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EXPENDITURE DETERMINATION FOR IMPROVING UTILITY STANDARD OF A RESIDENTIAL BUILDING

OKREŚLANIE WYDATKÓW NA POPRAWĘ STANDARDU UŻYTKOWEGO BUDYNKU MIESZKALNEGO

A b s t r a c t

In the article a method was presented that allows determining a range of necessary repairs in a building in order to increase its utility standards and settle the order of repair performance. The proposed approach consists of four computational stages. To solve them it was necessary to use suitable techniques and computational methods, i.a. linguistic assessments to assess a building and proposed repairs, quasi-fuzzy scalling method while determining the validity of operating demands and criteria assessment and the TOPSIS method for choosing the most favourable repair range for a building.

Keywords: operating requirements, building utility standard, building repair

S t r e s z c z e n i e

W artykule przedstawiono metodę pozwalają określić zakres koniecznych napraw w budynku do podniesienia jego standardu użytkowego oraz ustalić kolejność ich wykonania. Proponowane podejście składa się z czterech etapów obliczeniowych, których rozwiązanie wymagało przyjęcia odpowiednich technik i metod obliczeniowych, m.in. ocen lingwistycznych przy ocenie budynku i proponowanych napraw, metody pseudorozmytego skalowania przy określaniu istotności wymagań eksploatacyjnych i kryteriów oceny oraz metody TOPSIS do wyboru najkorzystniejszego zakresu napraw dla budynku.

Słowa kluczowe: wymagania eksploatacyjne, standard użytkowy budynku, naprawa budynku

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1. Introduction

Present methods for maintaining residential buildings raise many questions and doubts. There are two unsettled issues which influence each other. The first is the law [10], which impose an obligation on an administrator to maintain a building and not allow its value to deteriorate, however, the law does not specify a utility standard, which should correspond to a residential building. The second one is the problem of financing the expenditure on buildings' maintenance, which particularly concerns those repairs which are not enforced by law. This occurs due to lack of funds, which usually come from the so-called repair fund. Their rate is established not on the basis of particular repair needs, but it is based on arrangements between the building administrator and its residents. This often leads to a situation, in which the only repairs performed are those which, if ignored could result in the exclusion of the building from such use, i.e. bad building technical state, faulty gas installation.

The problem described, in which the lack of financial means prevents the upgrading the utility standards, which are undefined and thus not regulated by law,which in time leads to a gradual loss of its market value and higher costs of operating the building. There were several attempts to counter the presented situation. Many authors developed studies, in which they presented a partial or complete solution of the discussed problem [4, 11].

The basic problem of residential building maintenance, discussed in many scientific studies, is a proper diagnosis of its state [5, 7]. It involves determining operating requirements, which should correspond to the building, as well the method used for its assessment. An equally important problem faced by the administrator, which is in accordance with the act [10] is the proper use of funds. Examples of the methods, in which solutions for the optimal allocation of financial means intended for renovation are proposed, have been presented in many studies [3, 6, 8, 9].

The situation described at the beginning demonstrates another problem which needs to be solved: determining the optimal range of building repairs in order to maintain the utility standard. It primarily requires the determination of operating requirements, which the residential building should correspond to. Their choice should be consistent with real possibilities for improvement in the scope of accepted requirements, but their level should be established on the basis of the administrator's knowledge and experience, as well as the residents' requirements.

In this article the authour suggests a method which will determine the repair range in order to improve building utility standard and their performance costs. The method consists of four essential parts: building assessment and its comparison with the accepted utility standard, determination of possible repairs, their choice and the order of performance.

2. Proposed method

The method proposed consists of four essential tasks shown in Fig. 1. Their solution required the application of suitable computational methods presented later in the article. The application of the model allows for the completion of two tasks. The first is the determination of the most favorable repair range, from the point of view of assumed assessment criteria, the performance of which will allow for upgrading the building utility standard to the required level. The second one is the arrangement of the order of repair performance on the basis of technological dependents that determine their performance.

