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## BUILDING CONDITION ASSESSMENT AND DEFECT ANALYSIS ON HERITAGE SHOPHOUSES IN PENANG, MALAYSIA: CASE STUDIES

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**ABSTRACT:** This paper presents the condition of building and defects analysis on shophouses constructed before 1900s and after 1900s. In general, difference types of material used, types of construction and building defects will show the different condition of the building. A survey was carried out on two types of shophouse in Penang which is at Armenian Enterprise (built before 1900s) and George Town World Heritage Incorporation (built after 1900s). All data related to the buildings was taken through site observation and informal interview between researcher and the technical staff at Majlis Perbandaran Pulau Pinang (MPPP), Heritage Department and also building owner. Each elements of the building such as roof, wall, ceiling, floor and also services was carefully examined to find out the type of materials used and their condition. The compressive strength on columns and walls was determined through the Rebound Hammer Test. Based on the result that obtained from the test, the different number of rebound hammer was collected although it was taken on the same surfaces of walls and columns. It is happened because of various factors such as surface smoothness, moisture content and others that gave different result of rebound number. There are many type of common defects occurred in both buildings such as dampness, termite attack, cracking, plaster loose, efflorescence and also blistering of paintwork. All of these are depends on the age of building, environment condition, the building function and also maintenance work that was carried out on each building.

**KEYWORDS:** condition of the building, shophouse, compressive strength, building defects

### INTRODUCTION

'Shophouse' is one of the buildings, which belongs to the residential and commercial sector. Basically, shophouses in George Town fall into 6 main historical styles which is include Early "Penang" style, "Southern Chinese" Eclectic style, Early Straits Eclectic style, Late Straits Eclectic style, Art Deco style and Early Modernism style where each of shophouses style will shows the differences of building condition. Defects and damages in the building are common phenomenon to building mostly. Defects can be referred to fault on something that detract from perfection, whilst building damage can be seen when any structure, material, equipment and also element of the building was not fully functional.

Visual inspection is the easiest and the most fundamental method to use in order to inspect the existing structure. However, this method may not be applicable for inspecting defects which does not appear on the surface. Therefore, non-destructive test may use to assess the properties of a material, component or system without causing the damage.

Armenian Enterprise at Lot 124, Armenian Street was chosen as first case study as well as a sample of shophouses built before 1900s. This property was built in early 1890's to 1910's and was referred as Early Straits Eclectic Style. In addition, the GTWHI is located at Lot 116 & 118, Acheh Street was chosen to correspond to the shophouses that was built after 1900s. This property was built in 1940 which has been referred as Late Straits Eclectic Style.

### METHODOLOGY

Before the building inspection work was started, the approval from building owner must be obtained. The inspection of building condition requires a few observations and procedures to facilitate the evaluation of building condition. In this study, the inspection started from outside to inside areas of the building. There are two types of inspection used to evaluate the condition of the building which is, visual inspection and non-destructive test. Each elements of the building such as roof, wall and others was carefully examined. After that, there are two type of tests were carried out to determine the compressive strength on building structure such as columns and walls and also to establish the thermal comfort for external and internal space of the building.

### OBSERVATION, RESULTS AND DATA ANALYSIS

#### 1. Roofs

The roof at Armenian Enterprise was used asbestos, while terracotta tiles were chosen as roof tiles at George Town World Heritage Incorporation (GTWHI). The roofs condition for both buildings can be classified as poor condition where are damp patches due to roof leakage can be seen easily at Armenian Enterprise. Meanwhile, the roof tiles at GTWHI have not more than 5 number are slipped and

broken (Figure 1). Air-well is constructed at the centre of the building in Armenian Enterprise to allow enough ventilation and natural lighting inside the building.

Basically, roofs are laid on timber battens and bound by timber mortar. They were supported by purlins set into the load-bearing gabled walls. Horizontal timber purlins which has been referred as roof beams are installed between load-bearing walls and acted as brace for the structural party walls. There are some limitations during conduct the inspection where the roofs cannot be access.

