



# Study of the Durability and Strengthening of Historical Building Construction in Yogyakarta

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## ABSTRACT

Yogyakarta has many historical buildings with a building age of more than 150 years. These buildings are historical heritage which is very important to be preserved because they are silent witnesses of events and stories that are beneficial for future generations. Historical buildings have had various conditions until now, namely they are still surviving in well-maintained conditions, have been damaged, or have collapsed. This article aims to determine the factors that affect the resilience of historic buildings and efforts to strengthen historic buildings used to protect against collapse. The research method carried out by the first step is to carry out direct visual observation of the current condition of the Pura Pakualaman building accompanied by primary data collection by conducting direct interviews regarding the condition and history of the building in relation to external and internal factors that affect building resilience, restoration efforts, renovations, strengthening that has been carried out, then analyzes the field data obtained to carry out a study of the resilience of the building against the factors that influence it and the effectiveness of the strengthening of the building that has been carried out. The results show that the internal factors that affect the durability of buildings are material age and maintenance management which have not been integrated, while the biggest external factor is the earthquake in 2006. Efforts to strengthen the building have been carried out starting from the roof because it is a critical element, then columns as structural strength, and wall reinforcement from cracks.

**Keywords**— *historical building, earthquake, Pura Pakualaman, resilience, reinforcement (key words)*

## 1. INTRODUCTION

The Pakualaman area is one of the cultural heritage areas stipulated by the Governor of the Special Region of Yogyakarta through Decree No. 186 of 2011 [1]. The spatial concept in the Pakualaman area has similarities with the Yogyakarta Palace but on a small scale, namely embracing the concept of Catur Gatra. This concept has elements of culture, art, economy and religiosity found in the elements of the center of government, center of social activity, center of worship, and center of the economy. Pura Pakualaman which was established in 1813 is the central palace of the Duchy government which is still valid today and was designated as a cultural heritage building through a decree of the Minister of Culture and Tourism on January 8, 2010.

In addition to these four elements, the Pakualaman area also contained the residences of princes, relatives and officials of the Pakualaman Duchy, known as nDalem. Until now, the nDalem is still inhabited by heirs from generation to generation, so that the Pakualaman area can be called a living cultural heritage area.

Historic buildings have had various conditions until now, namely they are still surviving in well-maintained

conditions, have been damaged, or have collapsed. Renovation and adaptation of historic buildings to obtain the utilization of new functions is an interdisciplinary effort that requires the cooperation and involvement of all parties in the investment process. Restoration to the splendor of these unique buildings often requires a striking balance between protecting the original substance of the structure and the requirements for future use. Choosing a reinforcement method that allows increasing the bearing capacity of brick walls while reducing disturbance to the historical content of the structure requires an individual approach to the problem and an intelligent analysis of the proposed solutions [2].

Likewise, if you look at the age of the buildings in the Pura Pakualaman complex which are more than 150 years old, damage and a serious threat of changing the shape of the building to a more modern one cannot be avoided. Since its establishment, many factors, especially internal and external, have affected the physical condition of the buildings at Pura Pakualaman so that the ups and downs of building maintenance are very important to study and trace.

In line with the background, several problems can be formulated, namely knowing what factors can affect the resilience of a historic building from the owner's side and how the owner's attitude towards strengthening efforts is being made so that the historic building is protected from collapse. This study aims to determine the factors that influence the resilience of historic buildings and efforts to strengthen historic buildings used to protect against collapse.

## 2. THEORITICAL REVIEW

### 2.1. Maintenance of Historic Buildings

According to the Law of the Republic of Indonesia No. 11 of 2010, concerning Cultural Conservation [3] in paragraph 5 of article 75 it is stated in paragraph (1) "maintenance is carried out by caring for Cultural Conservation to prevent and overcome damage due to natural influences and/or human actions". Provisions related to restoration are regulated in paragraph 5 of article 77. According to paragraph (1) "restoration of damaged Cultural Conservation Buildings and Cultural Conservation Structures is carried out to restore physical conditions by repairing, strengthening and/or preserving them through work reconstruction, consolidation, rehabilitation and restoration". In paragraph (2) it is stated that "the restoration of the cultural heritage building as referred to in paragraph (1) must pay attention to the originality of the material, shape, layout, style and/or workmanship technology, the original condition with the smallest possible level of change, the use of techniques, methods and non-destructive materials, and executor competence in the field of restoration".

