

CLASSIFICATION OF FACTORS CONTRIBUTING TO ROOF LEAKING ON MALAYSIA HERITAGE BUILDINGS FOCUSING ON CONCRETE FLAT ROOF AND METAL ROOFING

ROSLAN TALIB¹, A GHAFAR AHMAD¹, MOHD ZAILAN SULIEMAN¹ and DAVID
BOYD²

¹School of Housing, Building & Planning, Universiti Sains Malaysia

²The Birmingham School of the Built Environment, Faculty of Technology, Engineering & the
Environment, Birmingham City University, United Kingdom

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 exercise, the paper tabulate lists 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 focusing on the concrete flat roof as well as the metal roofing for the selected heritage structures within 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 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 problem 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 syndrome; Heritage; building; maintenance; defects; Malaysia

1. INTRODUCTION, BACKGROUND AND LITERATURE RESEARCH

According to Kamal and Harun (2002), 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), 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) 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) 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) 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) stated that roof system is very important as it provides shelter for the interior spaces of

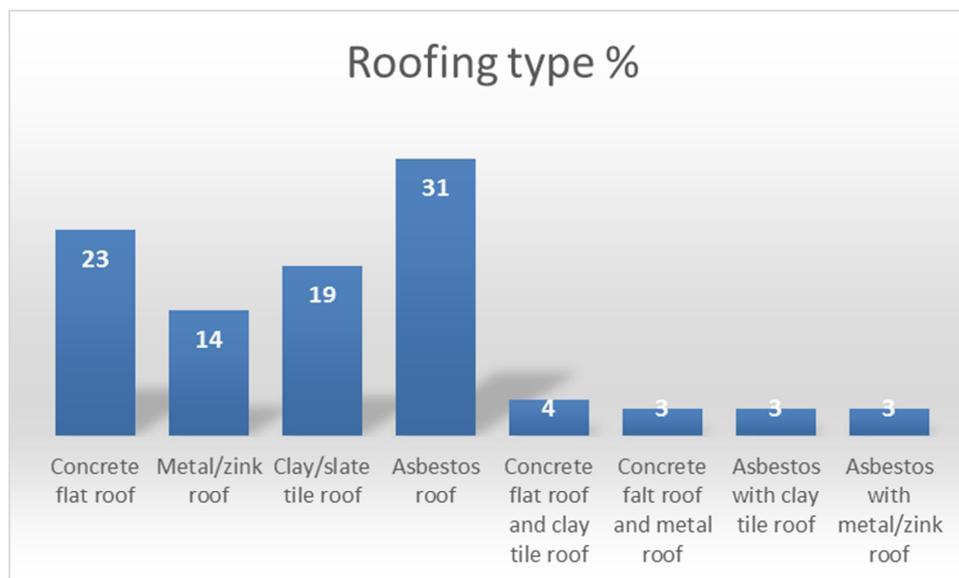
¹Corresponding Author- Tel.: +604 653 4525 E-mail: roslantalib@usm.my

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 quality construction workmanship and more regular inspection and maintenance. The details of the buildings selected for this research can be traced from <https://usm.academia.edu/RoslanTalib/Papers>. Kindly refer to 2 files labelled with Roof Leak Heritage on Malaysia (file 1[1-30 cases] and 2[31-64 cases]-21 Mar 2014 data) containing the selected total of 64 cases on identified heritage buildings for the paper study.

2. RESEARCH OBJECTIVES AND METHODOLOGIES

2.1 Data Collection Methodology

Fig. 1 Analysis of the roofing type for the building collection selected for the research exercise.



After having done the analysis from data collection (from a total of 64 selected heritage buildings identified), it seems like the asbestos roof is the most material being used as the roof covering structure for this study (see Fig.1). 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.

The link [https](https://usm.academia.edu/RoslanTalib/Papers) of the academia.edu files (Roof Leak Heritage file 1 and 2) clearly shows the classification criteria data schedule information pertaining to each of the selected heritage buildings for the ease of data analysis exercise.

