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Factor affecting roof leaking focusing on clay roof tile and asbestos roof for Malaysia heritage buildings

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ABSTRACT

The purpose of this paper is to share the findings on the typical problems facing the heritage or old buildings in term of the problem of building leakage scenario in Malaysia. From the problem finding, 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 for heritage structure in this hot and humid tropical climate. The good thing 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 use 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.

Introduction

According to (Kamal and Harun 2002)[1], 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.

Marshall et al. (2014) 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.

According to (Rashid and Ahmad 2008)[2], the conservation of heritage or historical buildings is a method on preserving structures which are historically and culturally important to the nation. 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

(Addleson 1992)[3] 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.

(Kamal and Harun 2002)[4] 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.

According to (Abdul Rahman et al. 2014)[5] 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.

(Talib and Sulieman 2012)[6]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 however are avoidable by use of more appropriate design techniques, better

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quality construction workmanship and more regular inspection and maintenance.

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. 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.

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 Harun2002)[7], 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.

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.

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.

Data Analysis and Discussions

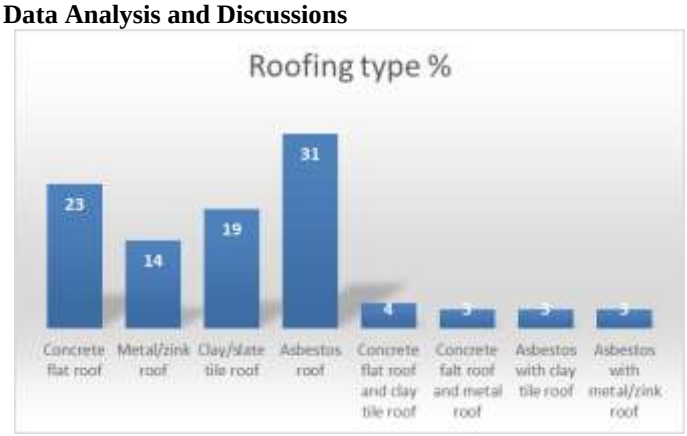

Figure 1. Classification of roofing types for the buildings selected for this research

After having done the analysis from data collection, it seems like the asbestos roof (see Fig.1) is the most material being used as the roof covering structure for this study. This is due to from the number of Melaka traditional houses that has been in the list considered a good added value to Melaka State Government tourism pack. Most of these house having the *'nusantara'* tropical architectural design with the sharp high pitch roof type to minimise the running rain water during the rainy monsoon season end of the year (particularly on the Malaysia's peninsular side). As the process of removing these asbestos roof become more regular in recent years, there are still some houses where the individual owners require certain financial assistant especial from the local government to replace those defective asbestos roof to the new asbestos free roofing type which much more available on market with various types even with green product label and having similar asbestos corrugated profile. The next roofing type from the list is the flat concrete roof which is derived from a simple abstract geometrical modern shape thus require proper waterproofing system to cover its top as tight as possible from water seepage. With the waterproofing technology in the advance stage right now, proper installation on the system with superb supervision for the concrete flat roof; the modern boxy design for the flat roof can be done and as in favour for the designer architect to satisfy. The analysis indicated that after concrete flat roofing, the clay or slate roof tile is the most in numbers as well as the metal or zinc type of roof. On the bottom of the list are the buildings where a combination of different type of roof from the flat roof combining with metal, clay or asbestos roof also among the old buildings type in the data finding research.

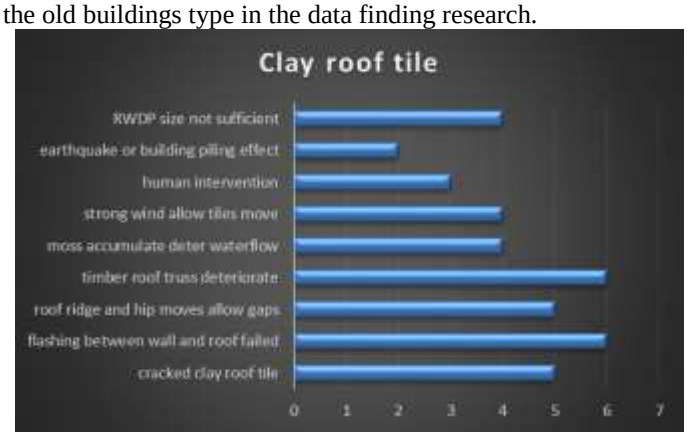

Figure 2. Identified factors leading to water seepage on clay roof tile for the case studies

The above chart (Fig.2) showing 9 identified typical defects always happened to the clay roof tile or slate roof tile as well on selected old structures or historical buildings in Malaysia.

