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Research Article

Relationship between Non-Destructive Testing of Rebound Hammer and Destructive Testing

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Abstract

This paper deals with Experimental investigation for M-20& M25 grade of concrete having mix proportion 1:2.09:3.02 &1: 1.98:3.88 with water cement ratio 0.45 & 0.42 to study the destructive strength, grade of concrete, & rebound number. A result data obtained has been analyzed and compared with destructive results. A relationship between rebound numbers vs. destructive strength represented mathematically and graphically. Result data clearly shows that increase the strength of concrete in 28 days rebound number and destructive strength for M-20 & M25Grade of Concrete.

Keywords: *Concrete mix, destructive strength, rebound number, grade of concrete.*

1. Introduction

Concrete has significantly influenced the nature of engineering projects. Concrete, as a composite material, is generally composed of cement, sand, aggregate, water, mineral admixtures and chemical admixtures. Considerable work has been conducted to develop rapid, nondestructive tests (NDTs) that provide a reproducible measure of concrete quality in a structure. Unfortunately, as is usually the case in concrete testing, all these NDT generate results that are affected by various parameters such as aggregate type and size, age surface of concrete, moisture content, and mix proportions. Therefore, the correlation between measured properties and strength differs for various concretes and must be limited to the concrete in question. However, the NDTs are also convenient and have been used for many years in quality management of engineering materials. These tests are useful in determining the differences in concrete quality from one part of a structure to another. Developed in Germany in 1930, the rebound hammer test (RHT), based on ASTM C805 and B4408 Part 4, can be utilized for testing concrete surface hardness. In 1948, Schmidt developed the Schmidt rebound hammer test. This device is universally used because of a hardened steel hammer impacted on the concrete by a spring. The RHT is a convenient NDT. The surface of hardened concrete is struck with the hammer, and concrete compressive strength is estimated via the surface hardness rebound value. In 1979, the ASTM listed the rebound hammer testing method (ASTM C 805-79) as a standard testing method, explaining that this method can be used to estimate the uniformity of concrete and detect areas of inferior quality within a concrete structure; however, it is not a substitute for concrete strength testing methods. The general view held by many users of the Schmidt rebound hammer is that it is useful in assessing concrete uniformity and in comparing one concrete against another, but can only be used as a rough indication of concrete strength in absolute terms.

2. Use of NDT for evaluation of concrete structures

The purpose of establishing standard procedures for rebound hammer testing of concrete structures is to qualify and quantify the material properties of in-situ concrete without intrusively examining the material properties. There are many techniques that are currently being research for the NDT of materials today. To study the influences of few variables which affects the concrete characteristics a laboratory investigation was made.

1. The fixed parameters were type of cement, fine aggregate, water, curing condition, temperature and humidity, molding procedure, type of compaction etc.
2. Mixes of different types of samples of cubes size150mmx150mmx150mm.
3. Different Non destructive testing methods such as rebound number by Rebound Hammer were tested and Compressive strength was also tested by compressive strength testing machine (destructive testing) on same cubes.

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3. Experimental Investigation

1.The concrete mix proportion was made for Mix Design of M20 & M25 Grade of concrete were tested by Non-destructive testing (Rebound Hammer) and Destructive testing (Compression Testing Machine)as shown in fig.. Following table shows readings of all these tests conducted on casted cubes. Following graph shows correlations between non-destructive and destructive test results.

2. The age of concrete cubes were considered for standard 28 days for compressive strength by Compressive Testing Machine, and Rebound number by rebound hammer.

3.1 Test Specimens

Testing of Specimen

- 6 readings (rebound numbers) were obtained for each cube, at different locations on the surface of the specimen.
- The cube was divided into grid blocks of equal spacing and 6 points were marked at equal intervals for taking the Rebound Hammer test.
- The cubes were then given a load of 7 N/mm^2 (as specified by the IS CODE 13311) in the Compression Testing Machine and the Rebound Values were obtained.
- The cubes were then loaded up to their ultimate stress and the Breaking Load was obtained.
- The following tables lists the Rebound numbers (rebound index), Mean Rebound Value and the actual Compressive Strength as obtained by the Compression Testing Machine.

