Analysis of Compressive Strength of Existing Higher Educational Institutions (HEI) Concrete Column using a Schmidt Rebound Hammer

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Abstract: The Schmidt rebound hammer is principally a surface hardness tester with an apparent theoretical relationship between the strength of hardened concrete block and the rebound number of the hammer. This study analysed compressive strength of some selected concrete columns of Civil Engineering block at Covenant University Ota, using the Schmidt rebound hammer. It is aimed at determining variation in the concrete column strength of the HEI building in relation to standard compressive strength required of a concrete column. Data for the study was collected by carrying our Schmidt rebound hammer test (non-destructive test) on the concrete column within the study area and the rebound value (R) was measured to determine the present compressive strength of the concrete column. In carrying out this experiment, the standard experiment procedure of the Schmidt hammer test was followed. The analysis of the performed non-destructive test on the HEI concrete column was presented through tables and figures. The result of the study shows that there is variation in the compressive strength of the HEI concrete columns sampled using Schmidt rebound hammer test. The result indicated that the average compressive strength gotten through the rebound values of the sampled concrete columns compressive strength falls within the minimum required strength between 25N/mm² and 30N/mm² expected of a concrete column of an existing structure. The study therefore, concluded that the concrete columns of the HEI building sampled is safe, stable and it can satisfy the need for which it was built. Furthermore, because of it stability it can resist the load coming to it and this make it habitable for learning.

Keywords: Concrete; Higher educational Institution; Schmidt Rebound Hammer.

1.0 Introduction

Concrete is an important material used as construction material for both public and private buildings, and it has far greater strength among other component of construction material produced with the same production ratio [1]. Concrete strength in construction is often found to be more than any other material mixed with cement such as mortar. Since concrete usage is the major yardstick used in determining the quality of concrete, researchers have since done more to look for different ways of determining its compressive strength without affecting the structure itself before or after its usage. In achieving this, researchers have developed different ways of determining compressive strength of concrete such as destructive test after concrete production and non-destructive test after its usage. To determine its strength after usage for any component of building such as columns, beams, foundations and others, researchers have since developed a non-destructive apparatus called the Schmidt rebound hammer. Carrying out a non-destructive test using the Schmidt hammer does compromise the intended
performance of any component of a structure member being investigated or neither the quality of its concrete. Yüksel [2] stated that finding an in-situ compressive strength of any given concrete using this method of testing is ideal because of its easiness. Leshchinsky [3] summarized gains of using the Schmidt hammer as ability to access and test concrete strength component in any part of a building with less labour stress, or damage to building. The apparatus is the most used device for non-destructive testing of concrete because of its low cost and simplicity. Although, using this apparatus as a means of determines the concrete uniformity is not expensive, there are standard procedures that need to be followed to achieve better results using the rebound hammer [4]. A non-destructive test result using a Schmidt rebound hammer dependent upon the type of surface finish and its preparation, temperature, carbonation and the degree of saturation [1]. However, [3] opined that using the Schmidt rebound hammer as an apparatus in testing any component of building causes a lesser amount of damage to the building. Conversely, [5] opined that using the Schmidt hammer is of no value if its results is not meeting the required standard expected from any part of a structure tested. Yılmaz [6] and [7] stated that the use of Schmidt hammer in testing concrete is limited by different factors such as; area of testing, empirical equations for material usage, direction of testing, condition of the surface to be tested and material type use for concrete production.

1.1 Schmidt rebound Hammer as testing tools for concrete

In testing concrete of an existing structure the Schmidt rebound hammer is the most commonly used apparatus used to determine its strength through a non-destructive process. This is because of its simplicity, easiness of its operation, rapidity and non-destructiveness of the Schmidt rebound hammer in determining the strength of concrete. The test carried out on concrete is classified as hardness test because the rebound of its elastic mass hangs on the strength of the component surface tested against which the mass impinges. ACI manual [8] stated that concrete strength is equal to its absorbed energy. The study of [9] showed that the Schmidt hammer test involves the associated stress-wave propagation and complex problems of impact. In using Schmidt rebound hammer to test for concrete strength, it experimental data relationship can only be obtained from available or given specimen base on non-destructive testing results. Aydin [1] asserted that in Schmidt hammer test this relationship dependent upon the type of surface finish and its preparation, the degree of saturation, carbonation, and temperature. The study of [10] added that results of Schmidt hammer test on concrete is affected by so many factors which include aggregate type, mix ratio, type of hammer, testing area, honey-comb, and scaling, and rough texture.

