Progress in Engineering Application and Technology Vol. 3 No. 1 (2022) 163-175

PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Study on Building Defect by Using Non-Destructive Test at Masjid Jamek Panchor, Muar, Johor

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DOI: https://doi.org/10.30880/peat.2022.03.01.019
Received 16 January 2022; Accepted 11 April 2022; Available online 25 June 2022

Abstract: An existing concrete building will be deteriorating with time due to various factors and bring impact on concrete durability and structural safety. Masjid Jamek Panchor Muar Johor is one of the earliest built in this area. This building is located at Panchor, Muar, Johor. According to En. Ghazali, among the old inhabitants that usually visited the mosque, the Masjid Jamek Panchor had already been constructed by the time the year 1929. Therefore, assessing the current concrete strength of the existing building is necessary for ensuring safety. Hence, the objectives of this study are to identify the types of building defects that occur at Masjid Jamek Panchor, Muar, Johor to measure the defect by using the Non-Destructive Test method and to recommend the solution to conserve the building. Therefore, visual inspection including defect mapping and condition-based assessment using Condition Survey Protocol 1 Matrix was conducted at the beginning to achieve the first objective. Next, to fulfill the second objective, two type of selected Non-Destructive test were carried out. The Rebound Hammer Test and Ultrasonic Pulse Velocity Test were conducted on eight selected columns. The collected data correlated with concrete strength and concrete quality created by previous researchers to achieve the second objective. Lastly, three recommendations to conserve the building were proposed. First is corrective maintenance follow by preventative maintenance and last is condition-based maintenance. Based on the data collected from both tests, it was found that the highest concrete strength of the column is column 2 with 45 N/mm^2 (based on Rebound Hammer data) and column 8 with V=3733 (based on Ultrasonic Pulse Velocity data). In conclusion, most of the concrete strength of elements is more than 45 N/mm^2, and concrete quality is considered as good although defects appeared.

Keywords: Building Defects, Non-Destructive Test, Conserve, Visual Inspection

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1. Introduction

Failure has a big impact on life. Finding out what went wrong is crucial to deciding whether current standards are adequate to prevent future failures or if they need to be updated and communicating the findings to the profession is critical to preventing failures. When we talk about failure analysis, we mean determining why an element or component failed [1]. Material selection, design, product application, production method, and the mechanics of failure inside the part are typical concerns.

The word is often used to describe the investigation of system failure rather than component failure, as well as the development of procedures and administrative strategies to avoid reoccurrence. Understanding typical building flaws is the only way to ensure that cures are offered [2]. Instead of demolishing good or historic structures, it is important repairing and maintaining them in a modest, unglamorous manner, while working closely with the buildings. To analyse the reason of a failure and then determine who is accountable, engineers must have a full understanding of not only load, strength, and stability, but also business and practise design and construction [3].

Failures are rare if characterised as a catastrophic structural collapse. A deficiency is a weakness in the construction that causes degradation and danger [2]. Some defects, like cracks or pipe leaks, are obvious right once, while others take years to notice.

Some old structures in Malaysia are in danger of failing due to a lack of knowledge and improper management of repair and maintenance costs [4]. In essence, it is critical to identify and diagnose faults in each architectural feature of a historic structure, as defects can arise in numerous locations and have varying causes and symptoms. Only a few old constructions in Malaysia are made of cement. The purpose of a condition investigation is to identify physical flaws in a building and avert failure.

1.1 Problem statement

The performance of the existing concrete structure will be decreasing with time due to deterioration ofconcrete and lead to shortening concrete durability [5]. There are many factors that will be resulting in the deterioration of concrete. The most common factors are environmental influences, initial structuraldesign mistakes, improper materials used and construction procedures, temperature, and inappropriateuse of structure [3].

Defects and damage to reinforced concrete structural require minimum maintenance, although their strength is higher than that of other construction materials [6]. This is because excessive loads or environmental conditions will induce faults in the concrete, such as cracks or damage. The quality, environment, and frequency of usage all influence the damage levels and rates of each construction material, component, and appliance.