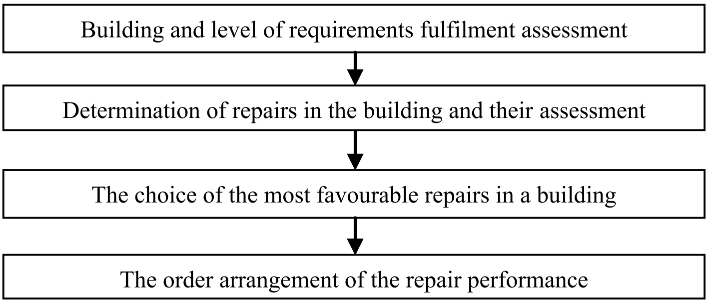

Fig. 1. Stages of the proposed method

2.1. The assessment of the building and the fulfilment level of assumed operating requirements

Due to the lack of guidelines in the law, which would form the basis for determining the building utility standard, the experts' knowledge is used to conduct the following tasks:

1) The assumption of operating requirements R_q to the building assessment and the determination of its assessment range (building's elements).
2) Determination of operating requirements level of building elements S_i^q for the assumed utility standards.
3) The state assessment of chosen building elements A_i^q.

In the point 1 and 2 linguistic terms are used: bad (B), poor (P), medium (M), good (G), very good (VG), to which values were assigned from 1 to 5 respectively.

2.2. Determination of repairs in the building and their assessment

Repairs for the building are arranged on the basis of the elements' building state assessment which was carried out earlier. They can be carried out in many possible ways, so- called variants V_{ij}^k . Each of them presents a different solution in terms of materials and performance technology applied and the costs of their performance. The estimation of the repair increase of each component of building element in relation to the assumed operating requirements is calculated in a following way:

$$\Delta A_{ij}^q = (\max A_i^q - A_i^q) \cdot A_{ik}^q \,/\, \max A_{ik}^q \qquad (1)$$

The repair influence on the operating requirements increase V_{ij}^k is evaluated using linguistic terms: very big (VB), big (B), medium (M), small (S), very small (VS). To each of them the values: 10, 7, 5, 3, 1 were assigned respectively. It is also possible to use intermediate assessments: VB/B, B/M, M/S, S/VS.

2.3. Multi-criteria assessment of the proposed building repair

In order to choose the most favourable building repairs, a multi-criteria TOPSIS method was adopted [2]. A set of alternative repairs V_{ij}^k of every component of building element C_{ij} was assessed. For their evaluation four criteria were used K_s. The first one K_1 is the increase of building utility value ΔBUV that is calculated as follows:

$$\Delta BUV = \sum_{q=1}^{4} w_q \cdot \Delta A_{ij}^q \tag{2}$$

The second criterion K_2 is the cost, which can be estimated on the basis of available price lists of repair works or a quantity survey submitted by a contractor. The third and the fourth criterion are respectively: K_3 the difficulty of carrying out the repair in the building and K_4 its durability. To assess both of them such linguistic terms are used as: very big (VB), big (B), medium (M), small (S), very small (VS), to which numerical values for K_3 from 1 to 5 and for K_4 from 5 to 1 correspond. Rank order of the proposed repair variants requires prior calculation of assumed criteria significance. To do it, a method of pseudo fuzzy scalling was applied [1].

Only these repair variants V_{ij}^k are assessed, whose increase ΔA_{ij}^q will provide the achivement of utility standard building element S_i^q for at least one of the operating requirements R_q. The condition is marked as $C(F, U)$, for which F means its fulfilment while U its unfulfilment.

2.4. The order arrangement of the repair performance

For the set of the k^{th} repair variants of j^{th} components of i^{th} building element $V_{ij}^k = \{V_{11}^2, V_{12}^1, \ldots, V_{mn}^p\}$ their performance order is arranged. It is determined providing technological dependents, which influence on the order of their performance. It involves assigning each of them to their antecedents a and consequents c. It was written as $V_{ij}^{a,c}$. The order, in which repairs can be carried out, is showed in the form of a graph. Its initial vertices are these repairs of i^{th} element of j^{th} component, whose numbers are in accordance with their antecedents $a(r, s)$, and its final vertices are these repairs, whose numbers are in accordance with their consequents $c(w, z)$. This solution can also be applied in the situation when we want to determine only the repair scope preceding the performance of the particular repair.

