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Construction Anomalies and need for Waterproofing in UAE

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ABSTRACT

This article aims to increase knowledge about construction anomalies in engineering structures and contribute to making recommendations for waterproofing restorations of substructures, building roofs and special structures. This article focuses on investigating the methods used to make these structural elements impermeable and which materials are most suitable for each situation. The use of geomembranes in building foundations increases the durability of these critical structural elements, but they are used in only a small percentage of buildings around the world. It is associated with increased initial costs and lack of information on the subject. The use of impregnation protection becomes even more important when the water table is close to the foundation of the building and water is absorbed by capillary action. The fact that these structural elements are underground makes them difficult to access if repairs are needed. Waterproofing of these structures should therefore always be considered in projects, as these elements are almost impossible to repair. However, not all types of foundations or all parts of foundations can be covered with a waterproof membrane. Only foundation foundations (separate, straight, connected with lintels), mat slab foundations, and pile heads or pile head blocks can be sealed.

Keywords: Foundations, Substructures, Waterproofing, Membrane, Anomalies

I. INTRODUCTION

Concrete has been utilized in construction projects all over the world since it was discovered in the nineteenth century. Long after its discovery, this material was believed to be impermeable, therefore waterproofing protection was never needed. After some time, it was realized that concrete was not actually impermeable and that some performance issues in concrete structures were caused by water absorption, hence the permeability of concrete could not be ignored.

Following this finding, concrete structural elements needed to be waterproofed, especially the more vulnerable ones like roofs, underground walls, and foundations. Finding methods that would protect the buildings well while not interfering with their construction or the material's physical and chemical properties was therefore important.

The soil may contain infiltration water, accumulated water, suspended water, capillarity water, condensate water, groundwater, absorbed water, and interstitial water, which can all have an impact on a building's foundation.

The following categories of humidity are taken into consideration in this article as they have an impact on building foundations: construction humidity, ground humidity, humidity resulting from hygroscopic phenomena, condensation humidity, and humidity resulting from unavoidable causes. The ground humidity and the construction humidity were determined to have the greatest impact on foundations.

Finally, bacteria, plant roots, soil acidity (pH), and groundwater level are some of the main factors contributing to the destruction of subsurface constructions.

II. Construction Anomalies

An anomaly is a deficiency or defect in the system that, under the situations examined in this article, could harm the aesthetic quality or degrade the structure. The science of building pathology examines the four key phases of an abnormality's upsurge: diagnostic, prognosis, agents that cause the anomaly, and optimal course of action.

The best approaches to remove or fix the abnormality can be determined by carefully weighing these four factors. The choices are to eliminate the causes of anomalies, replace the afflicted components and materials, safeguard against degradation agents, and remove the anomaly itself.

It goes without saying that eliminating the problem is the greatest treatment. On building foundations, however, this technique would not be feasible because it is exceedingly challenging (and perhaps impossible) to access the damaged area, making the repairs highly expensive.

The most frequent anomalies that affect a building's foundation are flaws in the concrete (anomalies that develop during construction), which increase the material's permeability and allow deterioration agents to seep in from the surface; anomalies in the waterproofing membranes; and anomalies brought on by the gradual wear of the waterproofing coating system.

Concrete has flaws such as holes, porous areas, and concrete segregation (Figure 1). If there is no coating system in this situation, the degradation agents will have nothing to stop them from penetrating the element, which could lead to a lot of issues. This issue can be avoided if a waterproofing solution is considered from the very beginning of the project, extending not only the service life of the structural element but also that of the membrane and the waterproofing solutions utilized.

Figure 1. Anomalies during execution: voids and segregation of concrete

Even with the proper waterproofing protection in each situation, it may nevertheless sustain some damage that gives degrading agents access to the structural component, leading to a weak point in the system. The membranes most frequently display holes, folds, swelling, and cracking.

Below are some solutions to the concerns outlined above, with a focus mostly on mat-slab foundations because, as was previously said, repairing a pile is generally exceedingly difficult and expensive.

It could be possible to move forward with a comprehensive repair of the component once the waterproofing system is installed on top of the mat-slab foundation because it can be easily reached by removing the pavement slab. On the other hand, it is impossible to access the system when it is positioned at the bottom. It is suggested in this situation to internally fix or conceal the problem.

In order to prevent accelerated deterioration of the foundation, it is crucial to select the waterproofing system that best suits each circumstance, taking into account the elements that cause the greatest issues in each case: water, humidity, soil acidity (pH), microorganisms, and groundwater level.

