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Classification of Factor Affecting to Roof Leaking on Malaysia Selected Heritage Buildings

Roslan Talib[1], A Ghafar Ahmad[2], Mohd Zailan Sulieman[3]
[1,2,3]*School of Housing, Building & Planning, Universiti Sains Malaysia.*

***Abstract*—The purpose of this paper is to share the findings focusing on the typical building problems facing the heritage or old buildings in term of the problem of building leakage scenario in Malaysia. Looking from the problem finding perspective, the paper tabulate a list of potential solutions best practiced by the local waterproofing implementer. It is important for the reader to take advantage on the information of the extensive list of the real case studies pertaining to the building leakage syndrome typically happened mostly to heritage structure in the Malaysia hot and humid tropical climate. The plus side about this paper is that all the case studies are derived from the real selected projects done by the associated building maintenance contractor for the last 20 years. By identifying the possible factors that cause the leakage, one can take early steps to prevent the same defects form repeating thus saves a lot of money! From the finding analysis, this paper also giving the formulation ideas that can be used for creating a framework to prevent or minimize the building leakage syndrome from happening again. As the old buildings or the buildings that old enough to be considered worth to keep are becoming more valuable to either the central Government or the local council; the analysis from this paper may give some meaningful tabulation on how to maintain these heritage buildings from leakage especially from the roof seepage thus make the property much more valuable to the owner and may give profit to the locality as well.**

***Keywords*—Leakage, Heritage, Building; Maintenance, Defects, Malaysia**

I. INTRODUCTION

Roofing is the most important part of any building or house structure. Stressed by Talib, buildings' waterproofing is extremely important to the humid tropical climate region like Malaysia and the selection of the waterproofing material for the housing buildings for example can be based on the level of roof material exposure to the rainwater (Talib, 2008)[1].

With this fact, according to the Malaysian Government 2014 Budget allocation presented by the Prime Minister of Malaysia, Dato Seri Mohd Najib Tun Razak, the Malaysian Government had allocated some 4 Billion Ringgit to initiate private developer to build more houses on their high impact projects to ease-up affordable public housing problem! At the same time, the Government had allocated from the budget 100 Million Ringgit for the maintenance budget given to one of the Ministry to maintain the ministry buildings as well as 82 Million Ringgit to refurbish unfinished housing project for about 8,200 housing schemes. Some of the maintenance works mentioned by the Prime Minister is like doing repainting of the houses as well as doing the lift maintenance for the flat and apartment building. It is interesting to note that from the previous Government budget in 2012 and 2013, the Government had allocated 1 Billion Ringgit specifically for the buildings maintenance and classroom addition of the public schools in Malaysia and allocated another 450 Million Ringgit in 2014 budget for the maintenance and upgrading the interior for the same school buildings.

For convenience, the readers can do the cross reference on all the Malaysia and UK building leakage cases detail at *http://usm.academia.edu/RoslanTalib* tabling information like failure causes as well as possible best solution suggestion.

II. RESEARCH OBJECTIVES AND METHODOLOGIES

The objective of this research paper is to identify the typical factors that effects on the building leakage that happened focusing to the historical or heritage buildings in Malaysia as well as to the selected 'old' regular buildings with potentials. Among the objectives is to identify the building defects that start-up the water seepage mainly form the rain water or the piping leakage.

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The research intention also to identify the most occurred leakage, so that the solution method can be recommended to ensure the problem will not be repeated (the latter part will be presented into the next paper research). At the same time, the objective is intended to identify typical defects that always cause the water seepage into the interior of the building thus making problem to the occupier as well as its internal valuables. To improve the data quality, only the case studies that can contribute to establish the method to prevent roof leaking are being considered. The identification method to determine the type of leakages and the possible causes has been carefully categorized in order to improve data findings leading to the best possible solutions.

A. Data Collection Methodology

All the Malaysian cases data are based on the collection of real rectification works on selected building leakage projects as well as from author and research assistant personal observations. The reparative tasks were done by the local waterproofing specialist contractor implemented mostly at the cities located within the western part of Malaysia's Malay peninsula; cities like Kuala Lumpur, Petaling Jaya, Jasin, City of Melaka, Taiping and Penang. A total of 64 real project case studies as well as from personal observation has been identified and selected, accumulated since 1994. According to Kamal and Harun (2002)[2], it is believed that there are more than 37,000 historic buildings built between 1800 and 1948 throughout Malaysia which are worthy of preservation and conservation.

