

Building Design Failure. Why Did It Fail? How It Could have been Avoided?

Roslan. Talib¹, Aghafar. Ahmad², and Mzailan. Sulieman³

Abstract—The purpose of the paper is to share the findings on the typical problems facing the buildings in term of the problem leading to building leakage scenario in Malaysia. The paper tabulate list of potential solutions best practiced by the local waterproofing implementer with data on real case studies pertaining to the building leakage typically happened from roof as well as the toilet or cracked building expansion structures. 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 leakages, one can take early steps to prevent the same defects from repeating thus saves on the financial side. The finding indicates the formulation ideas that can be used for creating a framework in preventing or minimizes the building leakage syndrome from happening again. The analysis from this paper may give some meaningful tabulation on how to maintain these standard buildings from leaking especially from the roof seepage thus make the property much more valuable to the owner.

Keywords—Building leakage, rectification works, building failures, Malaysia

I. INTRODUCTION

BUILDING'S design failures affect society at large due to possible danger posed; they also result in direct and indirect cost in repairs, abnormally high maintenance, disputes and possible loss of building use. Internal and external related defects are generally caused by inadequacies in design, poor workmanship, building usage not in accordance with design and lack of or incorrect maintenance. Dampness and cracks are common manifestations of defects. Interior dampness can however often lead to cracks; making it difficult to determine root cause and appropriate repair. Not all manifestations may be considered defects and not all defects are serious to the extent that it will affect building stability and occupant safety. Materials are often blamed for the failures when the cause lies in the choice of unsuitable materials and/or when their limitations are recognized and taken into account in constructing and design detailing. A

Roslan. Talib¹ is the head of Interior Design Programme with the School of Housing, Building & Planning, Universiti Sains Malaysia, Pulau Pinang 11800 USM (phone:+60194033507 ; fax:+6046532931; e-mail: roslanusm@gmail.com).

Aghafar. Ahmad², is with the School of Housing, Building & Planning, Universiti Sains Malaysia, Pulau Pinang 11800 USM (phone:+6046532820 ; fax:+6046532931; e-mail: aghafar@usm.my).

Mzailan. Sulieman³ is with the School of Housing, Building & Planning, Universiti Sains Malaysia, Pulau Pinang 11800 USM (phone:+6046533163 ; fax:+6046532931; e-mail: mzailan@usm.my).

new Dutch standard NEN 2767, believed to be a world-first in Building Condition Assessment attempts to provide insight and uniformity in defect assessment and classification, translating the diagnosis in condition scores. The standard is expected to contribute towards improving communications for all involved including litigations relating to defects and building failures. This paper will give examples typically found during the building maintenance exercise. Also, the report focuses into the problem of the interior and exterior side of building design failures which are having great impact to its occupant.

II. BUILDING DESIGN FAILURE –THE ANALYSIS

A. Rusty & Leakage on the metal roofing

Why did it fail? Metal roofing will show the rust failure after quite some time due the rain and shine due to harsh tropical weather. How it could have been avoided? To rectify this rusty problem –

1. The metal surfaces need to be treated with water proofing and rust proof special paint to ensure the same metal roofing material can still be used and no need to be replaced.

2. Certain part of the roof may have holes on it need to be treated to ensure not leaking. Special treatment using water proofing coating and fiber-matte can solve the hole on metal problem. As expected the holes appear because of metal failure due to rusting



Fig. 1 The existing metal roof showing the rusty appearance and having several spots with holes allowing rain water penetrate towards the inside of the building



Fig. 2 Rectification work done by applying layers of waterproofing coating on top the metal surfaces

B. Expired Sealant (External)

Why did it fail? The typical problem joining two materials of the floor and wall/column is the silicone sealant not functioning due to time and weather. Failure to replace the dead silicone/epoxy may result in building leakage. How it could have been avoided? To rectify this from happening -

1. The only solution is to replace with the new building construction sealant.
2. Ensure using the silicone with high quality endorsement for better and longer time performance.
3. It is best to apply the new sealant during the hot day for better result.



