Comparatively Study of Non-Destructive test with different methods in various curing days

Chandramohan Pahade[1], *Umang* Parmar[2*], *Ahmed* Salaam[3], *D S N M* Rao[4], Manjunatha[5], *Atul* Singla[6], *Gottipati Venkata* Rambabu[7]

[1]Department of Civil Engineering, IES Institute of Technology and Management, IES University, Bhopal, Madhya Pradesh, India 462044.
[2]Department of Mechanical Engineering, Aditya Silver Oak Institute of Technology, Silver Oak University, Ahmedabad, Gujarat 38248.
[3]Hilla University College, Babylon, Iraq.
[4]Department of EEE, GRIET, Bachupally, Hyderabad, Telangana, India.
[5]Department of Mechanical Engineering, New Horizon College of Engineering, Bangalore, India
[6]Lovely Professional University, Phagwara, India.
[7]Department of Mechanical Engineering, MLR Institute of Technology, Hyderabad, Telangana, India-500044

Abstract. In non-destructive testing, materials, components, or assemblies are inspected, tested, or evaluated without being destroyed. In non-destructive testing, materials, components, and assemblies are evaluated for quality and integrity without damaging them. The use of non-destructive testing (NDT) is a popular method for assessing the strength and durability of existing concrete structures. An ultrasound pulse velocity test and a rebound hammer test are included in the NDT test. An NDT test includes both ultrasound pulse velocity testing and rebound hammer testing. Strength tests are conducted with rebound hammers, while quality tests are conducted with ultrasonic pulse velocity tests. A lab-made concrete cube was tested on three different ages-seven, fourteen, and 28 days-without destroying it. There were 15 cubes that were treated using non-destructive methods. Using both Schmidt rebound hammer and ultrasonic pulse velocity tests, we determined which non-destructive testing method was faster. In addition to surfaces, Schmidt rebound hammers are the toughest tools to use. Rebound number and concrete strength seem to be connected. Schmidt hammers were employed in both vertical and horizontal settings. Concrete's ultrasonic pulse velocity is mostly determined by its identity and modulus of elasticity, that are motivated by the substances used in making the concrete in addition to its placement, compaction, and curing techniques.

Keyword. Ultrasound pulse velocity, rebound hammer test, Concrete structures, Schmidt rebound hammer, Concrete strength correlation, Surface testing.