In many cultural heritage areas, restoration as a conservation effort has proven to have a significant economic impact, but restoration must be carried out in accordance with the principles of cultural heritage protection [4]. In line with the principles of cultural heritage protection, it can be coordinated with the currently applicable national and regional regulations on the environment, landscape, history and culture, thus providing the necessary knowledge for the implementation of appropriate conservation policies for regional cultural heritage including collaborative management strategies among stakeholders. the interests of both the government, the private sector, and owners [5].

The Pura Pakualaman area is a cultural heritage area that has historic buildings and is still being personally maintained and used by family relatives from Paku Alam who occupy the Pura Pakualaman building. However, there are several parts of the Pura Pakualaman gandhok building that are still used for public purposes as school buildings. As a historical area, adaptive reuse of historic buildings is one aspect of sustainable urban construction. It is not only sufficient to give new functions to historical buildings, an appropriate strategy must be proposed for decision makers to achieve the maximum effect of cultural continuity and spatial improvement [6].

### 2.2. Risk of Damage to Historical Buildings

Damage risk assessment is needed, especially since the city of Yogyakarta is prone to disasters. It was recorded that there had been a major disaster in 2006, namely an earthquake and in 2010 when Mount Merapi erupted, most of the historic buildings and historic sites were affected. This condition makes each cultural heritage important for risk assessment [7]. The 2006 earthquake natural disaster resulted in many buildings being lightly, moderately, or severely affected, including buildings in the Pakualaman area. Following are some principles of earthquake-resistant buildings [8]: if a small intensity earthquake occurs, the building should not suffer damage to its non-structural and structural components; if a moderate intensity earthquake occurs, the building may suffer minor damage to its non-structural components but the structural components may not be damaged; whereas if a large intensity earthquake occurs, the building may experience moderate to severe damage to both the non-structural components and the structural components, but before the building collapses there is still enough time for the occupants of the building to get out safely.

A maintenance management success measurement tool allows building owners to assess their activities and compare them to strategic goals for building renovations or refurbishments to measure capabilities and deviations in a structured and integrated manner. can be identified [9]. Major reduction factors have been grouped into three main areas: physical, biological, and human-induced damage [10].

Efforts that are often made in relation to the performance of historic buildings so that they are in accordance with the service life of the building, namely by carrying out prevention and maintenance. Prevention is intended as a range of activities useful for limiting risk situations associated with cultural assets in context, given the need to consider territorial hazards, such as earthquakes, floods and landslides, as well as human-induced hazards, including abandonment, as a means of advancing risk management techniques. Maintenance is understood as a series of activities and interventions aimed at managing the condition of cultural property, integrity, functional efficiency, and identity [11].

### 2.3. Resilience and Reinforcement of Historic Buildings

Building resilience is the strength or durability of the building from things that can cause the building to fail under load or collapse. Reinforcement is all steps to increase earthquake resistance in a finished building. Understanding of maintenance of cultural heritage buildings for managers, owners, and planners/executors is very important so that conservation actions can run well. Accuracy in handling steps and orderliness of procedures in handling cultural heritage buildings is an important part of the success of maintenance actions [12].

Diagnostics have a key role in detecting building damage, because different types of diagnostic methods

must be applied in all cases when a certain building condition has to be detected, regardless of whether it is a restoration project or a maintenance programme. The site-based diagnostic approach is usually applied in the case of routine inspections carried out by the building owner or during the planning phase of a renovation project. A structure-based diagnostic approach is usually applied in the case of professional damage surveys or failure detection of building structures, in which case buildings are examined based on structural logic [13].