In the process accumulating the data, a series of interview were made with the building owner, building maintenance representative and of course the reparative contractor. It is quite interesting to note that all the Malaysian cases are the real maintenance rectification works and has been given 10 years warranty or even up to 15 years depending on the type of material used for the said work. Thus the standard of work must be in performed within the highest quality and using the best product standard for each job. Other than that, the redo waterproofing work must be done within the budget to make business profit thus the detail rectification works step must be done at the best as well as within the stipulated time frame given by the building owner.

B. Strategies grouping identification

To ease-up reader for reference from the charts, the author had done several grouping identifications ensuring each factor related to the point discussed. Al the charts are based on the information found from the collected data. The categories include the type of defects, type of roofs and types of material used for rectification works. Ratings were given to show the frequency of activities.

III. Data Analysis And Discussions

A. List of Selected Heritage considered Buildings

The Table 1 below is the summary of the collection of the 64 buildings that has been selected for the survey.

TABLE 1
SUMMARY LIST OF THE SELECTED 'OLD' BUILDINGS FOR THE SURVEY RESEARCH

Built	Building	Architecture	Type	Owner	Location
1801	Bastion House Museum	Military style	Institutional	Government	Melaka Town, Melaka
1807	High Court building	Palladian, Neo-classicism	Institutional	Government	Kuala Lumpur
1850	Police Headquarters	Neo-classicism	Institutional	Government	Kuala Kubu Bharu, Selangor
1870	General Hospital	Corbusier	Institutional	Government	Kuala Lumpur
1880	Lake View Hotel	Art Deco	Commercial	Individual	Taiping, Perak
1882	Hospital Pulau Pinang	Corbusier, International	Institutional	Government	Georgetown, Penang
1883	Perak State Museum	Palladian	Institutional	Government	Taiping, Perak
1886	Central Market	Art Deco	Commercial	Government	Kuala Lumpur
1890	Hospital Bukit Mertajam	International	Institutional	Government	Bukit Mertajam, Penang
1890	Larut Matang Municipal Council	Neo-classicism	Institutional	Government	Taiping, Perak

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1892	Central Train Station	Moorish	Transportation	Government	Kuala Lumpur
1897	Perak State Prison	Military style	Institutional	Government	Taiping, Perak
1898	Taiping Clock Tower	Neo-classicism	Office	Government	Taiping, Perak
1900	Yusuf Awal house	Malay traditional	Residential	Individual	Kg Air Baruk, Jasin, Melaka
1902	Haji Babu house	Malay traditional	Residential	Individual	Simpang Kerayong, Jasin
1910	Lorong So mosque	Functional	Religious	Community	Georgetown, Penang
1910	Chief Ali Kadir house	Malay traditional	Residential	Individual	Kg Rim, Jasin, Melaka
1916	Kg Air Baruk mosque	Nusantara	Religious	Community	Jasin, Melaka
1920	C.A. Lim building	Art Deco	Commercial	Individual	Georgetown, Penang
1920	Maritime Museum	Military style	Institutional	Government	Melaka Town, Melaka
1925	Che Ibrahim house	Malay traditional	Residential	Individual	Kg Chabau, Jasin, Melaka
1927	Jasin shop house	Eclectic	Mixed-use	Individual	Jasin, Melaka
1930	Taiping Shop Houses	Eclectic	Mixed-use	Individual	Taiping, Perak
1930	Fatimah house	Malay traditional	Residential	Individual	Kg Chinchin, Jasin, Melaka
1930	D.O./A.D.O residence	Palladian	Residential	Government	Jasin, Melaka
1930	Jalan Weldman shophouse	Eclectic	Mixed-use	Individual	Rawang, Selangor
1932	Chief Jaafar house	Malay traditional	Residential	Individual	Merlimau, Jasin, Melaka
1937	Kg Rim mosque	Nusantara	Religious	Community	Jasin, Melaka
1937	JPJ office	Malay traditional	Office	Government	Jasin, Melaka
1938	Universiti Sains Malaysia	Mixed with Corbusier, Military style, International	Academic	Government	Glugor, Penang
1950	Muharam Samo house	Malay traditional	Residential	Individual	Kg Air Baruk, Jasin, Melaka
1950	Terendak Army Camp building	Military style	Office	Government	Masjid Tanah, Melaka
1950	Johan Sabtu house	Malay traditional	Residential	Individual	Merlimau, Jasin, Melaka
1950	Chetty Association house	Vernacular	Office	Individual	Jln Gajah Berang, Melaka
1950	Kasmah house	Malay traditional	Residential	Individual	Kg Duyung, Melaka
1959	Bank Negara Malaysia	Corbusier	Institutional	Government	Georgetown, Penang
1959	Bangunan Tuanku Syed Putra	Corbusier	Office	Government	Georgetown, Penang
1960	TUDM weapon storage	Corbusier	Military	Government	Subang, Selangor
1962	EPF building	Corbusier	Office	Government	Petaling Jaya, Selangor
1970	Abdullah Mansor house	Malay traditional	Residential	Individual	Kg Morten, Melaka
1970	Bujang Siam house	Malay traditional	Residential	Individual	Kg Duyung, Melaka
1978	KOMTAR	International	Mixed-use	Government	Georgetown, Penang