Table 1. Rectification classifications leading to the leakage improvement for the clay or slate roof tile type of roofing.

Clay/slate roof tile	Rectification	Rectification	Rectification
Cracked clay roof tile	Cracked tiles need to be replaced with good one manually.	Ensure to replace with closer original resemblance. If repairable, apply sealant epoxy along cracked line.	Cracked may result from premature tile/shingles. Ensure quality selection of shingles.
Flashing between wall and roof failed	Ensure metal flashing properly glued with epoxy sealant seal into the wall.	Expired sealant to replace with new one.	Ensure metal flashing overlay in two layers.
Roof ridge and hip moves allow gaps	Defects require to make good i.e. rearrange manually.	Possible to lay sealant epoxy between joints to avoid leakage.	Also due to poor laying of tiles at first place.
Timber roof truss deteriorate	Deteriorate truss need to be replaced manually.	Option to replace timber truss with maintenance free metal one.	If use timber, ensure use termite free type.
Moss accumulate deter water flow	Moss need to be removed periodically.	Ensure roof design min.12.5 degree low pitch.	Regular maintenance required to move moss.
Strong wind allow tiles move	To rearrange tiles manually.	Prefer design orientation with maximum wind resistant.	Typical problem is wind up-lift.
Human intervention	Monitor human movement on roof location.	Regular maintenance inspection required.	Installing new structures on roof top must be in waterproof condition.
Roof tile gap due to earthquake, building piling effect or soil movement.	Ensure building having mechanically vibrate proof design feature.	Must use micro piling/less vibrate type of piling for building next to site.	Monitor on soil movement near site.
RWDP size not sufficient	Replace new sufficient size RWDP with new one.	Prefer to use uPVC type.	RWDP and roof joint piece must be sealed properly to ensure leak free.

Table 2. Rectification classifications leading to the leakage improvement for the clay or slate roof tile type of roofing.

*Asbestos roof	Rectification	Rectification	Rectification
Strong wind create gap between roof sheet	To rearrange tiles manually.	Prefer design orientation with maximum wind resistant.	Plant more trees to protect building from strong wind. Be selective on tree species.
Crack roof sheet	Cracked sheet need to be replaced with good one manually.	If sheet at repairable condition, use sealant epoxy along crack line.	Cracked may cause from defective sheet/lines. Quality selection or product required.
Roof flashing to wall not function	Ensure metal flashing properly glued with epoxy sealant into the wall.	Expired sealant to replace with new one.	Long term: To install expansion joint with sealant at metal flashing/wall joint.
Timber roof truss deteriorate	Deteriorate truss need to be replaced manually.	Option to replace timber truss with maintenance free metal one.	Ensure use treated (termite free) timber for roof truss. Inject termite chemical inside site soil.
Roof sheet have gap due to building movement i.e. earthquake, piling, soil movement	Ensure building having mechanically vibrate proof design feature.	Must use micro piling/less vibrate type of piling for building next to site	To make good insufficient depth and width of foundation.
Metal nail/screw/sealant not function	Replace missing screw or nail with new one. Installation must be in orderly manner.	Replace old sealant with new one immediately.	Double protection: put sealant epoxy on top of screw/nail.
Human intervention	Monitor human movement on roof location. Workers must be fully supervised.	Any installation of new structure on roof must be leak free with waterproof detail.	
RWDP size not sufficient	Replace new sufficient size RWDP with new one.	Prefer to use uPVC type.	RWDP and roof joint piece must be sealed properly to ensure leak free.
Moss accumulate deter water flow	Moss need to be removed periodically.	Ensure roof design min. 10.0 or 12.5 degree low pitch.	
*due to proven health risk, do not maintain and use asbestos roof. Total replacement if required. Use asbestos free roof type.			

From the research list finding, clay roof tile is the third most frequent roofing type found after surprisingly asbestos roof and concrete flat roof. The analysis indicated that the most problematic scenario on the leakage for the clay roofing is the deterioration of the timber trusses that permit the rain water seep through the moved roof tiles hence giving problem to the building interior. The timber trusses normally deteriorated due to the presence of the termite that attacking the wood. Most of the timber trusses constructed during that time may not have been treated rightly with the anti-termite chemical or through the time period the chemical may not worked and normally timber work require highly careful maintenance with the owner traditional treated it with the special wood oil. Nowsday, most of the building owner especially the house owner prefer to have metal roof trusses as the main element of their roof covering structure to eliminate termite problem hence be able to overcome at least the roof leakage part. It seems like the fail of flashing also contributed important roofing defects for the case studies.

