikcija*, *stanje objekta*, *tržni centri*