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GO GREEN2015

INTERNATIONAL POSTGRADUATE CONFERENCE ON GLOBAL GREEN ISSUES

"Incorporating Green Approaches for Resilient Future"

7 - 8 OCTOBER 2015 | Dewan Kuliah Al-Khawarizmi

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Characterization of Lime Plaster of Ipoh Royal Club for Conservation Purpose

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Abstract

This study addresses the defects and performance of lime mortar and plaster due to dampness which is one of the most severe occurrences that leads heritage building to decay and deteriorate. Acting as main component of building's historic fabric, lime mortar and plaster are significantly affected by environmental factors and thus demand further proper conservation and repair works. The lack of understanding on the evolution of the material characteristics and wrong decision making on the new composition of lime has further resulted in the recurrence of decay and deterioration of the material. The purpose of this study intends to investigate andidentify the lead source of dampness in the walls ofthis heritage building in Ipoh. The detail study sought to determine and analyse scientifically theoriginalmortar and plaster characteristics in terms of their moisture content, strength and composition which is affected by dampness. The knowledge of the decay progressions and its contributing elements with the studied characteristics of the material will allow a better understanding on the usage of this materialas well as proper training to interpret clues on techniques in order to succeed in future conservation works.

*Keywords:*Heritage Buildings, Building Defects, Building Conservation, Lime Mortar, Lime Plaster, Dampness

1.0 Introduction

Lime plasters have been widely used as rendering of brickwork, and stonework since remote times. For decades plaster had covers the facade of the heritage building and help preserves the material that constitutes the structure of the wall from external weather conditions. Breathability and vapourpermeabilitycharacteristic of lime hasallow moisture to pass through them and then the moisture disperseseither externally or internally. This characteristic helps to prolong life of the heritage buildings.

Despite the lasting qualities of materials, heritage buildings are facing deteriorations due to aging process and several factors including climatic conditions, dampness and structural failures. Major defects that occur the most in heritage buildings is dampness. Moisture and dampness is the most frequent and dangerous defects in buildings, and contributes more than 50% of all known buildings failures (Al-Hafzan Abdullah Halim et. al., 2012). According to Al-Hafzan Abdullah Halimet. al., 2012 too, dampness can be defined as water penetration through the walls and certain elements of a building.It is important to properly identify the source of the problem to eliminate the dampness defects.Ifthe source or cause of the problem is not well treated, or the problem is incorrectly diagnosed, the original problem will continue to develop and unnecessary or incorrect repair work may cause added problems.

This research is concerned with lime-based plasters for the conservation of heritage buildings.Limeplasters need proper repairs techniques and conservation work as they are greatly affected by environmental factors. The material, sometimes have change from their original composition which cannot be examinedvisually by naked eyes. Although the properties of the materials can be identified through the texture, color and moisture, but the original composition cannot be recognized because of the material may be too old and they may have already combined with new elements.

The purpose of experimental analysis done on lime plasters in this research was to determine the elemental composition and the strength due to aging process and defects factors. Therefore, information of the original condition of the materials is important as well as the factors that have led to the formation of the current situation of the material used in the building.It is important to really understand the original materials with right composition used for conservation work.

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2.0 Case Study: Royal Ipoh Club Building

For this research, the chosen case study building is Royal Ipoh Club, Perak which isone of the old landmarks overlooking the Ipoh Padang.Royal Ipoh Club is a Tudor style colonial building ages about 120 years from the 1895 was in use as laundry house for the officers by the Japanese Imperial Army. It may be established much earlier than 1895 but records of the history were lost during the Japanese Occupation during World War 2. This building is located at JalanPanglima Bukit Gantang which has been identified and include under Entry Point Projects to conserve and preserve the heritage buildings. This Entry Point Projects was under the Ipoh Special Area Draft Plan (RKK). Royal Ipoh Club was among 14 heritage buildings under category 1 and has been listed under the National heritage Act 2005.This building was chosen because it had been severely affected by dampness and it would provide a basis for further studies to be conducted on buildings located in similar conditions and situations.

2.1 Building Details

The building under study is one and half storey clubhouse consists of few functional room like lounge, billiard room, gym, office, library etc.The external walls of the building are constructed with brick walls with timber strip finishes in the inside wall. Windows are made of glass louvreblades fixed in hardwood frames with hardwood doors. The front elevation faces the west, the right elevation faces thesouth, the back elevation faces the east and the left elevation faces the north. The compound is full paved areas.

