

ASSESSMENT OF WATERPROOFING FAILURES IN CONCRETE BUILDINGS AND STRUCTURES

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Abstract

This paper focuses on waterproofing failures in concrete buildings and structures. The objectives of this paper are three folds; (1) to determine the main factors that contribute to waterproofing failures in concrete buildings and structures (2) to discover different types of present waterproofing system applied for concrete buildings and structures (3) to propose remedial waterproofing solutions of concrete buildings and structures. There are 4 case studies were carried out at Cyberjaya, Malacca, Kuala Lumpur and Seremban. Each of them consist of different type of building namely SOHO (small office), Commercial building, Hotel Building and shopping mall. The results obtained shows that the main factors that contribute to waterproofing failures in concrete buildings and structure are cracks, deteriorated waterproofing system, honeycombs in concrete and construction joint failure. At the moment there are few types of present waterproofing system applied for concrete buildings and structures such as cementitious system, sheet membrane system and liquid system. Remedial waterproofing solutions of concrete building structures includes cleaning, removing old sealant or joint, injecting appropriate epoxy or chemical grout and applying a new layer of waterproofing system.

Keywords: *waterproofing; building defects; cracks; swimming pool; capillary action; building*

INTRODUCTION

Water is a liquid form that comes from the sea, lakes, rivers and rain; where also known as the important fluids of living organisms but contrasted to the building. Water is the root of serious defects and continuing problems in building and building materials. Due to its natural physical which is watery and slippery, it can get into places where it should not be by flowing freely by the gravity force, by pressure, soakage, through capillary action or by vapor diffusion. Many of serious cases have been arising in constructed building due to the present of water in the building. It can basically affect the building material where it can lead us to unseen blemishes and progressive decomposition by the chemical reaction between the Water, Material and also the presence of Oxygen or Carbonate. Waterproofing was found during the century of Noah's Ark which is caused by 40 days of non-stop rainy weather that leads people to take effective action to prevent the water from entering the residence and habitats. During this era, then people used hay, leaves and other possible methods to curb the water from keep on flowing. Thus, it is impossible to stop the water, however, it does help to control the amount of water flowing.

Protecting a structure with a coat of waterproofing membrane is a crucial element of its design and construction. Water can infiltrate the concrete or masonry barrier of basement area via capillary action. Relying on the physical porosity of the cement and saturation of the exterior, it is possible that water can enter the basement at any location. Due to the negative effect of the presence of water in a building may cause, a proper attention is needed in selecting a quality and suitable waterproofing material based on its location. Living in the era of technology, there is various type of new materials being invented for waterproofing

treatment which is more effective to prevent the absorption of water by the concrete. For example, when it comes to the waterproofing of swimming pools, constant hydrostatic pressure are combined with the rigid and porous structure of concrete pose serious challenges for an effective and lasting job. A suitable preventative measure shall be taken to avoid future cracks of structure that will affect the performance of waterproofing membrane and, at last, can cause a leaking in water retaining structure.

Defects in building structure are a matter of great concern and should be given attention. When a building is not up to the expected standard and does not perform very well, many questions to be raised up by the house buyers and the occupants. The answer to the uncertainty consist of was it due to the poor quality of the material? Is it the contractor does not perform the quality assurance during the construction stage? Was it caused by poor workmanship during the installation? Does a proper maintenance have been correctly implemented? The most appropriate answer always related to the age of the affected building component, the presence or absence of human error or exact nature of the problem. Damage and defects issue in the building can cause a bad implication and brings up negative effects to all parties either directly or indirectly. It is not only threatening the occupant's safety, but it may worsen the aesthetic value of the building. The causes of the defects in construction world should be dug up till the tail in order to facilitate the earliest planning and preventative action ensuring minimal risk of damage and defects (Ali, 2016).