It is important and required to analyse the impact of new buildings on existing buildings. Masjid Jamek Panchor is one of the area's oldest. This building is at Muar, Panchor, Johor. According to En. Ghazali, the Masjid Jamek Panchor had been built by 1929 among the old residents who frequented the mosque. The building is 797.80 m^2. Locals and Pagoh Education Hub students regularly occupy this mosque. The structure appears to have various flaws. Concrete cracking, spalling, and moulding are structural problems. Observation photos are underneath. (Figure 1 and 2)

Figure 1: Mould Growth

Figure 2: Concrete cracking

1.2 Objectives

This study was conducted to understand the physical defect that occurs at the building and provideguidance on the technique of how to prevent them. The main objective of this study are;

i. To identify the types of building defects that occur at Masjid Jamek Panchor, Muar,Johor.
ii. To measure the defect by using the NDT test method at Masjid Jamek Panchor, Muar,Johor.
iii. To recommend the solution to conserve Masjid Jamek Panchor, Muar, Johor.

2. Materials and Methods

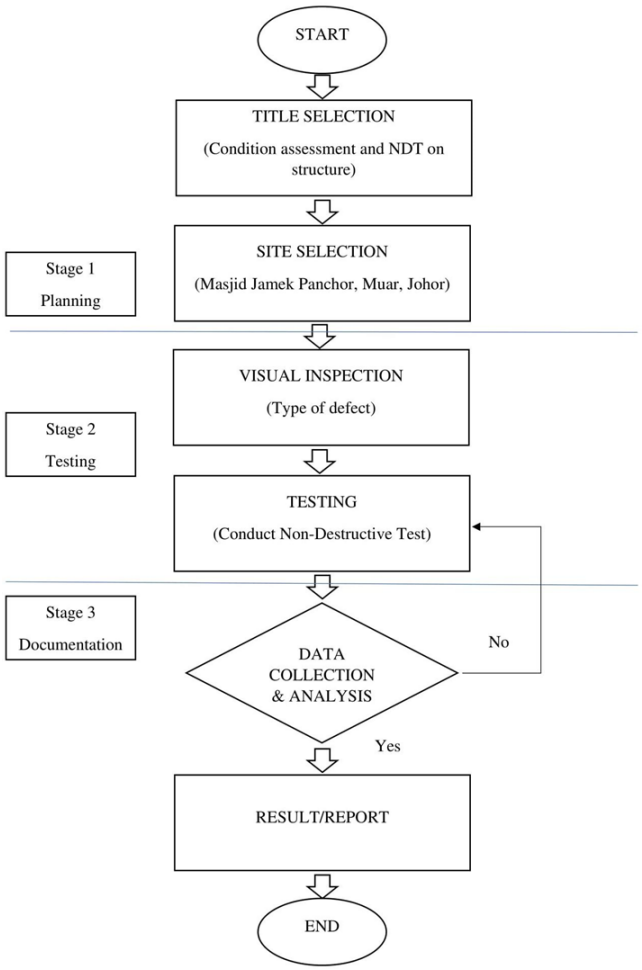

Figure 3: Methodology Chart

In this study, the quantitative analyses approach has been applied. The method was divided into 3 phases. For the first phase is planning, follow by testing for second phase. Then, third phase is documentation where calculation and data analysis were performed. and for the fourth phase, involves theanalysis of data. Figure 3 shows on the methodology of this study.

2.1 Non-Destructive Test

NDT stands for Non-Destructive Testing. It is a set of inspection procedures that allow inspectors to analyse a material, system, or component without permanently damaging it. NDT is an indirect way of collecting building information [7]. NDT ensures the element's dependability and quality. In this approach, NDT ensures the element's dependability and quality. Concrete nondestructive testing is extremely precise and beneficial. There were swo type of NDT that been applied in testing the concrete. First is Rebound Hammer Test and second is Ultrasonic Pulse Velocity.

2.2 Rebound Hammer Test

This test is also known as the impact hammer or accelerometer test, and the test is based on the principle that the rebound of an elastic mass depends upon the hardness [8]. If it is to be utilized to determine strength, a correlation between the rebound hammer reading and the strength of the concrete under inquiry must be established. The rebound principle, on the other hand, is more widelyaccepted. Below is the image of equipment that been used in conducting Rebound Hammer Test;

Figure 4: Rebound Hammer

2.2.1 Method of testing

i. The concrete surface with the grinding stone should be smooth.
ii. Unlock the plunger by pressing it against the concrete and slowly sliding it away. This extends the plunger from the body and secures the hammer mass to the plungerrod.
iii. Hold the plunger to the surface and press the body towards the test object slowly. The major source which connects the hammer mass to the body is extended as thebody is pushed.
iv. If the body is pushed to the limit the lock will be released and the energy stored inthe spring will send the hammer mass to the tip of the plunger.
v. The mass has an impact on the plunger rod shoulder and rebounds. The sliding indicator travels with the hammer mass during rebound and marks the reboundingdistance.
vi. The rebound number is read out of the scale and the plunger is then pressed on theside of the body to lock the rebound position of the plunger.