III. HISTORY AND USAGE OF WATERPROOFING

The types of waterproofing that proved to be more effective and thus most popular are prefabricated membranes. They were created in Central Europe somewhere between the 1960s and the 1970s. However, it wasn't until the next decade that bitumen started to appear in membranes. Currently, there are three major types of membranes available: bitumen, synthetic thermoplastic polymers, and synthetic elastomeric polymers.

TABLE I

Prefabricated Waterproof Membranes

Bitumen Based membranes	Modified bitumen Styrene-butadiene-styrene resins (SBS) Atactic polypropylene (APP)	
Synthetic polymer based membranes	Thermoplastic	Plasticized polyvinyl chloride (PVC-P)
		High-density polyethylene (HDPE)
		Polyethylene high-density (PEHD)
		Thermoplastic polyolefin (TPO)
		Ethylene propylene rubber (EPR)
		Chlorinated polyethylene (CPE)
		Polyisobutylene (PIB)
	Thermoplastic Elastomeric	Ethylene/propylene copolymer (E/P)
		Chlorosulfonated polyethylene (CSM)
	Elastomeric	Ethylene-propylene-diene monomer (EPDM)
		Copolymer of isobutylene with

		isoprene (Butyl) (IIR)
		Chloroprene rubber (CR)
		Nitrile butadiene rubber (NBR)

Only a few of the membranes listed in table 1—including modified bitumen, SBS, APP, PVC-P, HDPE, TPO, and EPDM—are utilized in foundations. Utilizing materials that have been prepared on-site could be another choice. The bituminous emulsions, invented in 1920, and the bituminous paint, developed later to replace the first in locations where aesthetic concerns were present, are examples of this form of waterproofing.

The following factors, which include service life, aging, stretching, resistance to cold, flexibility, resistance to vegetation roots, environmental adaptability, application method, and commercial dimensions, determine the types of waterproofing systems used in building foundations as well as their properties and performance.

The HDPE membrane, with a service life of 150 years, and the bentonite geocomposite, with a service life of 100 years, are the materials with the longer service life period, according to rigorous analysis. Following these are membranes made of polyvinyl chloride, polyolefin, polypropylene, and polyethylene (PVC, TPO, PP, and PE, respectively), as well as ethylene-propylene-diene (EPDM), which has a service life of 50 years on average. The materials with the shortest service lives are blown bitumen and anything made on-site (emulsions, bituminous paint, and cement-based coating). When the other qualities are examined, it is shown that the EPDM membranes perform the best overall.

Moreover, how each form of waterproofing protection is applied: On prefabricated materials, welding or mechanical fixation is used. In-situ made materials are fixed using a trowel, brush, or roll.

Depending on the brand, the membranes' size and nominal thicknesses change. When selecting a coating type for a particular circumstance, it is important to carefully consider the material's properties to make sure it is appropriate for the setting and/or type of foundation. For instance, the membrane's ease of handling is crucial in the case of foundation footing because it must protect against all the elements.

Bituminous membranes and materials made on-site can both be applied in several layers. Because they strengthen the system, the various layers are particularly crucial in the last ones.

IV. WATERPROOFING SYSTEMS FORMED, TECHNIQUES AND APPLICATION FIELD

Different waterproofing systems can be used for different types of foundations. However, in any case, there are types of coatings that perform better than others. Therefore, it is necessary to consider all the main characteristics of the protection system to ensure that the best solution for the particular situation is used.

For foundation footings (both separated and connected by reinforced concrete beams), the optimal waterproofing solution is to apply a primer coat, followed by a waterproofing membrane and protective panels to protect the membrane after the element is built. is applied (Fig. 2).

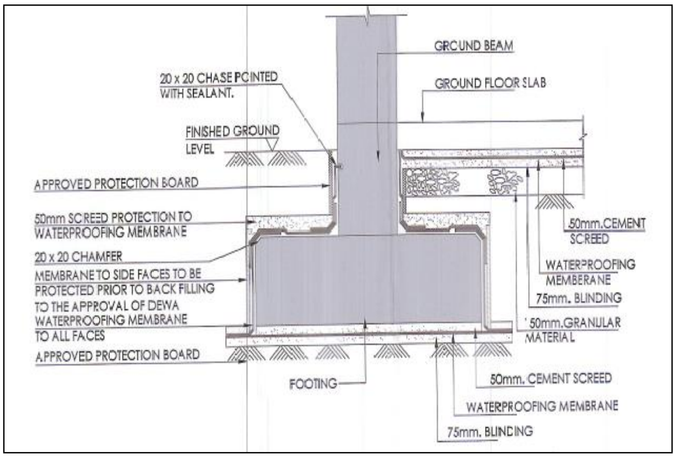

Figure 2. Waterproofing protection for Isolated Footing

However, the protection of a foundation connected by a fall is very difficult and expensive, since its shape requires performing some finishing details on the membrane. These finishing details are critical to any coating system and should be avoided. should be indented.

