



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 1, January 2024

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

[ijirset@gmail.com](mailto:ijirset@gmail.com)

[www.ijirset.com](http://www.ijirset.com)



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

Poras Mehta <sup>1</sup>, N. G. Gore <sup>2</sup>

P.G. Student, Department of Civil Engineering, M.G.M.'S College of Engineering and Technology, Navi Mumbai, Maharashtra, India<sup>1</sup>

Associate Professor, Department of Civil Engineering, M.G.M.'S College of Engineering and Technology, Navi Mumbai, Maharashtra, India <sup>2</sup>

**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. 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. In this paper comparative analysis is done of NDT results of in-situ concrete with and without plaster for 15 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. Correlation analysis was performed to measure strength of relationship between the test results obtained on plaster and concrete. Based on it regression analysis was performed to develop correction factor and these correction factors were validated on 3 sites.

**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 which 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 and to develop correction factor to perform non-destructive tests on in-situ concrete without chipping off the 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 is established. For this research NDT testing will be done on various sites on concrete with and without plaster. NDT will be first 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, establishing correlation between concrete and plaster results and developing suitable correction factor for performing test on concrete without chipping off the plaster.

#### IV. EXPERIMENTAL RESULTS

Non-destructive testing of 15 different sites was carried out. 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 locations were so selected that at those locations plaster was sound and uncracked. Hammer tapping was done to find out hollow and debonded plaster. Total 105 rebound hammer test, 105 USPV test and 66 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.

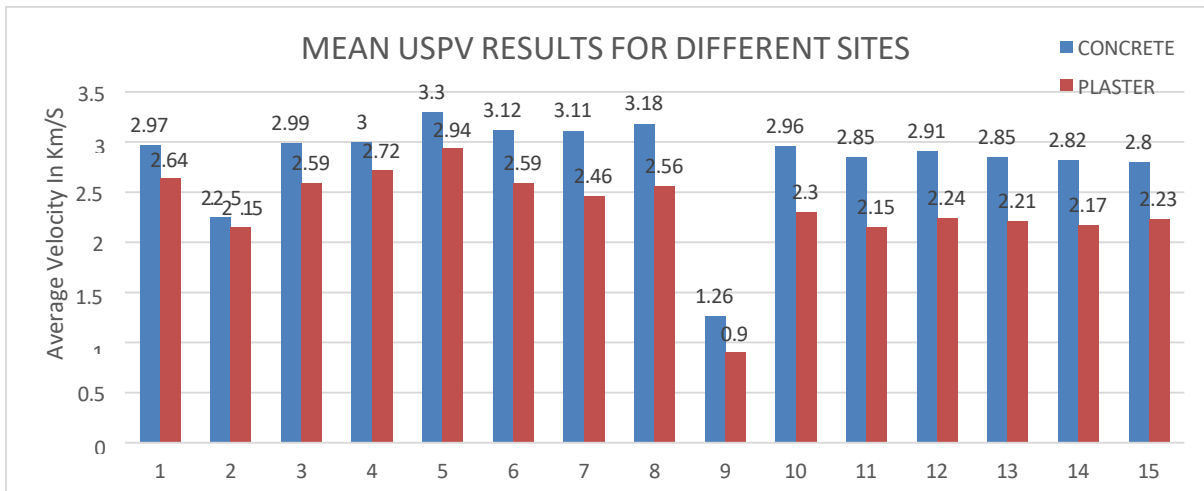


(1)

(2)

(3)

