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USE OF NON-DESTRUCTIVE TESTS TO AVERT THE RISK OF BUILDING COLLAPSE

Anthony N. Ede*
Department of Civil Engineering, Covenant University, Ota, Nigeria

Oluwarotimi M. Olofinnade
Department of Civil Engineering, Covenant University, Ota, Nigeria

Olatokunbo M. Ofuyatan
Department of Civil Engineering, Covenant University, Ota, Nigeria

Opeyemi Joshua
Department of Building Technology, Covenant University, Ota, Nigeria

Oluwadamilola Aremu
Department of Building Technology, Covenant University, Ota, Nigeria
*Corresponding Author: anthony.ede@covenantuniversity.edu.ng

ABSTRACT

Structural integrity assessment involves the determination of reliability and soundness of a structures over time and has evolved greatly over the years. The use of destructive testing is not acceptable in integrity assessment of structures since it leads to partial or wholesome destruction of the structure. This makes the use of non-destructive tests as the most viable option. As the need for structural assessment continue to acquire a high level of significance in relation to the great economic and social importance of safety and minimization of structural failures, the use of non-destructive tests (NDTs) methods continue to acquire more relevance in structural health monitoring. Due to a high rate of structural failures in Nigeria, caused by internal defects that cannot be easily detected by visual inspection, it has become necessary to adopt modern structural health monitoring tool such as NDT to assess the integrity of structures. This study assesses the integrity of a concrete columns via NDTs method as a way of reducing the risk of building collapse. The appropriateness of concrete cover was gauged using Profoscope's rebar locator because defects related to poor concrete cover can often lead to complications in structural integrity. Six columns of the ground floor of a two story building were assessed and 10 tests were performed on the each column. Statistical method was used to validate the tests data, resulting in the mean value and standard deviation for each column. Of the six columns, one failed the reliability test showing that this particular NDT method can be valuable tool in effectively assessing buildings prone to the risk of building collapse.

By being able to diagnose the risk, then it will contribute in reducing the occurrence of building collapse in nations prone to structural failure.

Key words: Reinforced Concrete, Non-destructive Test, Profoscope, Building Collapse, Structural Health Monitoring.

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1. INTRODUCTION

The safety of structures cannot be overemphasized as it remains one of the cardinal factors to be considered for any product including buildings. The integrity of building structures can be checked through tests. Testing is a fundamental method to ascertain the quality of products. For the construction industry, the most common type of tests are those conducted on materials to determine the strength and validate the conformity to code specifications. This type of test is always destructive and can be effectively applied to test specimen but not to already built-up structures. The destructive methods involve damaging of parts of the existing building that is being tested in order to evaluate the desired properties. The major disadvantage of destructive methods on concrete structures as an example is that the in-situ strength of the concrete cannot be gotten without destroying the structure and it is also not enough to predict the performance of the structures under unfavourable conditions [1]. To overcome the limitations of destructive test, non-destructive test methods can be adopted.

Non-destructive test methods can be safely adopted to test the quality of materials or integrity of structures. Non-destructive testing (NDT) is the assessment of material properties or structural integrity without harming or destroying the test specimen or part of the structure being tested. Non-destructive testing encompasses testing that causes no significant structural damage to the structure. It does not affect the future performance examined, it is able to determine the durability and strength of a structure without damaging it and it can be carried out on site. In recent years, NDT method is assuming greater importance as the engineering community aspires to timely identify the existence, location and extent of damages or flaws in material samples or structures in order to avert the risk of potential failures. The use of NDT' method for better functional safety of structures has attracted many researchers. Sohn [2] reviewed the structural health monitoring procedures emerging in literature between 1996 and 2001. Ede et al. [3-4] used dynamic-based damage assessment method to evaluate strength degradation in Fiber Reinforced Polymer Composite (FRP) Strengthened RC Beams under static loads. Musolino [5], assessed the feasibility of defect detection in concrete structures via Ultrasonic investigation. Ede and Pascale [6] proved that dynamic-based NDT method is effective in assessing structural damage of FRP-strengthened reinforced concrete beams under cyclic loads. Ede, Olofinnade and Sodipo [7] demonstrated that Building Information Modelling Tool is an effective way of identifying and fixing flaws that have potential of leading to structural failure.

