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Crack Assessment on a Residential Building Due to Peat Soil Settlement at Ayer Hitam, Muar

Tuan Norhayati Tuan Chik[1], Nursyahirah Suhaimy[1], Nor Athirah Farhah Mat Jali[1] , Nor Aiza Erme Mohamad[1]

[1] *Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn, Parit Raja, 86400, MALAYSIA*

*Corresponding Author: thayati@uthm.edu.my
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Abstract

Frequent problems in structure that build on the peat soil is cracking. This is due to the settlement that occurred by the peat soil as it has low in bearing capacity. The crack occurred on the residential building have become the main concern as crack happened on building showed the earliest sign of degradation. The increasing number of visible cracks at residential building with varies in length and width has a doubtful taught either the residential building is safe or not to be used. Apart from cracking, the concrete strength of the residential building is a concerned as the crack occurred may reduce the concrete strength. A single-storey residential building at Kompleks Penghulu Mukim Ayer Hitam, Muar is used to perform field measurement with respect to the cracking and concrete strength. 25 number of visible cracks with different length and width has been detected while monitoring the building. The crack length and size were measured using ruler and measuring tape. For measuring the concrete strength, a non-destructive testing (NDT) was used using Schmidt Rebound Hammer and Ultrasonic Pulse Velocity (UPV). The total 15 point was tested on column and wall inside the residential house by using two modes of transmission for UPV testing which was semi-direct and indirect transmission. The result of both rebound number and UPV has been analyze using statistical evaluation. The result is then being compared with the previous researcher that using the same regression mode of linear and non-linear mode when doing the analysis. From the result, it is found that the regression model for rebound hammer is more reliable to be used as the regression coefficient value got is nearly to one. For overall cracking and concrete strength quality, it is also found that the residential building needs proper maintenance as the settlement still happened and it is affected the residential building's safety.

1. Introduction

Residential building refers to a structure with one to four dwelling units that is used or occupied or intended to be used or occupied for residential purposes, for the purposes of a home inspection. Some of the residential building in Malaysia is constructed on the peat soil as there are presence of peatland on that area. The main issue caused by the settlement of the peat soil towards the building is cracking. Due to the movement of the building, there is a high visible cracking on the wall, and other parts of the building. When the stress on a building component exceeds its strength, it develops cracks. . Externally applied forces, such as dead, live, wind, seismic loads, or foundations, can cause stress in building components. Internally applied forces, such as temperature variations, humidity changes, and chemical reactions, can also cause stress in building components [1].Cracks detract from the building's aesthetic appeal, destroy the wall's integrity, compromise the structure's safety, and even shorten its lifespan [1]. Due to the settlement occurs towards the building, types of cracks can be identified which is structural cracks and non-structural cracks.

Research to analyze the concrete strength due to peat soil settlement. The defects in the building may be due to the poor ground condition and poorly advised alterations. This study focused on the prediction of the building condition by analyzing the cracks and concrete strength that has occurred by the movement of the building itself. The presence of defects in materials that can act as cracks is a major issue in ensuring the safety of these structures. A non-destructive technique (NDT) is being developed to detect potentially hazardous cracks in critical sections of structures to detect these faults. Traditionally, visual inspection, rebound hammer testing and ultrasonic pulse velocity have been used to carry out this process. Different NDT techniques are available for estimating concrete strength, and it must be chosen based on the state of the component to be tested, as each NDT technique has its own set of advantages and disadvantages.

The objectives of this research are to monitor the visible cracks occur on the building, to measure the in-place properties of concrete for quality assurance of existing condition based on UPV test BS:1881: Part 203 and to examine the strength of the concrete quality using the non-destructive technique (NDT) of rebound hammer and ultrasonic pulse velocity equipment. The significant will contribute to the benefit of society considering that the building is a residential building. It is vital to make sure that the building is safe to be used and it will not harm the residents. Thus, to make sure that the building is safe to use, the damage as stated in this research cracking occur due to peat soil settlement, it is important to be evaluated to assess the building strength condition of the building. This helps to identify an appropriate model to evaluate the structure durability and compressive strength when subjected to deterioration. Hence, the use NDT in observing and collecting data is more convenient and does not bring harm towards the building. Hence, this study helps to encourage future exploring the advantages of using NDT while performing the test.