Defective waterproofing can be the root cause of defects that related to moisture. The purpose of installing a waterproofing membrane is to avoid water seepage problem by concrete. When there are an excessive amount of water absorbed by the concrete without any waterproofing system, not only the reinforcement bar will corrode but the structure will start to produce water and leads to leaking problem. From leaking problem the defects will expand to crack and spalling of concrete. In Malaysia, waterproofing a building is a must especially on the roof structure, toilet, basement area and any building façade that are exposed to water. Malaysia is a country that is prone to sun and rain, because of that, many waterproofing failures that occurred is related to roof structure area. Found in the Malay Mail Online, "New buildings could also have structural defects" stressed that not only a building of 10 years old are having structural defects but they found that almost all of the new building were constructed with a lot of defects during the inspection for vacant possession. Due to the shortcoming of workmanship, many minor defects has to be found and the most serious defects are the leaks in the electrical riser rooms. Furthermore, many new defects were found on a newly built Public School in Umbai, Melaka. Many parents are worried about their children's safety as many cracks in the structure of the building has been found (Ayob et al., 2017). Based on that matter, he also wondered how the new building that completed last 2 months has faced many cracks and leaks in the roof. He claims that the building defects might occur due to the apathy attitude of the contractor (Chang, 2015)

Undeniably, most of the problems faced by high-rise building owner are the inter-floor water leakage issue. Many of new invention in making a better high rise building has been invented and put into consideration, among them are built a building that can withstand an earthquake with seismic engineering, green buildings with energy and water efficient measures and fire resistant with comprehensive fire prevention measures. Despite all the new technologies, unfortunately, there are none of the provisions in building codes to look into an issue that bothers many building owners and occupants which the water leakage problem

(Habib and Rahman, 2007). Waterproofing usually costs a fraction of the overall project cost. Due to this problem, many of the contractors are trying to minimize the cost in waterproofing membrane. Price is the prime concern in choosing a product. Quality and workmanship are also important considerations. Timely delivery and stock availability are important as Malaysia construction projects depend on tight schedules. Seventy percent of waterproofing material sells directly through agents or distributors to end users who are architects, contractors, and developers. The highest investment when it comes to leaking is repairing the failure of the waterproofing membrane.

On the other side, based on The Star, our former Prime Minister has ordered an immediate inspection of all government buildings. Based on this statement, The Former Prime Minister ordered an immediate inspection of all government buildings for defects referring to a spate embarrassing defects in new government offices incident. The collapse of a ceiling due to a leaky sprinkler system at the Entrepreneur and Cooperative Development Ministry in Putrajaya (Online, 2011). Leakage, rising of dampness, water seepage syndrome is not only happening in the old building but also new building. There is various type of leakage category which is caused by different sources. Poor construction practices of the contractor like the use of damaged formwork and its early removal, failure to remove entrapped water and poor execution of waterproof membranes could cause defects in the completed building. Due to all the factors, water leakage will happen and caused dampness to the building. As we all aware, there is a case in Terengganu which involving the Batu Burok Aquatic Centre with RM18 Millions of construction cost is facing a problem of swimming pool leaking. Based on Bulletin Online, the aquatic stadium has just been open for 1 year and there are many problems has occurred mainly is the swimming pool. Many restaurant owner complaints that there is water seeped through the walls of their shop lot and causing a bad smell and also water ponding in their shop. The water is believed to be caused by the swimming pool leaking. This case has been reported to the contractor but there were none action was taken and the shop owner afraid if there is no any action being taken, the continuous damage will happen and bigger failure can occur to the aquatic stadium (Opalyn, 2013)

REVIEW OF RELATED LITERATURES

Definition of Waterproofing

Waterproofing is a coating or membrane applied to a surface, such as foundation wall, to prevent the intrusion of water under pressure; materials may include asphalt, felt, tar or various synthetic membranes. As to increase the reliability and durability of building it is a must to install a waterproofing membrane. The structural component and building need a protection from the penetration of water or either from the construction material itself that can harm the concrete through seepage of water or other corrosive fluids. Waterproofing is a relatively impervious membrane, coating or sealant used in concealed locations to prevent water from entering or passing through either the horizontal or vertical building material. Waterproofing is design to exclude water even when the water is under a hydrostatic head. Waterproofing prevents the entrance of water that is under pressure by forming a continuous membrane around walls, through concrete footings and under the concrete slab. There shall be no openings are present that allow leakage or passage of water and water vapor. Figure 1 shows the complete waterproofing solution for a building



Figure 3. Complete waterproofing solution for a building

Importance of Waterproofing

In design terms, the floor must be designed to endure upward thrust and wall must be designed or endure the lateral pressure, thus, waterproofing must be a design from the best and suitable materials to curb the entrance of water through any portion of the structure that are exposed to moisture. Waterproofing preserves the structure from the excessive amount of groundwater and rainwater. There are many possibilities that water can penetrate through the structure, among them are through cracks, expansion joints, opening in walls and roof and also it can seep through solid that are prone to porous characteristic. Water can cause costly damage to a building through the various way which is through heavy rain seeping through the exterior exposure, leaking from plumbing and cracking and etc. In order to prolong the life of a building, a serious action shall be taken in term of installing and designing waterproofing membrane to prevent the water from entering via the pores and voids in the structure.