2.2 Discussions and Findings

The chart below (Fig.2) indicate 14 identified cases where the water leakage has been occurred in relation to the concrete flat roof only! From the list, the analysis indicated that each of the typical leakage scenario eventually having its own cases with 9 the highest case and some has 3 the lowest. It is interesting to note that for this concrete flat roof 9 cases has been identified where the hard waterproofing membrane has been expired thus won't be able to protect the roof. It is to most of the cases that the current waterproofing membrane has reached its warranty period of about 10 years and require a removal and to install a new one.

The next typical defects happened for the flat roof is the failed of epoxy coating laid on top of the concrete roof mostly due to hard hot weather or sometimes with interference of human activities done on top of the roof. Also due to harsh hot and humid condition of the year also can give crack effect of the concrete hence permit rainwater inside the old heritage buildings. Normally, stained has been clearly identified on top of the concrete underneath of one structure and need to be rectified before it become worse and effecting the interior furniture. Springer (1977) mentioned that there must be a work programme to survey the main structure of the buildings especially the roofing part during the first year of the post construction stage to ensure the repairs to the main structure can be planned if required.

Fig.2 Possible of defects build-up for the concrete flat roof identified for the case studies.

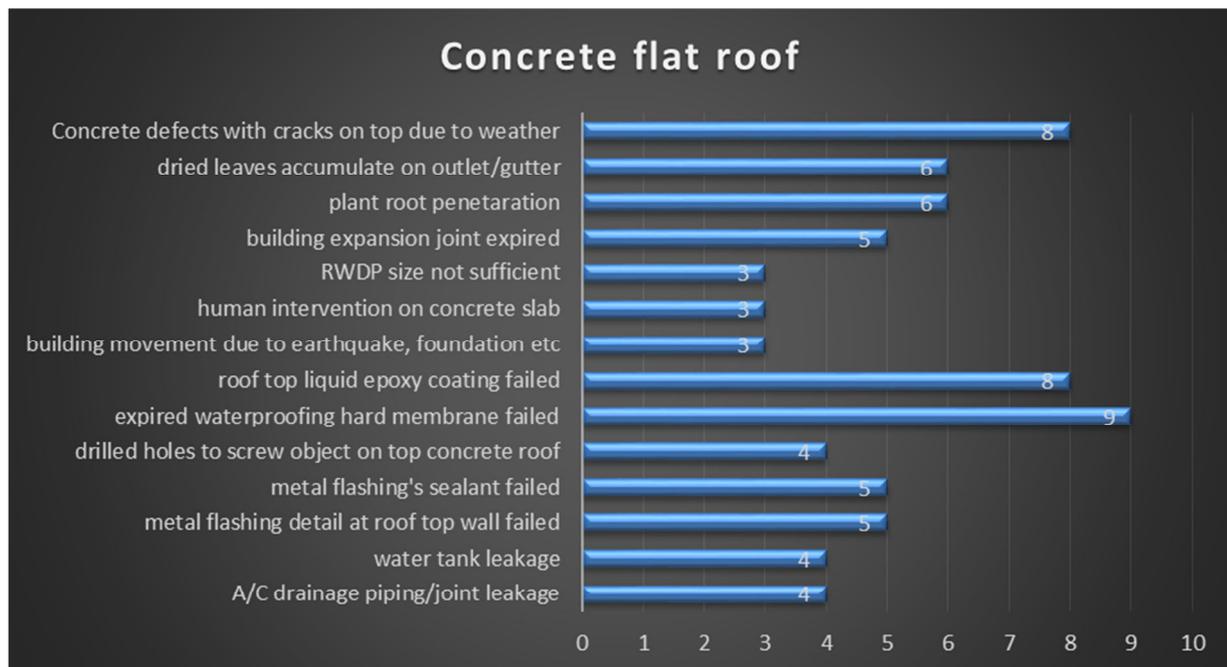


Table 1. Rectifications analysis schedule tabulated for the concrete flat roof identified for this case studies.

CONCRETE FLAT ROOF	Rectification	Rectification	Rectification
A/C drainage piping/joint leakage	Replace leaking drainage pipe or joint.	Use Bina Plastic© uPVC pipe/joint or similar brand with Dunlop Ecobond© solvent based PVC pipe adhesive glue.	Regular a/c maintenance required.
Water tank leakage	Repair weak points inside and outside the tank	Paint anti-rust coating at rust surfaces	Paint epoxy coating at joints
Metal flashing detail at roof top wall failed	Ensure metal flashing properly glued with epoxy sealant seal into the wall.	Flashing location must be at easy accessible area for maintenance.	Use flashing type with galvanized corrosive free.