## 2. Walls and partitions

Internal walls were predominantly consists of soft burnt clay bricks construction with a mixture of lime and sand at both shophouses. The load bearing walls at both sides of the shophouse were support the roof load through timber purlins which is span horizontally across the width of the building. Wall surface at Armenian Enterprise throughout the ground floor was found in poor condition, with various areas of damage due to flake of plasterwork and water staining noted into wall decoration as shown in Figure 2. Timber decay and mould growth also were appeared at the internal walls and partitions walls. These defects are the result from the continual damp conditions.



Figure 1: Slippery and broken roof at GTWHI building



(i) Loose plasterwork of brickwork



(ii) Water staining on wall

Figure 2: Common building defects on wall

However, the external walls condition at GTWHI is in fair condition. There is no crack that related to the foundation movement. The internal walls conditions are in poor condition. Efflorescence due to chemical actions inside the bricks and plaster loose (Figure 3) are the common defects that appeared on internal walls especially at store area. This problem was occurred because the building has lack of damp proof membrane. The damp proof membrane must be provided on the floor to prevent absorption of salt from the soil.

## 3. Floors and staircase

Floors throughout the ground floor at Armenian Enterprise predominantly made from cement concrete and timber floor were used at the first floor. From the observation, internal floor of the building



Figure 4: Termite attack can be seen on timber planks at the first floor

can be categorized as poor condition. Termite attack and timber decay (Figure 4) are the most common defects that appeared on the internal floor. Special investigations are needed to solve the problems. Whilst, the floor condition at GTWHI are in good condition where there is no defects occurs.



Figure 3: Plaster loose near to the store area at GTWHI building

In Armenian Enterprise, there are two numbers of staircases which is located at dining room and kitchen area. They were made from timber construction and granite on the lower steps. Granite is used to avoid timber steps and frames from contacted with the wet floor, as well as symbolizing permanence and strength. Staircase handrails were also found to be in a poor condition due to timbers



decay on the top and below of the handrail (Figure 5). Overall, the staircase condition at Armenian Enterprise was in poor condition and some part of the damage timber need to be repaired and changed immediately. However, all staircases that provided at GTWHI are in good conditions.

#### 4. Ceilings

There are no ceiling installed at the ground floor on Armenian Enterprise building. Suspended ceilings that made from timber were used at the first floor. Ceiling area within the section of the building is generally in poor condition. This is because there are many dirty patches and damp patches found on the ceiling. Dirty patches were noted on the ceilings because there is no insulation under joists.

Most of the ceilings at the ground floor on the GTWHI building were made from suspended type and used plaster board. Generally, ceiling areas within the main section of the building are in acceptable condition. However, water staining on ceiling has obtained at store as shown in the Figure 6. It was caused by the absence or ineffectiveness of damp-proof course in the floor upstairs. Based on interview with the staff of the building, they mentioned that the source of dampness has been repaired but they are still waiting for a budget from Local Authority to paint the wall and ceiling. There is no immediate repairs are necessary at the present time because the ceiling is still in good condition.

#### 5. Electricity

In Armenian Enterprise, electricity meter and consumer units are located in front of the buildings. The electrical system within the premises appeared to be in good condition since it can functioned properly. Each conductor was surrounded by insulation that was enclosed by an additional protective casing. However,



there is no adequate cover to place the electricity wires and others. The electricity wires need to put in a box or something that can protect the material inside the meter unit. From Figure 7, it can be seen that the electricity wire look messy and harmful to everyone.

Based on the information, GTWHI building is connected to main electric supply. The electricity meter and consumer units are located in front of main entrance of this building. The wiring on this building appeared good and protected. Even after three times the renovation work was done, there is no major defect on services and the electricity circuit is still in good condition.

#### 6. Sanitary fittings

The sanitary fittings are generally modern in design and appeared to be serviceable. Floor areas and plumbing connections beneath the shower areas in toilet at the ground floor cannot be inspect because these area are concealed within. The water are comes directly from Perbadanan Bekalan Air (PBA), Pulau Pinang.

#### 7. Dampness

Damp penetration is one of major serious defects in building that caused deterioration on the both buildings structure. Moreover, it can also affect the health of the occupants and damage the building finishing. From the observation, researcher was found that there are several ways to dampness arising, including direct penetration through the structure, faulty rainwater disposal, rising damp and also dampness in solid floors.