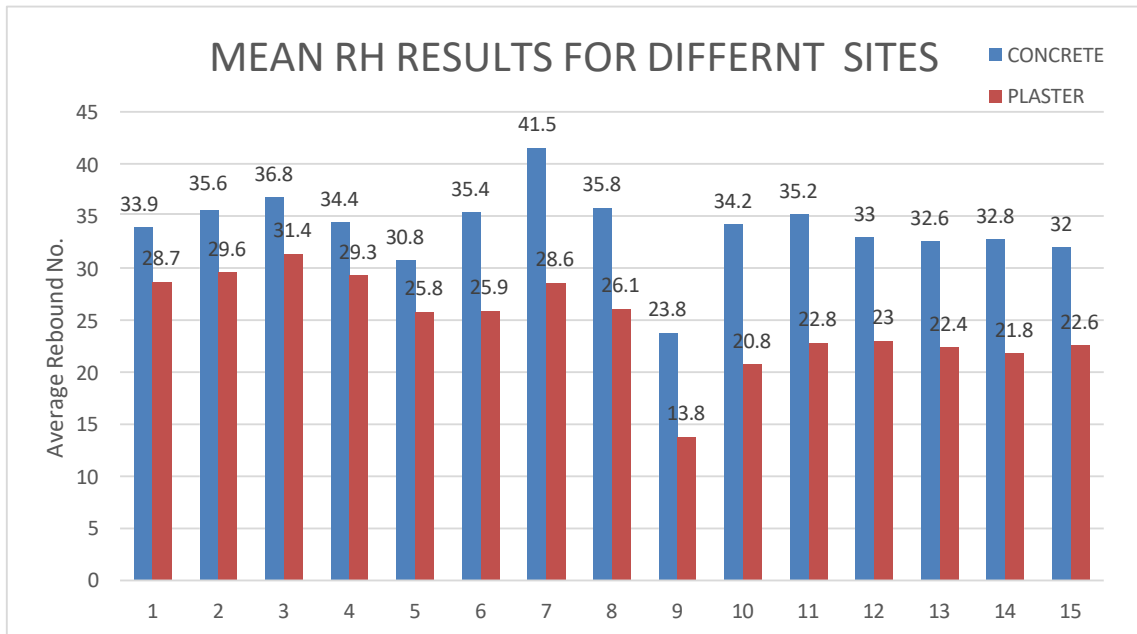
#### V. RESULTS AND DISCUSSIONS



(4)

The ultrasonic pulse velocity test results for different sites are shown in the fig (4). The mean velocity obtained on concrete was 2.82km/s and on plaster was 2.32 km/s. Mean variation with respect to concrete for plaster thickness less than 25mm is about -11%. Mean variation with respect to concrete for plaster thickness more than 25mm is about -22.75%. Table below shows comparative summary of USPV test results of all sites

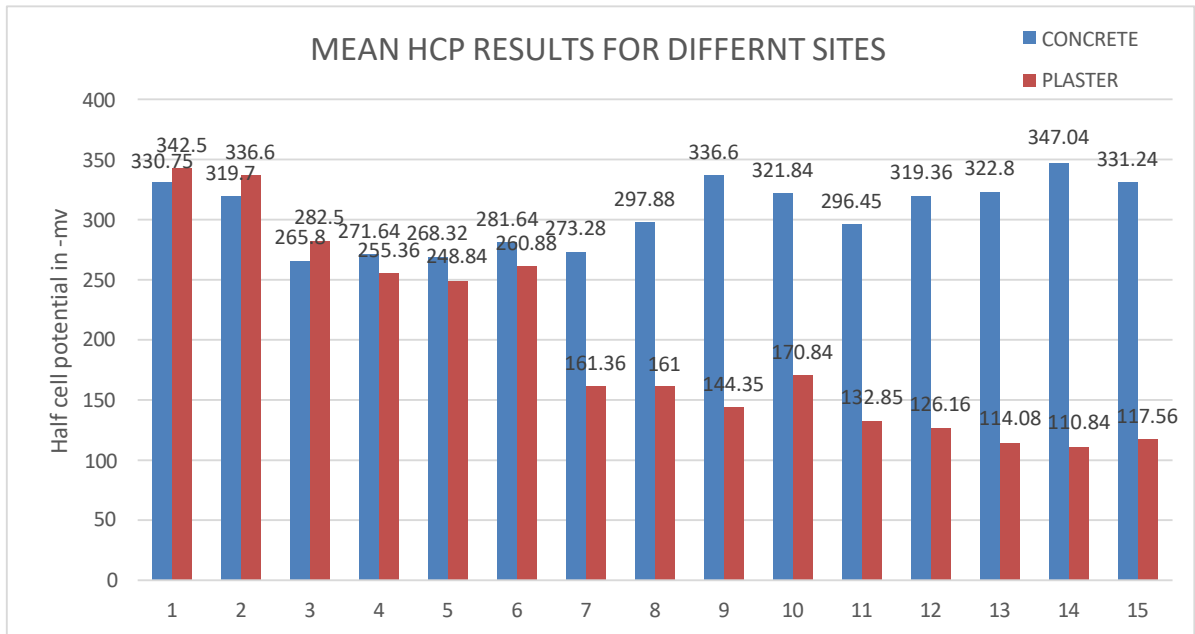
Site no.	Concrete strength (MPa)	Plaster thickness	Concrete velocity (km/sec)	Plaster velocity (km/sec)	Variation in velocity (km/sec)	Variation w.r.t. concrete (%)
1	20.34	20 MM	2.97	2.64	-0.33	-11.111
2	18.16	20 MM	2.25	2.15	-0.1	-4.444
3	19.81	20 MM	2.99	2.59	-0.4	-13.378
4	20	22.5 MM	3	2.72	-0.28	-9.333
5	25.96	25 MM	3.3	2.94	-0.36	-10.909
6	21.64	25 MM	3.12	2.59	-0.53	-16.987
7	22.73	30 MM	3.11	2.46	-0.65	-20.900
8	23.25	30 MM	3.18	2.56	-0.62	-19.497
9	15.38	30 MM	1.26	0.9	-0.36	-28.571
10	17.1	37.5 MM	2.96	2.3	-0.66	-22.297
11	16.4	35 MM	2.85	2.15	-0.7	-24.561
12	21.02	40 MM	2.91	2.24	-0.67	-23.024
13	18.93	40 MM	2.85	2.21	-0.64	-22.456
14	23.15	40 MM	2.82	2.17	-0.65	-23.050
15	18.91	40 MM	2.8	2.23	-0.57	-20.357
	Mean		2.82	2.32	-0.50	-18.06