For the 9 defects above (see Table 1); the list indicating the rectification frameworks to overcome the defects pertaining to the clay or slate roof tiles on the said heritage buildings of the research paper study. The above table indicating on the best possible rectification works that can be done for each identified leakage problem pertaining to the concrete flat roof. Each of the 9 defective cases has been identified with the detail rectification works to overcome the tile or even slate roof seepage together with suggested waterproofing material to be used which are derived from the actual rectification works done. The list above helps the maintenance crew to identify each of the possible leakage scenario on the heritage buildings and also indicating on the step by step rectification works and it can become as a guideline framework for the crew. It is the intention of this paper to list up the possible rectification works to ease-up the maintenance management team in doing the maintenance works for the heritage building. It can become as an initial guidelines to be used for the leakage work pertaining to the clay tile roof. It is interesting to note that the all the rectification steps identified are based on the real experience from the actual task done by an experience waterproofing implementer. The method of works are to ensure works done in proper steps and using the right and best waterproofing materials in order to ensure the tasks not be repeated as the warranty been given for 10 years and any repeated works are not economical to waterproofing business as well as to the owner.

The chart below (Fig.3) shows 9 typical seepage situations always occurred through the defected asbestos corrugated sheet or asbestos roofing extracted from the data collection done. It seems the most defect cases for most heritage buildings with asbestos roofing has gap in-between the sheets due to the high wind speed effect as well as cracked on the sheet, flashing problem, deteriorate timber trusses and nail or crew not function as well as expired sealant.

Most of the problem having this type of roof is the when it comes to about 10 years; with having the hot and frequent rainy season, the corrugated asbestos decking always will permit in brittle condition or the layers of epoxy coatings or sealant found on top of the asbestos surfaces will deteriorates and may permits water seepage or even furthermore having small holes that simply can permit the rainwater into the internal of the house or an old building

The above schedule (Table 2) listing out 9 typical problems dealing with the water seepage normally happened in regards to the use of asbestos as a covering material of roof structure. The list also come with the best possible rectification tasks in order to solve the leakage problem. It is hope that the list above with the suggested rectification works can be used as an initial solution framework for the maintenance management team to deter the leakage syndrome of these historic buildings. The analysis found out that the 9 typical scenarios always occurred in regards to the water seepage in relation to the asbestos roof of the selected old structures be able to the maintenance crew to schedule their maintenance tasks in order to ensure avoid future roof leak. The rectification works above are based on the real experience in handling the seepage problem on actual tasks of the old buildings. With the conservation works to ensure the original state of the physical appearance being conserve together with the 10 years warranty to be given to the building owner; the correct steps and procedure must be done properly to avoid double cost in case the job need to redo if first attempt failed. However, due to proven health risk, do not maintain and use asbestos roof. Total replacement need to be done if required and use asbestos free roof type available on market.

Figure 3. More identified factors leading to water seepage on clay roof tile for the case studies

Conclusion

Having an initial guidelines or initial frameworks dedicated to specific roofing or covering material for the heritage or old buildings for this case are a good thing to benefit building maintenance team. The paper focusing on the suggested best possible rectification works for the asbestos roof and for the clay or slate tile roofing. The rectification works must be done in proper steps and to use the correct method and choosing the right material in order not to repeat the same process hence become not economical in term of business aspect of the waterproofing company. Normally the rectification works come along with at least 10 years warranty period thus all the step and procedure must be right to avoid repeating reparative works. It is important to ensure that all the rectification works done maintaining the physical appearance of the historical building; the look as what it should have been before been maintain. Thus, the choice of the right waterproofing system together with the correct material is very important and has been considered when the tasks has been undertaken. (Stringer 1977)[8] has suggested that building maintenance must be regarded as the safeguarding of an investment; an investment which in the case to keep the building and the equipment in such a condition as to enable it to serve the tenants in the way it was intended and for which it was designed.

While the finding determined that even though asbestos roof surprisingly the most numbers of the old building undertaken in this research, flat concrete roof as well as the

metal roof are the two types of roof that mostly being as roof covering structure of the analysis. As a conclusion, by determining and identifying the factors always leading to the clay tile roof and asbestos decking's water leakage, the predicted defects can be obtained and some money can be saved by having periodical maintenance check-up. After all, it is the objective of the research at least to put some savings on the maintenance aspect hence be able the Government to spend more money on other useful matter. (Talib 2008)[9] concluded that any type of roofing covering one structure especially those buildings located in the tropic must be in good maintenance condition meaning leading to the minimum maintenance cost approach as well as utilising improved materials, design and methods to ensure that the necessity for rectification works are become less regular.

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