In addition, exposure to weather condition like heavy rain and sunlight, especially in Malaysia, it could cause structural problems. For example, if wooden decks are used and not being waterproofed, a sign of discoloration, water stain, rotting and fungi growth can be seen. When walls are not properly waterproofed, it will result from a hydrostatic pressure creating cracks and leaks on the walls and floors. In achieving a healthier and sustainable environment, we must avoid any moulds and mildew growth. Mould and mildew breed easily in a place that is prone to humidity and moisture. The growth of this bacterium can cause respiratory problems like asthma and also prompt allergic reactions. There is no alternative to remove these fungi's spores inside the house; the only way that could remove such growth would be to control the moisture (Mailvaganam and Collins, 2004). By reducing humidity, preventing condensation and water seepage, it can decrease the growth of mould and mildew.

Causes of Waterproofing Failure

Shoddy Installation

With the rapid growth of the construction industry, workers are in short supply. In spite of the training programs conducted by several institutions, there appears to be a general lack of labour, both skilled and unskilled workers. Most of the construction workers are foreign and there is no strict regulation of the qualification of tradesman job. Thus, the standard of workmanship becomes hard to control and the blame is being borne by the developer. Poor workmanship naturally leads to building defects. It is far more serious if the defects are unrecoverable, and permanent damage is done. The chemical composition and the installation way of a waterproofing membrane differ. The criticality and complexity of assembling each material on the site greatly influence the attitude of an individual. Although most membrane systems are installed by licensed applicators trained by the manufacturer, poor on-site practice and an indifference to quality control during the installation often produce a final product of dubious performance and durability. Any defects that occur during the installation of the membrane, it may require complete membrane removal. The poor workmanship during application of the materials and incorrect implementation of the design is the main reason for the failure of waterproofing system. In order to curb the workmanship issue, a good construction monitoring and quality assurance service shall be implemented to ensure the installation of waterproofing system is carried out correctly and in accordance with the specification. Contractor and construction managers are also contributing problems in the installation of waterproofing through their lack of knowledge of the importance of waterproofing performance.

Structural Deformation and Joints

Joints are the weakest link in any combination of the structure. When there is any leakage occur, the sources of leaking often close to the source of the failure in the building fabric. Thus, contractor and architects should exercise and observe the best practice in their detailing and sealing in order to prolong the waterproofing performance. In terms of waterproofing the joint sealing system, there are differences in terms of the mechanism and functionality, application area, preconditions for installation, required weather condition for incorporation, durability and long-term performance, sensitivity to improper handling. Expansion of joints has caused the membrane to tear or rip loose from edges or flooring thus it allows water to affect the structure. Expansion joint should be installed in the concrete to accommodate the thermal, seismic and settlement movement.

On top of that, during the construction stage, it is important to prevent the excessive moisture from being trapped between the reinforced concrete structure and membrane. Water can evaporate through wet cement screed and reinforced concrete. Once the waterproofing membrane is laid, any trapped moisture subjected to increased temperature from the weather will form a vapour which it will exert itself directly below the waterproofing membrane. If the trapped moisture is not released, the build-up pressure will begin to form a blister on the membrane itself and dampness is observed.

Design and Choices of Material

Waterproofing technique preserves a structure's integrity and usefulness through an understanding of natural forces and their life cycle process. Plus it also involves choosing the right design and materials to counter the damaging effects of these natural forces. The main purpose of waterproofing design is to prevent leakage. Once the purpose is being identified, the design must incorporate an effective system to prevent and absorption of moisture. Roofing is a structure of a building that prevents water intrusion usually from gravitational forces in horizontal or slightly inclined elevations. Although waterproofing typically applied to the surface and exposed to the elements, roofing system also can be internal or sandwiched between other building components. Below grade waterproofing is to prevent water under hydrostatic pressure from entering into a structure or its components. These systems are not exposed to any weathering for example by ultraviolet rays or rain water. Above grade waterproofing, is a combination of materials or system that prevents water intrusion into exposed structure elements. These materials can be subject to hydrostatic pressure from the wind, exposed to weathering and pollutant attack. The building envelope is the combination of all roofing, waterproofing, damp proofing, flashing and diverter system (Christine, 1999).

