

Comparative Analysis of Effectiveness in Application of Bitumen Membrane and Synthetic/Foil Membrane Material's in the Case of Flat Roofs in Sarajevo

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Abstract:- This research aims to find out which waterproofing material is currently more in use in construction of flat roofs in Sarajevo, Bosnia and Herzegovina. By choosing interview method aim was to investigate what are the thinking's of the Architects and Civil Engineers in case of waterproofing process and with which materials are they familiar. Therefore, discussion was based on answering the Research questions which are one of the main reasons why this paper is done. Waterproofing is a broad term, and it is different technical procedures to protect parts of an object or buildings that are temporarily or permanently subject to moisture and water, regardless of the source of moisture and water. The term waterproofing is commonly considered a protective measure of the buried parts of the object with the fact that in the construction of a flat roof on the object waterproofing has a very important role. It should be remembered that with good waterproofing, besides the basic structure, we protect the internal spaces from the water penetration, respectively moisture.

Keywords: Flat Roof, Membrane, Bitumen, Typology, Insulation, Foil, Waterproofing, Water, Synthetic.

I. INTRODUCTION

Several millenniums back designing buildings exists. As a basic need of shelter It is reasonable to assume that for a long time huts, and later buildings, mostly of modest size, were made to respond. Social life, however, which had primarily taken place in the open, eventually often involved accommodation in buildings too. The Pyramid of Djoser in Egypt, designed by Imhotep between 2630 and 2611 BC, is the first established construction of a monumental scale that is considered to be the brainchild of a named architect. The history of architecture is told through mainly large-scale structures of symbolic importance erected for religious, government, cultural, and social purposes before the modern period. The rulers who commissioned them also had palaces designed and built for themselves, to serve as status symbols as much as living quarters. Other construction styles appeared in modern times that achieved architectural respectability In

modern times other building types emerged that acquired architectural prestige (diverse additional cultural centers, commercial edifices, transportation hubs, educational institutions, and more). Until very late in the modern period, residential structures, other than houses for the very famous, were not considered suitable of architectural publicity. (G.Goldschmidt, 2011)

The word insulation comes from the French word "isoler" (which is again derived from the Italian word "Isola", meaning the island) and means separating, isolating or detach (Ciganjek, 1965). To isolate means to separate an object - in case of this thesis, a building - from some other thing, influence or environment, action, penetration, etc. Isolation of water flow is, therefore, a measure, arrangement or construction that separates the building, walls, and space of the building from water and harmful environment. Isolation against water is the most common layer that is placed between the wall and the harmful environment, a layer that permanently and efficiently prevents water from penetrating the walls and the interior of the building and damaging the parts of the building with integrity and impermeability. Consequently, the insulation is made from the impermeable materials, which we call insulating materials (Ciganjek, 1965)

All constructed buildings are exposed to the external climatic influences. Experiences have shown that the water cannot be opposed, but it should be allowed light and smooth path in the desired direction (Minela, 2015). Construction materials such as concrete, brick, steel, and wood are not water-resistant. For this reason, it is necessary to protect the construction objects from its activity. Protection of building structures from moisture and water is known as waterproofing. Waterproofing materials make a special kind of building materials for which very strict quality requirements apply. These materials are not constructive, nor bearable, but are responsible for the usability and condition of the construction. Selection of suitable waterproofing materials and proper installation are very important. Waterproofing represents various technical procedures that protect parts of objects that are temporarily or permanently exposed to the effects of moisture and water. Therefore, waterproofing implies the

installation of a watertight, physical barrier, which aims to prevent the penetration of water or moisture within the building. In addition to preventing the entry of water or moisture into the walls or floors of building, waterproofing prevents various damage to the constructive part of the building and helps to preserve the aesthetic appearance of the building. (Minela, 2015)

Investment costs for waterproofing are insignificant concerning the total construction cost and the cost of equipping the building, and therefore it is insignificant to save on waterproofing. On the contrary, it is recommended that waterproofing is dimensioned with a higher degree of safety, as this reduces repair, maintenance and exploitation costs, which in the end means increased profitability. (Ciganjek, 1965)