In Nigeria, building collapse is very widespread, with the consequent loss of precious lives and waste of economic resources. This contravenes the Sustainable Development Goals [8]. Poor materials have been listed by various authors as being among the principal causes of building collapse in Nigeria [9-11]. Because of the prevalent cases of building collapse being verified in Nigeria, this research uses Profoscope test apparatus to assess the state of concrete cover of reinforced concrete some columns in a building under construction, situated in a freshly developed estate where a building collapsed occurred recently. This is to verify the integrity of the building before taking decision on continuing the construction work or to make amends that will reduce the risk of collapse.

2. METHODOLOGY

For this research, non-destructive test was used to assess the rebar location in a reinforced concrete structures. The equipment specifically used for this scope is Profoscope. The research was conducted on a structure in mist of 5-units of two-storey residential buildings after one of the units collapsed in 2017 while still under construction (Figure 1). The major causes that can lead to the collapse of the building include poor workmanship, use of substandard products, poor concrete mix or inadequate concrete cover among others. Profoscope test was used to assess the concrete cover to reinforcement in an effort to diagnose possible defects and therefore prevent further collapse. Figure 2 shows the Profoscope test apparatus, while table 1 contains the description of Profoscope.

Figure 1 The building unit that collapsed (Aremu, 2018).

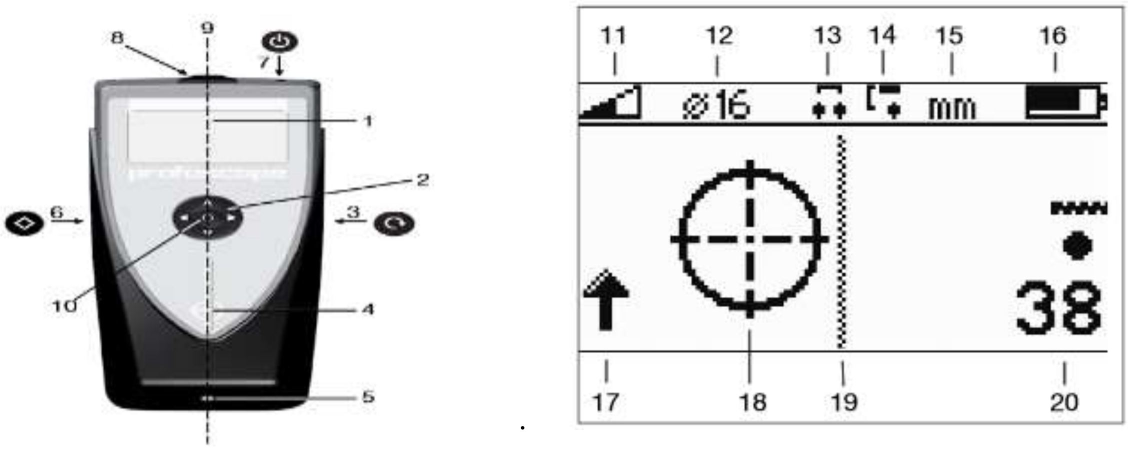

Figure 2 Profoscope test apparatus

Table 1 Description of Profoscope apparatus

Display	Navigation
Reset Key	Measurement Centre
LED Indicator	Function Key
On/Off Button	Battery Compartment
Centre Line	Select Button
Measuring Range	Reference Rebar Diameter
Neighbouring Rebar Correction Active	Minimum Cover Alert
Measuring Unit	Battery Status
Signal Strength	Riffle Scope
Centre Line	Measured Cover Depth

3. TEST PROCEDURE

The surface to be tested was smoothened using a grinding wheel or stone to ensure a suitable smooth surface. The Profoscope was placed on the surface to be tested and then moved gradually in a desired direction. The equipment was moved until the LED indicator came on. This loctaes the rebar directly underneath the measurement centre. Once the rebar is found, the measurement center is rotated to obtain the value for the cover concrete. When that is found, the LED indicator comes on to confirm the value obtained. Then the concrete cover can be read off the Profoscope and then the value can be recorded. Then the profoscope is reset and the process repeated again. For each column, ten (10) readings are taken at various points and the average is recorded as mean cover. The approach adopted in this research is as similar to the one adopted in [12].

4. RESULTS AND DISCUSSION

Profoscope test was conducted to get the concrete cover to reinforcement of six columns. The minimum concrete cover envisaged in the design was 25mm, such that columns with less than 25mm cover was considered to be inadequately covered. For each column, ten (10) Profoscope tests were conducted and the average was recorded as the mean cover. Results obtained for each of the columns are shown in figures 3 to 9. Figure 9 represent the mean cover for all the columns.