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It is interesting to note that these buildings ranges from the individual traditional Malay houses, a 'Nusantara' style mosques to the large structures i.e. the Pulau Pinang Hospital group of buildings as well as the number of buildings for Universiti Sains Malaysia located on the island side of the Penang State. The oldest building in the list is the Bastion House located right in the town area of Melaka City which was built in 1801 the same year James Wyatt, and English architect, a rival to Robert Adam actively designed prominent buildings in the United Kingdom in the Neo-Classical and Neo-Gothic style. It is interesting to note that most of the building in Malaysia has been designed around this period (late 19th century to early 20th century) were designed in this Neo-Classical style which is the most popular style during that time. This style can be traced back through the local building i.e. the Kuala Kubu Bharu Police Headquarters' office in Selangor State which was built in 1850 and still being used.

Following Kamal and Harun (2002)[3] indicating that the present Malaysian legislation on historic buildings is not sufficient and suitable to protect such buildings from being demolished and destroyed. Under the Antiquities Act 1976, a historic building or monument aged must be at least 100 years old to be listed or gazetted by the Government through the Museum department to give protection and encouragement for preservation and conservation. However many important buildings have not yet reached this age, are not protected, others have been neglected or destroyed. It is interesting to note that the KOMTAR building in Georgetown which was built 1978 having only 36 years age span also in the list as it is the landmark building was the tallest in Asia at that particular time with geometric shape 65 storey and having unique geodesic dome designed by world famous American architect-engineer inventor Richard Buckminster Fuller. However, due to poor management running by the current state administrator the one time successful biggest urban design project in Asia has been neglected and in poor conditioned. It is hope that this paper may spark the administrator to improve the building condition hence following the sample guidelines in doing the restoration works even though the building is on the newest of the 'heritage' list building.

B. Grouping of Selected Buildings

From the 74 case studies done, the majority of the ownership of the selected buildings are owned by the Government with about 23 buildings (see Figure 1). These buildings include range from public hospital, university buildings as well as some offices and condominium.

It is interesting to note that the second category is owned by individual owner as there a quite some number of the buildings are traditional Malay houses which had great potential to become as tourist attraction if the houses are architectural in good condition. According to Rashid and Ahmad (2008)[4], the conservation of heritage or historical buildings is a method on preserving structures which are historically and culturally important to the nation.

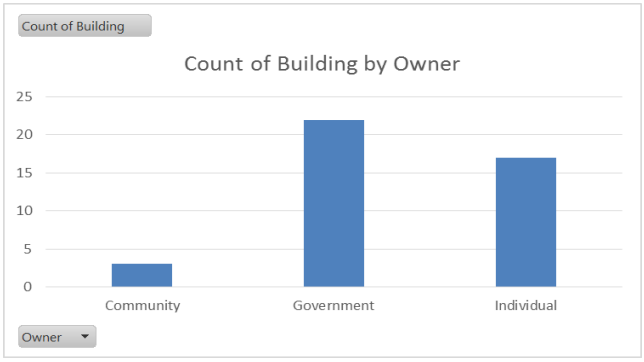

Figure 1 Graph Showing Building Owner Numbers Divide In 3 Groups.

