Correlation between Destructive Compressive Testing (DT) and Non Destructive Testing (NDT) for Concrete Strength

Oke, D. A.[1], Oladiran, G. F.[2], Raheem, S. B.[3]

The Department of Civil Engineering, The polytechnic, Ibadan, Oyo State, Nigeria

Abstract— *Concrete is the most widely used construction material worldwide. Strength of a concrete structure may have to be assessed without causing physical damage to it, due to various reasons like its monumental importance or the legal dispute on whether the strength of the concrete in the structure is satisfactory enough or not. In an attempt to meet the above demand, correlation and comparison between Destructive Test (DT) and Non Destructive Test (NDT) were carried out.*

A total of 24 concrete cubes (150 mm x 150 mm x 150 mm) were cast with concrete mix ratio of 1:2:4. 12 cubes were tested destructively for compressive strength with compression machine and 12 cubes were also tested non-destructively with Schmidt Rebound Hammer. Compressive strength test results at curing ages (7, 14, 21 and 28days.) were collated and analysed.

The results obtained from the non-destructive testing method were correlated with the results obtained from destructive testing method. The coefficient of correlation between the two set of compressive strength was 0.988 which indicates a perfect relationship between compressive strength results from both methods.

Keywords— Compressive Strength, Non Destructive test, Destructive Compression test, Schmidt Rebound Hammer.

I. INTRODUCTION

The standard method of determining strength of hardened concrete consists of testing concrete cubes in compression. It is very important to ascertain the compressive strength of concrete before subjecting to its anticipated loads. Compressive strength of hardened the concrete can be determined using the destructive (DT) and non-destructive testing (NDT) method. The destructive testing (DT) method is carried out by crushing the cast specimen to failure while non-destructive testing (NDT) is carried out without destroying the concrete specimen. The rebound (Schmitz) hammer is one of the most popular non-destructive testing (NDT) method used to test the strength of the concrete.

This is due to it relatively low and simplicity in use. Although the non-destructive testing (NDT) result are much quicker compare to the destructive methods. They are more of an approximation than exact compressive value. In as much as the rebound hammer result are quicker and do not destroy the surface of concrete tested, there is no established relationship between compressive strength obtained using NDT and DT.

Various non-destructive methods of testing concrete have been developed, which include, Firing method, Skramtayev's method, Polakov's method, Magnitostroy method, Fizdel ball hammer, Einbeck pendulum hammer, Ball indentation hammer, Rebound hammer, Pull out techniques, Windsor probe, Ultrasonic pulse velocity methods, Radioactive and nuclear methods, Magnetic and electrical methods. In all these methods of tests, due to simplicity, rebound hammer test based on surface hardness becomes most popular in the world for non-destructive testing of in-situ concrete.(Kaushal Kishore 2000).

The rebound (Schmitz) hammer is one of the most popular non-destructive testing (NDT) method used to test the strength of the concrete. This is due to it relatively low and simplicity in use. Although the non-destructive testing (NDT) result are much quicker compare to the destructive methods. They are more of an approximation than exact compressive value. In as much as the rebound hammer result are quicker and do not destroy the surface of concrete tested, there is no established relationship between compressive strength obtained using NDT and DT.

Pratt D.U. and Lawrence J. (1990) claims non-destructive test (NDT) methods are used to obtain information about a structure in an indirect way.

The research aimed at comparing the strength of concrete obtained by Schmidt rebound hammer (NDT) and compressive testing machine (DT).

II. MATERIALS AND METHODS

The various types of materials used in this study to cast the concrete include: Fine aggregate (sand), Coarse aggregate (granite), Cement and Water.

A total of 24 concrete cubes (150 mm x 150 mm x 150 mm) were cast with concrete mix ratio of 1:2:4. 12 cubes were tested destructively for compressive strength with compression machine and 12 cubes were also tested non-destructively with Schmidt Rebound Hammer. Compressive strength test results at curing ages (7, 14, 21 and 28days.) were collated and analysed.

TABLE 1
TABLE SHOWING NUMBER OF CUBES TESTED

Test Methods	Age 7	Age 14	Day 21	Day 28
Schmidt Hammer Test (N.D.T)	3	3	3	3
Compression Machine Test (D.T)	3	3	3	3
Total				24

III. RESULTS AND DISCUSSION

3.1 Slump Test

The result of slump test carried out to assess the workability of fresh concrete is shown in table 2.

TABLE 2
SLUMP TEST RESULT

Percentage (%)	Slump (mm)	Kind of slump
1:2:4	20	True

3.2 Compressive Strength Tests Results

The compressive test results achieved by crushing cured cubes under the compressive test machine at different crushing ages are shown in table 3 From the results obtained a gradual general increase was recorded in strength of concrete, with the concrete cubes attaining the highest strength at 28th day curing age.

3.3 Schmidt Hammer Test Results

The Schmidt hammer is used to get the surface hardness of concrete which is a function of the concrete strength. The rebound numbers gotten were converted to compressive strength using the standard conversion graph. Three cubes were subjected to testing with the Schmidt hammer on each of the different curing ages.