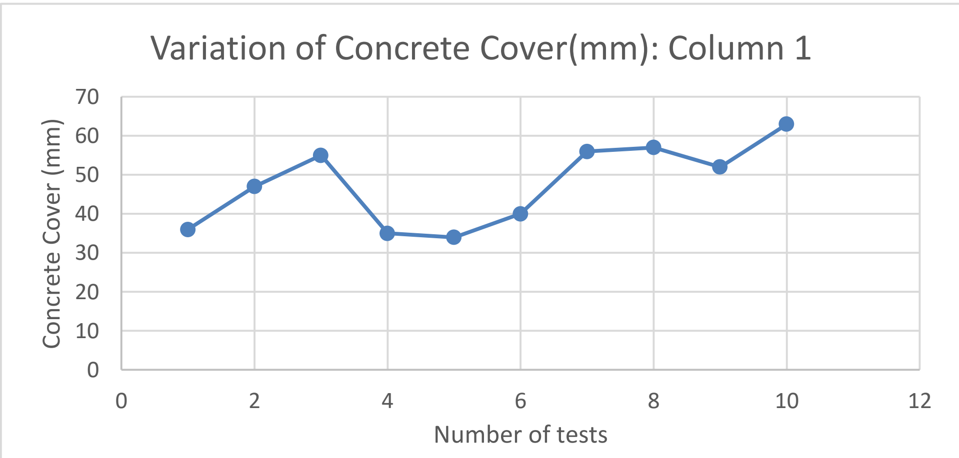

Figure 3 Variation of Concrete Cover for Column 1

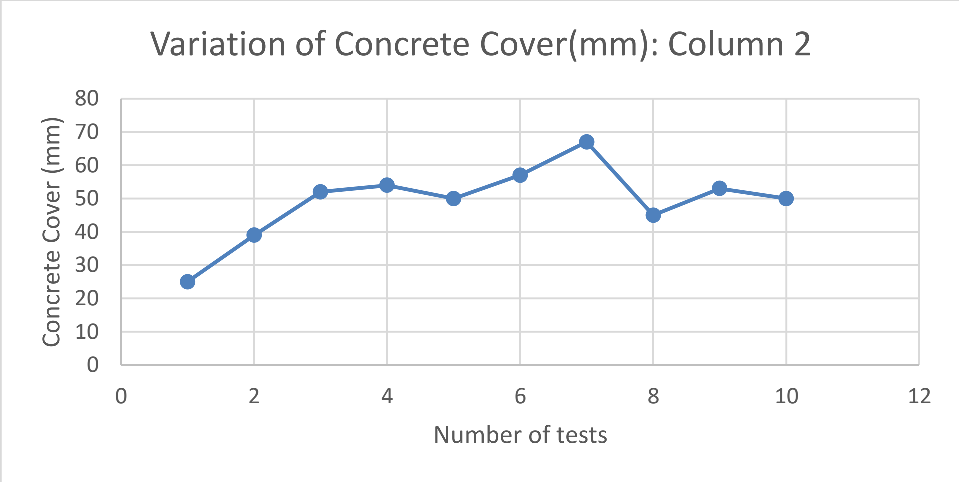

Figure 4 Variation of Concrete Cover for Column 2

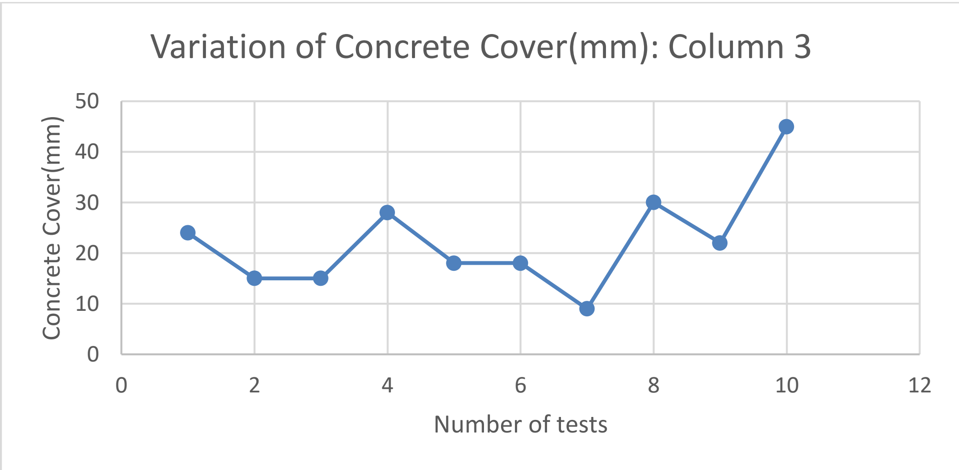

Figure 5 Variation of Concrete Cover for Column 3

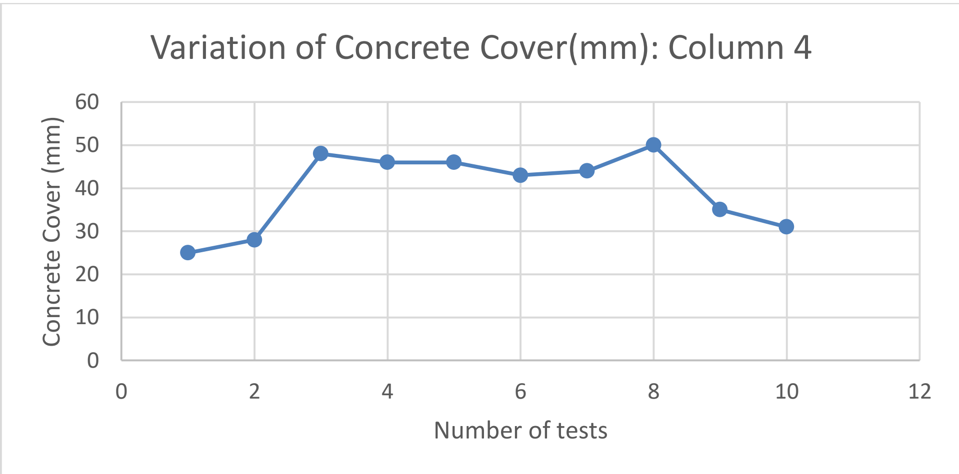

Figure 6 Variation of Concrete Cover for Column 4

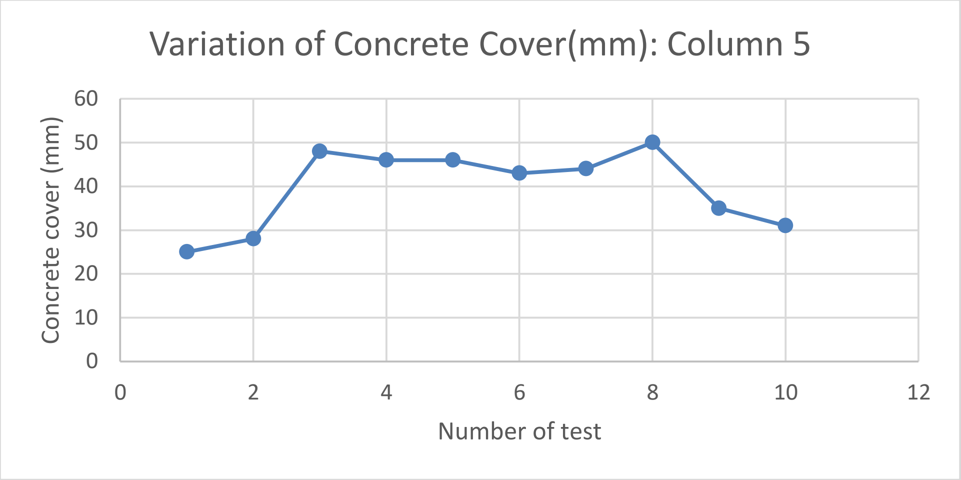

Figure 7 Variation of Concrete Cover for Column 5

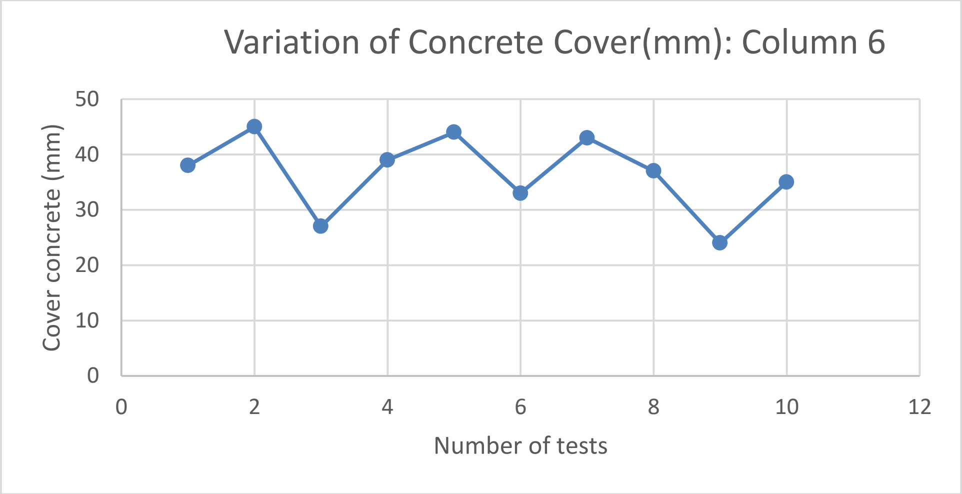

Figure 8 Variation of Concrete Cover for Column 6

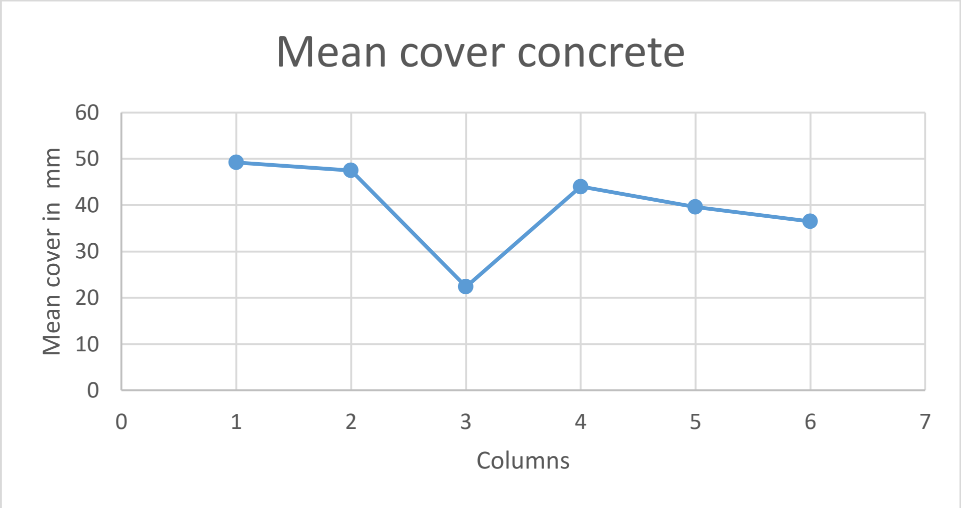

Figure 9 Mean Concrete Cover for the 6 Columns

From the results shown above, it can be seen that the state of column 3 grossly inadequate. This brings to the fore the myriad form of challenges that can be verified in reinforced concrete structures. Reinforced concrete structure is a composite material made up of very dissimilar materials. The various constituent materials [13-14] can sway the structural behaviour in various ways. The