Heritage Building of *Residensi Tunku Abdul Rahman*: Preserve and Conserve for The Future

Mokhtar Noor Aisyah[2,*], *Che Ani* Adi Irfan[1], *Johar* Suhana[2], *Khalit* Nur Athirah[2], *Mat Jusoh@Hussain* Afifuddin Husairi[1], *Harun* Nor Zalina[3], *Khaidzir* Mohd Fadhli Shah[1], *Adnan* Amira Shazlin[1]

[1] School of Liberal Studies (CITRA), Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor Malaysia

[2] Department of Architecture and Built Environment, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor Malaysia

[3] Institute of The Malay World and Civilization (ATMA), Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor Malaysia

Abstract. Residensi Tunku Abdul Rahman is over 100 years and registered as National Heritage. Heritage building sets certain standard in preserving their value where weather and climate change have become biggest challenge in maintaining the status. Humidity, hot and rainy weather, also sunlight in tropical region made some damages to the building. Therefore, preserving and conserving the building is important to give knowledge and create awareness to the public. This research made to inspect the damage and defects of the building, then, propose the scope of conservation work and building conservation. Analysis of damage/defects thorough the building using the Building Condition Assessment Rating System (BCARS) by identifying the level of building condition and its' rating. The basis of the assessment is in the aspects of safety, functionality, and maintainability of the building that was assisted by several equipment used for the purpose of damage assessment and measuring work. Based on the analysis, there are 71 types of damage that were identified including rotten and broken wood louvres and wall surfaces with a total of 15 damage each and a percentage of 7.5% each. Taking care of heritage building from climate and weather change needs constant preservation and maintenance.

1 Introduction

The Tunku Abdul Rahman Putra Memorial Residence Building is over 100 years old and located on the hill of Jalan Dato Onn, Kuala Lumpur. The building was registered as a National Heritage in 2007 under the National Heritage Act 2005 (Act 645) - making this residence a historical site and an old monument that gazetted and landholding status is in perpetuity. This building was completed in 1888 as the official residence of the British Resident Officer in Selangor until 1955 [1,3]. This two-storey residence was a stone structure and marble floors on the ground floor and wooden floors on the upper floor. Later, it became the official residence of Tunku Abdul Rahman Putra Al-Haj in 1956 until early 1970s. This residency stores and preserves all the personal and government treasures belonged to Tunku before, during and after he became Prime Minister [2]. Therefore, conserving and preserving this Residency Building is important to give knowledge about Tunku's life, struggle, and leadership as the Father of Malaysian Independence as well as create awareness to the public on how to take care of country's architectural heritage in hot and humid climate of Malaysia.

* Corresponding author: aisyahmokhtar@ukm.edu.my

Fig. 1. The Residensi Tunku Abdul Rahman in Kuala Lumpur.

In preserving the historical value of the buildings through weather and climate change, study has been made to inspect the damage and defects of the building and to provide the scope of conservation work and building conservation proposals [4]. This study only covers a visual inspection of the building and the area around the perimeter of the building without involving the main structure of the building. Visual inspection is the first step to safety assessment to identify and evaluate any defects that may cause harm or hazard to the building and its occupants. Any cracks, scratches, corrosion, dents, anomalies, inconsistencies and discoloration will be identify. Closed, hidden or inaccessible parts of the structure are not inspected. Only non-destructive methods are used when the inspection is carried out. This study is important to understand the impact of future's climate change to old buildings, and later provide better treatment, maintenance and restoration to get along with climate change.

2 Objectives

The objectives of inspecting the damage and defects of the building are firstly, to check and record the condition of the existing building for the external and internal areas. Visual inspection throughout the building were conducted to get the physical information of the building for defects and decay. Secondly, to provide the scope of conservation work and building conservation proposals. This will be discussed after analysis through the data acquired from visual inspection and other study. Thirdly, to conserve and preserve the historical value of the existing colonial buildings through weather and climate change. Doing this will involve coordinating maintenance works throughout the years as long as the buildings stands.