2. Literature Review

A household structure or apartment might be composed of several rooms confined by wall surfaces, ceilings and flooring. The structure needs to be located above the ground and be made use of as a home. The geotechnical properties of civil engineering structures, such as shear strength, permeability, and compressibility of the soil, determine the structure's stability [2]. One of the first signs of deterioration is cracks in the concrete surface. Structures that are required for maintenance, as well as continuous direct exposure, will undoubtedly cause severe environmental damage [3]. Structural cracks can develop for a variety of reasons, including poor design, faulty construction, or overloading of architectural components [4] .The structural crack may be active and dormant as the movement is observed to continue. Structural cracks jeopardised the building's stability and could be difficult to repair. Non-structural fractures are caused by internally produced stresses in building materials, which do not always lead to structural deterioration [4].

NDE, often known as non-destructive testing (NDT), is a set of technologies for evaluating materials for faults (such as fractures or cracks) or damage induced by use. Some of the most frequent techniques include visual examination, microscopy, liquid or dye penetrant inspection, magnetic particle inspection, eddy current testing, x-ray or radiographic testing, and ultrasonic testing. Over the past years, research studies and experimental studies have been conducted to analyze the crack growth and the strength of concrete. On-site building inspection, also known as in-situ evaluation, is a challenging task that necessitates the use of the NDT technique [5]. The focused study on the findings from previous study about the building inspection and evaluation using UPV and rebound hammer has been tabulated in Table 1.

Table 1 *Building inspection and evaluation using UPV and rebound hammer*

Author	Methodology	Results
[5]	This study used UPV with direct and indirect transmission to assess in-situ data of the timber post and beams.	The result from the test showed that some parts of the structural timber have extensive deteriorations and some parts of the timber element are still sound and the structure was under examinations.
[6]	This study used combination of rebound hammer and UPV for evaluation of existing concrete structure.	The result for columns and wall showed that the concrete is good quality except the one with the lowest UPV of 1.31 km/sec and RN of 24 for the column and UPV of 2.0km/sec for wall. As for slab rebound hammer test result are more reliable compared to UPV data as it used indirect transmission.

[7]	This study used combination of UPV and rebound hammer for structural health monitoring where the testing was made in laboratory for concrete cube and the other testing at the existing building.	The test result for laboratory comparison between rebound hammer, UPV and compressive strength showed R^2 value of 0.9194 for UPV while R^2 of 0.9364 for rebound hammer. For in-site comparison, R^2 value of 0.9824 for rebound hammer and R^2 of 0.0275 for UPV. According to the findings, when such correlations were developed separately for different grades of concrete, the correlation between UPV values and concrete strength for any measurement made did not improve.
[8]	This study used combination of rebound hammer and UPV to estimate the compressive strength of building stones and bricks.	The findings showed that the general relation between rebound hammer, UPV and compressive has the R^2 value of 0.9384for rebound hammer and R^2 of 0.6625 for UPV. using a combined method of rebound number and ultrasonic pulse velocity to estimate compressive strength for the studied stones and bricks was generally more reliable than using either rebound number or ultrasonic pulse velocity alone.
[9]	This study used rebound hammer and UPV to compare the accuracy of these two methods in estimating the concrete strength.	The results showed that rebound hammer has the R^2 value of 0.794 while UPV has R^2 value of 0.790 for 1:2:4 mix and R^2 of 0.783 for rebound hammer and 0.777 for UPV in 1:3:6 mix. The sensitivity of the UPV in measuring strength influenced by the concrete age, while rebound hammer showed less sensitivity compared to UPV.

3. Methodology

3.1 Phase 1: Site Visit and Building Measurement

A residential building which is located at Jalan Muar, Parit Hassan Ahmad Satu in Kompleks Penghulu Mukim Ayer Hitam was chosen as a case study where in-situ evaluation is conducted. This building is selected as a case study location considering the location and the condition of the building itself that has been experiencing settlement due to peat soil. Since the drawing of the building is not available, the dimensions of the building structure have been done using ESTEEM.