This study analysed a specific relationship between rebound values of compressive strength of concrete columns of an existing Higher Educational Institutional in order to determine observable variation in its strength.

2.0 Method and procedure

The experimental procedure for this research was carried out in accordance with [11] and [12]. Concrete columns to be tested were carefully selected and the surface of the concrete columns to be tested were prepared and smoothened using a grindstone. The Schmidt hammer was positioned perpendicularly to and against the test surface and the rebound hammer was pushed against the test surface at a moderate speed with a fixed amount of energy applied, until an impact is triggered. The plunger was allowed to strike perpendicularly to the surface, because its result will be affected by the angle of inclination of the hammer. The rebound values after impact were recorded taking at least 10 readings from each tested concrete columns.

For accuracy of the rebound value, its lowest and highest values were deducted before calculating the Average Rebound Value (ARV) in order to determine the actual rebound value (R) for each concrete column sampled. The test was carried out on three different identified 450mmx750mmx4000mm main concrete columns within the HEI building. This research makes use of the following equipment, apparatus and tools: Schmidt rebound Hammer, grinding stone, measuring tape in carrying out its experiment procedure. To have a good basis for the results, the rebound value(R) was measured to
determine its specific relationship with the compressive strength of the concrete in accordance with [13] and [14]. The safety procedure for the research was in line with the finding of [15].

3.0 Result and discussion

3.1 Rebound value for Concrete Column 1

Result from table 1 shows that the Average Rebound Value (AVR) for concrete column 1 is 27.18N/mm² after making ten (10) impacts. The lowest value recorded was 25.45N/mm² while the highest value recorded was 29.55N/mm². The result shows that the rebound value (R) for CC1 is within the minimum strength required for a load bearing concrete column. The result is in alignment with the result of [16].

| S/N | Sample (mm) | No of Impact | Rebound value (N/mm²) | Deductions (N/mm²) |
|-----|-------------|--------------|-----------------------|--------------------|
| 1   | Reinforced concrete column of 450x750x4000 | 1             | 25.75                 | 25.75              |
|     |             | 2             | 26.69                 | 26.69              |
|     |             | 3             | 25.45                 | Lowest value       |
|     |             | 4             | 28.65                 | 28.65              |
|     |             | 5             | 26.85                 | 26.85              |
|     |             | 6             | 26.75                 | 26.75              |
|     |             | 7             | 28.45                 | 28.45              |
|     |             | 8             | 27.95                 | 27.95              |
|     |             | 9             | 26.35                 | 26.35              |
|     |             | 10            | 29.55                 | Highest value      |
|     |             | Total         | 217.44                |                    |

Average rebound value (ARV) = \[
\frac{\text{Sum of the total value}}{\text{Number of Impact}}
\]

\[
R = \frac{217.44}{8} = 27.18 \text{ N/mm}^2
\]

3.2 Rebound value for Concrete Column 2

Result from Table 2, shows that the average Rebound value(R) for CC2 is 26.33N/mm² after ten (10) impacts. The lowest value recorded was 24.55N/mm² while the highest value recorded was 27.65N/mm². The result shows that the rebound value (R) for CC2 shows slight variation its but its value still falls within the minimum concrete strength required for loading bearing concrete column. The result is similar to the result of [4].

