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# Comparative Analysis of NDT Results of In-situ Concrete with and without Plaster

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**ABSTRACT:** Non-destructive test (NDT) is a method of testing existing concrete structures to assess the strength and durability of concrete structure. NDT is a fundamental part of every structural audit. Some popular NDT test are rebound hammer test, ultrasonic pulse velocity test (USPV), Half-cell potential test (HCP), covermeter test, carbonation test, etc. According to IS codes, NDT are to be performed on the concrete surface. To perform NDT on concrete surface the plaster is to be first chipped off and then replastered. The various disadvantages of chipping the plaster and replastering are it is time consuming, it leaves behind an ugly patch, it is unsafe for worker if test is to be performed on beams or slab. In this paper comparative analysis is done of NDT results of in-situ concrete with and without plaster. Non-destructive testing of 5 different sites was done. Non-destructive testing is carried out in-situ concrete with plaster and then again carried out for in-situ concrete without plaster. Variation of NDT results of rebound hammer test, ultrasonic pulse velocity test and half-cell potential test when the test is performed on in-situ concrete without removing plaster was established. Based on the results of the tests it can be concluded that Mean velocity of USPV test for plaster for all sites is less than that of concrete. Also Mean rebound no. of rebound hammer test of plaster for all sites is less than that of concrete. However Mean half-cell potential of plaster for 3 sites was more negative and for two sites was less negative than that of concrete. Mean variation of all test with respect to results obtained on concrete are also presented in this paper.

**KEYWORDS:** Non-destructive testing, Rebound Hammer Test, Ultrasonic Pulse Velocity Test, Half-cell Potential Test.

## I. INTRODUCTION

Structural Audit is an overall health and performance checkup of a building like a doctor examines a patient. It ensures that the building and its premises are safe and have no risk. It analyses and suggests appropriate repairs and retrofitting measures required for the buildings to perform better in its service life. As per clause No.77 of revised Bye-Laws of Cooperative Housing Societies the Society shall carry the 'Structural Audit' of the building once in 5 years if age of building is 15 years to 30 years and once in 3 years for age of building more than 30 years. Non-destructive testing of concrete is very important step in any structural audit. A number of non-destructive tests (NDT) for concrete members are available to determine present strength and quality of concrete. The range of properties that can be assessed using non-destructive tests and partially destructive tests is quite large and includes such fundamental parameters as density, elastic modulus and strength as well as surface hardness and surface absorption, and reinforcement location, size and distance from the surface. Most popular NDT test are rebound hammer test, ultrasonic pulse velocity test (USPV), Half-cell potential test (HCP), covermeter test, carbonation test, etc. Rebound Hammer test is a Non-destructive testing method of concrete which provide a convenient and rapid indication of the compressive strength of the concrete. Ultrasonic pulse velocity (UPV) test is an in-situ, non-destructive test to check the quality of concrete. A half-cell potential measurement is a non-destructive method to assess the corrosion risk of steels in concrete.

According to the IS codes these tests have to be carried out on concrete surface. To perform NDT on concrete surface plaster is to be first chipped off and then replastered. The process of chipping the plaster and replastering is time consuming. It also leaves behind an ugly patch since the plaster is not repainted. Chipping off plaster is also often opposed by the house owners causes delays in work. Chipping the plaster is sometimes not feasible some cases e.g. if NDT test is to be carried out beam with greater floor to floor height it becomes very difficult and



unsafe for the worker to carry out chipping. All these factors along with other practical difficulties increases the cost which is finally to be borne by the customer.

## II. LITERATURE REVIEW

The present work is aimed at comparative analysis of NDT results of in-situ concrete with and without plaster. Various studies have been carried out till date for various NDT test but none of them performed NDT test directly on plastered in-situ concrete and compared it with in-situ concrete test results.

**Ndagi et al. (2019)** reviewed the ultrasonic pulse velocity test by considering arrangement options and common factors which affect the results obtained and attempted to make recommendations to obtain reliable results. Based from his review various factors which affect pulse velocity are cement type, aggregate type and size, water cement ratio, distance between transducer, admixture, positioning of transducer, concrete age, steel reinforcement, temperature, transducer coupling agent. He concluded that direct method of transmission yields highest accuracy both in casting and horizontal direction when compared to indirect and semidirect methods. Ultrasonic pulse velocity test is affected by the factors such as presence of reinforcement, w/c ratio, path length, position of transducer and less significant factors such as cement type, temperature, shape and type of aggregates and shape of test specimen. Ultrasonic pulse velocity test is poor technique for assessing strength unless combined together with other strength technique like rebound hammer test. Limitations of the ultrasonic pulse velocity test are it lacks precision when detecting deterioration during early concrete age, inconsistency in assessing deteriorations of concrete with silica bound aggregate.