* Corresponding Author : umangparmar.me@socet.edu.in

1 Introduction

Non-detrimental testing ensures the great and integrity of concrete systems all through construction or post-construction. Identifies problems such as delamination, and spaces, or cracks in concrete, helping with timely maintenance [1-2]. Concrete buildings perform better when non-destructive testing (NDT) is conducted without any damage being done [3]. This method is critical for comparing the properties of concrete, durability, and ability defects inside concrete factors. Various non-destructive methods are employed to examine concrete structures, providing valuable insights into their condition and helping engineers make knowledgeable decisions approximately protection, repairs, and overall structural safety [4]. The importance of NDT in concrete lies in its capacity to provide specific records approximately the structural soundness, supporting make sure the protection and longevity of concrete-primarily based infrastructure [5]. Concrete can be examined non-destructively to determine its strength and qualities without causing damage to structures that are already in place. Concrete tests are used to assess existing constructions' compressive strength and other characteristics [6]. They yield quick findings and provide insight into the actual strength and characteristics of the concrete. While testing specimens for compressive, flexural, and tensile strengths is part of standard procedures, there are a number of drawbacks, such as delayed results, differences in curing and compaction conditions between the specimen and real structure concrete, and a dependence of strength properties on specimen size and shape [7-8]. Despite the inability to directly measure strength properties, various non-destructive assessment methods have been developed. The NDT method is only one of the main methods for analyzing the strength of concrete and existing concrete structures, and judging the quality of concrete [9]. NDT testing includes rebound hammer, ultrasonic pulse velocity test, penetration test, [10]. Radiography test, sonic integrity test etc. But most used techniques rebound hammer test quality for strength For and are ultrasonic pulse velocity testing these are often used together as the former can determine the surface strength of the concrete, the shear to it to determine the quality of the core [11]. They so make the perfect match. Furthermore, it is convenient to employ these methods both at the construction site and in the laboratory. Non-destructive test on concrete said so because these tests can be performed in situ as well as in laboratory without destructing the concrete member & results about strength and durability can be obtained [12]. These tests have been present for forty years and are regarded as an effective way to examine and control the quality of existing concrete structures as well as their strength and longevity. Of solidified concrete without seriously harming the building [13-14]. Under some circumstances, these techniques are also used to investigating crack depth, micro cracks, and gradual deterioration. Although non-destructive testing techniques are easy to use, analysing and interpreting test data can be challenging [15-16]. This method may not provide completely accurate strength estimates because specimens are not loaded to function. These methods attempt to measure some other properties of concrete from which estimates of strength, durability and stiffness are obtained. Some such properties of concrete are stiffness, imperviousness, repetition frequency, pulse frequency, and ability to propagate ultrasonic pulse velocity thereby [17]. Concrete cubes produced in a lab conducted two non-destructive tests after 7, 14 and 28 days of use. 15 cubes in all received non-destructive testing to ascertain their quality [18]. When it came to the non-destructive testing (NDT) process, ultrasonic pulse velocity tests were quicker and more accurate than Schmidt rebound hammer tests in terms of time and accuracy. The Schmidt rebound hammer's main function is to test the hardness of the surfaces it is used on. There appears to be a relationship between rebound number and concrete strength [19]. Schmidt hammers were frequently used in both vertical and horizontal orientations. many variables that affect the concrete's ultrasonic pulse velocity, including its identity and modulus of elasticity, which are both affected by the materials used in the concrete's production, as well as the way it is placed, compacted, and cured [20].

2 Methodology

In this method, ultrasonic pulse velocity and rebound hammers are used to inspect concrete non-destructively. The compressive strength of concrete was assessed through the use of an ultrasonic pulse velocity and a rebound (Schmitz) hammer's momentum during NDT. During this experiment, the surface hardness of an elastic mass was used to test the concept that it determines its rebound. Weighing 1.8 kg, rebound hammers are effective in the lab and on the industrial site. A test was carried out following every curing period to determine whether the concrete had hardened. On each concrete specimen, the test was repeated five (5) times, resulting in 15 readings. Using Schmidt hammers and a nondestructive test method, this experimental study tests standard concrete cubes. Standard crushing strengths were produced by preparing concrete cubes with varying curing days. Testing specimens and testing programmers are used in this study to determine concrete's compressive strength using nondestructive testing (NDT). Several types of blocks were cast, including slabs, cylinders, cubes, and cubes with inserted bars. Casting specimens is done with 43 grade cement. Fine aggregates are made from locally available river sand.

Table 1: Requirements material

S.no	Materials	Value
1	Grade of Concrete	M30
2	Type of cement	OPC
3	Max size of aggregate	20mm
4	Degree of quality control	Good
5	Type of exposure	Severe
6	chemical admixture type	Super plasticize

Table 1 showing that the "Grade of Concrete" specified as M30 indicates the concrete mix's target strength at 28 days after curing, which is 30 megapascals (MPa). "Type of cement" indicates Ordinary Portland Cement, a very popular and widely used cement type for building projects throughout the world. Concrete mixes can contain aggregates up to 20mm in size, affecting their workability and strength. A "Degree of quality control" classified as "Good" implies that rigorous quality control measures are implemented during both the production and placement phases of the project, ensuring consistency and reliability. A designation of "Type of exposure" as "Severe" indicates that the concrete may be subjected to harsh environmental conditions after placement, and therefore needs to be resilient to elements such as extreme weather conditions or chemicals. Last but not least, the inclusion of "chemical admixture type" as "Super plasticizer" indicates that a super plasticizer chemical additive is utilized to improve concrete workability and reduce water content without compromising strength, thereby simplifying handling and placement.