Waterproofing can be defined according to (Duleeka, 2015) as the formation of an internal or external membrane which is capable of preventing water from entering or escaping through a permeable layer. In the building sector, there are several specific ways of establishing internal or exterior membrane. Waterproofing admixtures that are applied to the concrete during the mixing phase establish internal membranes. External membranes are provided using sheet membranes and liquid coatings on the concrete surface. Waterproofing is an essential requirement of a facility to secure itself against any danger caused by water and other chemicals. Waterproofing system is necessary for:

- A durable structure
- Hygienic environment
- Pleasing aesthetic appearance

Thus, the key purpose of a waterproofing material is to avoid the infiltration of water and other soluble salt into the concrete to induce rust, leakage and other problems. Furthermore, waterproofing material can be very efficient in reducing the rate of corrosion until it is completed by keeping the steel surface from receiving moisture and oxygen. (Duleeka, 2015)

In recent buildings, flat roofs are being more often used instead of a pitched roof. In addition, one of the major factors is the waterproofing of flat roofs, because the water-tightness of the roof depends on the efficiency of this material. After an analysis of the waterproofing materials used in flat roofs made by the authors, it can be inferred that, due to their various production processes and nature, the corresponding environmental impacts vary significantly. This is a significant matter as the environmental effect of human behavior and decisions is constantly involved. The financial stability is also very important, considering the growing value of the environmental component when it comes to choosing to purchase a given material. In addition, due to the membranes used, environmental effects differ significantly, and so do their life cycle costs. (Miriana Gonçalves, 2019)

Flat roofs have exacerbated construction and physical problems to the utmost because they are the most important and complex part of the building. Research has shown that different materials absorb or repel the sun's rays in different ways. Tests on such roofs have shown that temperatures on the flat roof surface in summer can be as high as two times the air temperature. It all depends on the color and type of cover and how the layers are arranged (construction, fall layer, thermal insulation, waterproofing, etc.) (Kiš, 2016)

Based on a research (Duleeka, 2015) history of waterproofing dates back to biblical times, where liquid bitumen coatings were used to waterproof boats. However, in the early 19th century, certain methods were developed by mixing various materials with bitumen to obtain waterproofing materials. These kinds of materials were primarily used in those days to waterproof roofs. After those certain developments were made to improve the effectiveness of waterproofing in order to meet the industrial requirements.

Regardless of the material, several performance considerations must be taken into account when selecting a roof membrane. The most significant factor is durability. In order to have great performance a roof must:

- Remain waterproof.
- Withstand all atmospheric conditions during its planned service life (such as storm, rain, snow, hail, UV radiation, high temperatures, and thermal shocks).
- Avoid diverse pressures during the process, application, and service from internal or external causes.

Membrane exposure to heat, solar radiation, rain, wind, and emissions can cause physical and/or chemical changes that have negative effect on the membrane's properties. As a consequence of roof traffic, improper maintenance and lack of repair, this degradation can make worse. Results greatly increase the ability of roof designers to make appropriate membrane selections that will maximize roof durability and longevity (A.H. Delgado, 2005)

Bitumen is a complex combination of chemicals that are organic and inorganic. Asphalt and maltenes, which are responsible for the viscoelastic properties of bitumen, are the major organic compounds. Unmodified bitumen is not used in roofing applications due to its inherent limitations, such as brittleness at low temperatures and tendency to flow at high temperatures, taking into consideration its normal viscoelastic properties. Therefore, attempts have been made to improve the properties of bitumen by combining it with natural or synthetic rubbers or lattices, to obtain new materials that have high elasticity. (A.H. Delgado, 2005)

Today, there are many companies involved in the manufacturing of single-ply membranes. The advantages of such systems include the speed of installation and the elimination of open flames or heated asphalt. However, these systems must be installed by properly trained and

manufacturer-approved installers. Most single-ply manufacturers claim that their products have a service life of at least 15 years. The membranes are formulated to resist UV radiation, heat, and bacterial attack. The nomenclature used in the industry for these single-ply systems is based on the main chemical ingredient (e.g., PVC, EPDM, etc.). This is convenient for discussion purposes but it must be remembered that all of these membranes contain additives, which are required to impart the desired properties such as flexibility and wear ability. In general, there are two main categories of polymeric sheets: elastomeric and thermoplastic. (A.H. Delgado, 2005)

II. METHODOLOGY

This chapter presents Qualitative method for interviews that is used for data collection based on comparative analyses of two different materials used in last 10 (ten) years that are located on the roofs of buildings. Interviews results will be used for comparative analysis. In order to analyse interviews here are Research questions set by author. The list of research questions is listed below:

1. What are the reasons of application bitumen membranes in the contemporary world in which many other alternative waterproofing insulation materials have been produced and applied in flat roofs instead of bitumen membranes?
2. Does the bitumen membranes have alternative in the last 10 years?
3. Is the method of application the most important part of the entire waterproofing process?
4. Is the bitumen membrane in the 21st century still the best solution for the development of all types of flat roofs?
5. Which waterproofing material (Bitumen membrane and synthetic/foil membrane) has the ability to reuse – recycle?
6. Is the unavailability of synthetic/foil membranes on the Bosnian and Herzegovina market the only reason why these materials are not the first choice of users?

III. ANALYSIS AND EVALUATION

Weight factor will be calculated based on the years of experience of the participants that are interviewed. 196 years is the total number of years of experience of all 9 participants. By dividing total number of years of experience with 10 (ten) weight factor coefficient 19,6 as a maximum weight factor will be reached.

- $196/10 = 19,6$ weight factor coefficient

Engineers working in construction industry based on Bosnia and Herzegovina and abroad will be target population for the purpose of investigation in this paper. Two main engineering professions that are involved in the process of designing and constructing are:

- Architects
- Civil Engineers

According to the weight factor defined in upper part here is the list of 9 participants in interview their weight factor is evaluated in the table 1. listed below:

Table 1.

Participants	Weight factor coefficient
1. Participant – (37 years of experience)	3,7
2. Participant – (10 years of experience)	1,0
3. Participant – (15 years of experience)	1,5
4. Participant – (32 years of experience)	3,2
5. Participant – (30 years of experience)	3,0
6. Participant – (20 years of experience)	2,0
7. Participant – (20 years of experience)	2,0
8. Participant – (25 years of experience)	2,5
9. Participant – (7 years of experience)	0,7

IV. RESULTS AND DISCUSSION

In this part list of questions that were used in the interviews will be displayed. List of questions is listed below:

1. When we talk about waterproofing materials on flat roofs, what is your 1st choice, what do you recommend?
 - 1.1. On the basis of what criteria is this attitude based?
 - 1.2. When choosing (that) waterproofing material, is there a restriction on the use of flat roof space?
 - 1.3. How important is the matter of material availability at the market of Bosnia and Herzegovina, during the selection procedure?
 - 1.4. Which distributors of waterproofing materials do you do business with?
2. What is the most important part / aspect when we talk about waterproofing?
 - 2.1. How much does the market itself dictate the choice of waterproofing materials?
 - 2.2. What can the Bosnian market offer from waterproofing materials?
3. What is the reason for using bitumen strips in addition to other / more modern insulation materials?
 - 3.1. To what extent have new / modern waterproofing materials managed to push / replace the bitumen strip (approx. In%)?
 - 3.2. To what extent are other / new waterproofing materials present on the market?
4. Which waterproofing material do you think is better bitumen strip or synthetic foil (in general)?
 - 4.1. Based on what criteria do you think is better?
 - 4.2. Which one of these two waterproofing materials is better/easier for application?

- 4.3. Do either of these two materials have the possibility of reuse or recycling?
5. To what extent does the purpose of the flat roof space play a role in choosing a waterproofing material?
- 5.1. Can any type of flat roof be water-protected with bitumen strips and synthetic foils?
6. If you had to build three different types of flat roofs, what waterproofing material would you use to make all three?
- 6.1. Why exactly (that) waterproofing material?

Therefore, it can be stated that data collection for Interviews were based on two methods. First method was based on a face to face meeting and making audio record of entire interview by receiving the permit of participant which is recorded too, however entire interview was recorded and later written down in electronic form. The second method was established on e-mailing the participants the questions and asking them to fill out the answers for the questions. All Research questions should be answered through the Interviews in order to analyse Interviews. All answers will be collected for each Research Question and weight factor of participants which have same answer will be added together and divided by total weight factor of all participants, moreover, it will be multiplied by hundred for getting the exact percentage of each answer. On the base of percentage, the answer for Research questions will be listed out. If the weight factor of the answer is under 50% it means that statement is rejected on the other hand, if the answer is over 50% statement is partly supported therefore, if the answer is above 75% that statement will be fully supported in total.