Fig.3 Applying new sealant epoxy must be done in a hot day for best result

C. Expired Sealant (internal)

Why did it fail? When the time comes, the building sealant applied between the indoor and outdoor spaces such between the glasses walls with fully air-conditioning 24 hours may deteriorates and become as hard as stone. How it could have been avoided? To rectify this from happening-

1. The only solution to take out the old sealant and replace with the new silicone.
2. Due to the area with high traffic most of the time, the new sealants replacement must be done during the less traffic time to ensure nobody spoil-up the flaccid epoxy.



Fig. 4 Expired sealant located in the internal side of the building with cracks appearance

D. Flat Concrete roof leakage

Why did it fail? Most of the problem with building having flat roof is the cracks on the surface of its flat concrete part thus permit the water penetrates through the inner part of the building. This may cause serious damage on its internal parts such as it furniture, equipment etc. How it could have been avoided? To rectify this crack from happening-

1. To do the water-proofing treatment by using proper material to treat the cracks.
2. Normally, the crack lines been treated with water proofing cementitious paint like material been applied.
3. High quality cotton fiber and silicone epoxy also may be applied if the cut quite deep.
4. If the cracks appear at the most of the concrete surface area; the coating type water proofing liquid membrane need to be applied with several layer. Apply first layer with asphalt to ensure correct liquid membrane thickness achieved.
5. Again, the best condition is doing this rectification works during the hot weather



Fig. 5 Concrete flat roof having long cracks line being rectified to ensure rain water do nor seeping through the weak lines

E. Concrete Corridor flat roof top leak

Why did it fail? Most of the building having the side of the building with concrete flat top designed for its verandah walkway roof cover. There is always the builder left over this roof part with no proper water proofing thus creating leakage problem. How it could have been avoided? To rectify this from happening-

1. Problem may be solved if the designer goes for the pitch roof design to cover this walkway.

2. However, if the client still prefers the flat top concrete, please ensure proper water proofing treatment has been done before accepting the handover.

3. This photo shows the asphalt type of leak free material has been applied on its bare concrete surface.

4. Asphalt type of leaking liquid membrane with proved performance like ATLAS-COTE brand© may be a good choice for its good performance due to the harsh tropical climate.



Fig. 6 The building originally has not been water proofed and task been taken to rectify this using asphalt type material over bare concrete flat slab

F. Small size Rain Water Down Pipe (RWDP)

This is the problem where the size of the Rain Water Down Pipe (RWDP) pipe size is too small to cater the amount of rain water (see Fig. 7). Thus, this photo shows the process of making another hole to install another RWDP. How it could have been avoided? To rectify this from happening-

1. To ensure that the architect/designer to consider having use bigger size of RWDP to cater the amount of rain water.

2. The bigger surface of roof top with the flat concrete roof may need bigger and more numbers of RWDP.

3. Failure of this part may result in over flow of rainwater and water penetration through the internal part of the building. This will surely damage the interior of the structure.

G. Expired Building Joint Sealant

Why did it fail? This defect happens when the sealant joint between two parts of the building failed (see Fig. 8). The failed part always let the water to penetrate through and allow cracks to appear. How it could have been avoided? To rectify this problem from happening-

1. To replace the old epoxy sealant with the new one.
2. Please ensure you take off the old non-functional sealant completely and clean-up the surface from foreign objects.
3. Due to the hot tropical climate, the stretching and shrinking of the concrete require maintaining this joint sealant in due time is important.



Fig. 7 The process of cutting the concrete wall slab to allow in making bigger RWDP



Fig. 8 The process of installing new building joint sealant after removing the expired epoxy

H. Leakage Concrete Flat Roof

Why did it fail? Flat roof building always give the charmed geometrical iconic shape form the observer. However, having tropical climate require proper implementation to cover its bare flat concrete surface. This photo shows the process of torching the hard water proofing membrane been applied to cover the top. Improper membrane installation always allows water to seep through and create problems. How it could have been avoided? To rectify this thing from happening-

1. To ensure the joint between the membrane sheet overlapping gap having minimum 50mm lap to minimize water seepage.

2. Also to ensure the torching heat been applied evenly to let the membrane bottom glued well on top concrete surface.

3. Proper cleaning of the concrete surface before the membrane application had been done.

4. Please ensure the water proofing membrane having the skirting up to the building beam edge to defer water seeping as seen on this photo.