Figure 1: Front elevation of Royal Ipoh Club building

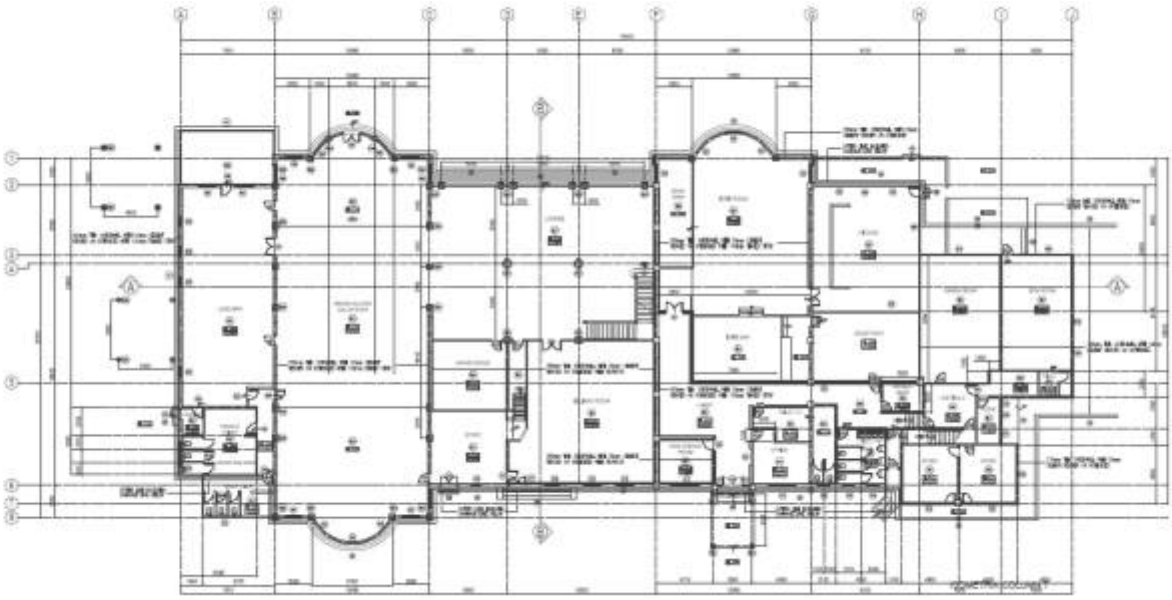

Figure 2: Ground floor plan for building under study

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3.0 Method

This study sought to identify areas in the walls of the building severely affected by dampness throughvisualobservation and experimental method. Four major phases or approaches to any dampness investigation which are visual inspection, non-destructive test by using moisture meter, destructive test for more detail investigation, and homing in on the problem (Al-Hafzan Abdullah Halim et al. 2012; Burkinshaw and Parrett,2004).The study was carried out usingmethod consists of 2 main phases which are Phase I; Visual Analysis, and Phase II; Experimental Research.

3.2 Phase I: Visual Observation & Analysis

First phase of this study was aimed at visual observation of dampness problems occurs in study building. Based on this observation, samples location, numbers and types of defects were determine. Visually observes defects occur on building were mapping to the drawings.Sadbhor and Botre (2013) explained that visual inspection consists of 3 items which are visual screening, data collection and condition assessment.This procedure will help in determine the factors that may lead to the defects happen and to fully understand the building condition. According to Al-Hafzan Abdullah Halim(2014), types of defects can be identified and recorded based on these symptoms which are fungal attack and unwanted growth, erosion of mortar joint, peeling of paint, insects, termites attack and decay, roof defects, dampness through walls, defective wall plaster, poor installation of air conditioning system, cracking and slanting wall and defective rainwater pipes.

3.2 Phase II: Non-destructive & Destructive Tests

Experimental research in Phase II is composed of 2 tests: 1. In-situ / Non-destructive tests,2. Laboratory /Destructive tests. Non-destructive tests were conducted on plasters which are found to be damaged during the visual observation. This test was carried out without causing any damages or destruction to the fabrics of the study building. Moisture meter and concrete hammer test were instruments used to determine the relative humidity and the hardness of wall surfaces.

In order to achieve precise quantitative results a laboratory analysis was carried out. A destructive testing method, X-ray Fluorescence spectrometric (XRF) is used to identify the composition of materials. Results from the test will determine the mainmaterial present in the old plaster and the ratio for the mixture.A total of 16 lime plasters samplings weighing 10 grams from defects area were taken to laboratory for XRF spectrometric analysis.Samples are brought into a clear crystalline fused bead (Figure3b) by fused with lithium tetraborate. This fused bead is then irradiated by high energy X-Ray beam to produce a secondary x-rayusing XRF machine (Figure 3c & 3d).