Conservation involves works undertaken to preserve the condition of the building to its original state and this also includes the subsequent maintenance works. Maintenance is identified as a means on prolonging the lifespan of the historical structures. Without proper and systematic maintenance works, without doubt, the historical buildings will deteriorate and becoming dysfunctional as well as unfit to be used. From the case studies, it seems the least own building owner having potential for the heritage value is by the community itself. Only few buildings on this category been selected such as chetty community centre in Melaka or Lorong So Mosque in Pulau Pinang.

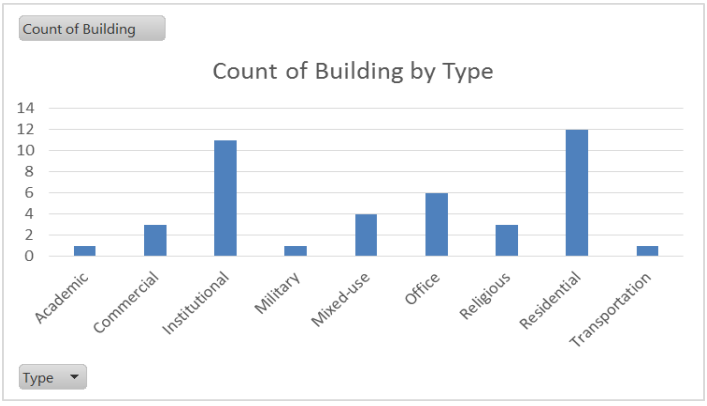

Figure 2 The Count Of The Selected Buildings By Its Type

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It is interesting to note that from the data collection list (Figure 2), it is interesting to note that the most number of buildings involved are the residential type. These includes the traditional Malay houses mostly located within the historical state of Melaka where PERZIM (Melaka State Museum Board) had identified these house having huge potential for tourism attraction due to its easy access (located next to the main road) as well as having high quality architectural input. However, it is not an easy task to ensure the restoration works can be done in good and orderly fashion as most of the original individual owner has long passed away and the nominated current owner most of them having disputes. The next type of the buildings most involved for the survey is the institutional buildings having ranges of buildings from the hospital buildings to the state museum buildings. The third one is the office building type range from the Government Syed Putra office buildings located in Georgetown as well as Bank Negara Office building nearby.

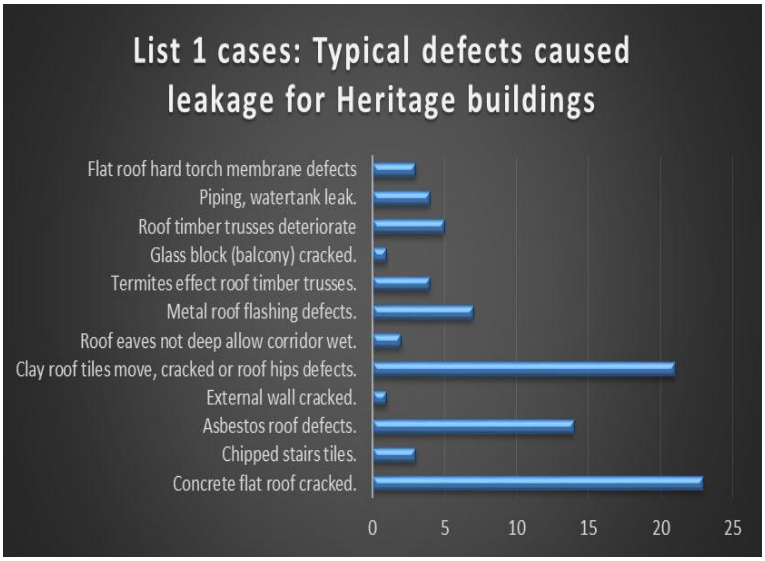

Figure 3 The List Of Cases 1 Shows The Typical Defects Caused Leakage For Heritage Buildings

As referred to the above graph analysis (Figure 3); from the case studies done, it seems the most defects caused the building leakage is from the concrete flat roof having its surface with cracked defects and start permit water through it. This is the most typical defects found to most of the buildings that have certain portion of it having concrete flat roof with other part of the buildings having different type of roof material i.e. metal roofing or even asbestos roof.

The next typical defects that permits water leak into the building is through the buildings having clay roof tile. The crack not only happened at the roof tile but also at the roof hips as well. These are the buildings types that we must regularly watch in order for us to ensure the valuable interior stay intact from the expensive furniture or the costly computer internet office units. The cracked may derived from the poor quality clay roof or hips tile as well as from the human intervention.