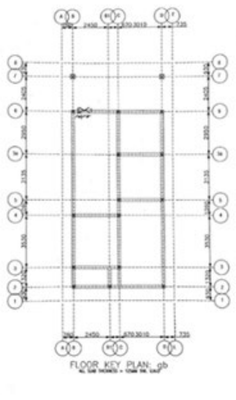

Fig. 1 *The layout of the residential building*

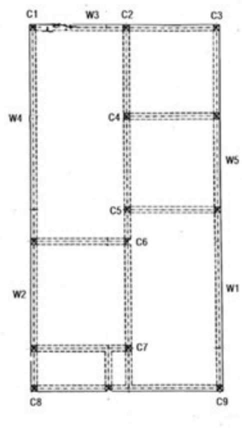

Fig. 2 *The location where the testing will be conducted*

3.2 Phase 2: Field Measurement and The Data Collection at Site

In-situ measurement is conducted to obtain the length and width of cracks, rebound number and the pulse velocity generated by the wave that is passing through the concrete structure. The measurement of the visual cracks will be done using ruler and measuring. The result of the length and width of the crack will then be classified according to its category. The rebound number will be measured by Schmidt Rebound Hammer and the UPV data is measured and recorded using ultrasonic pulse velocity (UPV) equipment.

Fig. 1 *Schmidt rebound hHammer* **Fig. 2:** *proceq ultrasonic tester*

For rebound hammer test, it will be conducted horizontally at 0°. Total 14 point where the test will be conducted, and the location scattered on the residential building. Nine rebound numbers will be measured at every point and the average of the rebound will be calculate. From the average value, the data is then will be plotted manually into the rebound hammer graph to get the compressive strength at the point. For UPV test, two ways to arrange the transducer is possible to be used semi-direct transmission and indirect transmission. The same 14 point as rebound hammer testing will be mark at the proposed area before the testing begin. The mode of transmission and the path length for column and wall is shown in Table 2 and Table 3.

Table 2 *Mode of transmission and the path length for column*

No	Location	Mode of transmission	Path length (m)
1	C1	Semi-direct	0.125
2	C2	Indirect	0.125
3	C3	Semi-direct	0.125
4	C4	Indirect	0.150
5	C5	Semi-direct	0.125
6	C6	Semi-direct	0.125
7	C7	Semi-direct	0.125
8	C8	Semi-direct	0.125
9	C9	Semi-direct	0.125

Table 3 *Mode of transmission and path length for wall*

No	Location	Mode of transmission	Path length (m)
1	W1	Indirect	0.200
2	W2	Indirect	0.200
3	W3	Indirect	0,200
4	W4	Indirect	0.200
5	W5	Indirect	0.200

3.3 Phase 3: Statistical Analysis

AThe NDT reading will be used for statistical analysis. The best-fitting expression is clearly one with a correlation coefficient close to 1.0. The model used to get the correlation coefficient will be proposed using linear model and non-linear model. From the graph, the result of both models will know. The higher value nearly equal to1.0 will be chosen between the two model. The correlation coefficient value will be compared in this study when compressive strength is compared to rebound number and compressive strength is compared to ultrasonic pulse velocity.

From the result of the correlation coefficient R^2 value for both rebound hammer and UPV, R^2 data will be compared between those two. The higher R^2 value of either between the comparison of compressive strength between rebound number and the comparison of compressive strength between ultrasonic pulse velocity will then be compared from previous researchers.

4. Results and Discussion

The data acquisition from the visual inspection on crack width and length, ultrasonic pulse velocity and rebound hammer of the building has been obtained. The data gathered on 9th April from the visual inspection of crack width and length, ultrasonic pulse velocity equipment and rebound hammer are presented in table. The inspection of the visual cracks has been made where the length and width of 25 cracks has been measured using ruler and measuring tape. The mode of transmission of ultrasonic pulse velocity test conducted used was indirect transmission and semi-direct transmission. The data from the ultrasonic pulse velocity equipment was recorded and transferred in table to evaluate its concrete quality ratings based on its pulse velocity recorded.

4.1 Crack, Width and Length, Rebound Number and Ultrasonic Pulse Velocity Measurement

Visual inspection on cracks occurs has been made scattered inside the house. Total 25 number of cracks have been found inside the house where the length of the cracks is from 0.33m to 1.2m with varies size from 0.3cm to 1.4cm.