| S/N | Sample (mm) | No of Impact | Rebound value (N/mm²) | Deductions (N/mm²) |
|-----|-------------|--------------|-----------------------|--------------------|
| 2   | Reinforced concrete column of 450x750x4000 | 1             | 24.55                 | 24.55              |
|     |             | 2             | 27.45                 | 27.45              |
|     |             | 3             | 22.45                 | Lowest value       |
|     |             | 4             | 27.65                 | Highest value      |
|     |             | 5             | 26.85                 | 26.85              |
|     |             | 6             | 23.75                 | 23.75              |
|     |             | 7             | 27.45                 | 27.45              |
|     |             | 8             | 25.85                 | 25.85              |
|     |             | 9             | 27.15                 | 27.15              |
|     |             | 10            | 27.55                 | 27.55              |
|     |             | Total         | 210.60                |                    |

Average rebound value (ARV) = \[
\frac{\text{Sum of the total value}}{\text{Number of Impacts}}
\]
3.3 Rebound value for Concrete Column 3

Result from Table 3, shows that the average rebound value (R) for CC3 is 25.85N/mm² after ten (10) impacts. The lowest value recorded was 21.65N/mm² while the highest value recorded was 28.45N/mm². The result shows that the rebound value of (R) for CC3 shows variation from the first and second concrete columns but its value still falls within the required concrete strength required for a load bearing column. The result is similar to the result of [1].

**Table 3. Analysis of Rebound value for CC3**

| S/N | Sample (mm)                                | No of Impact | Rebound value (N/mm²) | Deductions (N/mm²) |
|-----|--------------------------------------------|--------------|-----------------------|--------------------|
| 3   | Reinforced concrete column of 450x750x4000 | 1            | 21.65                 | Lowest value       |
|     |                                            | 2            | 25.95                 |                    |
|     |                                            | 3            | 26.45                 |                    |
|     |                                            | 4            | 25.45                 |                    |
|     |                                            | 5            | 27.35                 |                    |
|     |                                            | 6            | 25.85                 |                    |
|     |                                            | 7            | 28.45                 | Highest value      |
|     |                                            | 8            | 25.95                 |                    |
|     |                                            | 9            | 23.45                 |                    |
|     |                                            | 10           | 26.35                 |                    |
|     |                                            |              | Total 206.8           |                    |

Average rebound value (ARV) = \( \frac{\text{Sum of the total value}}{\text{Number of Impacts}} \)

\[
R = \frac{206.8}{8} = 25.85 \text{ N/mm}^2
\]

3.4 Compressive strength

The compressive strength result for the three concrete column samples based on the specific relationship with the rebound value (R) are shown in figure 1, and it showed differences in strength of the concrete columns sampled. With compress strengths of 27.18N/mm² (CC1), 26.33 N/mm² (CC2), 26.45N/mm² (CC3), and average compressive strength of 26.45N/mm² for all concrete columns tested within the HEI buildings using the Schmidt rebound hammer. The result further shows that there is variation in compressive strength of the concrete columns tested within the HEI. This result is in agreement with the findings of [1], [16], [17], and [18].

**Figure 1**: Analysis compressive of concrete column sampled in relations to the rebound value
4.0 Conclusion
The study analysed the compressive strength of existing Higher Educational Institutions (HEI’s) concrete column using Schmidt rebound hammer. From the study concrete column tested samples showed rebound values (R) and compressive strength of 27.18N/mm² (CC1), 26.33N/mm² (CC2), and 26.45N/mm² (CC3). This shows that there is a variation in strength of the concrete, which could be as a result of aggregate type, mix ratio, type of hammer, testing area, honey-comb, scaling, and rough texture. The study shows that although there is variation in the compressive strength of the concrete column sampled based on the Schmidt rebound hammer test, with overall average compressive strength value of 26.45 N/mm. This clearly indicated that the sampled concrete columns’ compressive strength values falls within the minimum required strength between 25N/mm² and 30N/mm² expected of a concrete column of an existing structure. The study therefore, concluded that the concrete columns of the HEI building sampled is safe, stable and it can satisfy the need for which it was built. Furthermore, because of its stability it can resist the load coming to it and this make it habitable.

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