3 Methodology

3.1 Building Damage Survey

Analysis of the discovery of damage/defects in the building using the Building Condition Assessment Rating System (BCARS) by identifying the level of building condition and building condition rating [5]. The basis of the assessment is in the aspects of safety, functionality, and maintainability of the building. Visual inspection was done to get general and physical information about the building's condition. Photographs were taken for records and be the evidence to propose or conduct conservation works. Dimensions of the structural elements were recorded to develop measured drawings of the building. Roof structure

damages, floors decays, and structural elements such as columns, walls, arches and transition elements damages/decays were recorded and inspected to construct the data that will be analysed to be later use for conservation works.

There are several equipments used for the purpose of damage assessment and measuring work for measured drawings of buildings. They are 3D Terrestrial Laser Scanner Model Leica RTC360 3D to document and record the environment in the form of 3D drawings. FLIR ix IR Camera - 60101-0301- uses an infrared camera that can help identify problems, and diagnose them more efficiently. It can be used to perform energy audits, detect moisture, detect mechanical wear, check electrical overloads, justify repairs and minimize downtime. Lastly, Surveymaster BLD- 2000 Protimeter & Protimeter BLD5702 Digital Mini & ClimaPilot ThermoHygrometer - a 'non-destructive' tool used to obtain moisture readings on wall and floor surfaces. For this study, only the wall was used as a subject for moisture study.

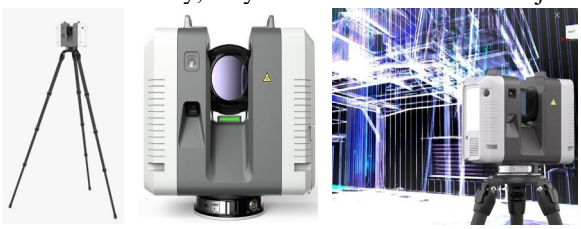

Fig. 2. 3D Terrestrial Laser Scanner Leica RTC360 3D equipment used to record the building in the form of 3D drawings.

Fig. 3. FLIR ix IR Camera equipment used to survey the surface temperature of materials.

Fig. 4. The work of retrieving damage data is in progress.

3.2 Other Study

Among the studies carried out to obtain information for use in the next conservation phase are such as humidity studies, paint scheme studies, wood species studies, material composition studies and so on. For this building, the study carried out was a moisture study on the wall facade, a study of the paint scheme and a study of wood species identification.

Building moisture studies are carried out on locations that show symptoms of building moisture, paint schemes on locations and elements that have been identified, while wood species on specific wooden elements such as doors, windows, pillars and roof components. The data collected from this study can provide an overview of conservation procedures or methods that are appropriate to their original condition, in line with what is outlined in the Heritage Building Conservation Guidelines [4].

3.2.1 Building Façade Moisture Study

The issue of dampness happened in old buildings. The prevalence of this happens not only due to natural factors, but can also occur due to system failure in the building. The issue of moisture in heritage buildings is a rather critical threat because it can affect the fabric of the building, especially in wooden materials and also in lime plaster materials [7]. It also gives off an unpleasant smell such as musty, stuffy and damp

Generally, this study is carried out to obtain humidity readings at locations that have been identified as having symptoms of humidity such as water spots, peeling paint layers, blistering and peeling, plaster cracks becoming porous, dull and cracking. Through visual observation of the symptoms, several location samples were selected for testing. The tools used are Surveymaster BLD-2000 Protimeter & Protimeter BLD5702 Digital Mini & ClimaPilot ThermoHygrometer; and readings taken in %WME.

3.2.2 Paint Scheme Study

The first objective of analyzing painted surfaces in historic buildings is to gain insight into the appearance of a room or building in the past [8]. Paint scheme study, known as architectural paint analysis is used to identify paint colors and decorative finish schemes and how they change over time. These techniques include archival research, on-site investigations, microscopy, and instrumental analysis experiments. For this building, the technique used is an on-site investigation technique, by referring and matching the sample with the 'color pallete' from the paint manufacturer. This study involved taking a small sample for reference purposes and the selection of this sample was done on the available part and has experienced exfoliation of the surface layer. These samples include paint layers outside and inside the building, upstairs, downstairs and wooden surfaces that use paint as finishing.

