SELECTION OF WATERPROOFING FOR PROTECTION OF UNDERGROUND STRUCTURES USING THE AHP METHOD

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Summary: Hydro-insulating materials serve not only to prevent the water penetration in a building but to protect it from its harmful influence. The bad water influence on a building is second in a row, just after the fire, and it is the cause of damage and collapse of the construction. The choice of the reliable hydro-insulating material is an investment that will pay off during the exploitation of the construction. The choice problem is often because of the multi-criteria. For solving this problem , the method of analytical hierarchy process –AHP- is suggested.

Keywords: AHP method, Waterprofing, Optimization.

1.   INTRODUCTION

The protection of building constructions from the harmful influence of dampness and water is one of the crucial factors that influences on the object lasting, as well as on people`s health. We should not forget that thermal material characteristics get worse when the material gets in touch with water.

The division of hydro-insulation material can be seen from different aspects. One of the basic ones is the place where that material was built on. In this paper it will be said only about a hydro-insulation as a way of protection of underground constructions , but also about the environment that these materials have been exposed to.

The underground objects or their parts are totally exposed to the influence of underground waters and as a result of it there is an exposure of special, aggressive influences that can be temporary or permanent.

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Every disorder of water permeability as a result has a lowered function of the object. Since the price of the hydro-insulation is less than 1% according to the total object price, and the damage caused by inadequate choice are much higher, we can see the importance of choosing this kind of object protection.

The fist need of hydro-insulation goes back in the time of Noah`s Ark .Forty days of constant rain inspired people to do something to prevent water coming into their homes. In those days people used straw, reed, leaves and things like that. The production of hydro-insulation materials goes together with the improvement and needs of civilization so that today on the market we can find both materials on natural basis and products of chemical industry-synthetic products.

Hydro-insulation materials can have a shape of a membrane-foil, coating and concrete additives. In this paper it will be analysed the following things, as alternative for the choice of insulating materials:

- Bituminous membranes
- Synthetic foil
- Bentonite membrane

The choice of hydro-insulating materials is a problem with multiple criterion. Some of them are numerical values while the others are descriptive. The aim of this paper is the presentation of the optimal kind of material according to the alternatives values for certain criterion as well as the relationships between criteria

2. AHP AS A METHOD OF MULTI-CRITERIA OPTIMIZATION

Optimization (lat. –Optimus, the best) is the process of improving of some existing solution and finding the best solution according to some criterion. The term ``the best`` solution implies that there are more than one solution and that they are not of equal value. The definition of the best solution depends on the problem analysed , the method of decision and allowed precision. The aim of the optimization is choosing the best out of the line of possible or favourable variants according to the taken criterion. The criterion is defined by the quality of management and represents the comparing measure during choosing the best variant. Also, the criterion is represented by (aimed) function that should reach global extreme for the best variant (solution), concerning the limitations that are possibilities of taking the aim. Changing the entrance parameters of the system, according to functions or system processes, we also change the given characteristics of the accomplished solution.The aim of the optimization is to choose the material that satisfies one or more criteria, whose interactive importance can vary. Optimization of the material choosing is, by its nature, with very multi-criteria. The criterion can be those fulfilling technological terms and also those with techno-economical parameters. Analytic hierarchy process- AHP, is a technique used in the area of multi-criteria decision-making. It is based on breaking the complex problem in the hierarchy, where the aim is on the top, while the criterion, subcriterion and alternatives are formed on several hierarchy levels. Person that makes decision compares the elements in pairs on every hierarchy level according to element on a higher level, using so called Saaty scale.

The final result of the comparison are vectors of relative importance (priority) of criterion and the alternative according to the aim.

Table No.1: Saaty scale

Intensity of Importance	Definition
1	Equal Importance
3	Moderate importance
5	Strong importance
7	Very strong or demonstrated importance
9	Extreme importance
2, 4, 6, 8	Intermediate values

According to AHP method, the central place in valuing the elements of hierarchy take matrixes of comparison of the given transformation of semantic marks about interactive importance of elements into numerical values. In that way, in the relation to every element of hierarchy, one matrix A is formed from the higher level by valuing of elements from the observed level of hierarchy. From each of that matrix it should be taken out the vector of priority of elements that can be marked as W.

