Wall finishing materials and heritage science in the adaptive reuse of Jakarta heritage buildings

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Abstract. Given its tropical setting, moisture problems are inherent issues found in walls of heritage buildings in Indonesia that require replacement of wall finishing materials with specific properties. This is where heritage science becomes an important approach in the creation of plasters and paints that best resemble its original and/or provide better performance through innovations. Heritage science possesses great potential in improving evidence-led conservation work in Indonesia by incorporating properties of traditional materials with present technology for cultural sustainability that is gaining urgency in the midst of burgeoning population growth. However, despite its growing application for historically significant heritage buildings, the need for preliminary scientific testing is not commonly acknowledged and applied in the adaptive reuse of small-scale heritage buildings in Indonesia. Therefore, this paper studies two UNESCO-funded pilot projects in Jakarta and tracks the role of heritage science throughout their conversion, and aims to evaluate the constraints, by conducting literature studies and eight interviews with various stakeholders involved. It is found that heritage science is yet a key player in Indonesian conservation works, however, it helps uncover material properties of wall finishing materials that best tackle moisture problems in Jakarta heritage buildings.

1. Introduction
Yung and Chan [1] stated that the adaptive reuse of heritage buildings is part of sustainable urban regeneration that involves the revitalization of otherwise decayed and obsolete buildings for better living environments with environmental, social, and economical benefits. Hence many heritage buildings are found to be converted to commercial buildings by small-scale developments to sustain its life in the long run.

2. Moisture Problems in Heritage Buildings
However, Smith [2] explained that moisture is one of the main sources of problems found in heritage buildings, especially in the tropics such as Jakarta. According to Bertoldi [3] despite being historical artifact themselves, wall finishing materials—such as plasters and paints—need to be replaced to protect the damaged building from further deterioration. According to Ayurdhawan et al. [4], replacement is important as moisture problems can cause damages on the walls as indicated by the presence of loose/flaking paints/plasters, efflorescence, the disintegration of bricks and renders, cracks, rising damp damages, and plant, fungal, and algae invasions.

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3. Heritage Science

This science is where heritage science serves to bridge the needs of both transforming heritage buildings into commercial spaces whilst protecting them from further moisture damage without losing its value as a historical object. Heritage science was first introduced in 2006 in the UK and is a discipline that combines scientific research and the conservation of heritage buildings. Strlic [5] stated that Heritage Science provides evidence for sustainable conservation and improves the wellbeing of communities surrounding the heritage sites. Brokerhof [6] elaborated that in conservation works, science plays an important role in uncovering traditional knowledge of the past using present technological advances to create new materials innovation for a better future. Heritage science fulfills its role as scientific input can enhance the process of replacing existing damaged materials with material properties bearing the closest resemblance to its original [7]. Based on the author’s observation, although frequently applied in practice for monumental heritage buildings, heritage science is a relatively untapped discipline in the commercial adaptive reuse of small-scale heritage buildings in Indonesia [9]. The urgency to scientifically evaluate the composition of existing wall finishing materials and the environmental context of the building to determine compatible replacements are often overlooked due to lack of awareness and financial constraints. On that account, this paper aims to analyse the application of heritage science specific in two small-scale heritage buildings in Jakarta into commercial spaces, namely Kedai Seni Djakarte and Historia Café.

4. Research Methodology

The study in this paper began with a literature review to identify the sources of moisture problems in heritage walls, subsequent compatible materials needed to replace deteriorated ones. Based on these theories, a case study was conducted to examine the role of heritage science, using two small-scale adaptive reuse projects in Jakarta. Lastly, a total of eight interviews were conducted to two private building owners, two heritage architects, one heritage expert from a local NGO, one contractor, and two suppliers of breathable plasters and paints involved in both projects. The purpose of the interviews was to gain insights on the application of heritage science in conservation works of both case studies.

Two UNESCO-funded pilot projects are chosen as they best represent the preliminary step taken by the Indonesian government to forge collaboration between private heritage building owners, heritage experts, and NGOs in adaptive reuse projects and made the online documentation accessible to the public. Case Study 1, Kedai Seni Djakarte (two-storeyed building occupying 320sqm) and Case Study 2, Historia café (two-storeyed building occupying 400 sqm) were built in 1913 as part of a larger office complex Batavia Zee en Brand Assurantie Mij by architect P.A. Moojen and 1914 for a trading company Matschappij voor Uitvoer en Comisiehandel (MUCH) by architect Eduard Cuypers company respectively. Both buildings are classified as Heritage Building Grade A—buildings with high cultural significance—as regulated by the Indonesian Provincial Regulation No.9 of the year 1999 regarding the Conservation and Reuse of Built Heritage.
5. Summary of Outcomes