4. Test Results Graphs

Various concrete cubes from lab have been tested with Destructive & Non-destructive testing methodology. The data of test results as shown in tabular format given below.

Sr No	Avg. Rebound value (q)	Destructive strength (s) N/mm2	Sr no	Avg. Rebound value (q)	Destructive strength (s) N/mm2
1	30.12	21.61	57	40.3	28.00
2	31.12	20.6	58	34.2	24.05
3	32.4	23.01	59	35.4	27.22
4	33.5	21.73	60	34.2	27.08
5	36.66	24.18	61	31.2	26.41
6	37.8	27.12	62	30.2	24.56
7	38.3	27.08	63	37.5	26.33
8	38.3	26.4	64	38.6	27.14
9	39.6	20.42	65	32.3	26.36
10	29	26.33	66	35.8	27.32
11	20.2	22.6	67	34.8	26.50
12	31.3	21.5	68	35	26.36
13	31.6	22.23	69	35.6	26.17
14	29.6	22.4	70	32.5	27.33
15	35.4	24.04	71	36.5	30.94
16	36.2	24.58	72	36.9	31.28
17	32.2	22.32	73	34.6	29.96
18	28.6	22.27	74	40	31.56
19	29.26	22.13	75	38.4	30.5
20	38.5	20.89	76	37.5	30.99
21	36.4	26.22	77	41.4	30.1
22	29	19.11	78	42.3	31.31
23	32.68	22.67	79	41.2	30.85
24	33.6	23.11	80	44.6	33.7
25	32	22.23	81	41.3	30.85
26	28.6	18.27	82	39.8	31.31
27	31.2	23.12	83	38.6	30.57
28	35	22.23	84	36	25.12
29	50	28	85	34.8	26.86
30	31.9	21.12	86	33.6	27.36
31	38.9	25.69	87	33.6	22.56
32	28.7	16.45	88	27.8	23.95
33	29.6	18.23	89	42.6	31
34	28.6	18.67	90	30.1	22.4
35	24	16.45	91	45.4	18.5
36	25.6	18.23	92	46.8	21
37	28.3	18.67	93	33.3	15.5
38	50.6	31.18	94	40.8	16.6
39	52.36	33.12	95	37.8	15.2
40	54.8	35.12	96	38.3	14.9
41	52	32.4	97	35.9	15.2
42	51.2	32.21	98	39.1	14.5
43	49.6	30.45	99	41.4	16
44	50.3	32.87	100	31	17
45	52	32.76	101	26.6	10
46	42.2	26.5	102	28.2	11.5
47	44	26.3	103	33.6	11
48	41.3	27	104	39.1	14.5
49	43.44	28.5	105	35.4	12
50	48.7	31	106	36.4	27.32
51	49.8	33.6	107	38.6	27.02
52	47.68	32.8	108	38.2	26.98
53	30.58	24.22	109	39.4	20.56
54	41	30.01	110	29.6	26.35
55	32.6	23.21	111	31	21.89
56	43.5	28.00	112	32	22.65
113	29.3	22.45	147	45.8	33.9
114	36	24.78	148	45.8	34
115	36.5	24.65	149	46.9	35
116	31.8	22.45	150	40.4	15.6
117	27	22.3	151	37.5	16.8
118	29	22.45	152	38.3	17.59
119	39	20.78	153	32.3	18.65
120	37	26.32	154	31.8	17.98
121	29.4	19.87	155	32.2	18.65
122	31.6	22.65	156	33.3	13.5
123	34.98	26	157	33.7	14.5
124	32.1	22.98	158	36.3	15

125	27.89	17.45	159	28.4	16.6
126	31.58	23.45	160	34.9	17.5
127	34.65	22.98	161	35.6	15.6
128	48.65	28.45	162	35.1	14.23
129	31.4	21.32	163	25.6	19.6
130	36.4	25.48	164	29.4	15.2
131	47.3	31.78	165	29.94	14.6
132	49	33.65	166	25.6	17.89
133	47.23	30.56	167	32.8	18.65
139	34.12	26.45	168	32	15.36
140	33.69	27.41	169	23.6	14.25
141	33.47	22.69	170	32	16.34
142	27.45	23.78	171	23.5	17.5
143	42.45	31.47	172	26	18.65
144	30.25	22	173	28	17.45
145	45.98	19	174	27.5	14.65
146	25.2	25			

5. Comparison between rebound number and destructive test for controlled specimens

The concrete mix proportion was made for Mix Design of M20 & M25 Grade of concrete were tested by Non-destructive testing (Rebound Hammer) and Destructive testing (Compression Testing Machine)as shown in fig.. Following table shows readings of all these tests conducted on casted cubes. Following graph shows correlations between non-destructive and destructive test results for controlled specimens.