### 3. RESEARCH METHODS

The research method used is the first step to make direct visual observations of the current condition of the Pura Pakualaman building accompanied by primary data collection by conducting direct interviews with BPH. Kusumo Bimantoro, he is the son of KGPA A Paku Alam X and also serves as Penghageng Purarekso who is in charge of asset maintenance. The next interview with JM. Radyacahyono as Purarekso staff who was given the task of supervising the rehabilitation and renovation work of the Pura Pakualaman building. Interviews were conducted regarding the condition and history of the building in relation to internal and external factors that affect the resilience of the building, restoration efforts, renovations, and reinforcements that have been carried out. Next, analyze the field data obtained to carry out a study of the resilience of the building against the factors that influence it and the effectiveness of the strengthening of the building that has been carried out.

It takes a lot of money to carry out renovation, restoration or rehabilitation of buildings in the Pakualaman area, so that the handling of damage prior to 2016 was carried out partially and was not properly integrated. For example, in the center of worship, the Pakualaman Great Mosque since it was built by Paku Alam II has only experienced a change in the addition of a porch terrace on the east side during the Paku Alam VIII period, after that there were no more renovation activities until 2017. In that year, the porch terrace on the eastern side east was dismantled, the tiles were replaced according to the original, and the height level was lowered to be lower than the main room in the mosque, because it was not in accordance with the rules of hierarchy. The addition of a parking lot building in the Pura Pakualaman area also follows the rule of hierarchy, that new buildings cannot be higher than old buildings. Some of these examples provide information that has become a commitment that in development or conservation there are two important things that must be considered, namely the first to maintain the integrity of the building and the second to pay attention to its hierarchy.

### 4. RESULTS AND DISCUSSION

Based on interviews and the results of a study of the 2021 building rehabilitation documents, four buildings have been carried out, namely the Gedhong Ijo building, the Maerakaca building, the Besalen Kilen building, the house south of the Gerbang Wingking which can be seen in **Table 1**.

**TABLE I.** REPAIRED BUILDING COMPONENTS

No	Table Column Head	
	Building Name	Repaired components
1	Gedhong Ijo	Roofs, gutters, gutters, walkway ceilings
2	Maerakaca	Roofs, gutters, gutters, walkway ceilings
3	Besalen Kilen	Roofs, walls, window sills, room ceilings, hallway ceilings
4	Back house	The roof uses a steel frame

Source: Archaeology Report Book 2021.

From **Table 1** above it can be seen that the roof is a critical component, because the main pattern of damage starts from the damaged roof covering so that rainwater can enter through the gap. Because the incident had been going on for a long time and was not immediately repaired, damage such as weathered, porous and moldy occurred in the framing components of the trusses, rafters, battens, beams, even to the column structure that supports the trusses. Apart from that, from the narrative of Pura Pakualaman, the roof components have high material value because they use high quality teak wood from Perhutani and are quite a complicated part of the work.

It is undeniable that the age of the building is a matter of concern in renovation and rehabilitation work, many wood materials have been damaged, especially porous, weathered, as shown in **Fig. 1** and **Fig. 2**.



Fig 1. Gandhok Kilen roof truss



Fig 2. Replacement of saka wood (columns) in the Gandhok Kilen Building

Another factor causing damage to the Pura Pakualaman building was the 2006 earthquake which cracked the walls at several points. The improvement efforts that have been made are by the grouting method, shown in **Fig 3**, **Fig 4**, **Fig 5**, and **Fig 6**.

Fig 3. Cracks in the Parangkarsa Building Wall



Fig 4. The Wall Breaking Work of the Parangkarsa Building



Fig 5. Pipework for Sikagrout Injection



Fig 6. Final results of grouting work

Major renovation and rehabilitation work that required high costs began to be carried out in 2019. This work has started to be supported by recording, data collection, and documentation of repaired components. Renovation and rehabilitation work will continue until 2022 using funds from the Privileges Fund of the Yogyakarta Special Region Government. Systematic application of funds with a money follow function system, namely following the work plan in accordance with urgent needs and gradually starting from the part that is crucial and has high material value.

## CONCLUSION

From the results of the discussion, it can be concluded that the factors, internal and external, that affect the seismic resistance of the Pura Pakualaman building are: Internal factors that affect the durability of buildings are the age of materials and maintenance management that have not been integrated, while the biggest external factor is the 2006 earthquake. Efforts to strengthen a building begin with the roof, which is a key element, then columns for structural strength, and wall reinforcement against cracks using injection methods.

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