(5)

The rebound hammer test results for different sites are shown in the fig (5). The average rebound no. on concrete was found to be 33.85 and that on plaster on was 24.84. Mean variation with respect to concrete for plaster thickness less than 25mm is about -17.4%. Mean variation with respect to concrete for plaster thickness more than 25mm is about -33.2%. Table below shows comparative summary of rebound hammer test results of all sites

Site no.	Concrete strength (MPa)	Plaster thickness	Concrete velocity RN	Plaster velocity RN	Variation in velocity RN	Variation w.r.t. concrete (%)
1	20.34	20 MM	33.9	28.7	-5.2	-15.339
2	18.16	20 MM	35.6	29.6	-6	-16.854
3	19.81	20 MM	36.8	31.4	-5.4	-14.674
4	20	22.5 MM	34.4	29.3	-5.1	-14.826
5	25.96	25 MM	30.8	25.8	-5	-16.234
6	21.64	25 MM	35.4	25.9	-9.5	-26.836
7	22.73	30 MM	41.5	28.6	-12.9	-31.084
8	23.25	30 MM	35.8	26.1	-9.7	-27.095
9	15.38	30 MM	23.8	13.8	-10	-42.017
10	17.1	37.5 MM	34.2	20.8	-13.4	-39.181
11	16.4	35 MM	35.2	22.8	-12.4	-35.227
12	21.02	40 MM	33	23	-10	-30.303
13	18.93	40 MM	32.6	22.4	-10.2	-31.288
14	23.15	40 MM	32.8	21.8	-11	-33.537
15	18.91	40 MM	32	22.6	-9.4	-29.375
	Mean		33.85	24.84	-9.01	-26.92

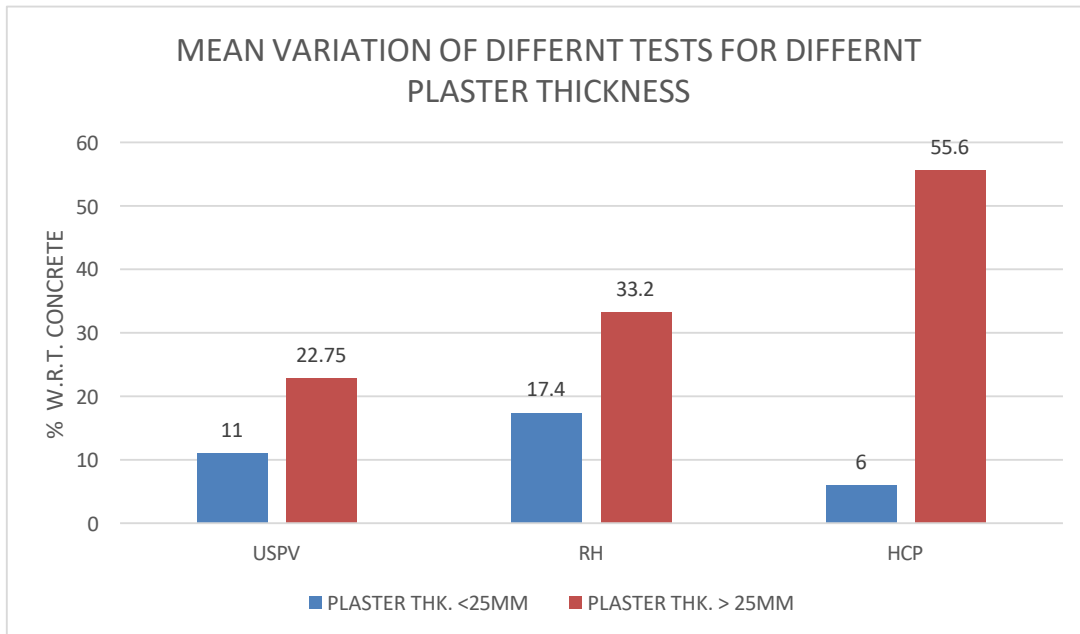


(6)