The approach proposed avoids unnecessary costs, which could arise as a result of the incorrect order of repair performance and planning in advance the repair expenditures and on this basis to secure funds for repair performance.

3. Example

To assess building utility standards BUS, four operating requirements were assumed: R_1 – structure safety, R_2 – utility safety, R_3 – heat protection and R_4 – building's look, for which a level of operating requirements S_i^q was determined, to which a set of assumed items were used in the example, four building elements E_i should respond (Tab. 1).

Table 1

The utility standard of building elements S_i^q and their assessment A_i^q

E_i	Element name	A_i^q/S_i^q							
		$Q = 1$		$Q = 2$		$Q = 3$		$Q = 4$	
1	elevation	*M*	*G*	*M*	*VG*	*P*	*G*	*B*	*G*
2	flat roof	*P*		*P*	*G*	*M*		*P*	
3	Stairs	*G*		*P*		–	–	*B*	
4	balkonies	*B*		*P*	*D*	–	–	*B*	

On the basis of the assessment of building elements A_i^q and their comparison with the values of operating requirements S_i^q, repairs were proposed, whose performance performance will allow the assumed element to maintain the utility standard. For each of the repairs two or three performance variants V_{ij}^k were suggested and ΔA_{ij}^q was calculated for them. The computational results are presented in Tab. 2. Of all the proposed repair variants five ones were rejected (V_{13}^1, V_{31}^1, V_{32}^1, V_{33}^1, V_{42}^1), because they did not meet the condition *C*(*F*) of achieving the required increase for V_{ij}^k.

Table 2

The proposed variants of component repair of a building element

E_i	C_{ij}			V_{ij}^k		ΔA_{ij}^q				*C*
i	*j*			*k*		$q = 1$	$q = 2$	$q = 3$	$q = 4$	
1	1	wall structure	WS	1	*A*1	1.2	–	–	–	*F*
				2	*A*2	1.6	–	–	–	*F*
	2	wall thermal insulat.	WT	1	*C*1	–	2.0	2,1	–	*F*
				2	*C*2	–	2.0	3,0	–	*F*
	3	wall plaster/cladding	WP	1	*A*1	0.4	0.6	–	2.4	*U*
				2	*B*1	0.4	0.6	–	3.2	*F*
				3	*B*2	0.4	0.6	–	4.0	*F*
2	1	roof structure	RS	1	*A*1	2.1	–	–	–	*F*
				2	*A*2	3.0	–	–	–	*F*
	2	roof thermal insulation	RT	1	*C*1	–	0.9	1,0	–	*F*
				2	*C*2	–	1.2	1,4	–	*F*
				3	*C*3	–	1.2	2,0	–	*F*
	3	roofing	R	1	*B*1	0.9	2.1	–	1.8	*F*
				2	*B*2	0.9	2.7	–	2.1	*F*
				3	*B*3	0.9	3.0	–	3.0	*F*

cd. tab. 1

3	1	stairs plaster	SP	1	*A*1	–	0.3	–	1.2	*U*
				2	*B*1	0.4	0.9	–	3.2	*F*
				3	*B*2	0.6	0.9	–	4.0	*F*
	2	stairs cladding	SC	1	*A*1	–	1.8	–	2.4	*U*
				2	*B*1	–	2.4	–	3.2	*F*
				3	*B*2	–	3.0	–	4.0	*F*
	3	stairs balustrade	SB	1	*A*1	–	2.1	–	1.2	*U*
				2	*B*2	–	3.0	–	1.5	*F*
4	1	balcony structure	BS	1	*A*1	3.2	–	–	–	*F*
				2	*A*1	3.6	–	–	–	*F*
	2	balcony cllading	BC	1	*A*1	–	1.2	–	2.0	*U*
				2	*B*1	0.8	4.0	–	3.2	*F*
				3	*B*2	0.8	4.0	–	4.0	*F*
	3	balcony plaster	BP	1	*B*1	0.8	0.8	–	3.2	*F*
				2	*B*2	0.8	0.8	–	4.0	*F*
	4	damp proofing	DP	1	*B*1	–	3.2	–	–	*F*
				2	*B*2	–	4.0	–	–	*F*

Description: A – repair, B – replacement, C – reconstruction, 1, 2, 3 – solution number, e.g. (A1)

For each variant of the component repair of a building element S_{ij} the increase of building utility value ΔBUV was calculated according to the formula (2). It was preceded by the estimation of operating requirements significance R_q, for which the following values were obtained: $w_1 = 0.466$, $w_2 = 0.068$, $w_3 = 0.168$, $w_4 = 0.298$.