2.3 Ultrasonic Pulse Velocity Test (UPV)

This test is done to assess the quality of concrete by ultrasonic pulse velocity method as per IS: 13311 (Part 1) – 1992.

Figure 5: Ultrasonic Pulse Velocity

2.3.1 Methods

i. The equipment needs to be calibrated by placing the transducer and receiver at either end of the reference bar.
ii. For the suitable test, locations are chosen for each transducer arrangement. The surface of the test location must be clean, smooth and dry. Preferably mould or formed surface, but its troweled surface is unavoidable, rub smooth the surface using a suitable polish material.
iii. The path length is measuring tape or calipers.
iv. Grease is applied to the surface of the test location to ensure proper contact of thetransducers with the concrete surface.
v. The transducer is positioned at the chosen test location. They are ensured properlyin contact with the concrete surface.
vi. Three readings are taken per test location. Four readings will be adequate to plot the best fit straight line for in-direct transmission.
vii. The average reading for each test location is calculated. The best fit graph straightline for the in-direct transmission. The average velocity is given by the slope of thebest fit line.
viii. The compressive strength of the test specimen is estimated by using the chart provided.

2.4 Calculation of UPV

i. The equipment needs to be calibrated by placing the transducer and receiver at either end of the reference bar.
ii. For the suitable test, locations are chosen for each transducer arrangement. The surface of the test location must be clean, smooth and dry. Preferably mould or formed surface, but its troweled surface is unavoidable, rub smooth the surface using a suitable polish material.
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3. Results and Discussion

The results and discussion section presents data and analysis of the study. This section can be organized based on the stated objectives, the chronological timeline, different case groupings, different experimental configurations, or any logical order as deemed appropriate.

3.1 Condition Survey Protocol 1 Matrix Analysis

From the CSP (Appendix A), there are nine defect that have been evaluate. The matrix colour for seven of them are green, one is grey and one is red.

3.2 Defect Mapping

Defect mapping is used to point the location of defects or problem. It used to mark or check off the locations of defects for the purpose of collecting frequency data of the various defects observed. A defect maps displays the location of defects and simplifies the process of data collection repair. Defect's

locations are marked so that workers will know where to look. The drawing of defect mapping is at the Appendix B.

3.3 Rebound Hammer Data

From the result, only one column that have "Fair" quality concrete that is from Column 3, six columns are fall in "Good" quality concrete and only Column 2 that including in "Very good" quality concrete. According to General Guideline for Concrete Quality based on Rebound Number by Z Yahya (2018), >40 (very good); 30-40(good); 20-30(fair) and, <20(poor). Below was the table that summarized the data:

Table 1: Data summary of Rebound Hammer Test

No.	Structure	Mean R	Corrected R(N/mm^2)	Concrete Quality
1	Column 1	34.4	34.3	Good
2	Column 2	44.4	45.0	Very Good
3	Column 3	30.0	29.9	Fair
4	Column 4	38.4	39.2	Good
5	Column 5	36.0	36.0	Good
6	Column 6	34.7	34.7	Good
7	Column 7	35.9	35.9	Good
8	Column 8	38.6	38.6	Good
			Average=36.7	Good

3.4 Ultrasonic Pulse Velocity Data

Table below shows the overall result of Ultrasonic Pulse Velocity of Masjid Jamek Panchor. The velocity shows the distance of pulse between transducer in meter per microsecond. When compared to the table of concrete quality in structures in terms of ultrasonic pulse velocity, the majority of the results are poor. It can be classified as minor flaws in this testing because the findings require a variety of factors, including not only velocity but also the strength of the concrete itself. However, the unfavorable outcome of defects is due to the fact that the flaws are substantial and must be monitored for maintenance. According to quality of concrete given by IS code (BS, 1881, 1983) as a function of UPV, >4500 (Excellent); 3500 – 4500 (Good); 3000 – 3500 (Medium/Fair); 2000 – 3000 (Poor) and <2000 (Very Poor).