From the data, seven cracks were in the moderate category, 11 cracks in slight category and seven cracks in very slight category. Out of 25 cracks, two cracks had the longest crack length which is crack at point C20 and C21 where the crack length is 3.64m with 0.1cm width. The shortest crack is at point C2 which the length is 0.32m with 0.5cm width. Differ from length, point C4 has the largest crack width which is 1.4cm and the smallest crack width of 0.1cm located at point C11, C12, C15, C17, C20 and C21. Table 4 provides a summary of the crack length and width at the house.

Table 4 *Summary of the crack length and width*

No	Point	Crack length (m)	Crack width (cm)	Category
1	C1	1.20	1.00 0.50	Moderate Moderate
2	C2	0.32	0.50	Moderate
3	C3	0.33	0.80	Moderate
4	C4	0.33	1.40	Moderate
5	C5	1.08	0.40	Slight
6	C6	1.08	0.90	Moderate
7	C7	0.33	0.31	Slight
8	C8	0.47	0.40	Slight
9	C9	0.40	0.30	Slight
10	C10	2.86	0.20	Slight
11	C11	0.90	0.10	Very slight
12	C12	0.71	0.10	Very slight
13	C13	0.50	0.40	Slight
14	C14	0.73	0.05	Very slight
15	C15	0.73	0.10	Very slight
16	C16	0.70	0.30	Slight
17	C17	2.00	0.10	Very slight
18	C18	0.30	0.20	Slight
19	C19	0.70	0.60	Moderate
20	C20	3.64	0.10	Very slight
21	C21	3.64	0.10	Very slight
22	C22	0.64	0.40	Slight
23	C23	0.44	0.20	Slight
24	C24	1.00	0.90	Moderate
25	C25	0.60 1.00	0.40 0.40	Slight Slight

Average strength exhibited by columns was found as 31.42 N/mm^2, with a peak compressive strength of 38.8 N/mm^2 at point C1, C2, C3, C8 and C9 which as the same mean R value of 39. Point C4 that has average mean R value produced compressive strength of 25.8 N/mm^2. Three columns have the lowest strength which the strength was 21 N/mm^2 where the location of the columns is located at the C5, C6 and C7 where the mean R value is 28.5. If the low concrete strength is confirmed, such column with low strength concrete need inspection through other testing methods and be strengthened using appropriate strengthening techniques. As for walls, all the test gives average strength of 36.24 N/mm^2 with 26.0 N/mm^2 and 38.8 N/mm^2 as the lowest and the highest strength respectively. From five point of tested location, four location stated similar mean R value of 39.0 which get the compressive strength of 38.8 N/mm^2. One location at W1 has the lowest mean R value of 31.5 where the compressive strength at that point is 26 N/mm^2. Table 5 showed the summary of rebound hammer test results on columns and walls.

Table 5 *Summary of rebound hammer test results on columns and walls*

Test location	Structural member	Recorded R value			Mean R value	Inclination angle (°)	Compressive strength(N/mm^2)
		39.0	39.0	39.0			
C1	Column	39.0	39.0	39.0	39.0	0	38.8
		39.0	39.0	39.0			
		39.0	39.0	39.0			
C2	Column	39.0	39.0	39.0	39.0	0	38.8
		39.0	39.0	39.0			
		39.0	39.0	39.0			
C3	Column	39.0	39.0	39.0	39.0	0	38.8
		39.0	39.0	39.0			
		33.0	34.0	31.0			
C4	Column	35.5	31.0	27.5	31.3	0	25.8
		24.0	35.0	31.0			
		28.5	28.5	28.5			
C5	Column	28.5	28.5	28.5	28.5	0	21
		28.5	28.5	28.5			
		28.5	28.5	28.5			
C6	Column	28.5	28.5	28.5	28.5	0	21
		28.5	28.5	28.5			
		28.5	28.5	28.5			
C7	Column	28.5	28.5	28.5	28.5	0	21
		28.5	28.5	28.5			
		39.0	39.0	39.0			
C8	Column	39.0	39.0	39.0	39.0	0	38.8
		39.0	39.0	39.0			
		39.0	39.0	39.0			
C9	Column	39.0	39.0	39.0	39.0	0	38.8
		39.0	39.0	39.0			
		33.5	32.0	3.00			
W1	Wall	32.0	30.0	31.0	31.5	0	26
		28.5	29.5	34.5			
		39.0	39.0	39.0			
W2	Wall	39.0	39.0	39.0	39.0	0	38.8
		39.0	39.0	39.0			
		39.0	39.0	39.0			
W3	Wall	39.0	39.0	39.0	39.0	0	38.8
		39.0	39.0	39.0			
		39.0	39.0	39.0			
W4	Wall	39.0	39.0	39.0	39.0	0	38.8
		39.0	39.0	39.0			
		39.0	39.0	39.0			
W5	Wall	39.0	39.0	39.0	39.0	0	38.8
		39.0	39.0	39.0			