The list of Research questions and answers is listed below:

1. What are the reasons of application bitumen membranes in the contemporary world in which many other alternative waterproofing insulation materials have been produced and applied in flat roofs instead of bitumen membranes?

Answer: Reasons that are listed in the interviews are: Safeness, Price, Habit, Improvements and Adaptability. It can be concluded that: total of 6,7 from 19,6 are supporting the reason is Safeness, while 4,7 out of 19,6 are supporting the reason is Price, however 9,2 out of 19,6 mansion habit as a reason. 3,2 out of 19,6 sad that it has improvements, therefore 2,0 out of 19,6 supported Adaptability as a reason.

2. Does the bitumen membranes have alternative in the last 10 years?

Answer: As stated in interviews 9,7 out of 19,6 confirmed yes as an answer and gave alternative Synthetic membrane however, 2,0 out of 19,6 stated no as an answer therefore, 7,9 total of 19,6 stated that it depends on the type of roof. Bitumen membrane doesn't have alternative in last 10 (ten) years.

3. Is the method of application the most important part of the entire waterproofing process?

Answer: It can be concluded according to Interviews that 13,6 out of 19,6 declared that method of application is most

important segment of the entire waterproofing process while 6,0 total of 19,6 quoted some other reasons as most important segment of the entire waterproofing process. Moreover, it is partly supported that application of waterproofing materials is most important segment of entire process.

4. Is the Bitumen membrane in the 21st century still the best solution for the development of all types of flat roofs?

Answer: As stated in interviews it can be confirmed that: total of 9,9 from 19,6 are suggesting Bitumen membrane as waterproofing material while, 9,7 from 19,6 recommends as waterproofing material Synthetic Foil. Total of 13,4 out of 19,6 are confirming that Bitumen strips are over 60% exceeded. However, 8,9 out of 19,6 confirmed that Bitumen strips are better waterproofing material while, 10,7 from 19,6 confirmed that Synthetic Foils are better waterproofing material. Therefore, total of 6,7 from 19,6 for all type of flat roofs would use Bitumen strips as waterproofing material while, 7,2 out of 19,6 would use Synthetic Foil for all types of flat roofs as waterproofing material and 5,7 out of 19,6 declared that it depends on the Roof type which waterproofing material will be used. It is partly supported that Bitumen membrane is the best solution for the development of all types of flat Roofs.

5. Which waterproofing material (Bitumen membrane and synthetic/foil membrane) has the ability to reuse – recycle?

Answer: As it is stated in interviews it can be confirmed that: total of 11,7 from 19,6 confirmed that Bitumen membrane can be reuse-recycle while, 4,5 from 19,6 are confirmed Synthetic Foil can be reuse-recycle. However, 5,7 out of 19,6 confirmed that none of materials can be reuse-recycle. 0,7 from 19,6 stated that they are not familiar with this information. When it comes to reuse of Bitumen membrane it can be confirmed that it is partly supported while, conclusion about reuse of Synthetic Foil membrane is rejected.

6. Is the unavailability of synthetic/foil membranes on the Bosnian and Herzegovina market the only reason why these materials are not the first choice of users?

Answer: It can be concluded according to the Interviews that total of 19,6 from 19,6 confirmed that unavailability of synthetic/foil membrane on the Bosnian and Herzegovina market is not the only reason why these materials are not the first choice of users and mentioning that today all materials are available on Bosnian and Herzegovina market. This prediction is fully rejected.

V. CONCLUSION

It is evident from the above analysis that, Bosnian and Herzegovina market offers all types of waterproofing materials and does not lag behind European market. In the world where on daily bases new Technologies are being discovered and presented to the people although, there are new modern waterproofing materials Bitumen Membrane is still

best option for construction of flat roofs in Sarajevo. As first and best alternative to the Bitumen Membrane Synthetic Foil Membrane is presented however, this research has discovered that statistically Synthetic Foil Membrane cannot be listed as official alternative to the Bitumen Membrane. Therefore, it is evident in this study that other new waterproofing materials, how time passes, are being more in use but Bitumen membrane is still best option according to the participants of the Interviews. As it is mentioned before there are few reasons why Bitumen Membrane is first choice when it comes to waterproofing of the flat roof Safeness and Habit are reasons that stands out the most. When this two reasons are combined it is winning combination and there is no reason for changing it.

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