The half-cell potential test results for different sites are shown in the fig (6). The mean half-cell potential obtained on concrete was found out to be -305.62mv and that on plaster was -197.71 mv. Mean variation with respect to concrete for plaster thickness less than 25mm is about ±6%. Mean variation with respect to concrete for plaster thickness more than 25mm is about -55.6%. Table below shows comparative summary of HCP test results of all sites

Site no.	Concrete strength (MPa)	Plaster thickness	Concrete potential in mv	Plaster potential in mv	Variation in mv	Variation w.r.t. concrete (%)
1	20.34	20 MM	-330.75	-342.5	-11.75	3.553
2	18.16	20 MM	-319.7	-336.6	-16.9	5.286
3	19.81	20 MM	-265.8	-282.5	-16.7	6.283
4	20	22.5 MM	-271.64	-255.36	16.28	-5.993
5	25.96	25 MM	-268.32	-248.84	19.48	-7.260
6	21.64	25 MM	-281.64	-260.88	20.76	-7.371
7	22.73	30 MM	-273.28	-161.36	111.92	-40.954
8	23.25	30 MM	-297.88	-161	136.88	-45.951
9	15.38	30 MM	-336.6	-144.35	192.25	-57.115
10	17.1	37.5 MM	-321.84	-170.84	151	-46.918
11	16.4	35 MM	-296.45	-132.85	163.6	-55.186
12	21.02	40 MM	-319.36	-126.16	193.2	-60.496
13	18.93	40 MM	-322.8	-114.08	208.72	-64.659
14	23.15	40 MM	-347.04	-110.84	236.2	-68.061
15	18.91	40 MM	-331.24	-117.56	213.68	-64.509
	Mean		-305.62	-197.71	107.91	-33.96

Mean variation of different tests for different plaster thickness are shown in fig. 7. From the results it can be seen that as plaster thickness increases the variation in test results also increases.



(7)

**Correlation analysis**

After analyzing variation for each test correlation analysis was performed to determine relationship between two variables i.e. concrete results and plaster results. The correlation coefficient was developed in Microsoft excel using correlation function. Correlation coefficient for various tests is calculated below.

Sr.no.	Test	R value	Relationship
1	Ultrasonic pulse velocity test	0.9291	Very strong
2	Rebound hammer test	0.758	Strong
3	Half-cell potential test	0.353	Weak

**Regression analysis**

Based on the correlation coefficient, regression analysis was performed for USPV test results and rebound hammer test results since they had a high r value. The regression analysis was performed in excel using regression data analysis. The purpose of doing regression analysis is to find out correction factor for concrete test results. From regression analysis an equation was developed which can be used to estimate concrete test results based on plaster test results and plaster thickness. Further prediction interval was developed to estimate the interval of test results.

From the regression analysis the equation to predict to concrete velocity when plaster velocity and plaster thickness is known is as follows: -

$$\text{Concrete velocity (Y)} = (\text{coefficient} * \text{plaster velocity}) + (\text{coefficient} * \text{plaster thickness}) + \text{intercept}$$

$$Y = (1.1077 * \text{plaster velocity}) + (0.02056 * \text{plaster thickness}) + (-0.37285)$$

Prediction interval is given by,

$$\text{predicted value} \pm t_{\alpha/2} * \text{standard error} = \text{predicted value} \pm (2.1788 * 0.10465)$$





Lower prediction interval = predicted value – (0.228), Upper prediction interval = predicted value + (0.228)

The equation to predict to concrete rebound no. when plaster rebound no. and plaster thickness is known is as follows: -

Concrete rebound no. (Y) = (coefficient \* plaster rebound no.) + (coefficient\* plaster thickness) + intercept Y = (0.9065\* plaster rebound no.) + (0.2499\*plaster thickness) + 3.7168

Prediction interval = predicted value ± t<sub>α/2</sub> \* standard error = predicted value ± (2.1788 \* 2.1045)

Lower prediction interval = predicted value – (4.585), Upper prediction interval = predicted value + (4.585)

**Validation of correction factors**

After developing correction factor additional three different sites were tested to check the correction factors. Tests were performed on plastered concrete and established correction factors were applied to test results to obtain test results of concrete. Prediction interval was also established. The actual tests results obtained on concrete were compared with those obtained by using correction factor. The actual test results were checked whether they were within the prediction interval. Also, the accuracy of point estimate was checked with the actual results. These results are shown in table 1 & 2.

