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The Assessment Of Standard Concrete Under Damage And Undamage Condition Using Non-Destructive Test (NDT) Method

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Abstract : Destructive testing on specimens taken during the building of structural elements, are currently the most prevalent method for controlling the quality of concrete on-site. In concrete works, the most common NDT method used are Penetration method, rebound hammer method, Pull out test method and Radioactive methods. Previously, studies on concrete strength were mainly using compressive strength test, so, in this study, UPV test which was NDT method will be employed. The main objectives of this study are to determine compressive strength of standard concrete using Design of Experiment (DOE) Method and to analyze the impurity of standard concrete under undamaged condition using UPV. This study will adhere to a conventional procedure in accordance with British Standard concreting procedures. This study will also employ the Design of Experiment (DOE) method. Materials such as cement, water, and aggregates are required in the production of concrete sample. Curing processes of 7,14 and 28 days were used to maintain moisture in the concrete and this initiative will take place on the campus of UTHM Pagoh. From this study, it is expected that the compressive strength is directly affected by the curing days, and the UPV test result will remain constant as the impurity of the concrete were determined by the quality controls during the concreting process. To achieve the study's goals, all of the data gathered from the sample testing were analyzed and debated. To ensure the accuracy of the data, it was advised that all normal operating procedures be followed.

Keywords: Compressive Strength, Ultrasonic Pulse Velocity (UPV), Design Of Experiment (DOE) Method

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1. Introduction

Concrete has become the most commonly utilized material in the construction of structures. The production of high-quality concrete began with a properly measured proportion of materials. Determining its compressive strength ahead of time may help contractors identify problems earlier and avoid the worst-case situation. Destructive testing on specimens taken during the building of

structural elements are currently the most prevalent method for controlling the quality of concrete on-site [1]. While the assessment of concrete using Ultrasonic pulse velocity (UPV) test method will provide the result for the impurity or current condition of the specimens or any concrete structure that can't be seen from the outer side of the concrete.

In this study, compressive strength testing was employed to focus on damaged conditions and UPV for undamaged conditions. In the past, studies on the strength of concrete relied only on compressive strength data from machines with damage. Therefore, this study's objective is to evaluate the state of concrete with utilizing the standard compressive strength test, and the UPV Test technique. On compressive strength, the curing days were predicted to have a direct impact, but not on the UPV Test. [2], [3]. The major goal for this work is to calculate compressive strength of standard concrete using design of experiment (DOE) approach and assessing the impurity of standard concrete under undamaged condition using UPV.

2. Materials and Methods

In order to carry out this study, the materials that will be used have been collected to be used later. In addition, to conduct this study, the methods that will be used have been identified in advance.

2.1 Materials

Raw materials come in a variety of forms and sizes and are used in a wide range of products. First of all, Preparation for all materials was done to carry out this study to the next process Cement, water and aggregate materials are the main materials used in this study.

- Cement
  The OPC (Ordinary Portland Cement) from the Campus UTHM Pagoh laboratory is used in this study. Because OPC is commonly used for cement stabilization, this type of cement was chosen.

- Aggregates
  Aggregates are split into two categories: fine and coarse. Fine aggregate and coarse aggregate from the Campus UTHM Pagoh laboratory had been used.

- Water
  The specimens were examined to ensure that no pollutants were present, as well as for mixingand curing the concrete.

2.2 Methods

Several processes have been gone through to prepare this study, these processes need to be done well and carefully to get perfect results. in carrying out these processes there is also a separate methodthat needs to be used when the process is carried out.

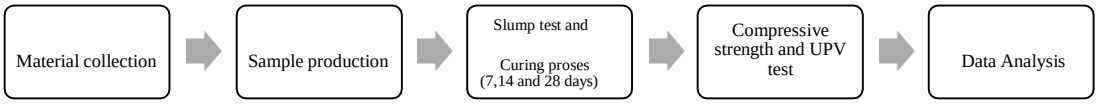

Figure 1: Flowcharts of the study methodology

2.3 Design Mixed

The British Standard Method of Concrete Mix Design (DOE) is used to compute the mix designof concrete in this study This method was used because it was a way to explore the link between various input variables (also known as factors) and important output variables in a systematic and efficient manner (also known as responses). It's a method for gathering information and producing discoveriesthat's organized. [4]

2.4 Slump Test

Procedure for concrete slump test: Fill the cone in three stages, compacting or tamping the concrete after each layer in an orderly, regular way with the steel tamping rod (this should be done 25 times per layer). [5] Remove any spilling concrete from the top of the cone once it has been filled, slowly,and steadily lift the cone vertically until it is free of the concrete and take a measurement from the rod to the top of the slump.

Figure 2: Procedures for slump test

2.5 Compressive Strength

It is possible to describe concrete's compressive strength as its ability to bear loads before breaking. The compressive strength test is the most crucial of the several tests conducted on the concrete since it provides information about the properties of the material.