Figure 3a.Fused process

Figure 3b. Clear crystalline fused

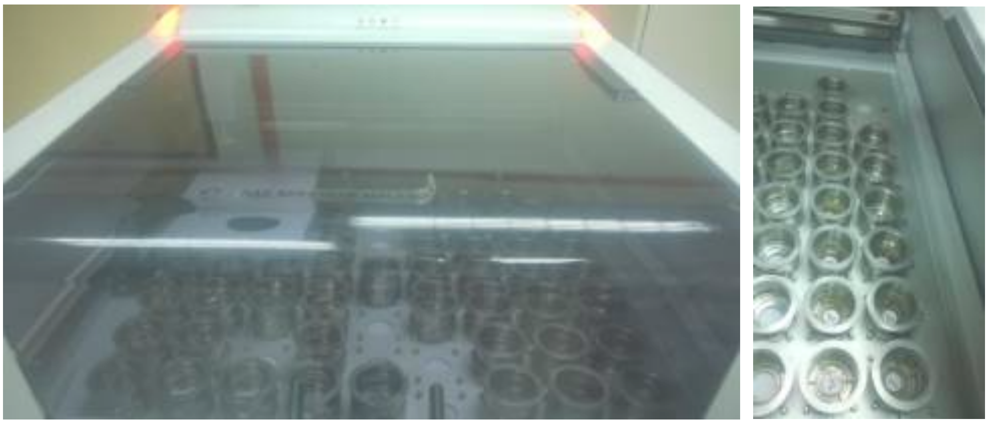

Figure 3c & 3d.Secondary x-ray using XRF machine process

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4.0 Result and discussion

4.1 Result from site inspection

The site inspection carried out led to the identification of several symptoms exhibited by the studybuilding.External walls were considered inthis study because of the interior wall of the building was timber strip finishes. The symptoms observed includesmould growth (Figure 4a), greenish stain and peeling of paint(4b &4c),stain and cracks (4d&4g), cracks in columns (Figure 4e), and blistering of paint and holes (Figure 4f)etc.Dampnesssymptoms on the walls located in the Southern, Western and Northern, orientations reached heightsof 900 mm respectively. These symptoms provided a basis for the second stage of the investigation tobe conducted. Peeling of paint was the main defects occur on the building walls. Peeling of paint occurs on building facades, mainly on plastered wall that exposed to excessive rain and dampness (Kayan, 2005).


Figure 4a.Mould growth


Figure 4b. Greenish stain


Figure 4c. Greenish stain and peeling of paint


Figure 4d. Stain and crack


Figure 4e. Cracks in column


Figure 4f. Blistering of paint and holes


Figure 4g. Crack and stain

Greenish stainwasidentifiedmost on the surfaces of the walls located in the eastern orientation.Thesesymptoms identified in the wall of the building kitchen due to leakage from ducting. A closer examination of the whole building revealed no symptoms of risingdampness. Defect also occurs due to condensation from air conditioning condensate pipe line.Referring to AbdulGhafarAhmad(2004), subject to building function, structures and effects on building fabric, several factors should be considered before installing air-conditioning units in heritage buildings because some defects such as leakage, dampness, mould growth will occur.

4.2Surface Hardness

Concrete test hammer was used to determine the compressive strength on building walls. A series of 5 rebounds were carried out for each test and was performed in different places on the wall. Horizontal impact direction used to test the hardness of wall surface (Figure 5). The results of the tests on surface hardness are gathered in Table 1.

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Figures 5 – Horizontal orientation of hammer during a measurement

Table 1. Results of surface hardness tests

Location	Rebound Value (n) (Impact Direction →)/	Location	Rebound Value (n) (Impact Direction →)/
External Wall			
1. Front Elevation, F1	30	9. Rear Elevation, R3	18
2. Front Elevation, F2	24	10. Rear Elevation, R4	25
3. Front Elevation, F3	16	11. Rear Elevation, R5	24
4. Front Elevation, F4	16	12. Rear Elevation, R6	27
5. Front Elevation, F5	22	13. Right Elevation, H1	19
6. Front Elevation, F6	18	14. Right Elevation, H2	22
7. Rear Elevation, R1	14	15. Left Elevation, L1	15
8. Rear Elevation, R2	18	16. Left Elevation, L2	19

Referring to Table 1, the test results obtained by concrete hammer test shows that most of defects walls can be categorized in poor condition with average rebound number are below 20.The lowest reading of compressive strength is on R1 wall with rebound number 14 while the highest rebound number was noted at F1 wall which is 30.