Damp also can affect the physical properties and endurance of materials which also may create ideal conditions for termite attack and beetle infestation. For example, a staircase which is near to the kitchen area at Armenian Enterprise was not quite saved to use due to termite attack problems. The measurement of moisture in walling material can be determined using a carbide moisture meter, while an electrical resistance can be used in order to obtain accurate measurements of the moisture content of timber within limited ranges.

#### 8. Crystallization of salts in brickwork

In general, the symptoms of crystallization of salts in brickwork are including the presence of white powder or feathery crystals on the surface (efflorescence), surface disintegration of the



Figure 5: Timber decay appeared on the handrails of staircase



Figure 6: Water staining on ceilings

brickwork and decay of individual brick in some cases. This defect was caused by chemicals action in the bricks. Efflorescence was happened when chemicals in the bricks are dissolved by water and come to the surface where they form a crystal especially when the surface dries. This may lead to crumbling of plaster and make the adhesion of decoration loss.

### 9. Thermal comfort test

Thermal comfort test was carried out to obtain the data which is may affects the human comfortability in while doing their job. The data includes surface temperature, temperature, relative humidity and sound level. All the data recorded for internal and external space of the building.

The test results show that thermal comfort outside of both buildings can be categorized as comfort zone. However, based on Table 1, the sound level at GTWHI was greater than Armenian Enterprise building which was recorded at 60dB. This is caused by the location of the building that near to the main road such as Carnavon Street and Acheh Street. Therefore, noise from the vehicles becomes one of the factors that contributed to the increased noise around the building.

Same with description above, thermal comfort inside the both buildings can be categorized as comfort zone. However, relative humidity at Armenian Enterprise was greater than GTWHI. This happened because of the outside building elements are more exposed to the sunlight. When weather is very hot at outside, mechanical ventilation such as fan or air-conditioning is needed. Mechanical ventilation will raise the relative humidity inside the building compared to the outside of building. The relative humidity increases when the temperature and dew point are get close together.

### 10. Rebound Hammer Test

The Schmidt Rebound Hammer was used to determine the compressive strength on columns and walls. It works on the principle that the hardness of the surface against which the mass impinges is depends on the rebound of an elastic mass.

According to Table 3, each column of both buildings can be categorized in fair condition where the average of rebound number on columns, external walls and internal walls are 20–30MPa. The lowest reading of compressive strength on columns was recorded at GTWHI. This is happened because of environmental actions and deterioration on that column which it can influence the results. From the informal interview with the staff at GTWHI, they were mentioned that there is corrosion on the steel reinforcement inside the column which can affect their compressive strength.

In addition, the highest rebound number on external and internal walls was noted at GTWHI. It is because the renovation work was done on that building for two times since 2000 and 2003. The renovation work was making the GTWHI building structure have good structure integrity than Armenian Enterprise.

## CONCLUSIONS

In conclusion, there are six common building defects on two types of shophouses which includes dampness, loose of plastering, termite attack, efflorescence, cracking and blistering of paintwork. The condition of shophouse at Armenian Enterprise, Lot 124 is in poor condition due to many building defects. Meanwhile, the condition of George Town World Heritage Incorporation (GTWHI) is acceptable. This is because of the building age, the quality of materials used, maintenance aspect and others. Therefore, in order to preserve the value of heritage building, each of shophouse need to be maintained and conserved by the conservation architects, surveyors, historians and also planners.

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Table 1: Results of Thermal Comfort Outside the building

Equipment	Armenian Enterprise	GTWHI
Surface temperature (°C)	32	29
Temperature (°C)	34	27.3
Relative humidity (%)	60	64
Sound (dB)	58	60

Table 2: Results of Thermal Comfort Inside the building

Equipment	Armenian Enterprise	GTWHI
Surface temperature (°C)	30	29.5
Temperature (°C)	30.3	27.3
Relative humidity (%)	69	65
Sound (dB)	50	50

Table 3: Results of Rebound Hammer Test

Building structure	Average reading, Mpa (Armenian Enterprise)	Average reading, Mpa (GTWHI)
Column	25	23
External wall	34	35
Internal wall	26	23