3.2.3 Wood Species Identification Study

Wood species identification is also important for the conservation of historic building heritage [9]. A wood species identification study was conducted to obtain information on the wood species used in the construction of several structures and components of this building. Among the building parts or components involved are doors and windows, wooden columns, wooden roof structures (louvers) and stairs. This identification study was carried out by timber verification service experts (Timber Verification Service - TVS) from the Malaysian Timber Industry Board (MTIB) to confirm timber sepsis. 12 samples were studied and the location of the samples varied. The results of this study will be used for wood selection in the process of replacing parts of wood that are severely damaged due to decay agents.

4 Results and Discussions

4.1 Damage Analysis

Analysis of the discovery of damage/defects in the building using the Building Condition Assessment Rating System (BCARS) by identifying the level of building condition.

Table 1. Amount of building damage by element.

Element	Lokasi				Amount
	Internal (Ground Floor)	Internal (1st Floor)	External (Ground Floor)	External (1st Floor)	
Roof & ceiling	15	22	17	14	**68**
Floor	2	2	2	-	**6**
Wall	31	27	11	4	**73**
Column	-	-	13	-	**13**
Stair	-	-	1	-	**1**
Door & window	14	-	1	-	**15**
Apron & drainage	-	-	7	-	**7**
Building services	8	3	3	2	**16**
OVERALL TOTAL					**199**

Table 2. Building damage assessment based on the Building Condition Assessment Rating System.

	Internal (Ground Floor)	Internal (1st Floor)	External (Ground Floor)	External (1st Floor)	TOTAL
Total mark [a]	564	437	581	304	**1886**
Total damage [b]	70	54	55	20	**199**
TOTAL [c] = ∑[a]/∑[b]	**8.1**	**8.1**	**10.6**	**15.2**	**9.5**
Overall Building Assessment	Condition based maintenance	Condition based maintenance	Repair	Restoration	Condition based maintenance

Table 3. Amount of damage according to the parameters of the level of damage and the level of building condition.

Score	Color Code Indication	Internal (Ground Floor)	Internal (1st Floor)	External (Ground Floor)	External (1st Floor)	Total	%
1-5	Very Good	111	69	20	6	**206**	**10.9**
6-10	Good	186	72	285	27	**570**	**30.2**
11-15	Fine	144	72	60	24	**300**	**15.9**
16-20	Critical	48	224	116	172	**560**	**29.7**
21-25	Very Critical	75	-	100	75	**250**	**13.3**
OVERALL TOTAL						**1886**	**100.0**

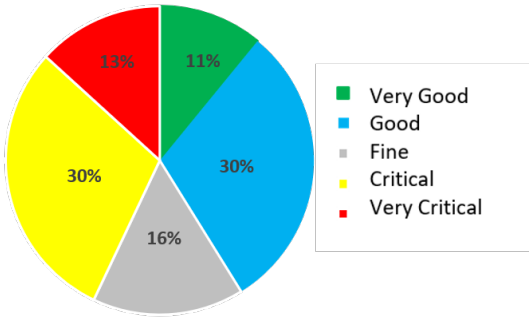

Fig. 5. The percentage of damage according to the parameters of the level of damage & the level of building condition.

Based on the analysis, there are 71 types of damage that were identified and recorded including rotten and broken wood louvres and wall surfaces with a total of 15 damage each and a percentage of 7.5% each. The second highest damage is the paint finish and the wall plaster is bubbling, peeling with a total of 13 damages with a percentage of 6.5% and the third highest damage is the crack damage along the wall joints and openings (doors) with a total of 10 damages and a percentage of 5.0%.

Drawings below show the location of building's problem/condition from ground to first floor, external and internal part of the building with its indication of damage. Damages mostly happened on the exterior part of the buildings. This caused by exposure to weather of rain, sun, and wind. This needs some prevention measure to maintain the building heritage.

Fig. 6. Location of building's external problem condition.