5.1. Causes of Moisture Problems in Heritage Buildings Walls

Figure 1. Sources of Moisture in Kedai Seni Djakarte and Historia Café

In the case studies, it was found that water penetration occurred through various sources; through capillarity of ground water, exposure to and leakage of rainfall, and the capillarity of a flooded gap between the two adjacent buildings. In both case studies, leakage was caused by long-term obsolescence which caused the roof to be in a severely deteriorated condition. The existence of a gap with 10cm in length between both buildings was discovered further exacerbate this condition as the top of this gap was not covered with any flashing which periodically caused prolonged flooding and increased water penetration to both buildings. Twenty years of abandonment resulted in both masonry walls containing high humidity.

5.2. Material Properties of Walls Finishing Materials: Plasters and Paints

5.2.1. Breathable Plasters. Reichel, A., Hochberg, A., & Köpke, C. [8] stated that classic plasters of the past are made of quicklime as it possesses good breathability as indicated by its porosity, elasticity, and velocity of capillarity. As members of a local NGO named Pusat Dokumentasi Arsitektur (Center for Architectural Documentation), Abieta, et al. [9] released a conservation booklet guide stating that replacement of plasters must be based on scientific research on its composition to enable the replacement plasters to contain similar properties.

Figure 2. Experimentation and Mixture of New Plaster on Site

Figure 2 shows the experimentation done on site for the composition of plasters used in both buildings. Grounded red brick, lime powder, Portland cement, and sand were bought from a local supplier and experimented manually which resulted in the discovery of its ratio that equals to 2:1:1:2. Interviews conducted with the architects, contractor, and materials suppliers involved revealed that the ratio was a result of a combination and modification of two sources: existing data sheet of plaster used...
in another heritage building (see table 1), and the empirical knowledge passed down from one construction worker to the other. The purpose was to imitate the plaster bearing the closest resemblance to the original while ensuring its breathability as indicated by the high value of liquid water permeability. High permeability allows moisture inside humid walls to evaporate from the surfaces [2].

**Table 1.** Data Sheet for Plasters Sampled from Bank Indonesia (2009) with 2: 1 ratio for Sand: Lime Powder

| Material Properties | Results          |
|---------------------|------------------|
| Physical Aspects    |                  |
| Density             | 1.5 g/m³         |
| Porosity            | 33.2%            |
| Composition         |                  |
| Sand                | 65%              |
| Lime Powder         | 32%              |
| Capillarity         | 0.256 gr/minute  |

5.2.2. Breathable Paints.

Three types of paint were used in both case studies, two of which are classified as breathable paints. It was found that acrylic paint was used for the first floor of both case studies in 2012 as private building owners were oblivious towards the inherent moisture problems of the walls. However, following the pilot project in 2015-2016 Silicate Paint and Silicone Resin Emulsion Paint (SREP) were used for the adaptive reuse of both floors on Case Study 1 and only on the second floor on Case Study 2. These two paints were the most frequently purchased in the local market for conservation projects across Indonesia. The former is silicate mineral paint produced by the German company, KEIM, which is regarded as high-quality breathable paints albeit expensive—while the former is silicone resin emulsion paint (SREP) produced only within the local market under the name PT. Archielite Prima Konstruksi.

**Table 2.** Data Sheet for KEIM Mineral Silicate Paint

| Material Properties | Results          |
|---------------------|------------------|
| pH                  | 11               |
| Liquid Water        | 0.12 kg/m²h0,5   |

On the other hand, the Silicone Resin Emulsion Paint is only distributed within the local market. It is a local home-produced paint which had been used for conservation purposes of several heritage buildings across Indonesia. Due to its local manufacture, the price of this paint is much lower than that of its international counterpart. Hence SREP becomes the second popular choice for authorities working in the field of conservation in Indonesia. Table 3 below is the results of a laboratory test to scientifically examine its material properties.
Table 3. Data Sheet for Silicone Resin Emulsion Paint (SREP)

| Material Properties | Results       |
|---------------------|---------------|
| pH                  | 9.70          |
| Porosity            | 3.8%          |
| Capillarity on       | 0.016 gram/minute |
| Bligon              |               |
| Capillarity on Brick Wall | 0.216 gram/minute |
| Brick Wall          |               |

From the tables above, it can be concluded that both types of paint share similar material properties which make them breathable, which are the high pH value and water vapor transmission rate. High pH value indicates the ability of plasters to prevent fungal and bacterial growth that burgeons in an acidic environment. Water vapor transmission rate is the velocity in which water sourced from moisture can vaporize from within the historic walls. All these properties demonstrate the breathability of the paint to withstand further moisture damage. From the data above it can be concluded that both silicate and silicone resin emulsion paint are breathable hence compatible for very humid walls.