These systems envelop a building or structure from top to bottom and from below grade up to the roof. Each item used or attached to the building envelope should be waterproof and appropriately connected to other envelope components to ensure that there is no opening or cracks in the envelope's integrity. The main reason of most waterproofing failure is due to improper waterproofing system and substrate design or installation.

Cracks

Crack is something that is inescapable in reinforced concrete structure (Edvardsen, 1999). Observation from many structural damages, most of the tensile cracks are the results of the restraint of imposed deformations, especially for water retaining structure. Since the structure is crack, it will become water permeable up to certain degree, depending on the crack width, length, and the hydraulic gradient. Cracks in the concrete surface are also a common source of leaks in waterproofing system. It is important to ensure that the concrete surface is free from any cracks before applying waterproofing system on it. For small crack with the size, less than 1/16 inches are usually can be treated by using the double thickness of waterproofing layer coat over the crack.

Meanwhile for crack that is more than 1/16, the crack shall be filled up with joint filler to fill up the crack area. Among all the option of waterproofing system either cementitious, membrane or natural clay, the ability to seal existing and future crack are limited. Another factor of cracking is due to the inadequate mixture, application, and curing process. These defects can lead to failure of waterproofing system and lack of protection that allows water to penetrate into the structure. Water seepage rate through cracks is depending on the crack geometry (Kubal, 2008). The seepage rate through horizontal cracks is larger than those through a vertical crack of the same width. Figure 2 shows the types of crack in building which will lead to water penetration.

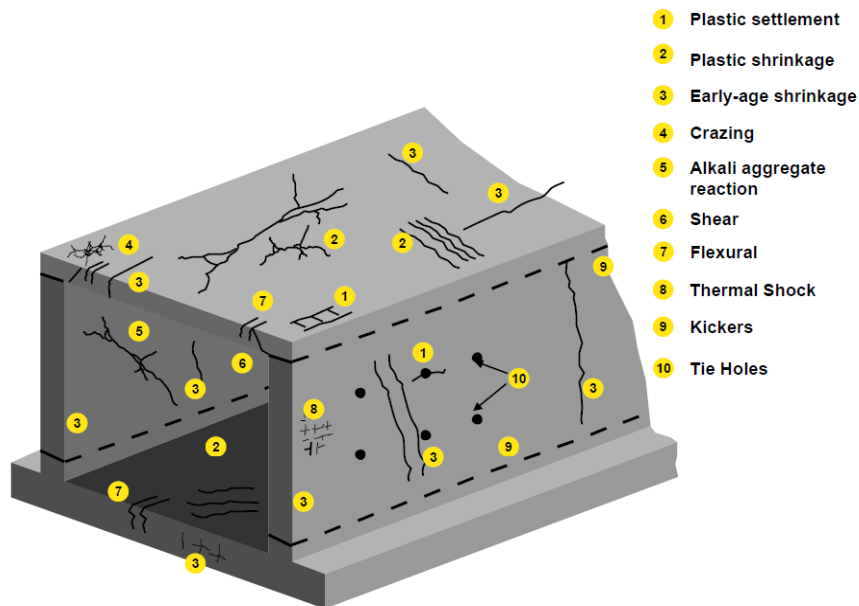


Figure 4. Types of crack building which will lead to water penetration

Types of waterproofing

Cementitious Waterproofing

Cementitious waterproofing is inexpensive and easy to apply but has no elasticity and cannot tolerate joint or crack movement. The bonding, durability, cohesion, tensile and flexural strength of substrate can be improved by using acrylic latex additives. Cementitious waterproofing can be used in below grade application where thermal expansion and contraction are accommodated by movement joints. The cementitious coating can be applied on both concrete and masonry surfaces and are often used in residential basement applications. The material used can seal active leaks, cracks, penetrations, cants, coves, and fillets. Cementitious waterproofing can be used in positive side or negative side applications. The chemical reaction between the materials penetrates or expands into the capillaries of porous concrete to reduce its permeability. In order to ensure the effectiveness of the waterproofing, it may require three to five coats of cementitious. These systems require high-quality workmanship and close field supervision to assure that proper mixing and application procedures are followed.