trending approach towards green concrete have led to myriad of constituent materials substitution whose b effect on structures are not yet well understood [15-18]. This shows that the cause of this gross defect can be numerous. But the most important thing is that the test approach adopted in this research was able to identify this gross defect. The cover concrete verified is below the minimum design specification 25mm and portend great danger for the structure. Such shallow cover concrete will not protect the steel rebar from water infiltration. And therefore the risk of corrosion of steel is very high. Once the steel corrodes, the composite action between concrete and steel can no longer hold thereby heightening the risk of building collapse. The discovery of this defect will surely affect the decisions to be taken on the structure.

5. CONCLUSIONS

This research used NDTs method to assess the integrity of columns in a reinforced concrete building. Profoscope tests were conducted on six columns in order to assess the adequacy of concrete cover to reinforcement. The minimum concrete cover envisaged in the design was 25mm and this research proved that column 3 was inadequately covered. The presence of inadequate cover to reinforcement elevates the risk of corrosion of steel rebar which consequently leads to loss of area of steel reinforcement. This has a great potential of leading to building collapse since the weakened steel reinforcement will no longer be able to contribute its quota in the composite strength required to carry the design load. This research has proved that the test method adopted is valid for diagnosing defects in reinforced concrete structures. In Nigeria, where cases of building collapse is very rife, the use of NDTs method will go a long way in identify possible defects that can lead to building collapse, thereby improving the sustainability of Nigerian structures as it will reduce the risk of collapse, save human lives and avoid waste of economic resources.

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