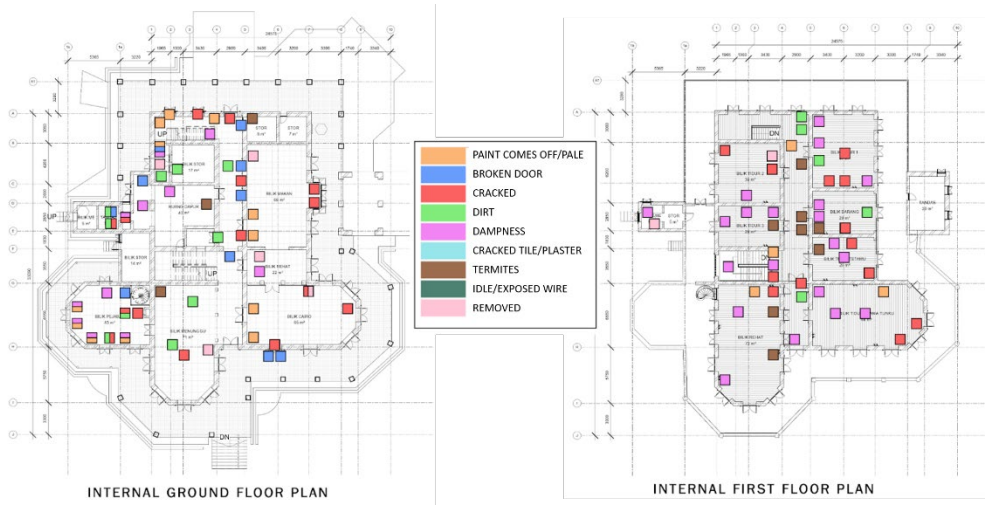

Fig. 7. Location of building's internal problem condition.

Fig. 8. Location of building's problem condition for all elevations.

From the drawings, lots of defects/decays happened around the façade condition of the building, also indoor area. Dampness was found in many areas outdoor and indoor. This caused by weather and climate change at the exterior, and roof leaking for the interior throughout more than 100 years old of the building. Exterior façade also faced paint that comes off or pale colour due to exposure to direct sunlight and rain. As temperature rises, exposed building's materials got dried and wet continuously in extreme conditions and created lots of cracks. All of these happened due to hot humid and rainy weather of tropical climate. Hence, conservation works need to conduct to preserve this building for the future.

The factors that contribute to the damage and defects are dampness caused by rising damp from the soil and exposure to weather such as rain and sun, shrinkage of building materials and finishes on its' surface which cause cracking, blistering, and peeling, also water leakage in the air conditioning system which results in damage to the ceiling, moisture, moss and dirt.

4.2 Conservation Works

Conservation work must be done carefully and meticulously. Any damage or disturbance to the original material and structure should be minimal and with the aim of obtaining the original design including the method of construction of the structure as the original. The goals of conservation need to be carefully understood, and this includes restoration work that needs to be carried out carefully to ensure that it does not cause further damage especially caused by weather and climate challenge that could remove the heritage character of the building. Listed conservation works below only to areas/buildings elements that affected by weather and climate change.

- Dispose of the damages, broken, rotten, missing and decayed part and replace with the same building material as the original, preferably from the same type of wood as the original.
- Finishing the soffit wood in its original condition
- repair damage by using appropriate methods, especially on rotted, leaking and broken parts. (location: the roof of the upper floor, and the roof of the lower floor in the 'porch' section and the wind insert.
- Remove the cracked layer of plaster using hand tools carefully to provide a flat surface.
- Making repair works that is a new patch based on a mixture of filler materials that complies with the original composition of the material.
- Injecting or installing waterproofing material at the base of the wall to prevent water seepage to the top of the wall.
- Any repainting work must follow a preliminary paint study to ensure that the new paint used matches the original.
- For parts of the floor that are cracked, broken, and removed, the replacement should be of the original building material or as close as possible to the original including the colour tone of the tile finish and mortar.
- For wooden poles, the wood species needs to be identified first. The decayed part needs to be determined up to the level of decay whether it can be reused and repaired using scientific techniques or using partial replacement, or to replace the decayed part with new wood of the same species and the same colour tone as the original.
- For wooden parts that have minor defects such as peeling paint, the original layer must be removed first and the repainting process must refer to the study of the paint scheme to obtain the same colour tone as the original.
- The repainting method refers to JKR's work standard [6] and the selection of the type of paint should be appropriate for its use (oil paint, outdoor use, weather resistant, etc.).
- Carefully remove the flaking finish layer, also the hardened stain and apply a new finish layer that refers to the tone and composition of the original building materials.
- For mirrored panels, any replacement work must match the original and this includes the thickness of the glass and the colour of the glass (for stained glass, replacement requires a scientific study first for reproduction work).
- For concrete stairs, the mossy surface needs to be cleaned first.
- Cracked and broken parts are repaired by patching using building materials comparable to the original. Information on the composition of the material mixture is required for these works. The patching work must be neat and harmonious with the original.
- For steel stairs, loose parts need to be re-tightened. The replacement of fixtures that have rusted and cannot be used again must be in accordance with the original size or those that match the original.
- Rusty parts need to be cleaned by removing the rust layer using methods that do not damage the surface (abrasive) and applied a finishing layer and undercoat that is appropriate for its type and use.