The solution to this problem is to change the project and select a matte slab foundation. This change allows the membrane to be applied horizontally (reducing the number of membrane finish details), which overcomes the problems associated with membrane application, and also means a simpler construction process. For mat and slab foundations, waterproofing can be applied above or below the concrete slab. If the water table is close to this component, it is imperative to install the membrane on the underside to prevent component degradation. If the water table is deep underground, the waterproofing system can be placed on top of the concrete slab.

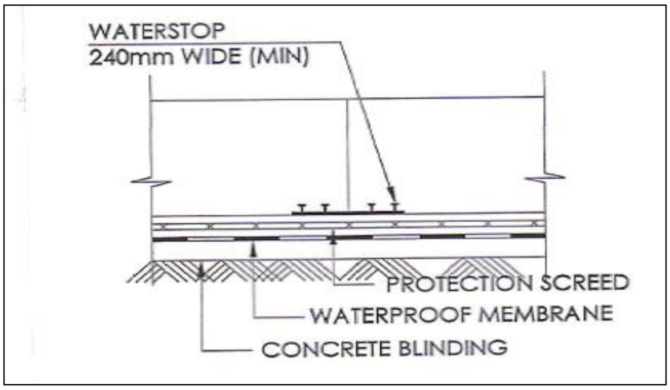

Figure 3. Coating System in Mat Slab Foundation applied to the bottom surface

An insulating pile and a rigid pile head called a cap pile block that connects multiple piles. Waterproofing systems cannot be placed around foundation piles and must be placed in the contact area between the foundation and the structural elements above. Figure 4 shows a schematic of a sealing system on top of the pile that provides impermeability. In this system a "water stop" is placed to block the flow of water. This piece must be carefully placed to ensure that the entire pile head is covered. Improper use of this system can lead to leaks.

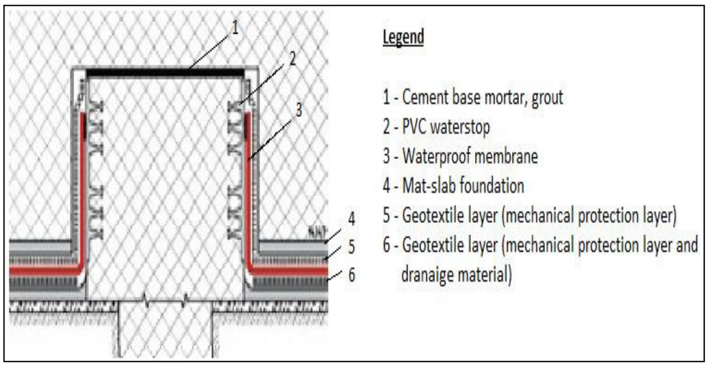

Figure 4. Scheme of waterproofing system in a Pile Head.

Figure 5 shows a scheme of the coating system of a pile cap block. The lower membrane and the upper membrane are made of the same material and are connected.

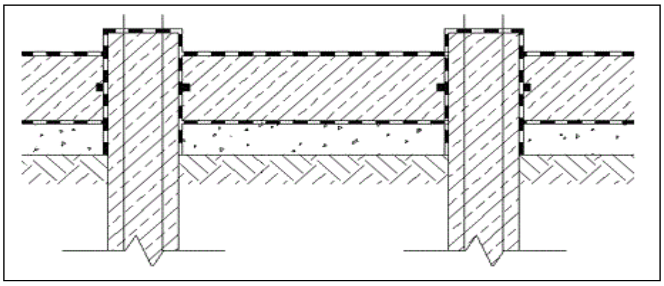

Figure 5. Scheme of waterproofing system in Pile Cap Blocks

The solutions provided below will help avoid gaps in the side coating between the pile head and the 'water barrier'. To do this, a one-component, cement-based, shrinkage-compensating mortar called mortar is used to create a watertight barrier. After refurbishment of a pile head that creates a rough surface, it must be cleaned to remove deposits that block the connection between the "old" concrete and mortar. To apply the mortar, the formwork must be used to give the concrete the desired shape and give the product the desired consistency. Since mortar is a very tolerant material, this solution is suitable for critical areas as shown in Figure 6.