Table 2: Data summary of Ultrasonic Pulse Velocity

Location	Structure	Velocity (m/s)	Concrete quality
Column 1	Column	2930	Poor
Column 2	Column	2920	Poor
Column 3	Column	2464	Poor
Column 4	Column	3093	Poor
Column 5	Column	3089	Fair
Column 6	Column	2857	Poor
Column 7	Column	3025	Fair
Column 8	Column	3733	Good

	Average= 3013	Fair

3.4 Solution to Conserve Masjid Jamek Panchor

When maintaining a building, management typically has various strategic options and numerous alternative decisions to consider. For example, it is possible to reduce the need for maintenance by addressing the root cause of failure and understanding its repercussions.

3.4.1 Corrective maintenance

Corrective maintenance is the most straightforward sort of maintenance plan, in which an element of a building is used until it fails. It covers all activities, including replacement or repair of an element that has failed to a point at which it cannot perform its required function [9].

3.4.2 Preventative maintenance

Preventive maintenance was created to address the shortcomings of corrective maintenance by reducing the chance of failure and avoiding unexpected failure. Time-based maintenance, planned maintenance, or cycle maintenance are all terms that apply to this method [9].

3.4.3 Condition-based maintenance

Condition-based maintenance is defined as maintenance undertaken in response to a significant deterioration in the performance or condition of a unit as indicated by a change in a monitored parameter of the unit's condition or condition. The condition-based approach to maintenance recognises that the fundamental reason for performing maintenance on an item is to address a change in the item's condition and/or performance. As a result, a condition survey, which is used to determine the true state of each component of a structure, can be used to determine the optimal time to do maintenance.

4. Conclusion

In this study, there are totally three objectives. The first objective is to identify the types of building defects that occur at Masjid Jamek Panchor, Muar, Johor. In order to fulfill this objective, a visual inspection was conducted. Through the visual inspection, the general information of the building, such as the function of the building in the past, had been collected. Furthermore, the visual inspection was also used to observe and investigate the condition of the testing building. It covered the testing building experiencing defects, which are wall cracking and staining, respectively. Both observed defects will not possess safety issues to the testing building.

The second objective is to determine the concrete strength of the existing building. In order to fulfill this objective, the Rebound Hammer Test and Ultrasonic Pulse Velocity Test were conducted on 8 selected columns. Based on the results obtained, it discovered the average concrete strength of all tested columns is 36.7 N/mm2 (obtained from Rebound Hammer Test) and 3013 (obtained from Ultrasonic Pulse Velocity Test), respectively. At the same time, the concrete quality of the column was determined based on the Rebound Number and UPV value. It found that the average concrete quality of the tested column is good (based on Rebound Number) and poor to good (based on UPV value).

The third objective is to recommend the solution to conserve Masjid Jamek Panchor, Muar, Johor. Three are three maintenance strategies recommended in order to conserve the building. Those strategies are corrective maintenance, preventative maintenance, and condition-based maintenance. All the objectives of this study were achieved.

There are some recommendations that can be taken for further study or further improvement:

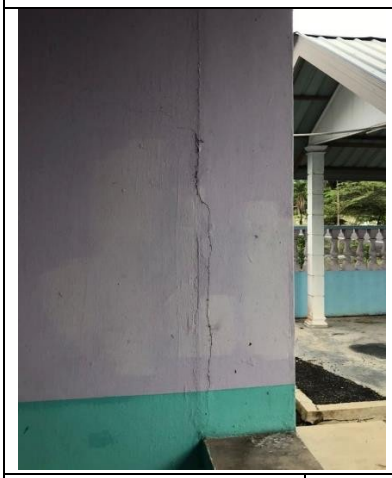
i. Create a unique correlation equation for the testing facility. From the prior research, the correlation equations employed in this study were taken. It is possible that there is an error because of the different proportionate mix and the testing conditions. It is possible to reduce the impact of this inaccuracy by creating a unique correlation for the testing facility.
ii. Conduct additional testing such as coring test, thermal imager, half-cell carbonation test. In this study, 95 percent confidence limits are doubtful for either of these tests. By adding other tests especially destructive tests, its able to increase the accuracy effectively
iii. For a longer length of time, conduct the research. Regular strength tests can be performed to keep tabs on the progress of a building's Construction.
iv. Checking out other buildings in the area. It is possible to compare the buildings, so the difference between buildings and the factors that caused the difference can be investigated.