Fig. 9 The process of torching the hard membrane on top of the concrete flat roof taking place

I. Lacking Construction Joints

Why did it fail? For bigger building complex, the phase construction technique allows certain part of the building having long lines of building construction joints lines. With no proper installation of backer rod roll may give water penetration hence create leakage problem. At this case, the leaking water will fall into the parked vehicle. How it could have been avoided? To rectify this problem from happening-

1. Ensure proper installation of high grade building joint backer rod roll between the gaps.
2. Most of the failure is when the contractor left over the installation of the joint by simply render the joint with concrete.
3. With no proper fiber joint installed will let cracks appear right after handing over.



Fig. 10 Putting the white color backer rod between the building joint or crack

J. Rusty Metal Ornamentation

Why did it fail? In this case, the building manager decided to install steel fence on top of flat roof raised edge for safety reason. However, through times, the metal reaction to weather letting ugly rust stained appear clearly on the white paint wall surface.

How it could have been avoided? To rectify this from happening-

1. Ensure to paint the metal surface with anti-rust paint material.

2. Also to ensure the metal screws using to hold the fence need to use from stainless steel type to avoid rust building.

3. The metal fence may need not to be erected if the maintenance crew using the safety belt equipment while doing routine maintenance works at this building edge.

4. Appearance wise not so great esthetically by having this fence installed on the upper part of the nicely designed building



Fig. 11 The rusty defects appear on top of the bright color paint at one of the condominium building near Kuala Lumpur

K. Cracked Concrete Dome

Why did it fail? Most of the concrete dome has been built by the colonial British copying the construction technique over in ruled India. However, to keep these domes in good shape require great care due to the Malaysian humid and hot climate (see Fig. 12). For this case, the concrete dome let many cracks appear on its surface thus letting the rain water seep into the concrete. At one point, the water reacts with concrete ingredient hence posing the leakage problem for the interior. How it could have been avoided? To rectify this leakage from happening-

1. Ensure proper water proofing rectification done in right sequence and right material being used.
2. All the crack lines must be treated first with leak proof material.
3. For this case, the first waterproofing layer to be covered on the dome surface is using asphalt type of material.
4. The next and final layers are suggested to use high grade cementitious liquid membrane to be applied.
5. Recommended this exercise during hot sunny day for better material absorption into the old concrete.

L. Cracked Play Court Surface

Why did it fail? Typical cracks appear on the surface of the play court hence interrupt the smooth usage of the course. The cracks also give not nice appearance looking from the distance. Late treatment may result into bigger and deeper holes appear on the crack (see Fig. 13).

How it could have been avoided? To rectify this crack from happening-

1. Ensure to do the correct treatment along the crack lines first before redo the court surface rectification.

2. Next to lay-out or paint-off all the court surfaces with right heavy-duty sport surface coating paint with correct thickness. When applying too thin or too thick of the coating may developed problem (hairline cracks). So, experience personnel dealing with this kind of work need to be find.

3. The cracks can totally being avoided if the builder use correct and right concrete installation process for the play court.



Fig. 12 The process in doing the rectification of this heritage building involving different sizes of concrete dome



Fig. 13 This play court require treatment to every single cracked lines before the whole coating being applied

III. PRELIMINARY SUMMARY

From the result of the visual finding, it can be concluded that the external factor affecting standard or historical buildings especially those located in Kuala Lumpur or nearby the Selangor State are due to climatic change, air pollution, and lack of maintenances. Climatic condition is the act of atmospheric event such as rainfall, temperature, air pressure and humidity. Due to the tropical climatic condition, Malaysia has heavy rainfall and warm sunshine all year round. Therefore the external part of the building tends to weather rapidly. For example, discoloration of external wall is cause by the solar effect as well.