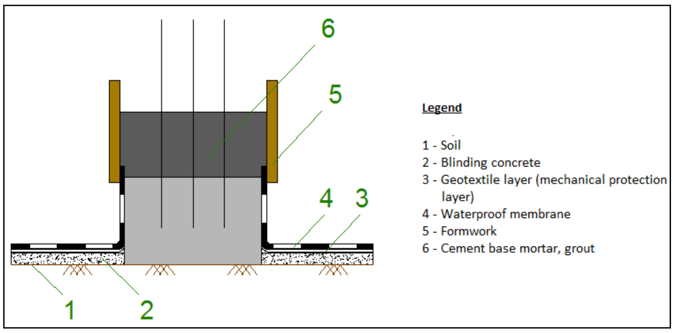

Figure 6. Waterproofing system of a Pile Cap using Grout

Finally, the solution shown below ensures continuity between the pile head and the sidewalk concrete slab. Developed by Sotecnisol, the system features galvanized steel surfaces with heat-welded steel bars that guarantee watertightness. The scheme of this solution and the materials used for it are shown in Figure 7.

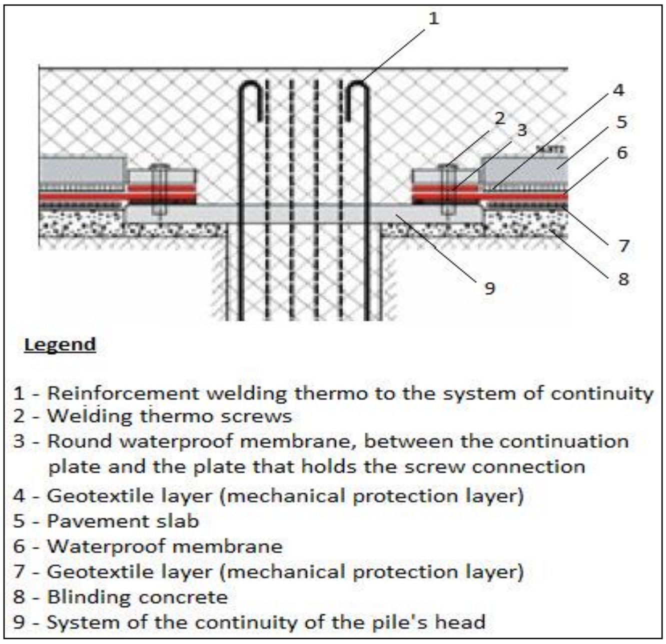

Figure 7. Scheme of Waterproofing system developed by Sotecnisol Company

This solution requires reinforcing the plate with pile head screws and using a new rectangular geomembrane. A new membrane should be connected to the first membrane by welding. In the next step the plate and steel rod are bolted to the pile head. Holes are drilled in the pile heads to accommodate steel rods that ensure a connection to the concrete. A ring-shaped membrane is then applied with holes only where the heat-welded screws are located so that the membrane can be attached between the plates. Finally attach the plate. Figure 8 shows this system before it was placed on the foundation.

Figure 8. Scheme of Waterproofing system developed by Sotecnisol Company

For the above waterproofing solutions, it is recommended to use only weldable membranes, excluding mortar systems.

PVC, TPO, EPDM. Bentonite geocomposite can also be used for this solution due to its flexibility and excellent water repellency. In mortar solutions, coatings are applied in a similar manner to coating the top of mat and slab foundations, except for the bond between the two materials provided by the drying of the mortar on the membrane. The prefabricated membranes used in this method are any of the previously mentioned waterproofing building foundations.

There is also the possibility to finish horizontal and vertical membranes with two different types of welds. Welding is, of course, used for finishing details of foundations with coating systems consisting of membranes applied by welding, and connections between waterproofing membranes of basement walls reaching the lower waterproofing membrane of the foundation. This situation only occurs with foundation footings and matte slab footings. FIG. 10 shows the welding of a vertically deployed membrane with a lower retaining membrane located on the inner surface of the vertical retaining membrane. This method avoids water buildup in the weld which can damage the joint. Geotextile layer splicing is placed on the inner part of the weld and can be applied or not applied. Figure 10 shows the membrane welds mounted horizontally to avoid weld degradation when the system is buried. The solution shown in Figure 9 has vertical welds that can be damaged by the weight of the floor. Use this solution only if you have enough space for welding.