TABLE 3
AVERAGE COMPRESSIVE STRENGTHS FOR BOTH N.D.T AND D.T

Test Methods	Age 7	Age 14	Day 21	Day 28
Schmidt Hammer Test (N.D.T)	15.68	18.80	23.06	34.61
Compression Machine Test (D.T)	14.03	17.60	20.6	27.50

3.4 Correlation and Regression Analysis

The strength of relationship and governing equation between the NDT and DT compressive strength test results were determined statistical tool.

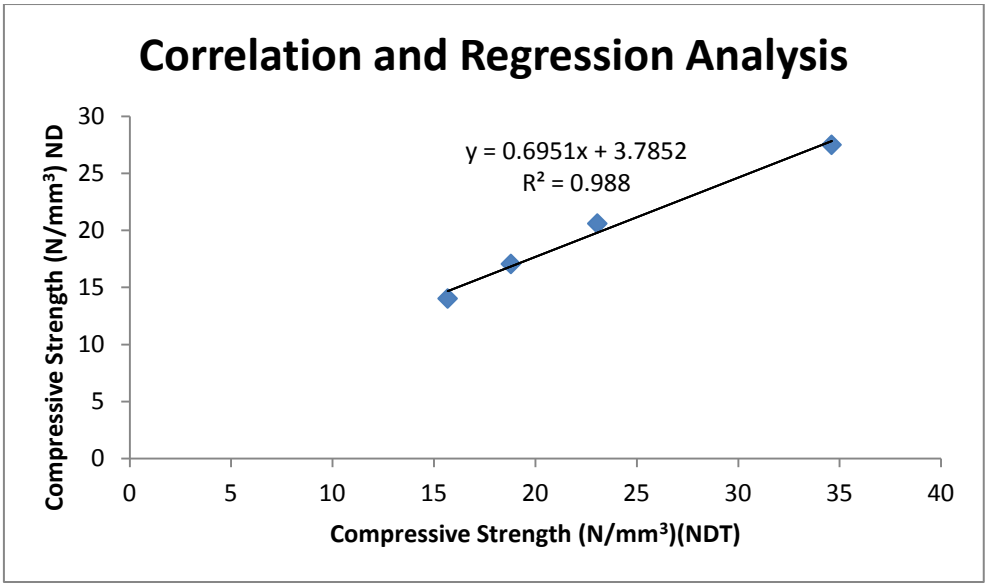

FIGURE 1: CORRELATION AND REGRESSION ANALYSIS

Conversion equation:

$$y = 0.6951x + 3.7852$$

Where "x" is the rebound hammer compressive strength of the concrete cube

Where "y" is the compressive strength of the concrete cube

Where R^2 is the correlation coefficient

3.4.1 Regression Validation

TABLE 4
REGRESSION VALIDATION

Curing Age	Schmidt Hammer Test (N.D.T)	Compression Machine Test (D.T) Experimental Values	Predictive or Correlated Values y = 0.6951x + 3.7852
7	15.68	**14.03**	**14.68**
14	18.80	**17.60**	**16.85**
21	23.06	**20.6**	**19.81**
28	34.61	**27.50**	**27.84**

IV. CONCLUSION AND RECOMMENDATIONS

The correlation among the strength values obtained by DT and NDT test methods on concrete cubes has been established. Schmidt Hammer test method has been used as a non-destructive test. The following conclusions have been drawn:

- There exist a strong relationship between the compressive strength results from both methods with Correlation coefficient of $R^2 = 0.988$.
- The predictive equation $y = 0.6951x + 3.7852$

The following recommendations were made based on result and observation recorded in this study.

- Increased number of test sample cubes is suggested to for better correlation of both rebound hammer test and compressive strength test values.

- The Schmidt rebound hammer is recommended for the assessment of compressive strength of hardened concrete to rule out difficulties (delayed feedbacks on laboratory analysis, epileptic power supply for running tests on concrete cubes.) in testing cubes for their strength using compression testing machine.

REFERENCES

[1] Aksahi t, Amasaki s (1984). Non destructive testing in concrete, ACI SP- 82 Detroit pp 19 – 34

[2] Amasaki S (1991) Estimation of strength of concrete structure by the rebound number CSJ Proc conc 45 pp 345 - 351

[3] Blezard (1998) "Durable concrete structure" Thomas Telford publishing company limited

[4] Bungey.J.H and S.G. Millard (1996). Testing of concrete in structure Blackie Academy and professional, London, newyork, 3rd ed, pp 286

[5] British Standard Institution, (1980). Method for determination of compressive strength of concrete cubes, BS 1881: Part 116, London, British Standard Institution.

[6] Duna Samson Omoniyi, Tope Moses. Correlation between Non-destruction testing (NDT) and destructive testing (DT) of compressive strength of concrete. September 2014, pp 12-17.

[7] Ferhat Asphin and Mehmet Saribiyik. '' Correlation between Schmidt hammer and destructive compressive testing for concretes in existing buildings, June 2010, pp 1664 - 1648.

[8] Greene G.W. Test hammer provides new method of evaluating hardened concrete, ACIJ.

[9] Hassan R.Hajjeh correlation between destructive and non destructive strength of concrete cubes vol.5, 2012, no. 10, 493-509

[10] Hassan R. Hajjeh, (2012) Correlation between destructive and Non-destructive strength of concrete cubes using regression analysis. Pp 493-509

[11] Kaushal Kishore, (2000) '' Non destructive testing of concrete by rebound hammer.