5.2.3 Physical Inspection of Current Walls Condition. After having analyzed the substances of plasters and paints used, a physical inspection was conducted by the authors to determine the compatibility of plasters and paints used (See figure 3). In Case Study 2, the first floor (areas painted with acrylic paint) experienced significant damage than the second floor (painted with SREP). The walls with murals painted in acrylic paint experienced the most significant damage as indicated by the presence of severe flaking of paints, efflorescence, disintegration of the bricks (figure 3). This painting demonstrates the non-breathability of the paint which exacerbates the damage. Meanwhile in Case Study 1, although both first floor (painted with silicate mineral paint) and second floor (painted with SREP) experienced overall lesser damage than Case Study 2, cracks and efflorescence can be found in several areas in the first floor due to the existing severe case of rising damp.

![Figure 3](image-url)  
**Figure 3.** Damages observed in Case Study 1 (left) and Case Study 2 (right)

5.2.4 Challenges of Heritage Science Implementation in Jakarta Commercial Adaptive Reuse

5.2.4.1 Lack of public awareness regarding moisture problems and the importance of involving Heritage Science. By collaborating with NGOs and heritage consultants, private building owners were able to acquire vital insights on adequate wall treatment they otherwise would be unaware of. In both case studies, private building owners were initially unaware of the high humidity of the building walls which can be found by the false selection of paints initially. However, after the
collaboration with heritage experts during the pilot project, the right decisions are made in terms of breathable wall finishing materials used.

5.2.4.2 Limited financial, technological, and human resources for holistic preliminary scientific research. Kennedy [7] elaborated that Non-destructive testing includes the means of portable laboratory equipment such as near-infrared spectroscopy (NIR), X-ray fluorescence (XRF), hyperspectral imaging, and et cetera. Micro destructive testing, the gathering of very small samples in specific areas, was conducted in both case studies since the advanced equipment for non-destructive testing on site are not yet available in Indonesia as they are very expensive and require qualified human resources to operate them. In both case studies, data regarding the extended context of the site was not analyzed in detail. Measurements were only limited to humidity levels of the masonry brick walls indicated by a small device by the paint supplier that only indicates a high level of humidity only when it is beyond 4.

5.2.4.3 The omission of technical data sheets of wall finishing materials used. Both projects are pilot projects that are well documented and made accessible online at lestarikanbangunanunua.org in the form of pdf file. The public can gain an understanding of the conservation process comprehensively through the conservation plan. However, it is found that it did not include extended information on the history of interventions applied to the building, as information is only limited to literature-based studies and highly summarized description of repairs and other changes made to the building.

5.2.4.4 Non-scientific-based knowledge transfer regarding the composition of new plaster. The plaster ratio found to be breathable on two projects based on modification through direct experimentation on site and past scientific examination. Hence composition of plasters is often loosely based on construction workers’ empirical knowledge, which should have been scientifically strengthened and modified through the involvement of heritage science.

6. Concluding Observations
It is found that the material properties of wall finishing materials that best combat inherent moisture problems in walls of heritage buildings are those that indicate their high breathability. Breathable plasters and paints are indicated by (1) high pH value and (2) high water vapor transmission rate and capillarity. The plaster ratio was formulated through manual experimentation which was found to be 2:1:1:2 for red brick powder: lime powder: Portland cement : sand. Silicate Mineral Paint and Silicone Resin Emulsion Paint are both proven to be breathable which can be observed by the minimum damage experienced by the surfaces painted. From this study, it is concluded that heritage science is still a very rudimentary discipline in Indonesia when implemented for small-scale adaptive reuse projects for two commercial spaces. Challenges of implementing Heritage Science in the case studies are observed to be (1) lack of public awareness regarding moisture problems and the importance of involving heritage science; (2) limited financial, technological and human resources for holistic preliminary scientific research on existing materials; (3) omission of technical data sheets of wall finishing materials used; (4) non scientific-based knowledge transfer regarding composition of new plaster. However since Heritage Science is already used in conservation projects across Indonesia, it can be potentially developed and integrated into small-scale adaptive reuse projects.

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