Air pollution due to traffic also one of the main factors of the buildings rapidly in deterioration condition. During the visual observation, several buildings have stained problem visually visible internally as well externally.

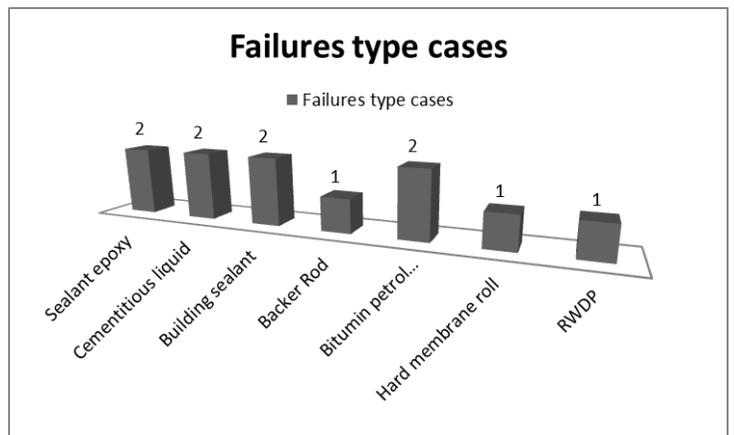


Fig. 14 It shows the typical building failures type cases found from the study such as the use of bitumen petrol based coating being applied for rectification works to enlarging holes to fit bigger RWDP

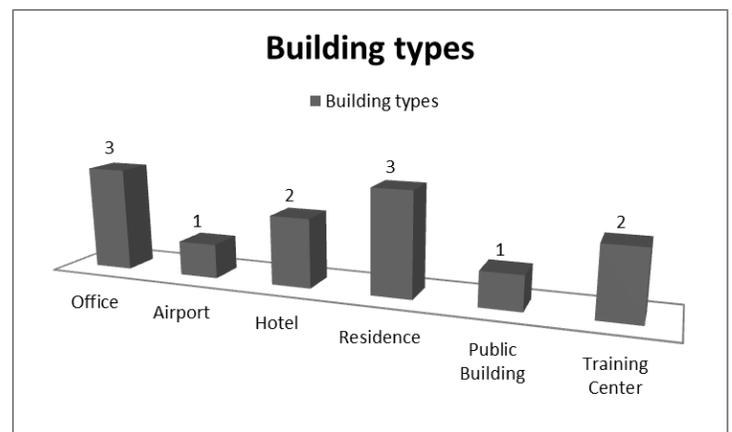


Fig. 15 The graph shows the types of building being categorized for segregation. Residential housing and office buildings are more common for the cases

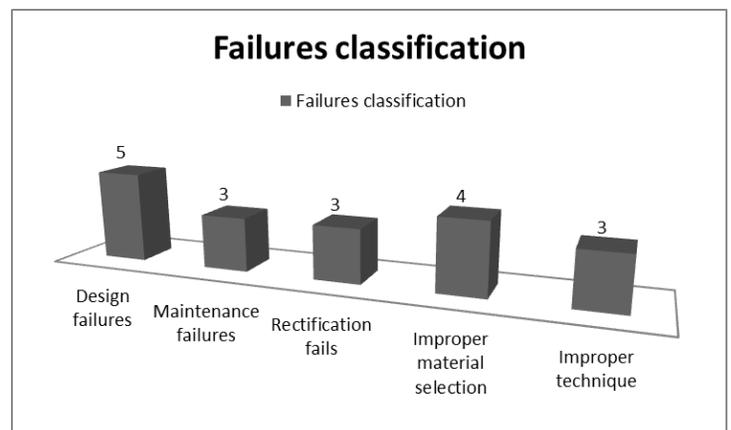


Fig. 16 The above chart states most of building failures started from the drafting table which are involved during design stage. The other 4 building failures can be categorized from maintenance problem, low quality rectification works, improper rectification material selection and wrong reparative technique

