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Application of risk analysis by the evaluation of buildings indoor environment

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Abstract. In civil engineering we face up to a wide line of risks of mostly technical character (accident hazard, formation of damages or defects). At present a continuous tightening of cladding energy parameters happens within the sphere of residential and civic engineering. With buildings built in the end of the past century it is not possible to meet completely these requirements without a considerable intervention (and not only into the cladding). Risks acting to users of such objects resulting from its use can be evaluated using the risk analysis method.

Introduction

During the lifetime of a building the defects of serious or less serious character may appear which have considerably negative influence on indoor environment of such objects. The defects may be caused by a wrong design of the designer (inappropriately designed materials, not observance of technological discipline during construction or by any other unprofessional interventions). Serious defects are also shown by age and insufficient maintenance during operation of the given construction (Figure 1, Figure 2).

Defects of external cladding and its influence on indoor environment of the buildings

The office building object in question, its external cladding is formed by steel load-bearing structure of atypical shape and beam filling shows serious defects at some places. During heavy rains the rainwater leaks in the contact points of these two structures. This in-leak results in mould formation in the interior which has negative impact on hygienic conditions of the indoor environment. The indoor environment quality is also influenced by acoustic properties of the designed constructions. [1, 2 and 3]

Evaluation of object conditions using the UMRA method (Method of Universal Matrix of Risk Analysis)

The method of universal matrix of risk analysis (UMRA) is based upon the comparative logic-numerical analysis of risk severity level for the given problem being resolved (project or its part) by an expert team.

The method of universal matrix of risk analysis has two stages:

- word phase – it is focussed on identification of project segment exposed to danger, sources of dangers endangering the segments. This phase is realised by an expert team. A matrix form which is further worked with in the numerical phase is the result.
- The numerical phase includes:
  - estimation of risk severity level using the UMRA matrix
  - qualification of the risk according to estimated severity levels. [4]

Consideration of wear and tear of the construction

We come out from the severity (*risk*) level Tab.no.1. We can select for example S_{vmax} = 4. This table can be modified by expansion of S_v values, the best in interval <1; 8>. The scale can be arbitrarily expanded or reduced, however it must remain comprehensible and easily applicable for the expert. [4]

Table 1: Wear and tear severity level

Evaluation of construction condition	Characteristics of the conditions and wear and tear of the construction	Severity level S_v
Excellent condition	the construction is in the excellent condition without any signs of any considerable wear and tear	1
Preserved	the construction is preserved with visible signs of ageing , however it still performs its function	2
Damaged	the construction with visible signs of damage, repairable, requiring stronger maintenance	3
Repair necessary	the construction urgently requires necessary radial intervention (repair)	4

To express the setting of damage we shall use the linear function which in dependence on severity level grade will be able to produce the financial value C_i. The function is defined as equation of a straight line set by two points in orthogonal system of co-ordinates by initial point A [0;1] and point B [4;0]. Vector u is thus given by points A; B and normal vector n is vertical.

u = B – A => u = (4; -1) and normal vector n = (1; 4)

A general straight line is defined by the relation:

$$ax + by + c = 0 \tag{1}$$

Into this straight line we shall fill in the normal vector n co-ordinates and we get:

$$1x + 4y + c = 0 \tag{2}$$

Resultant equation of the straight line for S_{vmax} = 4:

$$x + 4y - 4 = 0 \tag{3}$$

$$y = \frac{4 - x}{4}$$

$$y = 1 - 0.25 \times x$$

Individual coefficient of danger perception shall be set using the formula:

$$P_{ck} = \frac{\sum S_v}{S_{v\max} \times n_{act}} \times 100 \tag{4}$$

Where: P_{ck} is the individual coefficient of danger perception;

ΣS_v is summary of active windows values;

S_{vmax} is maximum value of the danger level;

n_{act} is number of active windows.

A danger is perceived within 0% to 100% as a construction completely safe or completely dangerous on the contrary. In case of more experts we obtain the final value by arithmetic mean.

Evaluation of administrative building using the risk analysis

The expert team evaluates an identified part of the administrative building which is affected by a certain danger - risk. This evaluation is totally dependent on erudition of the given expert and it is closely related to his or her theoretical and practical experience in the given problems. Number of parts of the problem evaluated by the expert team is arbitrary.

Table 2: Sample form for object evaluation – expert no.1

Project	**Administrative building**						
Segments of the project	**Sources of danger**						
	Corrosion	**Mechanical wear and tear**	**Biological degradation**	**Connection**	**Water in-leak**	**Material**	**Cracks**
Knots	3	2	3		3	2	
Rods	3	2	3			2	
Welds	3	2	3		3	2	
Waterproofing in area		2		3	2	2	
Waterproofing in details		3		3	3	3	
Bottom platforms		2			4	3	
Reinforcing FC core		2				2	
Walled partition walls		3				3	4
Light partition walls		3				4	
Roofing	2	2		3	2		
Stairs				2		2	

Figure 1, 2: Damaged flat roof waterproofing and rot of the administrative building evaluated in the tab.2

$\Sigma_{ijCijk} = 100$; $n_{act} = 38$; $\Rightarrow$ Ø $100/38 = 2.63$

$S_{max} = 4$;

Σ_{ijCijk} is summary of values of active windows;

n_{act} is number of active windows;

S_{max} is maximal values of danger grade.

By filling in the straight line resultant equation (3) for S_{vmax} = 4 we get:

$$y = 1 - (0.25x \times 4)$$
$$y = 0.3425$$

Individual coefficient of danger perception we shall get by filling in the formula (4):

$$P_{ck} = \frac{100}{4 \times 38} \times 100 \Rightarrow \underline{\underline{P_{ck} = 65.79\%}}$$

According to the expert no.1 the individual coefficient of danger perception is 65.79%, damage 34.25%.

Table 3: Coefficients of danger perception

Value	Team	Expert			
		1	2	3	4
Summary Sv^E	378	100	116	77	86
Active cell number	142	38	45	31	32
Pc_k		0.6579	0.6444	0.621	0.6719
Pc_t/Pc_k		0.945	0.925	0.8912	0.965
$(Pc_t/Pc_k)*100$		94.50	92.50	89.12	96.50

The resulting share of the danger perception coefficient is according to the expert team, which was in this case formed by four experts, set by arithmetic mean and is 93.15%.

Summary

At evaluation of the administrative building condition using the risk analysis method the defects of roofing and external cladding were assessed by the expert team as the most serious ones. The risk analysis results serve as a supporting background for officially appointed expert. A suitable maintenance of the object will be recommended upon the risk analysis of the administrative building. Moulds formed inside the object due to its age and insufficient maintenance of it during use which have negative impacts on health of users and comfort of the indoor environment. On that ground the value of the real estate is reduced.

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