Metal flashing's sealant failed	Replace expired sealant	Ensure getting warranty on sealant product.	Ensure metal flashing overlay in two layers.
Drilled holes to screw object on top concrete roof	Render holes with non-shrink cement	Seal holes with new sealant	Or paint epoxy coating with fibre mat on holes
Expired waterproofing hard membrane failed	Replace expired with new membrane	Lay coat of petro based primer before torch membrane	Membrane lapping must be in orderly. Have membrane skirting min. 0.5 metre height
Roof top epoxy coating failed	Relay new layers of epoxy coatings. Old coating to be removed.	Ensure coating been applied in hot and dry weather with clean surface.	Ensure liquid membrane thickness 1.5mm. To lay coating in intersecting direction with 3 layers
Roof slab cracked due to building movement due to earthquake, foundation etc.	Ensure building having mechanically vibrate proof design feature.	Must use micro piling/less vibrate type of piling for building next to the site.	Monitor on soil movement near site.
Human intervention on concrete slab	Always monitor human activities on roof top.	Installing new structures on roof top must be in waterproof condition.	Regular maintenance inspection required.
RWDP size not sufficient	To cut concrete making new bigger hole to fit larger uPVC RWDP	Suggest using uPVC type for easy maintenance.	RWDP and roof joint piece must be sealed properly to ensure leak free.
Building expansion joint expired	Replace old joint sealant with new flexible sealant epoxy.	Also possible to install new backer rod at joints.	Good understanding required on building's expansion joint design.
Plant root penetration	Remove vegetation until root part gone.	Put fibre-matte at the spot, then paint epoxy coating on it.	This may sign of inefficient run of rainwater. Re-render of flat top required.
Dried leaves accumulate on outlet/ concrete gutter	Long term: distance planting leafy tree. Suggest plant evergreen trees.	Install metal netting at gutter drain outlet.	
Concrete defects with cracks on top due to weather	Short term: do machine pressure injecting epoxy grout.	Long term: top surfaces treatment required i.e., install new waterproofing system	New waterproofing i.e. liquid membrane coating, hard torch membrane.

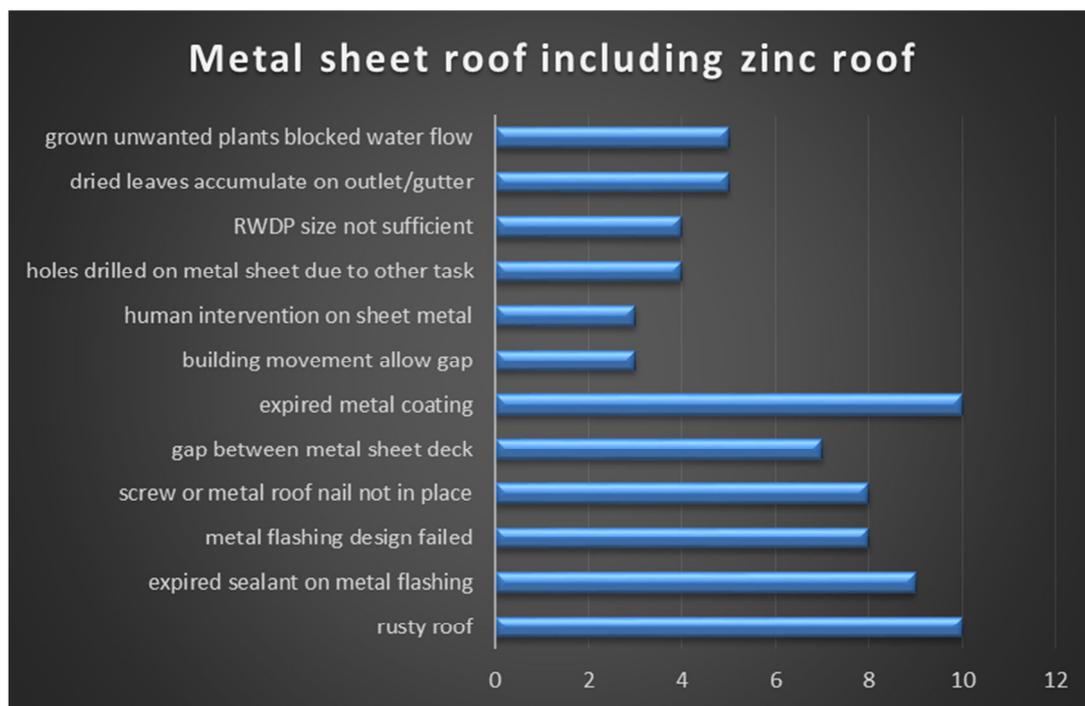
The above table (Table 1) indicating on the best possible rectification works that can be done for each identified leakage problem pertaining to the concrete flat roof. Each of the 14 defective cases has been identified with the detail rectification works to overcome the flat roof seepage together with 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 concrete flat 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 12 typical seepage situations always occurred through the defected metal sheet or zinc roofing extracted from the data collection done. It seems the most defect cases are most heritage building with metal roofing has expired epoxy coating paint or laid on top of the metal surfaces as well as the metal or zinc surfaces become in rusty condition. 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 metal decking always will permit in rusty condition or the layers of epoxy coatings found on top of the metal surfaces will deteriorates and may permits rusty and furthermore having small holes that simply can permit the rainwater into the internal of the house or an old building.