Liquid Waterproofing Membrane

In term of the membrane, there are only two types of waterproofing membranes; among them are sheet membranes and liquid applied membranes. Each of them has their own characteristic and specialties. The membrane has to achieve the waterproofing objective by being impermeable to prevent water entering or escaping. It has to be flexible and can cater normal building movement. The membrane has to be very durable and able to retain its integrity over a long period of time, and be able to blend itself to design details and specification of the building. Liquid applied membranes are usually applied on the site where the liquid being sprayed and allowed to set and form a water impermeable membrane.

It is known for its semi-flexibility, easy to apply, maintain and repair. The advantages of the liquid membrane are that they are fully bonded to the structure, can be UV stable and have the ability to breathe, cost effective systems and some are able to accommodate negative pressure. However, there are some disadvantages of the membrane where it is easily damaged, sensitive to humidity and weathering, poor bonding to substrates if not prepared correctly, short lifespan when it is left uncovered, influenced by building movement, and require careful supervision and control during the application to ensure proper curing of concrete, consistent thickness and uniform application. Figure xx shows an example of fixing bitumen membrane over building's expansion and movement joint. The liquid membrane is not very elastic so it does not bridge over cracks and gaps properly. The figure above shows the good practice to fix a lax bitumen membrane over building's movement and expansion of joints.

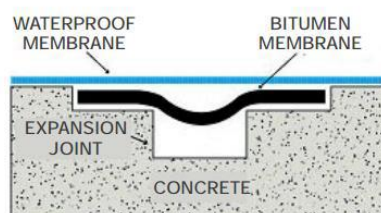


Figure 5. Example of fixing bitumen membrane over building's expansion and movement joint

Sheet based Waterproofing Membrane

Sheet membrane waterproofing includes thermoset and thermoplastic materials. Thermoset membranes may be vulcanized or non-vulcanized materials as well as performed rubberized sheets. Sheet waterproofing membrane is usually applied by heat or attached with an adhesive. Fully adhered system prevents migration of water under the membrane and is not as vulnerable to leaks caused by seam failures as other systems. It often comes in a roll where the asphaltic product is modified and bonded to a high strength fabric of polyester or fiberglass. Sheet membrane has the advantage of allowing protection board placement and backfilling operations to begin immediately after application. Plus, sheet membrane has elongation properties which make them suitable to protect a structure against any type of stress caused by the weather and normal structural expansion and contraction of a building. Water on adhesive field seams can result in leaks if even minor workmanship defects occur. It is very important that the workers read the instruction given by the manufacturer before any installation. The rubberized membrane is easy to install and have self-healing properties at small punctures. Seaming at lap splices does not require solvents or adhesive because the membrane sticks to itself to form a tight seal. Primers might be needed to assure good adhesion to concrete surfaces.

OBJECTIVES AND METHODOLOGIES

This paper focuses on waterproofing failures in concrete buildings and structures. The objectives of this paper are three folds; firstly to determine the main factors that contribute to waterproofing failures in concrete buildings and structures, secondly to discover different types of present waterproofing system applied for concrete buildings and structures and thirdly to propose remedial waterproofing solutions of concrete buildings and structures. Plenty of strategies are available to gather information and data for the research problem. In

this research, a case study strategy is used to achieve the research objectives in a qualitative nature. Case study is a form of qualitative descriptive research which the researcher conduct the study through observations, interviews, and tests. It is a research strategy that is based on the evaluation of the current and visible facts of the real world (Selvarajah and Johnston, 1995). In this study, a total of 4 sites are selected to achieve better coverage and collect more reliable data has been shown in Table 1. Building assessment is conducted to identify the leaking problem in the buildings. Records are done by using digital camera for further comparison during data analysis.

RESULTS AND DISCUSSION

Factors that contribute to waterproofing Failures in concrete buildings and structures

There are many factors that can contribute to the failure of waterproofing. Some of them have been discussed in chapter 2. "The 99% principle: Approximately 99 percent of waterproofing leaks are attributable to causes other than material or system failure" (Kubal, 2008). When to take into account of waterproofing system to be installed, both barrier and drainage systems, miles of sealant involved in building envelopes, it can be estimated that only 1 percent of envelope failures and resulting leakage is actually attributable to materials or systems actually failing.