The velocity of the UPV value will be calculated manually and the results of the UPV will shows the concrete quality ratings based on BS :1881: Part 203. Table 6 showed the concrete quality ratings based on BS:1881:Part 203 [10].

Table 6 *Concrete quality ratings based BS:1881:Part 203 [10]*

Pulse velocity (km/s)	Concrete quality (Ratings)
≥ 4.5	Excellent (E)
3.5 - 4.5	Good (G)
3.0 - 3.5	Medium (M)
2.0 - 3.0	Doubtful (D)
≤ 2.0	Very weak (VW)

Semi direct transmission was used at seven out of nine of the tested points. location C2 and C4 used indirect transmission as the location of the column is located at the center of the brick wall. Result for columns showed that concrete is doubtful and very weak where the lowest UPV was found as 280.899 m/s and which is located at C9. Low UPV data for this column may not be very reliable as the surface where the testing has been done was rough and there were some cracks occurred on the column compared to the other columns. The highest UPV was found as 2906.977 m/s where it is located at C4. Although C4 has the highest UPV, still the classification of the concrete quality is doubtful. Table 7 shows the summary of UPV result on the column.

Table 7 *Summary of UPV result on column*

No	Location	Mode of transmission	Path length (m)	Time taken (s)	Velocity (m/s)	Classification
1	C1	Semi-direct	0.125	0.0001406	889.047	Very weak
2	C2	Indirect	0.125	0.0000451	2771.619	Doubtful
3	C3	Semi-direct	0.125	0.0002420	516.529	Very weak
4	C4	Indirect	0.150	0.0000516	2906.977	Doubtful
5	C5	Semi-direct	0.125	0.0000754	1657.825	Very weak
6	C6	Semi-direct	0.125	0.0000541	2310.536	Doubtful
7	C7	Semi-direct	0.125	0.0000532	2349.624	Doubtful
8	C8	Semi-direct	0.125	0.0000472	2648.305	Doubtful
9	C9	Semi-direct	0.125	0.0004450	280.899	Very weak

As for wall, the mode of transmission used for every point is indirect transmission. The path length of 0.200m was measured and it is the same for every location. Differ from columns, the test result for walls showed that concrete is generally excellent and good quality except for W1 and W3 where the concrete quality ratings is at doubtful. The UPV was found as 2034.588 m/s at W1 and 2699.055 m/s W3. W1 is the same wall which showed low RN (26). Low UPV for this wall was effect by the cracks occurred which has affected the UPV readings. Table 8 showed the summary of UPV result on wall.

Table 8 *Summary of UPV result on wall*

No	Location	Mode of transmission	Path length (m)	Time taken (s)	Velocity (m/s)	Classification
1	W1	Indirect	0.200	0.0000983	2034.588	Doubtful
2	W2	Indirect	0.200	0.0000455	4395.604	Good
3	W3	Indirect	0.200	0.0000741	2699.055	Doubtful
4	W4	Indirect	0.200	0.0000435	4597.701	Excellent
5	W5	Indirect	0.200	0.0000398	5025.126	Excellent

4.2 Statistical Analysis

4.2.1 Relation Between Rebound Number and Compressive Strength

The best fit correlation between rebound hammer and compressive strength was discovered using statistical analysis of the experimental data. The relationship between column and wall rebound number and compressive strength was depicted in Figures 5 and 6. The R2 value for both columns and walls in a linear model is 1. There was slightly differ value for non-linear model as the R2 value for column is 0.998. As shown in the figures and tables, there are reliable relationships between rebound number and compressive strength for the columns and walls studied [8].