With detailed analyses of the tasks that the chosen method must fulfill, the technology of the suggested methods together with the experts opinions from this area , defined criteria that will be crucial for choosing the optimal solution. The criteria are:

- the price
- the reliability
- the power of resistance against the aggressive influence of the environment

By subliming the characteristics hydro-insulating materials, the choice of the previously given criteria has been made. It should be mentioned that this is not the only quality choice of the parameters that are analysed during the choosing of hydro-insulating material.

When we talk about price criterion, research of the producers` market in table number 1 we can see the average values for every alternatives.

Hydro-insulating material	PRICE DIN/M2
Bituminous membranes	450
Synthetic foil	1200
Bentonite membrane	1050

The criterion of reliability sublimes within itself a number of physical and mechanical characteristics of the material. One of the main characteristic is the resistance of the membranes against the sagging of the objects. Also, the reliability also means the behavior of the material throughout the time as well as other geological properties of the material. Resistance against aggressive influences from the outside represents the fact that is very important. The resistance of the material against water penetration is not enough for the material to justify its function. In the underground water there are often aggressive dissolved substances that can damage the material and ruin its water-proof characteristics. If the building works take place on the sea coast, one of the most important criterion is resistance against the salt

3.   THE APPLICATION OF THE AHP METHOD ON THE CHOICE OF HYDRO-INSULATING MATERIAL

Model of decision with hierarchy structure, in general, consists of the aim, the criterion, several levels of subcriterion and alternatives.

The aim is at the top of the hierarchy and we do not compare it with the other elements. On the fist next level are the criteria,that are compared in pairs with each other in the relation to upper element on the higher level. The number of comparisons is n* (n-1)/2. The same thing happens again on all hierarchy levels, to the last (the lowest) level (of the k level). The hierarchy model AHP applied on the choice of hydro-insulating material is shown on the graph number 1.
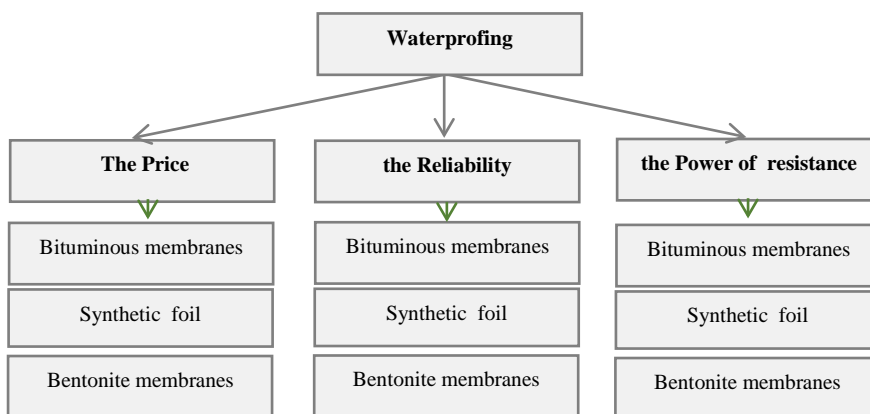
Graph No. 1: Hierarchy model AHP

The main problem in balancing of criteria is the copying of criteria differences for every alternative having value of Saaty scale.

The suggested solution is first to define the measure of the ``strong domination ``of one variant related to the other according to one of the criterion. The accepted measure of difference of two variants is the value of the standard deviation according to that criterion. So, according to one criterion, the variant i is ``strong dominant`` in relation to variant j if their difference equals the standard deviation of that criterion. When the ``strong domination`` measure is determined, the whole interval of value differences among combinations is divided on equal parts and the values are assigned measures from Saaty`s scale.

In order for criteria to be compared, it is important that their sizes are made comparable. For each of the criterion, the differences of the criteria values among combinations should be divided by the average value of the same criterion for all the combinations observed. In that way we actually put the value of criterion difference among combinations on proportional piece of the average value of the observed criterion.

The same thing is done with the measure of importance from Sati`s scale: the standard deviation of the criteria is divided by the average value of the same criterion.

When that procedure is done for all the criteria, that values have the same dimensions and only then can we apply the Saaty`s scale on them. The criterion of the price is numerical and it needs to be copied on Saaty`s scale. The first step is comparison of the values for every alternative (table number 2). The table is symmetrical on diagonal with variable presage.

Table No. 2: Criterion of the price - comparison of the values for every alternative

	Bituminous membranes	Synthetic foil	Bentonite membrane
Bituminous membranes	0	-750	-600
Synthetic foil		0	150
Bentonite membrane			0

The relationship of every value from the table 2 and the average value of the criterion of prices (900 dinars) is shown in table number 3.