Parking Multi-storey Car Park leakage (Case Study 1 at Mydin Giant Hypermarket)

The new Mydin giant hypermarket is built with multi-storey car park consists of several number of floors. The waterproofing failure can be detected on the ground floor and also along the ramp that acts as connecting routes to two different levels. Figure 4 shows the water stain that arises from the water below the structure. The stain can be seen along the wall. As discussed earlier, water can penetrate into the permeable building by capillary action. This moisture can dissolve soluble salts from the building materials such as calcium sulfate. From the figure above, we can see that there is a large evaporative surface where it allows the salt deposition to concentrated and forming thick crystalline deposits.



Figure 0. Imprint of water caused from rising damp

The sources of moisture penetration in the base of the walls are probably from the defective ground and defective design to protect the floor surface. Figure 5 shows the proper way layering involves in protecting the water from penetrating into the slab. The crack of the

concrete structure can be caused by many factors. One of them itself is from the presence of moisture in the concrete. Once a structure crack, automatically the waterproofing system of the structure is failed and it attracts more water to seeped through the structure. Figure 5(a) portrays the crack that can be seen on the surface of a ramp installed in the multi-storey car park. And Figure 6(b) is the picture of spalled concrete that can be found in the structure below the ramp. Figure 6 shows the way how spalling of concrete can happen.



Figure 5. (a) Cracking on the floor (b) spalled concrete

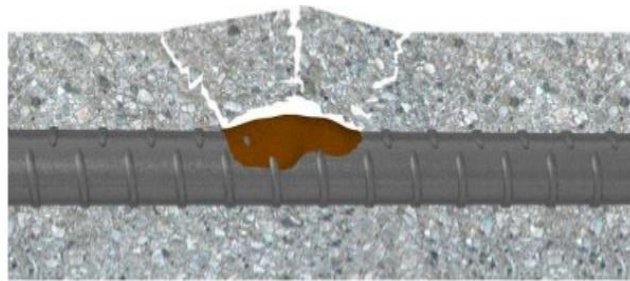


Figure 6. Occurrence of corrosion due to the presence of water in concrete structure



Figure 7. (a) Expansion Joint on the Parking lot surface and (b) the effect on structure below

From Figure 7, we can observe that the sealant of the gap or joint is deteriorated. Off all factors that affecting sealant performance, installation and workmanship are the most critical and most often causes joint failures. No matter how expensive the sealant selected and how well the joint is designed, an improper installation will lead to failures. A proper installation of joint should consider a backer rod in the design stage. Leaking stain can be seen on the below structure of the car park. The stain produced is in brown color which probably the steel

inside the structure is corroded. Expansion joint that is exposed to wear and moisture are usually used the closed-cell rod as a way to add insulation and waterproofing.

Mechanical & Electrical Floor (Case Study 2 at Equatorial Hotel)

The equatorial hotel is located in Malacca. The building was probably aged around 18 to 20 years old. The area where leaking stain can be detected and the most critical area is at mechanical & electrical floor of the building. It accommodates the water tank that serves water to the guests and also electrical panel room of the building. Figure 8 show the water stain that can be seen from the outside of the building. From this picture, it can be said that the water has been penetrating for quite some time. Waterproofing layer has a maximum 10 years life span. As for this building, the waterproofing system installed has exceeded its timeframe and the effect of waterproofing failure can be detected through the emergence of whities along the wall. Figures 9 show the condition of structure inside the M&E room.



Figure 8. The exterior condition of M&E room



Figure 9. The condition of structure inside the M&E room

Due to the age of Equatorial Hotel has been more than a decade, many of defects can be found in the structure. The emergence of mold, stalactite, and spalled concrete can be proved that damaged of insulation, waterproofing system. Deterioration of waterproofing will not only allow leaks but it also allows rain to be absorbed into the various concrete layers. Depending on types and technology of waterproofed used, some of the waterproofing company claims 30 years of life span guarantees.