4.3 Maintenance Works

Overall, according to BARIS condition assessment, this building is in Good condition and only requires Condition Based Maintenance. There are common damages found in old buildings - moisture, decay, broken, cracked and non-functioning problems that are detected at walls, roofs and ceilings, doors/windows, pillars, floors, and also in building facility systems such as air conditioning systems, and ELV (extra low voltage) components. Damages and defects especially involving leaks that produce this humid environment need to be monitored and repaired to reduce more severe damage that can affect the overall function of the building.

A maintenance plan is a structured strategy designed to ensure optimal performance and prolong the life of an asset. It outlines the schedule of tasks, procedures and resources required to maintain equipment, machinery or infrastructure in working order. Maintenance plans for heritage buildings are essential to maintain their historical significance and ensure their structural integrity. Given the unique nature of the heritage building, the plan had to strike a balance between preserving the original features and modernizing it to meet safety and functionality aspects. Especially under hot humid climate, with increasing earth's temperature, maintenance works are necessary for the building in combating climate change.

Maintenance as defined by Burra Charter (2013) as the ongoing protective care of the fabric, contents, and settings of a place. Maintenance can be categorized by why and when it occurs. The types of maintenance's proposal are as follows:

- Corrective maintenance: Work necessary to bring the building to an acceptable standard (often as recommended by the conservation plan). This maintenance is necessary to combat humidity, therefore, treatment of moisture is proposed every year for the building.
- Planned/preventive maintenance: Works to prevent repeated failures during the life of the building. This maintenance requires cleaning and paint work throughout the building. For wooden door and windows, linseed oil paint is proposed to protect the wood as it allows wood to breathe therefore it will not rot and will last for centuries. Building's surfaces should also be painted with weatherproof paint every 5 years.
- Emergency corrective maintenance: work which must be started immediately for health, safety reasons or which could result in rapid deterioration of the structure or fabric if not carried out. Broken louvres, structures, window, window's frame, and doors will be replaced with new. Areas that affected by mold should be handled first to remove harm and hazard to occupants and building.

By implementing a comprehensive maintenance plan, an organization can optimize operations, minimize costs, and ensure asset reliability. For this building, the building maintenance plan provided is a maintenance schedule that covers daily, weekly, monthly, and annual maintenance works. For maintenance frequency involving every 3 years and 5 years, the maintenance plan needs to be updated according to the current situation.

5 Conclusion

In order to preserve the architectural authenticity of this building, this information is evidence that can be a reference when it comes to building repair and upgrading works. And in line with the development of technology and the 4ir industry, this study completes the requirements in HBIM (Historical Building Information Modelling). By having visual inspection, obvious defects are easily identified. The defects are investigated either caused by humidity, weather or any other natural factors such as direct sunlight or strong wind during rain. Paint scheme, original materials such as timber, will be considered for conservation work of repainting using the right material/coating. This study could help HBIM by using the

data to identify specific works, tools and method for conservation works. After doing restoration and conservation works, maintenance is the most important work to preserve historical building. By having this data, conservator could provide daily, weekly, monthly, annually or any specific term of maintenance works to the building owner or care taker. All of this will be great help to historical building's owner in gathering data of their buildings to do restoration and maintenance works to embrace weather and climate challenge in the future. This could be done by doing the right restoration and conservation works as provided by research, and maintain good care of the building by following the proposed maintenance works provided.

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