Talib and Sulieman (2012)[5] stated that roof system is very important as it provides shelter for the interior spaces of the buildings. As part of an external envelope for a building, roof must be technically good and must perform aesthetically satisfactory. However, flat roof always cause problem in tropical climate country like Malaysia. Flat roofs should be designed to avoid the need for maintenance as far as this is possible; but inevitably some items of maintenance will occur. It is interesting to find out that the flat roof problems are numerous, diverse, complex, destructive and highly disruptive. The exposure of flat roofs to the extremes of the climate in tropical regions, give rise to the development of problems. Most of these problems however are avoidable by use of more appropriate design. In addition, the historical buildings that being studied for the paper especially those with flat roof; not only for buildings that have a total roof with flat surfaces; leakage can be avoided if techniques, better quality construction workmanship and more regular inspection and maintenance are done properly.

Next from the list indicating the buildings having the asbestos roof is the third type always having problem with leakage from the case study analysis. Asbestos has been classified as a cancerous material in 1977 by the International Agency for the Research on Cancer. Many countries in the world have already adopted new regulations accordingly. It is interesting to note that some numbers of building still having its roof with asbestos roof type and currently it's been reduced by replacing the old roofing to almost the same kind of asbestos corrugated roof profile with i.e. Onduline© with zero asbestos content which is made of recycle fibre as label as green product.

According to Abdul Rahman et al. (2014)[6] the enforcement of National Heritage Act 2005 has changed the landscape of national heritage, particularly in the development of preservation and conservation. Results of these changes have significantly increasing the demands of maintenance work in order to ensure the survival and functionality of the buildings.

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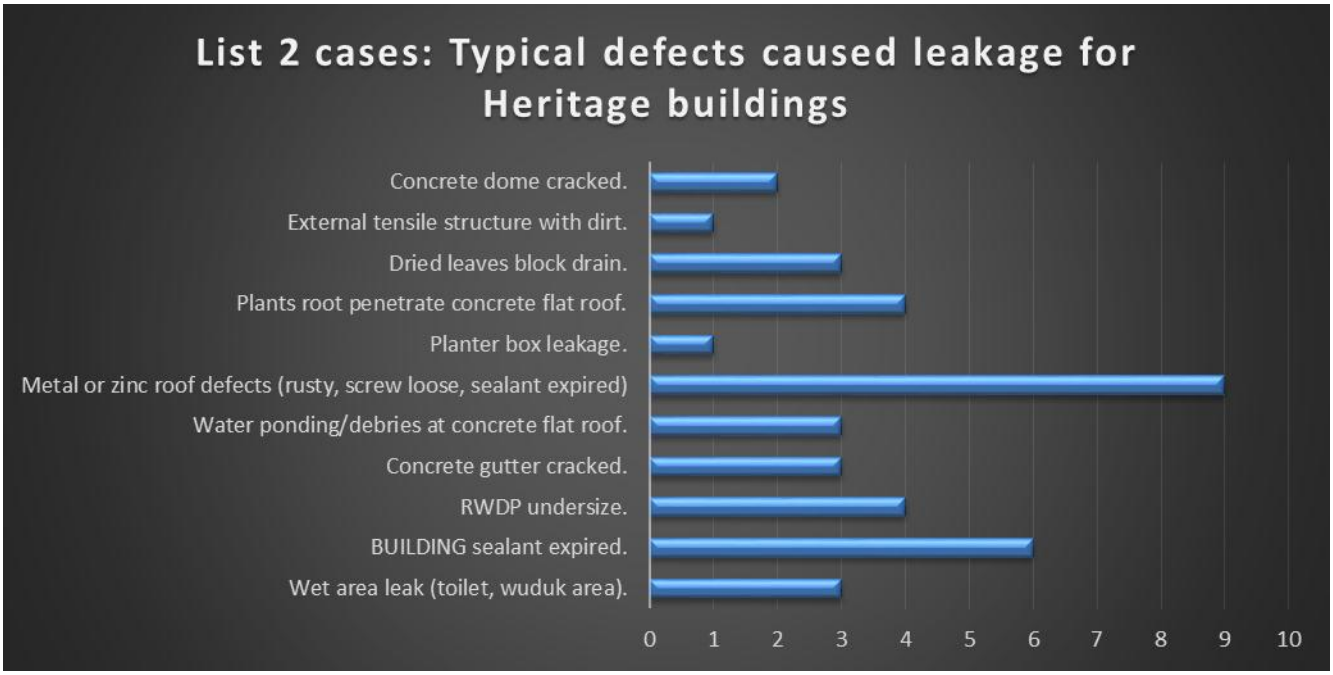