TABLE I
SUMMARY OF THE DEFECTS TYPES AND RECTIFICATION METHOD

Affected At	Defects	Rectifications	Building Type	Site	Case
Metal roofing	Rust, hole	Apply epoxy coating	Office- training center	Kuala Lumpur	1
External building sealant	Expired sealant, stone like sealant	Replace with new sealant epoxy	Airport building	Sepang, Selangor	1
Internal sealant	Expired sealant, stone like sealant	Replace with new sealant epoxy	Airport building	Sepang, Selangor	1
Concrete flat roof	Cracked	Apply layers of cementitious. Treatment at crack lines with fiber-matte. Case – apply with bituminous pigment	Office building	Bangi & Sepang Selangor	2
RWDP down size	Leak at existing RWDP	To drill new hole at concrete wall to place bigger RWDP	Hotel Residence	Kuala Lumpur	1
Building / joint	Expired joint sealant	Replace with new sealant epoxy.	Hotel Residence	Kuala Lumpur	1
Concrete flat roof	Slab cracked, existing hard membrane defective	To torch new membrane. Concrete surfae need to be treated. Layer of bituminous liquid to apply	Office- Residence	Petaling Jaya, Selangor	1
Construction Joints	Non-function backer rod and selant epoxy	To replace with new backer rod and install new sealant	Office- Residence	Petaling Jaya, Selangor	1
Metal Ornament	Rusty metal, stained wall	To ensure metal ornamnet being paint regularly (with anti-rust paint)	Condominium/ Residence	Bukit Jalil, Selangor	1
Concrete dome	Cracked dome	To apply ATLAS-Cote© petroleum based type of coating after cleaning treatment of the dome	Public Building owned by the city	Kuala Lumpur	1
Play court surface	Cracked on court surface	To apply epoxy coating. Cracks to be treated first	Training Center	Petaling Jaya, Sel	1

Finally, Table I above shows the summary of the defects types and rectification method for guide. From observation, smoke pollution from vehicle and human activity, causes the soiling of facade by deposition of black carbonaceous particle. Most buildings located facing or positioned near the main road have black carbonaceous particle. Lastly, lack of maintenances is another important factor impacting the deterioration of the standard or heritage buildings in Malaysia. Building maintenance team play importance role in preventing defects from reoccurring. Poor maintenances knowledge among the construction industry players or practitioners in dealing with the defect and building failures also contributed to the deterioration factor.

To sum up, it can be concluded that to get effective remedial material, understanding of the deterioration factor and the material characteristic is a must. Therefore, each defect has its

own character and the produce of the right remedial material can eliminate the defect to occur again. It is hope this paper at least be able to make awareness to prevent building failures reoccurring and give guides for better design and maintenance task.

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Roslan B. Talib (BSc. Milwaukee-USA’86, M. Arch, Ohio-USA’88) currently lead Interior Design Programmed at School of Housing, Building & Planning, Universiti Sains Malaysia. Mr Talib has been involved in project management and building maintenance sectors for about 15 years before joining the academic line. He is currently a graduate architect member of Malaysia Board of Architect (LAM) since 1992.

A Ghafar Ahmad (BSc Milwaukee-USA’86, M. Arch, Ohio- USA’88, PhD Sheffield-UK) is a Professor at School of Housing, Building & Planning, Universiti Sains Malaysia. He is currently representing Malaysia to the UNESCO committee in evaluating potential future list of heritage sites worldwide. Prof Ahmad expertise is on heritage buildings conservation tasks.

M Zailan Sulieman (BSc. B Tech-Johore -UTM, MSc, USM, PhD Building Tech.USM) is now teaching building defects with Building Survey Programme at School of Housing, Building & Planning, Universiti Sains Malaysia. Mr Sulieman had vast experience in building maintenance field academically as well as practically. He is now leading the HBP Concrete Testing lab; the only certified concrete laboratory testing in northern Malaysia. He is also a registered member with the Royal Institution of Surveyor- Malaysia.