3 Testing Procedure

3.1 Rebound (Schmidt) hammer test:

Recently, this technique has been the most widely used for testing concrete strength. Depending on how hard a surface is, an elastic mass will rebound differently. Hammer plungers press against concrete surfaces at the proper angle until the spring-loaded mass is actuated. Concrete's compressive strength can be measured quickly and easily using the rebound hammer test, a non-destructive testing method. Rebound hammers, sometimes called Schmidt hammers, are made out of a mass that is controlled by a spring and glides inside a tube casing on a plunger. In this test, concrete is measured for its elastic rebound and its strength, as well as for comparative analysis.

3.2 Test Procedure

- Testing must be conducted on a dry, clean, and flat surface. Stones and grinding wheels are recommended for removing loosely clinging scale. Compaction problems, grout loss, spalling, or tooled surfaces all produce rough surfaces that cannot be consistently repaired. In the event of impact, a minimum distance of 25 mm should be maintained from any edge or discontinuity in shape.
- In order to measure the concrete member's surface, place the rebound hammer at a right angle. On horizontal surfaces, the test can be performed either vertically upward or downward, or horizontally on vertical surfaces. It is also possible to hold the rebound hammer at intermediate angles if needed in order to achieve an intermediate rebound number for the same concrete.
- A rebound hammer test is performed on every available face of the structural member, around all observation areas. Before any measurements are taken, concrete surfaces are carefully cleansed. Each observation site generates six readings of the rebound index, and the average of these readings makes up the rebound index, after outliers have been removed in accordance with IS.

3.3 Ultra sonic pulse velocity test

The ultrasonic scanning method is accepted as one of the non-destructive methods for determining the integrity and homogeneity of concrete. A rebound hammer test is performed on every available face of the structural member, around all observation areas. Before any measurements are taken, concrete surfaces are carefully cleansed. The rebound index is calculated for each point based on six readings around the observation location. In accordance with IS, the rebound index is calculated after removing any outliers from these values. Within the concrete, shear and longitudinal stress waves form and spread throughout the substance. Initially, longitudinal waves arrive at the receiving transducer, which uses a second transducer to transform them into electrical signals. An electroacoustic transducer generates the ultrasonic pulse. When a transducer is used to start an induced pulse in concrete, the pulse is reflected multiple times at the borders between different phases.

3.4 Test Procedure

In this test method, an ultrasonic pulse is generated by a transducer in contact with one surface of the concrete section under test, through a known concrete path length (L) and in contact with another side of the concrete. The pulse velocity is given by (V):

$V = L/T$

It is therefore recommended to use direct transmission or cross probing when the ultrasonic pulse impinges on the surface of the material so that maximum energy propagates at right angles to the face of the transmitting transduce

Ultrasonic pulses generated by a transmitting transducer must be detected by a receiving transducer with sufficient acoustical coupling. There are other liquids that can be poured, including petroleum jelly, grease, liquid soap, and kaolin glycerol paste. When installing a transducer on a rough concrete surface, you must level and smooth the surface. It is necessary to have a minimum path length of 150 mm for one type of direct transmission through an unmoulded surface.
The frequency range of a transducer is typically 20–150 kHz. In case of short distances, transducers with high frequency are recommended, while in case of long distances, transducers with low frequency are recommended.

4 Results and Discussion

NDT helps ensure the safety and longevity of concrete-based infrastructure by providing detailed information about structural soundness. A non-destructive concrete test can assess concrete properties and strength without damaging the structure. Currently, concrete structures are tested for their compressive strength and other properties. In nondestructive tests, concrete is tested for rebound hammer velocity and ultrasonic pulse velocity. In order to measure concrete's compressive strength, an ultrasonic pulse velocity and rebound (Schmitz) hammer were used. Tests were repeated five (5) times for each concrete specimen, resulting in 15 readings. When performing non-destructive testing, concrete cubes are hammered with a Schmidt hammer while ultrasonic pulse velocity sensors are used.