Figure 4 The List Of Cases 2 Shows The Typical Defects Caused Leakage For Heritage Buildings

Further to that here is (Figure 4) another 11 typical defects always happened for the Malaysian roofing scenario that lead to the building leakage syndrome for the buildings considered worthy to preserve and potentially in the heritage list or already even in the list. It is interesting to note that the most frequent defects caused the seepage for the heritage buildings group case studies (group of buildings also content less than 40 years old as they have potential to be restored as tourist spot) is on the building's having metal or zinc as its roofing material. The problem with this building type is that it has rusty screws or rusty nails or just having the screw loose down or the most common is having the sealant not in performed as the sealant on top of the metal deck nail or screw are expired. All these defects simply permits water throughout the interior of the building hence gave problem to the occupant. Even though zinc or metal deck roof seems like a bit cheaper compare to clay tile roof or shingle roof tile, good maintenance of this material may give full advantages for the building owner.

However, due to the hot and humid weather or Malaysia, it seems like this type roofing material may not be suitable if the design not creatively solve the natural ventilation of its interior or simple air-conditioned the interior. Marshall et al. (2014)[7] mentioned that proper and timely maintenance will help to extend the life of the buildings. Notwithstanding the fact that all materials will fail at some point, and require repair and replacement, early failure may occur for various reasons including poor maintenance, poor design, poor specification, poor construction, poor maintenance and inappropriate use.

It is interesting to note that from the list, the expired building sealant is the second most typical problem identified for this research giving the typical problem in permits the water into the building. Building sealant epoxy is among the most important material for building maintenance concern and this material is as important to ensure the heritage building leak free. It is hope that the list above may give the maintenance manager an idea on the typical defects pertaining to the top part of a building structure a can become as a guide to prevent the seepage from repeating.

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IV. CONCLUSION

Addleson (1992)[8] suggested that when dealing with the rectification works of the heritage buildings, the architects should understand the discipline that the combined use of the materials, especially in the recent modern multi-layer construction systems with modern construction materials and imposes them in design detail solutions or creatively use the discipline as a motivation in design. Most of the building maintenance team do not really understanding on the typical problem facing the old building especially on the top part of a building structure that permits bigger proportion of rainwater into the building. From the list identified from this research, it is hope that the defects identification be able the crew make an effort to detect the defect as early as possible. At least with the data extracted from the real project that has been done or been identified to ease up reader or maintenance manager list-up the potential defects where they can identified these area make a preventive list. Please note that some portion of building seepage also happened when there is a water intrusion from the ground part and waterproofing also required to protect the wall or floor with damp roofing material. However this paper is focusing more into the upper part of the building where leakage syndrome is greater.

According to Stringer (1977)[9], while maintenance requirement are not generated solely by faulty design, poor materials or inaccurate specification, some proportion can be accounted from for by these factors. However lastly, Stringer (1975)[10] also suggested in his Housing Maintenance Manual to those involved in the building or housing sector i.e. the architects, surveyors, managers, contractors and tradesmen; all has much to contribute each other if the building structures or the houses of today are to remain as the assets of tomorrow. Among the most frequent method in preventing roof leaking is brushing the epoxy coating either on top of cracked flat top concrete roof or on top of rusty metal deck roof. It is hope after the typical defects has been identified, the selection of the method and the waterproofing material used including the selection of the type of the epoxy coating that available in the Malaysian market been properly chosen to suit the best practical done to solve the leakage problem.

For the short term preventive measure on building leakage, most of the maintenance team suggested to mechanically inject the liquid epoxy grout into the concrete slab from the bottom floor while the use of the cement group lay on top of the hole or cracked (after hacking) can be more on long term solution. It is interesting to note that most of building manager prefer to use hard membrane with granules to replace the problematic old waterproofing system as this granules type last much longer and a bit thicker compare to none granules.

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