**Dhananjay Mangrulkar et al. (2018)** did case study of various NDT done on a building whose age was 20 years. NDT test like ultrasonic pulse velocity test, rebound hammer test, carbonation test and half-cell potential were done to assess the quality of concrete. In their study 30 readings of half-cell potential were taken, carbonation test and ultrasonic pulse test was done on 30 members. All the test were performed without removing the plaster. Thus a correction factor of 1.1 had been applied to all the readings.

**Samia Hannachi et al. (2012)** combined rebound hammer test and ultrasonic pulse velocity test and their results were calibrated with results of mechanical tests on cylindrical specimens cast on site and on cores taken from existing structures. They also determined the concrete quality by applying regression analysis models between compressive strength and NDT values. All data of destructive and non-destructive test were provided by the laboratory CTC Constatine. They developed correlation between rebound number and compressive strength, compressive strength and ultrasonic pulse velocity, compressive strength and rebound number, ultrasonic pulse velocity for cylindrical specimens and cores. They developed regression equations for the same. They concluded that using more than one NDT tests provides a better correlation and gives more reliable strength evaluation of concrete. According to them combined method is better to evaluate compressive strength of concrete.

**Ferhat Aydin (2010) et al.** determined a relationship and developed correlation between Schmidt rebound hammer test and destructive test. For the study, samples were made from OPC and aggregate. Various concrete mixes were used to prepare standard cube specimens to compare with manufactured calibration curve. Two opposite faces of cubes were tested while specimens were placed in loading machine. Core specimen were drilled horizontally through the thickness of concrete elements and were tested using Schmidt hammer. Rebound number of cubes at 28 days and 90 days and cores was measured. According to the test results rebound number of cubes at 28 days and 90 days was more than that of cores at same age. They concluded that correction factor must be used to transform strength interval so obtained from Schmidt hammer for old concrete. They concluded that that rebound hammer test on existing building is not suitable to estimate the strength of old concrete. Schmidt hammer test results are influenced by many factors so correction factors have to be used. Corrections factors ranging from 0.5-0.8 are suggested to be used for strength for the strength of old concrete.

## III. METHODOLOGY

In this research, comparative analysis of non-destructive test results is done for in-situ concrete with and without plaster. Variation of NDT results when the test is performed on in-situ concrete without removing plaster will be established. For this research NDT testing will be done on various sites and on each site test will be done on concrete



with and without plaster. NDT will be performed on in-situ concrete with plaster i.e. without chipping off plaster and then on concrete. NDT performed are rebound hammer test, USPV test and HCP test. The results of this analysis will include rebound no., ultrasonic pulse velocity, and half-cell potential for different sites. The conclusion of this analysis is finding variation in NDT test results of in-situ concrete with and without plaster.

#### IV. EXPERIMENTAL RESULTS

Non-destructive testing of 5 different sites was done. Non-destructive testing is carried out in-situ concrete with plaster and then again carried out for in-situ concrete without plaster. To get realistic and accurate results of tests performed on concrete with plaster, test location were so selected that at those locations plaster was sound and uncracked. Hammer tapping was done to find out hollow and debonded plaster. Total 35 rebound hammer test, 35 USPV test and 18 HCP test were carried out. Rebound hammer test is carried out as per IS 516(part 5/sec 4 )2020. USPV test is carried out as per IS 516(part 5/sec 1) 2018 . HCP test is carried out as per IS 516(part 5/sec 2)2021. Fig. (1),(2),(3) shows NDT carried out at sites.



(1)