4.3Relative Humidity

Moisture meter was allocated and tested at 5 points on wall and the data is determined by relative humidity reading on the equipment. The result are gathered in Table 2.

Table 2. Results of relative humidity

Location	Relative Humidity rH (%)	Location	Relative HumidityrH (%)
External Wall			
1. Front Elevation, F1	51.7	9. Rear Elevation, R3	58.8
2. Front Elevation, F2	75.3	10. Rear Elevation, R4	46.3
3. Front Elevation, F3	87.7	11. Rear Elevation, R5	76.6
4. Front Elevation, F4	82.2	12. Rear Elevation, R6	76.9
5. Front Elevation, F5	84.2	13. Right Elevation, H1	54.1
6. Front Elevation, F6	84.4	14. Right Elevation, H2	44.4
7. Rear Elevation, R1	56.3	15. Left Elevation, L1	90.4
8. Rear Elevation, R2	59.2	16. Left Elevation, L2	68.5

Among all the affected walls, wall of the bathroom which is F3 located in western orientation which is the front elevation of the building were high in percentage. This is due to wall is closer to water source. Same goes with walls of the kitchen, R5 and R6.

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4.4 Result from X-ray Fluorescence

Analysis of the lime plasters by XRF was performed on samples prepared in the form of glass beads. The results of analysis are gathered in Table 3. Based on the results, most of the samples shows high percentage presence of silica (SiO2) with average percentage is 39.20%.Results from analysis of samples showed that that most of themwerevery similar in composition. Silica and calcium oxide predominate, withsubstantial amounts of alumina, titanium dioxide, magnesium and lesser amount of iron. Manganese oxide and phosphorus pentoxidedoes not occur at high levels in all samples.

Table 3.Composition (% oxide) of the samples analyzed by XRF

Plasters	**CaO (%)**	**MgO (%)**	**SiO_2 (%)**	**AlO_3 (%)**	**Fe_2O_3 (%)**	**TiO_2 (%)**	**K_2O (%)**	**MnO (%)**	**P_2O_5 (%)**	**loi**
1. F1	16.27	0.23	41.39	3.16	0.29	0.92	0.80	0.03	0.05	15.8
2. F2	12.07	0.43	41.57	3.95	0.44	1.11	0.94	0.03	0.06	18.0
3. F3	16.05	2.61	36.22	3.72	0.32	1.31	0.72	0.02	0.08	24.2
4. F4	22.00	1.06	31.65	2.87	0.31	1.91	0.37	0.03	0.09	32.6
5. F5	21.57	0.76	35.96	1.72	0.19	1.20	0.23	0.02	0.08	19.2
6. F6	23.35	0.71	36.80	1.32	0.19	0.34	0.17	0.02	0.04	21.5
7. R1	14.36	0.93	27.60	4.62	0.23	7.22	0.41	0.01	0.11	32.8
8. R2	14.67	1.21	38.27	3.37	0.40	3.00	0.60	0.02	0.08	19.7
9. R3	15.67	0.57	38.13	3.92	0.40	2.02	0.84	0.02	0.07	18.5
10. R4	7.08	0.25	45.12	3.04	0.65	0.75	0.19	0.03	0.06	11.0
11. R5	8.06	0.29	44.96	3.28	0.67	0.74	0.18	0.03	0.05	11.6
12. R6	9.29	0.37	45.33	3.36	0.79	0.51	0.17	0.03	0.04	8.87
13. H1	11.15	0.38	42.44	4.44	0.45	1.16	0.82	0.03	0.05	14.8
14. H2	12.60	0.45	41.00	4.18	0.56	1.40	0.80	0.03	0.07	16.5
15. L1	20.63	0.52	39.66	2.10	0.25	0.42	0.33	0.02	0.04	18.4
16. L2	18.24	0.39	41.09	1.65	0.23	0.46	0.45	0.02	0.04	16.5

loi – loss in ignition

7.0 Conclusion

In conclusion, there are 3 common defects appear on this building due to dampness includes cracks, blistering of colors and staining.This study focuses on the technical aspects that will helps to improve the understanding of building conservation process and emphasize the importance of investigation and analysis of building defects. The study shows that all building wall defects are same in composition with poor strength condition. Heritage building should be properly managed by deal with the causes of dampness and its related problems do not occur or, to at least minimize any loss of the building’s original fabric to tolerable values.

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