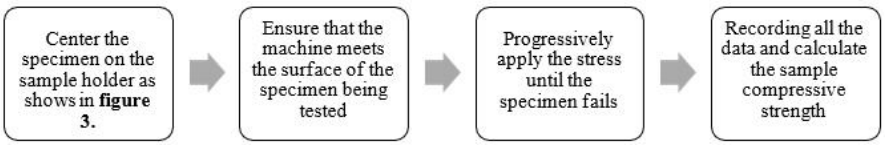

Figure 3: Compressive test machine and Flowchart of test procedure

2.6 Ultrasonic Pulse Velocity (UPV)

Nondestructive test to examine the quality of concrete and natural rocks is called an ultrasonic pulse velocity (UPV) test. [6] By monitoring the speed of an ultrasonic pulse as it passes through a concrete building or a naturally occurring rock formation, this test determines the durability and quality of rockor concrete.

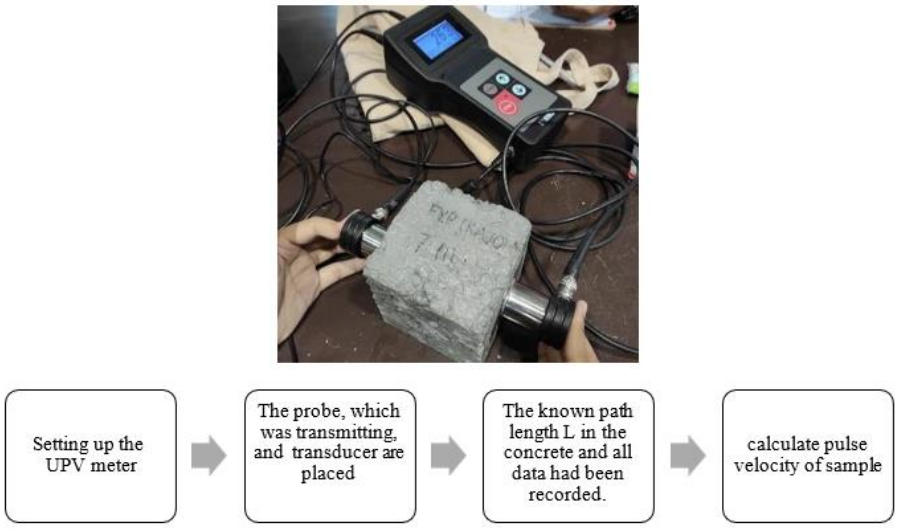

Figure 4: UPV Test on concrete and flowchart of the UPV test procedure

3. Result and Discussion

The results that have been obtained are observed and evaluated before being discussed in more depth about the results obtained to identify whether the objectives of the study have been achieved.

3.1 Results

The results obtained after assessing the strength of standard concrete using the Design of Experiment (DOE). One of the samples that met the actual design strength of 26.43 N/mm2 after being compressed for 28 days was ordinary concrete [7]. As the number of curing days grew, the concrete samples' compressive strength increased as well. As a result, compressive strength is directly influenced by the curing days. Average data for UPV test has also achieved the goal with 4 km/s velocity pulse for 28 days of curing. The data acquired demonstrate that this test enables measurement and control of a variety of key variables for the purpose of evaluating the concrete quality [8].

3.2 Density

Density is the mass of a material element per unit volume and it can be defined using formula Eq. 1.

$$\text{Density, } d = M/V \quad \textbf{Eq. 1}$$

The density of the concrete increased as the number of curing days increased, as can be observed from the results in table 3.1. After 7 days of curing, Sample 3 had the maximum density, measuring 2330 kg/m3. The lowest density measurement, 2290 kg/m3, is produced by sample 2 of both curing

days. These noteworthy results show in Table 1. were also attained as a result of the concrete sample attaining its true strength.

Table 1: Density of the Samples Curing for 7 days and 28 days

Sample	Density concrete (kg/m^3)	
	7 days	28 days
1	2310	2300
2	2290	2290
3	2330	2320
Average	2310	2303

3.3 Compressive strength test

After the compression test is performed on all the samples, recorded data should be calculated using the **Eq. 2** to obtain the value of compressive strength. The findings indicate that compressive strength improves in value with longer curing times. [9] The amount of water absorption grows together with the number of curing days, increasing the strength of the concrete sample. **Figure 5** shows the average compressive strength of the three samples as they expand from 7 to 28 days supports and indicates this. The second specimen was removed from the computation of the average strength for the 28-day curing because it had higher findings that varied by more than 15% from the results of the other two samples. The maximum average compressive strength was 26.43 N/mm2 after 28 days of curing, had reached the stated goal strength of 25 N/mm2, as determined by the DOE [10].

$$Compressive\ Strength = \frac{Maxium\ load}{\text{Cross-sectional area}} \quad \textbf{Eq. 2}$$