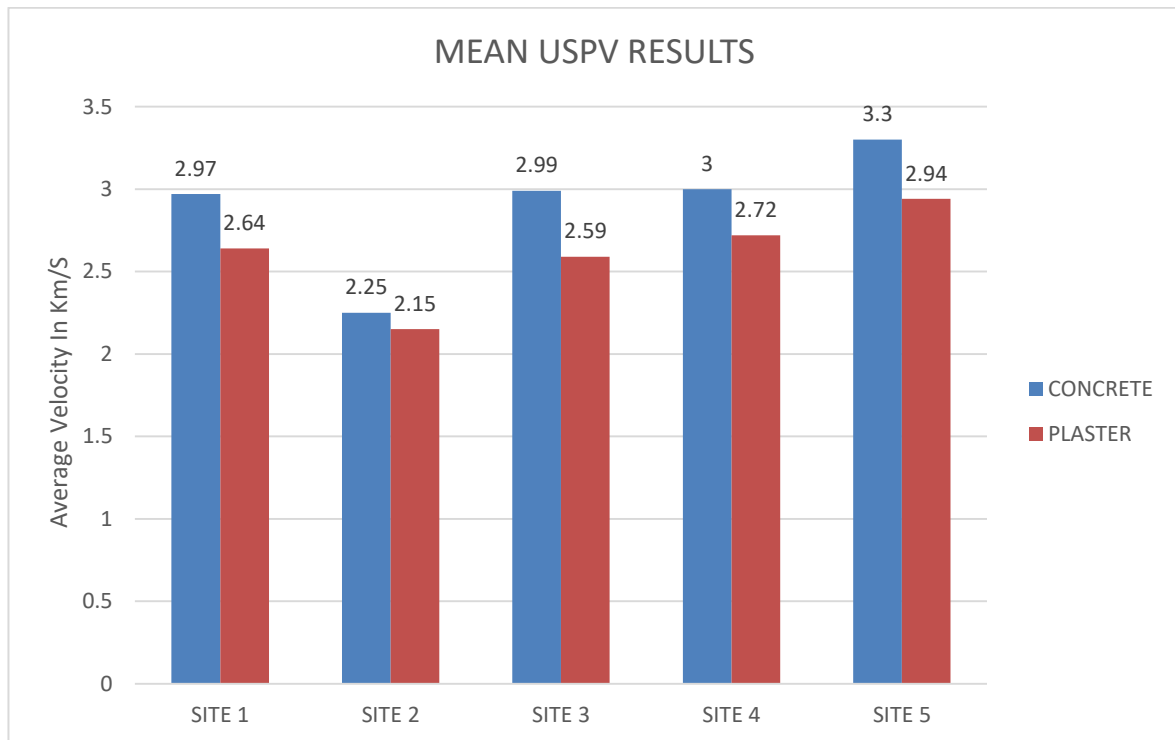
(2)



(3)

#### V. RESULTS

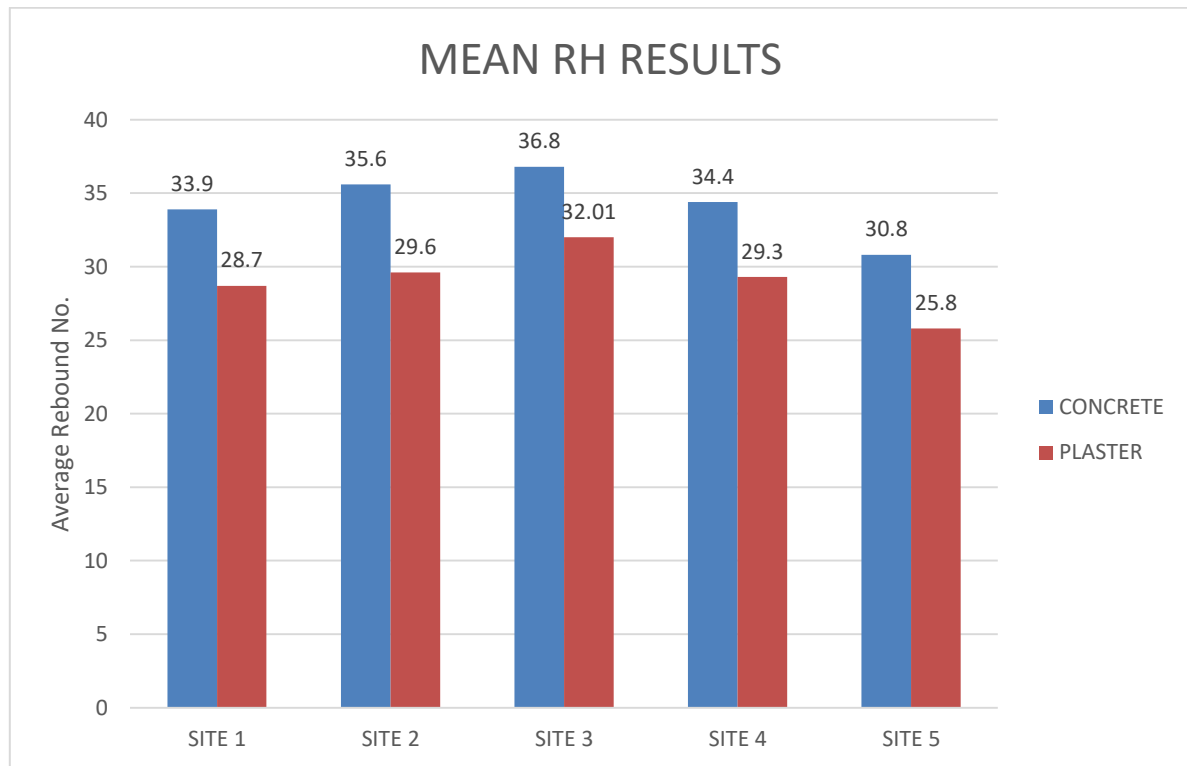
Sr.no.	Site name	Ultrasonic pulse velocity (KM/S)	
		Concrete	Plaster
1	Central stores, GAIL	2.97	2.64
2	Quality control lab, GAIL	2.25	2.15
3	First aid centre, GAIL	2.99	2.59
4	Central apartment A-wing, B-wing	3	2.72
5	Jaslok hospital	3.3	2.94



(4)

The ultrasonic pulse velocity test results for different sites is shown in the fig (4). The mean velocity obtained on concrete was 2.902 km/s and on plaster was 2.608 km/s.