Acknowledgement

The authors would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support.

Appendix A (CSP 1 Matrix table for defect at Majid Jamek Panchor)

<table>
<tr><td>Location</td><td>R1</td><td>Element/Component</td><td colspan="2">Ceiling</td></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="3">CSP 1</td></tr>
<tr><td>Condition</td><td>Priority</td><td>Matrix</td><td>Colour</td></tr>
<tr><td colspan="2" rowspan="3">  </td><td>2</td><td>2</td><td>4</td><td></td></tr>
<tr><td colspan="4">Description of defect:
Mould growth</td></tr>
<tr><td colspan="4">Recommendation:
Minor Defects / damages, need for monitoring, repairs, replaced to prevent serious defect / damages</td></tr>
<tr><td>Location</td><td>R2</td><td>Element/Component</td><td colspan="2">Ceiling</td></tr>
<tr><td colspan="2" rowspan="4">  </td><td colspan="3">CSP 1</td></tr>
<tr><td>Condition</td><td>Priority</td><td>Matrix</td><td>Colour</td></tr>
<tr><td>2</td><td>2</td><td>4</td><td></td></tr>
<tr><td colspan="4">Description of defect:
Mould growth</td></tr>
<tr><td colspan="4">Recommendation:
Minor Defects / damages, need for monitoring, repairs, replaced to prevent serious defect / damages</td></tr>
</table>

<table>
<tr><td>Location</td><td>T1</td><td>Element/Component</td><td colspan="3">Column</td></tr>
<tr><td colspan="2" rowspan="4">  </td><td colspan="4">CSP 1</td></tr>
<tr><td>Condition</td><td>Priority</td><td>Matrix</td><td>Colour</td></tr>
<tr><td>2</td><td>2</td><td>4</td><td></td></tr>
<tr><td colspan="4">Description of defect:
Peeling paint</td></tr>
<tr><td colspan="5">Recommendation:
Minor Defects / damages, need for monitoring, repairs, replaced to prevent serious defect / damages</td></tr>
<tr><td>Location</td><td>T2</td><td>Element/Component</td><td colspan="3">Column/wall</td></tr>
<tr><td colspan="2" rowspan="3"></td><td colspan="4">CSP 1</td></tr>
<tr><td>Condition</td><td>Priority</td><td>Matrix</td><td>Colour</td></tr>
<tr><td>2</td><td>2</td><td>4</td><td></td></tr>
<tr><td colspan="2" rowspan="2">  </td><td colspan="4">Description of defect:
Wall crack</td></tr>
<tr><td colspan="5">Recommendation:
Minor Defects / damages, need for monitoring, repairs, replaced to prevent serious defect / damages</td></tr>
<tr><td>Location</td><td>T3</td><td>Element/Component</td><td colspan="3">Column</td></tr>
<tr><td colspan="2" rowspan="3"></td><td colspan="4">CSP 1</td></tr>
<tr><td>Condition</td><td>Priority</td><td>Matrix</td><td>Colour</td></tr>
<tr><td>2</td><td>2</td><td>4</td><td></td></tr>
<tr><td colspan="5">Description of defect:
Cracking</td></tr>
</table>

Recommendation:
Minor Defects / damages, need for monitoring, repairs, replaced to prevent serious defect / damages

Location	T4	**Element/Component**	Column

CSP 1

Condition	**Priority**	**Matrix**	**Colour**
2	2	4	

Description of defect:
Cracking

Recommendation:
Minor Defects / damages, need for monitoring, repairs, replaced to prevent serious defect / damages

Location	B1	**Element/Component**	Beam

CSP 1

Condition	**Priority**	**Matrix**	**Colour**
3	2	6	

Description of defect:
Concrete spalling

Recommendation:
Minor Defects / damages, need for monitoring, repairs, replaced to prevent serious defect / damages

Location	W1	**Element/Component**	Wall

CSP 1

Condition	Priority	Matrix	Colour
2	2	4	

Description of defect:
Wall crack

Recommendation:
Minor Defects / damages, need for monitoring, repairs, replaced to prevent serious defect / damages

Location	W2	**Element/Component**	Wall

CSP 1

Condition	Priority	Matrix	Colour
4	3	12	

Description of defect:
Wall crack

Recommendation:
Minor Defects / damages, need for monitoring, repairs, replaced to prevent serious defect / damages

Appendix B (Defect mapping)

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