Table 2: Compressive strength for M30 at 7 days from both Rebound Hammer and UPV methods

Cubes No.	Strength from Rebound Hammer (N/mm²)	Strength from UPV (N/mm²)
1	20.84	23.6
2	18.76	23.1
3	17.94	21.8
4	18.2	22.6
5	18.9	23
Average	18.8	22.8

The Rebound Hammer test and the UPV method, which offer complementary observation on the characteristics of concrete, are the base of this study showing in Table 2. UPV measures concrete's strength by analysing the speed of sound waves travelling through it, while the Rebound Hammer test measures its compression strength by measuring its rebound index. On M30 concrete samples, a UPV test was conducted and a Rebound Hammer test was performed after seven days. Each concrete cube's serial number is accompanied by its corresponding strength, measured in N/mm2. For example, the range of findings for Rebound Hammer is 17.94 N/mm2 to 20.84 N/mm2, and the range for UPV is 21.8 N/mm2 to 23.6 N/mm2.

Table 3: Compressive strength of M30 after 14 days the usage of the UPV and Rebound Hammer techniques

Cubes No.	Strength from Rebound index (N/mm²)	Strength from UPV (N/mm²)
1	22.33	27
2	19	26
3	20.25	25.1
4	21.35	25.8
5	22.42	26
Average	21.07	25.9

The following Table 3 illustrates the compressive strength of the M30 concrete sample after 14 days based on hammer rebound and ultrasound pulse velocity (UPV). Every concrete cube has a unique serial number this is associated with the corresponding strength number. The UPV technique and the Rebound Hammer test provide complimentary insights into the qualities of the concrete for this examination. Concrete sample compression strength ratings differ according to data analysis. As a result, at 14 days, the UPV shows a range of strengths between 25.1 N/mm2 and 27 N/mm2, however the Rebound Hammer shows more than a few strengths between 19 N/mm2 and 22.42 N/mm2.

Table 4: Compressive strength for M30 at 28 days from both Rebound Hammer and UPV methods

Cubes No.	Strength from Rebound index (N/mm²)	Strength from UPV (N/mm²)
1	31	34.5
2	30.22	33.8
3	31.44	32.4
4	30.54	34.9
5	32.67	35.3
Average	31.1	34.2

As shown in the Table 4, ultrasonic pulse velocity (UPV) and rebound hammer compressive strength tests were conducted on M30 concrete samples over a 28-day period. A unique serial number is assigned to each concrete cube, and the strength of each cube is measured in N/mm2. In the UPV method, sound waves are measured by analysing the rebound index of hammers impacting concrete surfaces. The Rebounds Hammer test measures the material's strength by measuring the rebound index when a hammer strikes a concrete surface. Different concrete samples exhibit varying values of compressive strength. As an example, the Rebound Hammer shows strengths between 30.22 and 32.67 N/mm2, while UPV results display 32.4 to 35.3 N/mm2.