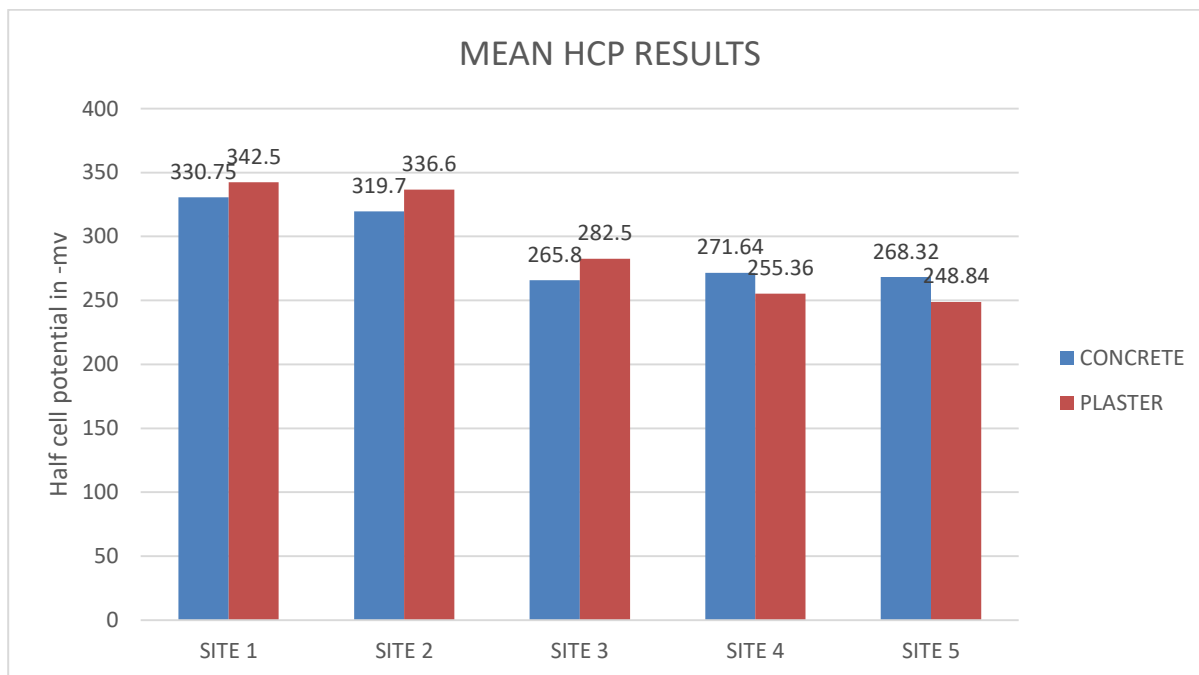
Sr.no.	Site name	Rebound no.	
		Concrete	Plaster
1	Central stores, GAIL	33.9	28.7
2	Quality control lab, GAIL	35.6	29.6
3	First aid centre, GAIL	36.8	32.01
4	Central apartment A-wing, B-wing	34.4	29.3
5	Jaslok hospital	30.8	25.8



(5)

The rebound hammer test results for different sites is shown in the fig (5). The average rebound no. on concrete was found to be 34.3 and that on plaster on was 29.08.

Sr.no.	Site name	Half-cell potential(-MV)	
		Concrete	Plaster
1	Central stores, GAIL	330.75	342.5
2	Quality control lab, GAIL	319.7	336.6
3	First aid centre, GAIL	265.8	282.5
4	Central apartment A-wing, B-wing	271.64	255.36
5	Jaslok hospital	268.32	248.84



(6)

The half-cell potential test results for different sites is shown in the fig (6). The mean half-cell potential obtained on concrete was found out to be -291.42 mv and that on plaster was -293.16 mv.

## VI. CONCLUSION

Based on the above results following conclusions can be made:-

- Mean velocity of USPV test for plaster for all sites is less than that of concrete.
- Mean rebound no. of rebound hammer test of plaster for all sites is less than that of concrete.
- Mean half-cell potential of plaster for 3 sites was more negative and for two sites it was less negative than that of concrete.
- Mean variation of USPV test is about 9.83% w.r.t. result on concrete.
- Mean variation of Rebound hammer test is about 15.25% w.r.t. result on concrete.
- Mean variation of HCP test is about +5.67% w.r.t. result on concrete.

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