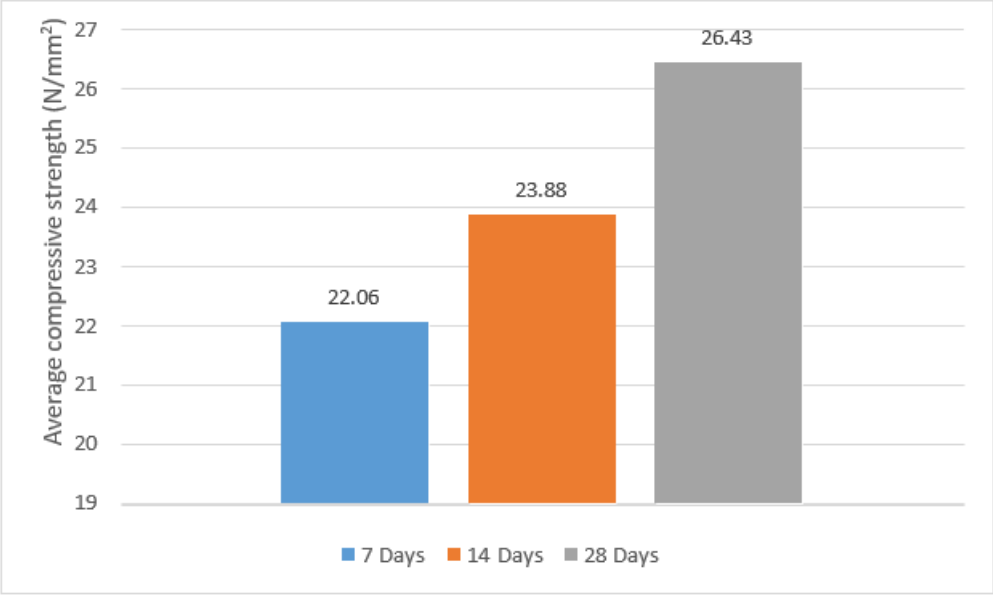

Figure 5: Average compressive strength for different curing days

3.4 Ultrasonic Pulse Velocity

The sum of UPV test a reduced average travel time from day 7 to day 28. The less time taken for pulse to go through concrete, the higher pulse velocity is achieved. The calculation must be performed using **Eq. 2** once the upv measurement is obtained to determine the pulse velocity of each sample. [11].

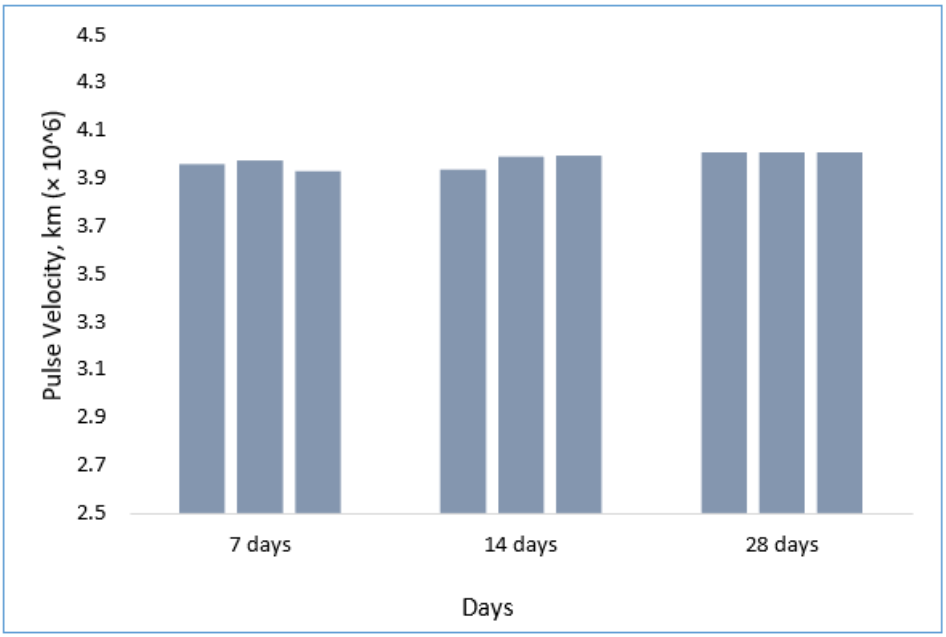

Figure 6: Pulse velocity for all samples

4. Conclusion

The study's objectives were carried out successfully throughout the two tests, which are the compressive strength test and the UPV test. Concrete specimens were created in this study with stringent quality controls to ensure that the data gathered from two major concrete tests was accurate. In compressive strength test, three specimens were examined for each curing day to determine the average strength, and any specimen whose results differed by more than 15% from the others had to be ruled out, as this indicated that some errors had happened during the procedure. The importance of performing a compressive strength test on concrete is that the data gathered will give you an understanding of all the properties of concrete. [12][13] The non-destructive test study focuses on the importance of having high-quality and long-lasting concrete structures, and it attempts to understand the capabilities and limitations of testing. Because concrete is a heterogeneous material, interpreting the relationship between strength and UPV can be difficult. It may be assumed that the use of UPV can help with the management of degradation and the quality of concrete. Depending on the results of this study, certain recommendations can be made. First and foremost, the amount of water in the mixture must be lowered [14][15]. Excess water produces larger spaces between aggregate materials, which fill with air as the moisture evaporates. In addition, the aggregates used must change in terms of their types and gradations. Aggregates account for 60-80 percent of the volume and 70-85 percent of the mass of concrete, respectively.

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