To assess the proposed repair variants, the four criteria K_s were assumed where K_1 is the rate of building utility value, K_2 is the cost of repair performance, K_3 represents the repair difficulties in the building and K_4 is the repair durability. Ordering repair variants with the use of the TOPSIS method required prior calculation of criteria significance, for which the following values were obtained: $w_1 = 0.26$, $w_2 = 0.33$, $w_3 = 0.23$, $w_4 = 0.18$. The rank of the repair variant V_{ij}^k of each component repair of a building element C_{ij} was showed in Tab. 3.

To increase building's utility standard BUS according to the assumed operating requirements values it was necessary to carry out 13 repairs and their choice is determined with its ranking position (Tab. 3). These are the repairs the most favorable from the point of view of the assumed assessment criteria.

To determine the order of each repair performance in the building, including the technological dependents which are between them, their consequent and antecedents were determined. This situation is shown in the form of a graph in Fig. 2.

Table 3

The ranking of building repair variants

E_i	C_{ij}	V_{ij}^k	K_1 [pt]	K_2 [zł]	K_3 [pt]	K_4 [pt]	Ranking
1	1	1	0.384	30 000	VB	M	2
		2	0.512	38 000	B	B	1
	2	1	1.063	107 000	S	B	1
		2	1.270	123 000	M	B	2
	3	2	0.814	58 000	M	B	2
		3	0.942	65 000	S	VB	1
2	1	1	0.672	23 000	VB	M	1
		2	0.960	29 000	B	B	2
	2	1	0.491	21 000	B	B	3
		2	0.670	23 000	M	B	2
		3	0.808	30 000	S	B	1
	3	1	1.185	45 000	S	M	2
		2	1.407	52 000	S	B	1
		3	1.638	63 000	M	VB	3
3	1	2	0.901	8 000	B	M	1
		3	1.093	23 000	M	B	2
	2	2	1.208	72 000	S	B	1
		3	1.510	87 000	M	VB	2
	3	2	1.110	58 000	S	VB	1
4	1	1	1.024	45 000	VB	M	1
		2	1.152	62 000	B	B	2
	2	2	1.928	47 000	M	B	1
		3	2.056	59 000	M	VB	2
	3	1	1.000	12 000	B	M	1
		2	1.128	18 000	M	B	2
	4	1	0.928	45 000	VB	B	2
		2	1.160	51 000	VB	VB	1

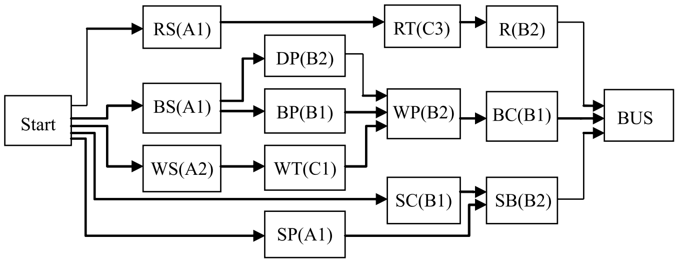

Fig. 2. The graph showing the order of repair performance in the building

4. Conclusions

The method presented in the article allows for assigning a scope of building repairs which provides a settled utility standard for a building. It required applying an individual approach to solving particular tasks of the presented method. One of them is the way in which the building assessment is carried out in relation to the assumed operating requirements with the use of linguistic assessments. Furthermore, the way in which the influence of each building repair is determined on the assessment of assumed operational requirements, is also developed. While choosing the proposed repair variants, the application of multi-criteria TOPSIS method is suggested. Bearing in mind, that according to the correct order of repairs carried out, the proper management of given funds depends on the way in which the performance of repair order should be settled, and this is also presented.

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