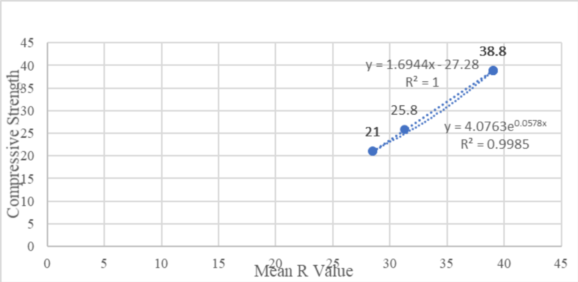

Fig. 5 *Relation between rebound number and compressive strength on column*

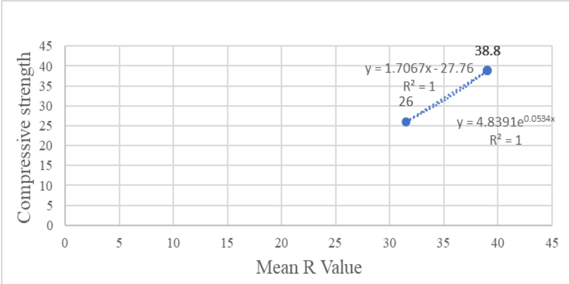

Fig. 6 *Relation between rebound number and compressive strength on wall*

Compressive strength increases as the rebound number increases, according to the findings. A linear and non-linear model was proposed for each structural member. Because it is a simple model with a higher R2 value for the regression coefficient, the linear model was chosen. Table 9 summarise the suggested models for relations between compressive strength and mean R value for rebound number for column and wall. As for column, the R^2 value from linear and non-linear model has a difference of 0.002 while for wall, the regression coefficient R^2 value is the same which is 1.

Table 9 *Summary of the suggested models for relations between compressive strength and rebound number for column and wall*

Structural member	Model type	Formula	R^2
Column	Linear	fc = 1.6944RN - 27.28	1
	Non-linear	fc = 4.0763$e^{0.0578RN}$	0.998
Wall	Linear	fc = 1.7067RN - 27.76	1
	Non-linear	fc = 4.8391$e^{0.0534RN}$	1

4.2.2 Relation Between UPV and Compressive Strength

The next figure depicts the relationship between ultrasonic pulse velocity and compressive strength obtained from the rebound hammer test at the column. In Figure 7, the linear model was chosen because it produced a higher R2 value for the regression coefficient than the non-linear model. As the scattered value was plotted, the line showed decreased order for the linear model. The regression coefficient R^2 value get was 0.1704 which is least from 1. From Figure 7, although some of the point has the same reading in compressive strength, but showed differ value of UPV. It was discovered that there was no relationship between increasing compressive strength and increasing velocity. The different reading of the UPV was affected by the condition of the located point and the mode of transmission used at each point either it is indirect transmission or semi-direct transmission. The relation between ultrasonic pulse velocity and compressive strength from the rebound hammer test at wall are shown in Figure 8. From the graph between compressive strength and velocity, it showed that the regression coefficient is slightly higher at wall compared to column. The R^2 value from the wall is 0.5405 from the linear model used. Same as columns, there were no relations between the higher in compressive strength, the higher the velocity in wall. This is because it can be seen that although the compressive strength at some point is high, the velocity get from the UPV is low.