Table 1 Accuracy of correction factors for USPV test

Site no	Test points	No. of correct predictions	Avg. Difference between point estimate and observed results (km/s)	Avg. Accuracy (%)
1	10	9	0.14	94.43
2	5	4	0.17	93.31
3	5	5	0.09	96.45

Table 2 Accuracy of correction factors for rebound hammer test

Site no	Test points	No. of correct predictions	Avg. Difference between point estimate and observed results RN	Avg. Accuracy (%)
1	10	9	2.37	93.36
2	5	4	3.07	89.78
3	5	5	2.03	93.44

**VI. CONCLUSION**

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

1. Ultrasonic pulse velocity when test is carried out on in-situ concrete without removing the plaster was less by about 18%. as compared to in-situ concrete whose plaster is not removed.
2. Rebound no. when test is carried out on in-situ concrete without removing the plaster was less by about 27% as compared to in-situ concrete whose plaster is not removed.
3. Half -cell potential when test is carried out on in-situ concrete without removing the plaster was less negative by about 34% as compared to in-situ concrete whose plaster is not removed. This is due to the fact that plaster acts as an insulator to the flow of current which increases the resistance and in turn increases the potential difference.
4. Thickness of plaster affects the test results.
5. As plaster thickness increases the variation between test results of in-situ concrete with and without plaster also increases. For USPV test there was variation of 11% and 22.75 % for plaster thickness less than 25mm and greater than 25mm respectively. Similarly for rebound hammer test the variation was 17.4% and 33.4 %.
6. % And for half-cell potential test it was 6% and 55.6 %.
7. There exists a very strong linear relationship between ultrasonic pulse velocity of in-situ concrete with and without plaster.



8. There exists a strong linear relationship between rebound no. of in-situ concrete with and without plaster.
9. There exists a weak linear relationship between half-cell potential of in-situ concrete with and without plaster.
10. Correction factor can be developed for performing USPVT test on in-situ concrete without removing the plaster. and the correction factor can predict the test results on concrete with about 90-95% accuracy.
11. Correction factor can be developed for performing rebound hammer test on in-situ concrete without removing the plaster. and the correction factor can predict the test results on concrete with about 90-95% accuracy.

#### REFERENCES

1. Samia Hannachi & Mohamed Nacer Guetteche “application of the combined method for evaluating compressive strength of concrete on site” open journal of civil engineering, volume 2,no.1 ,2012
2. A Ndagi, A. A. Umar, F Hejazi , M S Jaafar “ Non destructive assessment of concrete deterioration by ultrasonic pulse velocity: a review ” IOP conf series : earth and environmental science 357(2019) 012015 .
3. Dhananjay Mangrulkar & Manoj Chauhan “case study of RCC structure with the help of non destructive testing” international research journal of engineering and technology volume 05 issue 03 march 2018.
4. Ferhat Aydin & Mehmet Saribiyik “correlation between Schmidt hammer and destructive compressions testing for concrete in existing building” scientific research and essays vol 5(13), pp 1644-1648, 4 july 2010.
5. Chatchai Manathamsombat & Praveen Chompreda “factors affecting near surface tests of in-situ concrete structures for carbonation- induced corrosion” journal of Thailand concrete association vol.1 no.1 jan-jun 2013.
6. Wanchai Yodsudjai & Thanwit Pattarkittam “factors influencing half cell potential measurement and its relationship with corrosion level” Elsevier measurement 104(2017) 159-168.
7. Jiri Brozovsky & Jiri Zach “influence of surface preparation method on the concrete rebound number obtained from impact hammer test” 5th pan American conference for NDT,2-6 october 2011, NDT net issue 2011-12.
8. Tarun Gehlot & Akash Gupta “study of concrete quality assessment of structural elements using rebound hammer test” American journal of engineering research volume-5, issue 8, pp-192-198.



INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  [ijirset@gmail.com](mailto:ijirset@gmail.com)



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details