This is to note that the three columns identifying by the same rectification label as to highlight that the rectification works involved not only involved in one rectification step but it involved with more than one step. Thus for the summary schedule (please refer to Table 1 and 2) the author summarize the rectification works in 3 columns/steps for easy reference.

Fig.3. Possible of defects build-up for the metal sheet roof including the zinc roof identified for the case studies.



The next one is the problem arises when the sealant become not function or expired especially along the metal flashing and become permits water. Improper installation of metal flashing to the existing metal roofing always permit water seep through the leakage points and giving problem to the structure.

Table 2. Rectifications analysis schedule tabulated for metal sheet roof identified for this case studies.

METAL SHEET ROOF INCLUDING ZINC ROOF	Rectification	Rectification	Rectification
Rusty roof	Start with scrap the rust area. Paint anti corrosion paint epoxy	Lay fibre-matte on stain spot.	Paint 3 layers (intersect pattern) with epoxy coating
Expired sealant on metal flashing	Replace old sealant with new silicone sealant.	Ensure to apply new sealant during hot and dry weather.	

Metal flashing design failed	Ensure metal flashing properly glued with epoxy sealant seal into the wall.	Use of copper flashing due to its strength.	Ensure metal flashing overlay in two layers.
Screw or metal roof nail not in place	Replace missing screw or nail with new one. Installation must be in orderly manner.	Ensure new nail has anti-corrosion feature.	Double protection: put sealant epoxy on top of screw/nail.
Gap between metal sheet deck	Metal sheet to redo/refit manually orderly.	Gap may cause from strong wind.	
Expired metal coating	To scrap off peeled coating and paint 2 layers new epoxy coating.	Ensure coating act as corrosion resistant surface coating for metal roof.	
Building movement allow sheet gap	Rearrange metal sheet orderly manually.	Ensure design movement/wind resistant.	Urge use micro piling for building next to existing.
Human intervention on sheet metal	Ensure movement monitored by management.	To redo defects done manually.	
Holes drilled on metal sheet due to other task	Cover holes with sealant epoxy.	Avoid installing new item/gadget right on top metal roof.	
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.
Dried leaves accumulate on outlet/metal gutter	Long term: distance planting leafy tree. Suggest plant evergreen trees.	Install metal netting at gutter drain outlet.	
Grown unwanted plants blocked water flow	Remove manually unwanted plants.	Put fibre-matte at the spot, then paint epoxy coating on it.	

The above schedule (Table 2) listing out 12 typical problems dealing with the water seepage normally happened in regards to the use of metal or zinc 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 12 typical scenarios always occurred in regards to the water seepage in relation to the metal or zinc 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.

3. 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 flat roof concrete and for the metal or zinc roofing sheet. 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.

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 that mostly being as roof covering structure of the analysis. In summary, by determining and identifying the factors always leading to the flat concrete roof and metal or zinc decking's water leakage, the predicted defects can be obtained and principally some financial aspects 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.

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Email contact: roslanusm@gmail.com