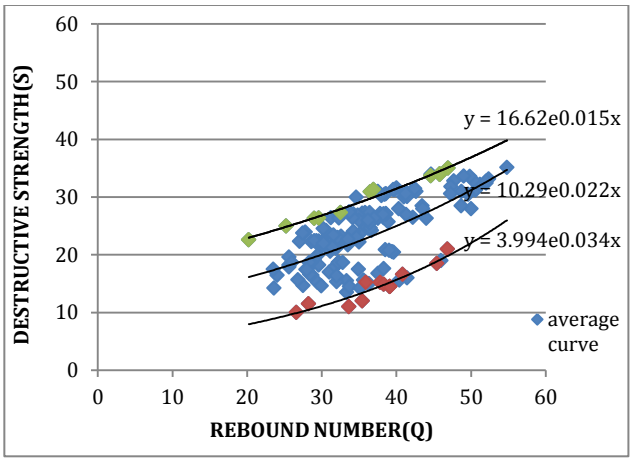

Fig.1 graph of rebound number v/s destructive *strength(s) of controlled specimens*

5.1 Three different curves were suggested for laboratory specimens now these curves shall be used to estimate compressive strength of specimens and compared with destructive testing

Sr No	Avg. Rebound Value (Q)	Strength By Average Curve Y=10.29e^0.022x	Strength By Upper Curve Y=16.62e^0.015x	Strength By Lower Curve Y=3.994e^0.034x	Destructive Strength (S) N/Mm2	% Diff Betⁿ Avg Curve And Destructive Strength(S)
1	37.8	23.64	29.3	14.43	27.21	-0.15
2	38.3	23.9	29.52	14.67	27.08	-0.13
3	39.6	24.59	30.1	15.34	26.4	-0.07
4	29	19.48	25.68	10.7	20.42	-0.05
5	31.3	20.49	26.58	11.57	27.14	-0.32
6	42.3	26.1	31.35	16.81	31.31	-0.20
7	41.2	25.47	30.83	16.19	30.85	-0.21
8	44.6	27.45	32.45	18.18	33.7	-0.23
9	28.7	19.35	25.56	10.59	16.45	0.15
10	31.4	20.53	26.62	11.6	18.23	0.11
11	28.6	19.31	25.52	10.55	18.67	0.03
12	27.4	18.8	25.07	10.13	16.45	0.13
13	25.6	18.07	24.4	9.53	18.23	-0.01
14	28.3	19.18	25.41	10.44	18.67	0.03
15	49.6	30.64	34.97	21.55	30.45	0.01
16	50.3	31.12	35.34	22.06	32.87	-0.06
17	52	32.3	36.26	23.38	32.76	-0.01

(+) average values are higher than destructive values
(-) average values are lower than destructive values.

Conclusion

In this project , we have tested more than hundred and fifty cubes for laboratory specimens and the following conclusions are derived from above study and investigation.

1. The percentage difference between compressive strength by non-destructive testing and destructive testing is low for laboratory specimen.
2.There is no much difference observed for rebound value (Q) when tested on 7th and 28th days of concrete sample .This indicate rebound hammer measures surface strength of concrete .
3. It can be concluded that strength gaining of concrete as per age (which is interior) is not reflecting by non-destructive testing (rebound hammer test).
4. Rebound hammer test gives more realistic results in early age of concrete.
5. The actual compressive strength of concrete is definitely higher than estimated compressive strength given by suggested lower curve.
Most preferably
6. Destructive result gives 6% more strength than average curve.
7. Out of three curves average curve gives more closer to the destructive values.

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