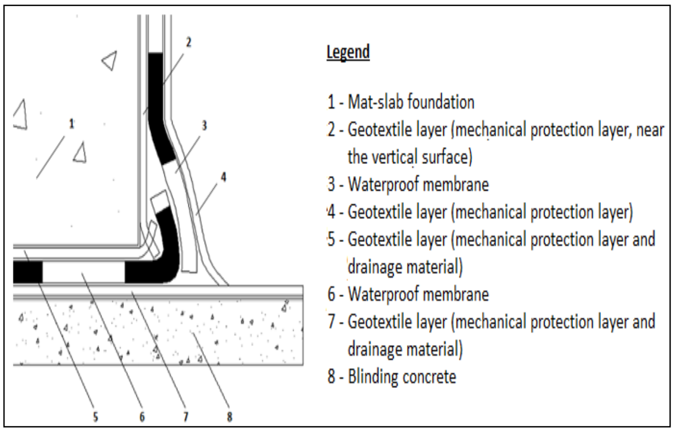

Figure 9. Splicing of the geotextile layer and the weld on the vertical membrane

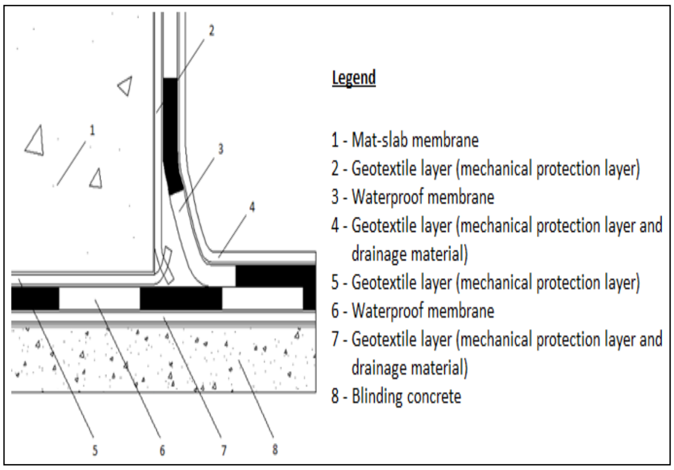

Figure 10. Splicing of the geotextile layer and horizontal welding of the membrane

The final scheme details the membrane finishing of the matte slab foundation with vertical masonry. When the sealing system is applied to the mat plate foundation, part of the membrane is left uncovered and connected to the masonry. This solution should be finished with a cement-based coating. Membrane finish details should be finished with grooves or grooving where mastic is applied in vertical applications to ensure a connection between the base and the membrane. The connection between the mastic and the tarpaulin prevents water penetration between the sheet and the wall. Figure 11 shows a schematic of this coating method placed on the bottom surface of a concrete slab.

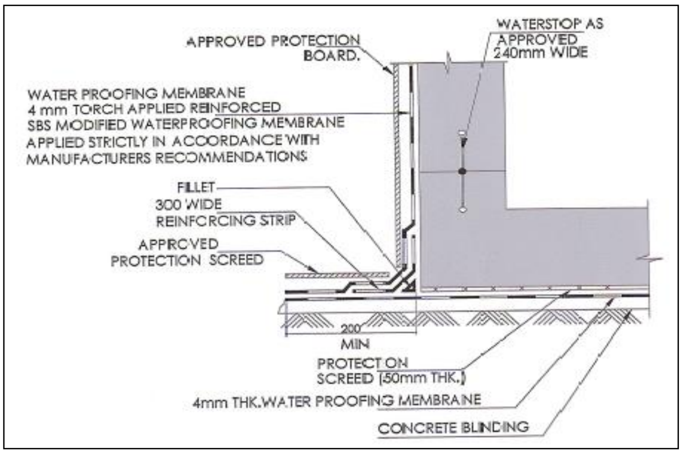

Figure 11. Waterproofing system bottom of Mat Slab connected with vertical

V. CONCLUSION

A high-quality waterproof coating of the foundation of a building can be easily achieved if it is considered from the beginning (at the beginning of the project). Building foundations are one of the most important structural elements and must be maintained in optimum condition to extend their life and extend the life of your building. Lack of normative and technical information has proven to be a major obstacle for companies, as there is no information on some run parameters, such as experimental tests and the materials most commonly used in each situation. Most of the information on this topic is based on the experience of manufacturers and engineers applying it. The use of waterproofing membranes in building foundation coating systems has proven to be an excellent solution as it creates a barrier that prevents water and other harmful substances from reaching the structure.

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