Swimming Pool Leakage (Case Study at the Face Platinum Suites)

The swimming pool of The Face Platinum Suites was installed on the rooftop of the building. It is a newly built building which the old is less than a year. They are using

suspended type of pool where it incorporates beams and columns to support the weight of the swimming pool.



Figure 10. Leaking that can be found on the swimming pool wall

The newly built swimming pool is facing a critical leaking problem on the structure. It has been rectified for a few times and yet there is still a watermark can be seen on the surface structure. This is probably due to highly porous or the presence of honeycomb inside the concrete. It is usually caused by using concrete that is too stiff or by not vibrating it sufficiently after the concrete has been poured. In addition, the most serious kind of leaks often entangles error in structural design. As seen in Figure 10, the remedial work has been done wrongly as they only applied a layer of plaster cement to prevent the pool structure from leaking. In addition, many construction techniques of swimming pool nowadays are not incorporating the used of water stop as they only connecting the structure directly.

Open Hard Landscape (Cyberjaya Commercial Office)

What we can interpret from Figures 11, it is proven that the waterproofing for the planter box of the hard landscape is deteriorated. This is mainly due to the aging factor of the structure. Cyberjaya Commercial Office has been built roughly for more than 10 years. Thus, it is common where the waterproofing system of the deck is deteriorated and some cracks can be observed. There is sign of blistering of concrete at the drain pipe of the planter box. This is due to the continuous moisture content in the structure. Below figure shows the construction layer of the planter box.



Figure 11. Cracking on the edge of planter box and deterioration of waterproofing on slab surface

Remedial waterproofing solutions of concrete buildings and structures

Rising Dampness

Rising damp may be defined as the vertical flow of water up through a wall structure where the water was derived from underground water. The water rises through the pores by the process of capillary action. Ground water contains an amount of soluble salt namely known as chlorides, nitrates, and sulfate. Thus, when any arises of damp, the first thing that may pop out is white dust where the salts accumulate within the surface structure. In order to avoid this situation to happen, the insertion of damp proof course is needed. For the remedial action that should be taken is by replacing the damp proof materials. Drilling method should be applied in order to achieve a fully effective treatment.

Crack

Cracks often develop that allow water and pollutants to enter a substrate. Crack is repaired through injection of epoxy. The epoxy seals the cracks and restores the structural nature of the substrate. Epoxies can fill the gaps by not increasing the load bearing capability. It has a high number in compressive strengths. If there is any future expansion or movement of crack, expansion and control joints must be installed or else the treated crack maybe allows for movement. Epoxy injection does not only restore the cracks but it also as well restores the waterproofing system. It can restore substrates to a safe condition before waterproofing application to be used as waterproofing itself by stopping leakage through a crack. Epoxy injection is often used for any cracks that are more than 3mm diameter. For any crack which is less than 0.3 mm, the repairing work shall be done by using chemical grout application.

Expansion of joint

Keeping the joint watertight will prevent moisture from seeping under concrete pads and causing them to heave or sink. Expansion joints are important for a driveway. Expansion joint was built to allow the pads to expand and contract with surrounding temperature and humidity percentages. Below is the detail drawing of expansion joint treatment.

Deteriorated Waterproofing

The purpose of waterproofing application is to prevent the water from penetrating into any concrete members. When the water penetrates into the subgrade or substrate for example concrete wall or foundation, the steel reinforcement that embedded in the concrete would corrode due to the chemical reaction caused by water and in addition, it will eventually fail the structure. Thus, a proper repair method is needed.

CONCLUSION

This paper focuses on waterproofing failures in concrete buildings and structures. Crack are the major factor that contributes to waterproofing failure followed by deteriorated WP, honeycombs concrete and problem at construction jointing. The life spans of most of the waterproofing applied on case study site are not more than 15 years old. A proper installation and maintenance is the main key factor of long life cycle process of waterproofing system.

Construction jointing plays an important role in preventing water seepage into the concrete structure. Sheet membrane system is the most system used in all site and location as it is the most durable and flexible waterproofing system.

ACKNOWLEDGEMENT

The author would like to thank Ministry of Higher Education Malaysia for their funding of this research under Fundamental Research Grant Scheme (Grant No. 203/PPBGN/6711514) with research title: Fundamental Study to Establish Thermal Insulation, Mechanical Properties and Fire Retardant Mechanism of Coir Fibre Reinforced Lightweight Foamcrete.

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