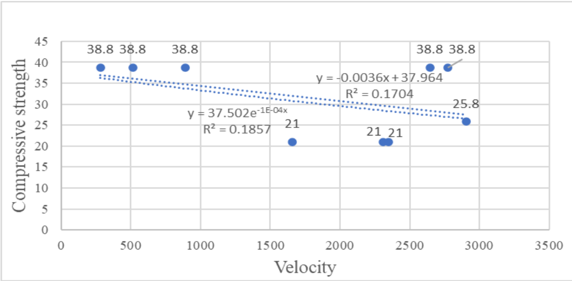

Fig. 7 *Relations between UPV and compressive strength test at colummn*

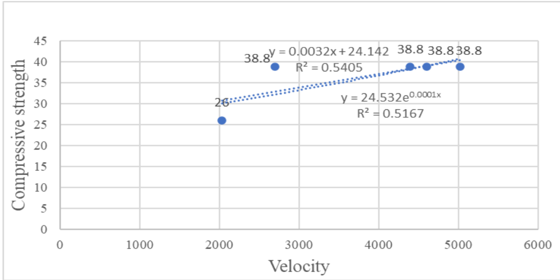

Fig. 8 *Relations netween UPV and compressive strength test at wall*

Table 10 showed the summarized of the suggested model for relations between the compressive strength and the UPV value. Linear model was chosen as it stated higher regression coefficient R^2 value compared to non-linear model. For column, the R^2 value for linear model is 0.1704 which is slightly higher from non-linear model which is 0.1591. the difference between the linear and non-linear model is 0.0113. as for wall, the R^2 value is the same for both linear and non-linear model which is 0.5405.

Table 10 *Summary of the suggested models for relations between compressive strength and UPV for column and wall*

Structural member	Model type	Formula	R^2
Column	Linear	$fc = -0.0036V + 37.964$	0.1704
	Non-linear	$fc = 37.502e^{-1E\text{-}04V}$	0.1591
Wall	Linear	$fc = 0.0032V + 24.142$	0.5405
	Non-linear	$fc = 24.532e^{0.0001V}$	0.5405

4.3 Comparison Between Previous Researcher

From the analysis that has been carried out, the NDT reading for rebound hammer and UPV has been obtained. The compressive strength corresponding to the rebound number, UPV, and compressive strength were reported, and an exponential expression was used to try to correlate the values of the rebound number, UPV, and compressive strength. The linear model and the non-linear model were proposed, and the linear model was chosen because it provided the best-fit expression with an R^2 value nearly equal to 1.0. Table 11 and 12 showed the result and comparison between the R^2 value for rebound hammer and UPV from previous researcher.

Table 11 *Comparison between the R^2 value for rebound hammer by previous researcher*

No	Proposed by	Proposed model for rebound hammer	R^2 value for rebound hammer
1	[7]	-	0.9824
2	[9]	$S = 1.012R + 1.218$ $S = 1.339R - 4.878$	1:2:4 mix = 0.794 1:3:6 mix = 0.783
3	[11]	$S = 0.788R^{1.03}$	0.77
4	[12]	$S = 1.5383R - 1.5725$	0.9441
5	This research	$S_{column} = 1.6944RN - 27.28$ $S_{wall} = 1.7067RN - 27.76$	1.0 1.0

Table 12 *Comparison between R^2 value for UPV by previous researcher*

No	Proposed by	Proposed model for UPV	R^2 value for ultrasonic pulse velocity
1	[7]	-	0.0275
2	[9]	$S = 15.05v - 43.27$ $S = 14.43v - 43.05$	1:2:4 mix = 0.790 1:3:6 mix = 0.777
3	[11]	$S = 1.19 e^{0.715V}$	0.59
4	[12]	$S = 5.6416v - 19.763$	0.8421
5	This research	$S_{column} = -0.0036V + 37.964$ $S_{wall} = 0.0032V + 24.142$	0.1704 0.5405

From the proposed model, the result showed that the rebound number has a better correlation compared to the UPV in compressive strength. The linear relationship between the rebound number and the compressive strength gave the best correlation, hence it was used.

5. Conclusion

From the study, it can be concluded that the length and size of the cracks may be increasing due do the active settlement of the soil that occur. From the UPV test most of the concrete quality was in doubtful and very weak where the pulse velocity was in between ≤ 2.0 to 3.0 km/s. However, it is found that the measured velocity is influenced by the mode of transmission used while performing the test. Direct transmission gave most accurate data compared to semi-direct and indirect transmission. Not only that, the surface of the tested point was also influenced the reading of the velocity. The velocity response decreased with the used of semi-direct and indirect transmission used when performing the test. Therefore, the measured data for the UPV testing is being compared to the rebound hammer data and it can be concluded that the Rebound Schmidt Hammer and the Proceq ultrasonic tester is reliable to examine the strength of the concrete at the residential building. Hence, there was no harm for the used NDT to the building's structural safety. It is important to always finding ways to avoid the problem caused by cracking. Some ways to avoid this problem is by adopting adequate materials and technique, proper design with effective specifications and long-term supervision needed to be made. As the case study is at a residential building, it is vital to do supervision and maintenance so that the building is safe to be used.

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