Table No 3: Relationship of every value and average value of the criterion price

	Bituminous membranes	Synthetic foil	Bentonite membrane
Bituminous membranes	0%	-83%	-67%
Synthetic foil		0%	17%
Bentonite membrane			0%

The measure of importance for comparing the combinations is formed in that way that for the measure of ``strong domination``(5, that is -5 according to Saaty`s scale) they took the value of the quotient of standard deviation with its average value and then the interval between was divided on equal parts, where the middle part of the interval is from -1 to 1 – the interval ``of the same importance``, a little bit shorter, because of the encircling of the value. That values are shown in table number 4.

Table No. 4: Significance measure according to Saaty's scale (only positive values are shown)

SAATY'S SCALE	1	2	3	4	5	6	7	8	9
Price	1%	11%	22%	33%	44%	55%	66%	77%	100%

Finally, matrix of comparison of price criterion with the values form Sati`s scale is shown in table number 5. The criterion of reliability and the resistance against the influences from the environment are particularities and assigning the values in Sati`s scale is done according to technical specifications of every material as advice together with the experts from this field.

In table number 6 is shown a matrix of comparison according to the criteria of reliability. The value and the comparisons are done according to the experts opinions from this field as well as analyses of technical specifications of the products of hydro-insulation in the Serbian market.

Table No. 5: Matrix of comparison according to Saaty's scale according to price criterion

	Bituminous membranes	Synthetic foil	Bentonite membrane
Bituminous membranes	1	-9	-7
Synthetic foil		1	3
Bentonite membrane			1

Table No. 6: Matrix of comparison according to Saaty's scale by the criterion of reliability

|	Bituminous membranes	Synthetic foil	Bentonite membrane
Bituminous membranes	1	-8	-5
Synthetic foil		1	6
Bentonite membrane			1

In the table number 7 is shown a matrix of comparison according to the criteria of the resistance against the aggressive influences. This criterion also sublimes within itself several characteristics. The values done in table number 7 are based upon the experts opinions from this field.

Table No. 7: Matrix of comparison according to Saaty's scale according to the criterion resistance to aggressive influences from the surrounding environment

	Bituminous membranes	Synthetic foil	Bentonite membrane
Bituminous membranes	1	-6	-5
Synthetic foil		1	4
Bentonite membrane			1

4. CONCLUSION

If the equal importance of all the criteria is defined, applying the calculations shown in Chapter 3, we get the following rank of alternatives:
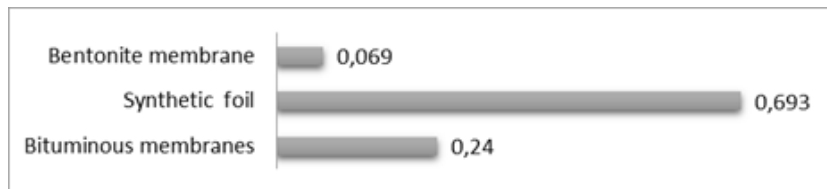
The degree of consistency of this solution is 0,068 so, since it is less than tolerant limit of 0,1, the result can be seen as consistent. We should not forget that the calculation was done according to the same importance of all the criteria because the relation between them is variable depending on the priority of the final users. The adequate choice hydro-

insulating material is something that will be shown as beneficial during the time of object exploitation. Since there are several criteria to be fulfilled, some of the methods of multicriterion optimization need to be adopted. AHP is one of the most famous methods of scientific analyses of scenario and decision making by consistent valuing of hierarchies whose elements are aims, criteria, subcriteria and alternatives.

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IZBOR HIDROIZOLACIJE ZA ZAŠTITU PODZEMNIH KONSTRUKCIJA KORIŠĆENJEM AHP METODE VIŠEKRITERIJUMSKE OPTIMIZACIJE

Rezime: Hidroizolacioni materijali umaju ulogu da, ne samo spreče prodiranje vode u objekat, već i da ga zaštite od njenog štetnog uticaja. Štetan uticaj vode na objekat predstavlja drugi po redu, odmah iza požara, uzrok oštećenja i propadanja objekata. Izbor pouzdanog hidroizolacionog materijala je investicija koja će se isplatiti tokom eksploatacije objekta . Problem izbora je, vrlo često, višekriterijumskog karaktera. Za rešavanje ovakvog problema predlaže se metod analitičkog hijerarhijskog procesa - AHP.

Ključne reči: AHP method, Waterprofing, Optimization