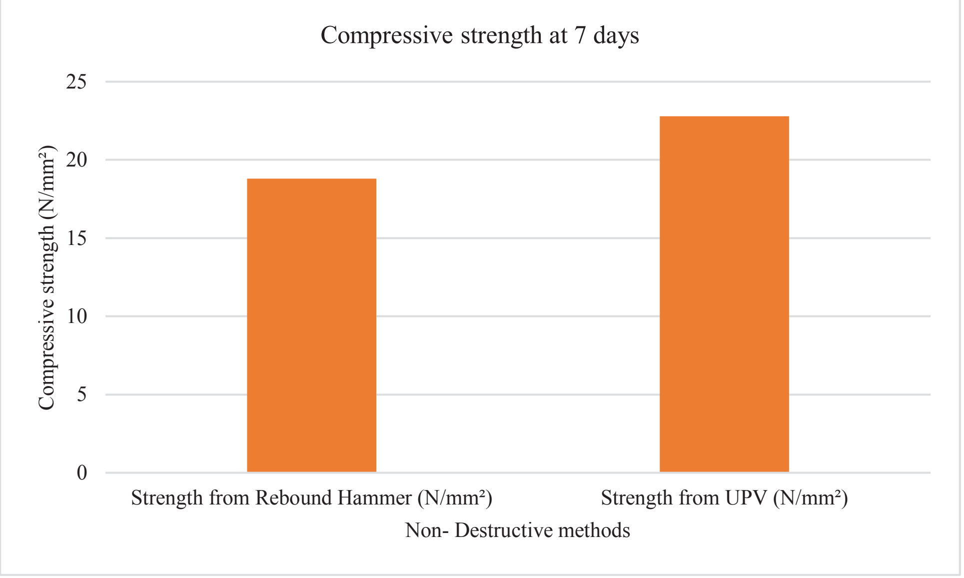

Fig. 1. Compressive strength from both Non – destructive techniques at 7 days

In comparing the average strength values derived from both methods, it appears that the Rebound Hammer technique yields a value of 18.8 N/mm2, whereas UPV values are 22.8 N/mm2. Fig. 1 shown in For the identical concrete samples at the 7-day mark, the UPV method tends to provide better strength values than the Rebound Hammer technique. In general, it can be said that the UPV method typically indicates better strength values than the Rebound Hammer approach. The findings offer engineers valuable insights into the concrete's quality and performance, allowing them to make informed decisions approximately its suitability for a variety of manufacturing uses.

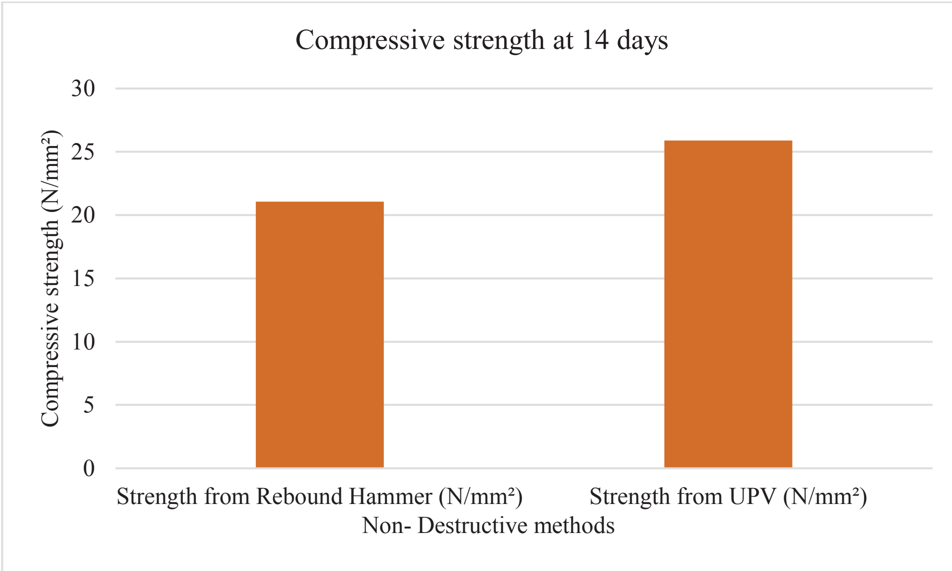

Fig. 2: Compressive strength from both Non – destructive methods at 14 days

Fig. 2 is based on 14-day compressive strength results obtained from ultrasonic pulse velocity testing and rebound hammer testing of M30 concrete samples, ultrasonic pulse velocity (UPV) was used as the method to evaluate the strength. A comparison of the strength values obtained from the two techniques is illustrated inside the following fig: the common strength for the UPV method is 25.9 N/mm^2; the average strength value for the Rebound Hammer technique is 21.07 N/mm^2. Based in this comparison, it is apparent that there is a noticeable difference between the 2 methods used for testing strength. By about 4.83 N/mm^2, the common strength value obtained via the UPV method exceeds the common strength value obtained by the Rebound Hammer method. According to such a discrepancy, the strength values of the same concrete samples are significantly higher using the UPV method at 14 days.

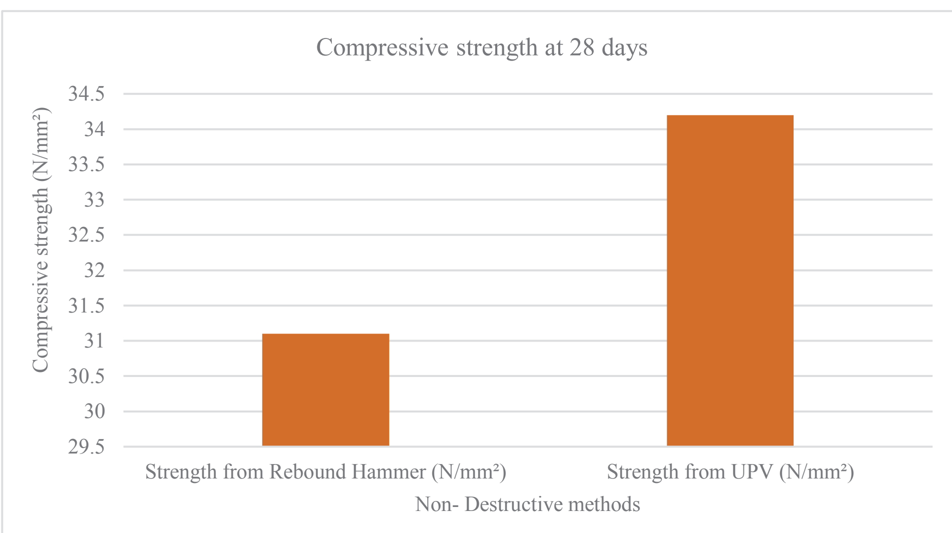

Fig. 3: Compressive strength from both Non – destructive techniques at 28 days

As shown in the Fig. 3 below, samples of concrete of M30 were compared in terms of ultrasonic pulse velocity (UPV) and rebound hammer 28-day compressive strength. From the statistics provided, we can see the average strength values obtained using each method: 31.1 N/mm^2 for the Rebound Hammer and 34.2 N/mm2 for the UPV. As can be seen from this comparison, there is a distinct disparity between the strength values that can be obtained from the two testing methods. As a result of the UPV technique, the strength value obtained is approximately 3.1 N/mm^{2}greater than that obtained through the Rebound Hammer method. A concrete's long-term performance is crucial for engineers and construction professionals as such insights provide valuable information. By expertise variations in strength values obtained from different testing methods, it is easy to make better materials selection decisions.

5 Conclusion

Ultrasonic pulse velocity and rebound hammer testing are examples of NDT tests. Rebound hammers are used to assess strength, and ultrasonic pulse velocity measurements are used to test quality. In this study, concrete cubes were aged for seven, fourteen, and 28 days in a laboratory before being subjected to two non-destructive tests. In all, 15 cubes were tested non-destructively. In this study, we compared the performance of a Schmidt rebound hammer and an ultrasonic pulse velocity test using nondestructive testing (NDT). A smooth ultrasonic pulse velocity measurement on hardened concrete is comparable to that obtained with a rebound hammer.

- Comparison of Compressive strength with Ultrasonic Pulse velocity (UPV) and Rebound Hammer techniques for M30 Concrete strength assessment at 7 14 and 28 days.
- Rebound Hammer method yields 18.8 N/mm2, UPV values 22.8 N/mm2 in 7 days UPV method yields average strength of 25.9 N/mm2, surpassing Rebound Hammer method's 21.07 N/mm2 in 14 days UPV method yields 34.2 N/mm2 strength values compared to 31.1 N/mm2 for Rebound Hammer in 28 days
- Significant difference observed between the two techniques, with UPV method showing higher strength values at 28 days.
- In general, it can be said that the UPV method generally indicates higher strength values than the Rebound Hammer method. The findings offer engineers valuable insights into the concrete's quality and performance, allowing them to make informed decisions about its suitability for a variety of construction uses.

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