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Case Study on the Compressive Strength Assessment of Pre-existing Columns in College Campus using Rebound Hammer

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Abstract - *As the name implies Non Destructive Testing (NDT) refers to a test which does not impair the intended performance of the element, member or structure under investigation. In this paper a non-destructive test i.e. Rebound Hammer is been performed with the purpose to investigate on the mechanical properties of the pre-existing concrete columns employed in the college campus. An N-type rebound hammer was used for the testing. This method requires short time to obtain the results, it's a non-invasive method and it does not affect the resistance of structural elements. Finally the interpretation of experimental values of Rebound Hammer Test was done as per recommended procedures by IS 13311:1992 and IS 516:1959 respectively.*

Key Words: **Non-destructive Testing, Destructive Testing, Rebound Hammer, Rebound Number, Compressive Strength**

1. INTRODUCTION

The evaluation of the concrete compressive strength is a fundamental step for the assessment of existing reinforced concrete (RC) buildings. This valuation can be conducted by the use of both destructive and non-destructive methods. Service life of concrete is found to be limiting in various environmental degrading factors as it is exposed to it. This therefore has brought about the need for test method to measure the in-place properties of concrete for quality assurance and for evaluation of existing conditions.

Nondestructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system. In other words, when the inspection or test is completed the part can still be used. The most popular non-destructive test is Rebound Hammer test, also known as Schmidt Hammer test. The principle of rebound hammer is to measures the hardness of surface.

2. TEST PROGRAM

2.1 Rebound Hammer Test

The Schmidt rebound hammer is principally a surface hardness tester, which works on the principle that the rebound of an elastic mass depends on the hardness of the surface against which the mass impinges. There is seemingly theoretical relationship between the strength of concrete and the rebound number of the hammer. The weight of the Schmidt rebound hammer is about 1.8 kg and is suitable for both laboratory and field purpose. The rebound distance of the hammer mass is measured on an arbitrary scale ranging from 10 to 100. The rebound distance of the hammer is recorded as a "rebound number" corresponding to the position of the rider on the scale.

TABLE - 2: Hardness Criteria for Concrete Quality Grading
(Is 13311 (Part 2):1992)

Average Rebound Number	Quality
Above 40	Very Good Hard Concrete
30 - 40	Good Concrete
20 - 30	Fair Concrete
Below 20	Poor Concrete

The test was performed over 77 columns. Each column was tested to obtained 12 rebound number i.e. 6 readings at the bottom and 6 at the top of the column.

Graph on the Rebound hammer itself was used to compute the compressive strength of the column. Some columns were declared unsafe just by visual inspections.

3. RESULT AND DISCUSSION

The rebound hammer method provides a convenient and rapid indication of the compressive strength of concrete by means of establishing a suitable correlation between the rebound index and the compressive strength of concrete.

TABLE - 2: Rebound Number of 77 Column

Column No	Position	Rebound Number						Average Rebound Number	Compressive Strength	Average Compressive Strength	Remark
		1	2	3	4	5	6				
C1	Top	40	40	44	42	40	46	42	44	41	NILL
	Bottom	40	40	44	38	34	38	39	38		
C2	Top	40	44	44	40	42	42	42	44	41	R/F is exposed at the bottom portion
	Bottom	38	44	42	38	40	40	40.33	40		
C3	Top	40	44	38	39	40	44	40.83	42	42	mild honey-combing
	Bottom	40	40	40	42	42	42	41	42		
C4	Top	48	48	50	60	44	46	48.66	56.5	55.5	NILL
	Bottom	50	58	40	46	46	50	48.33	54.5		
C5	Top	46	50	44	50	52	46	48	54.5	59.35	R/F bars are out from column
	Bottom	58	52	56	48	48	48	53.33	64.2		
C6	Top	38	40	44	32	38	40	38.66	38	44.25	NILL
	Bottom	38	40	60	44	42	52	46	50.5		
C7	Top	46	56	60	54	50	48	52.33	64.2	58.35	Moderate honey-combing
	Bottom	40	48	56	44	40	50	46.33	52.5		
C8	Top	44	52	50	52	62	50	51.67	64.2	60.35	NILL
	Bottom	46	44	40	48	56	60	49	56.5		
C9	Top	46	40	42	42	44	48	43.66	48	46	NILL
	Bottom	50	42	46	42	40	34	42.33	44		
C10	Top	46	44	46	46	46	46	45.66	50.5	47.5	NILL
	Bottom	40	42	48	44	42	42	43	44.5		
C11	Top	48	46	42	42	44	54	46	50.5	47.5	Distort edge of the column
	Bottom	50	50	42	42	44	40	43	44.5		
C12	Top	42	50	50	48	44	44	48	54.5	55.5	NILL
	Bottom	44	52	48	52	46	50	48.66	56.5		
C13	Top	40	32	38	40	32	42	37.33	34	41	NILL
	Bottom	46	40	38	44	42	46	42.66	46		
C14	Top	32	42	38	42	36	42	38.66	38	3	Distort edge of the column
	Bottom	40	38	44	36	40	42	40	40		
C15	Top	44	42	44	44	40	42	42.66	46	44	NILL
	Bottom	40	38	44	44	38	42	41	42		
C16	Top	0	0	0	0	0	0	0	0	18	Half Casted And Distort Edge
	Bottom	40	36	38	36	40	40	38.33	36		
C17	Top	0	0	0	0	0	0	0	0	0	NILL
	Bottom	0	0	0	0	0	0	0	0		

Column No	Position	Rebound Number						Average Rebound Number	Compressive Strength	Average Compressive Strength	Remark
		1	2	3	4	5	6				
C18	Top	48	48	44	30	42	44	42.67	46	45	NILL
	Bottom	40	40	50	38	44	42	42.33	44		
C19	Top	38	42	40	42	42	38	40.33	40	37	NILL
	Bottom	32	38	36	40	38	36	36.67	34		
C20	Top	48	44	46	44	60	46	48.00	46	47	NILL
	Bottom	36	42	42	48	52	42	43.67	48		
C21	Top	42	44	46	48	42	40	43.67	48	48	Distort Edge And Mild Honey-combing
	Bottom	36	44	42	46	42	56	44.33	48		
C22	Top	38	34	42	42	42	44	40.33	40	47.25	Distort Edge Of The Column
	Bottom	62	48	42	48	44	42	47.67	54.5		
C23	Top	32	34	30	32	28	38	32.33	26	31	NILL
	Bottom	40	36	36	40	44	34	38.33	36		
C24	Top	38	32	42	30	36	40	36.33	32	36	Distort edge of the column
	Bottom	32	38	50	40	38	38	39.33	38		
C25	Top	38	40	38	38	34	44	38.67	38	33	Distort Edge Of The Column
	Bottom	40	30	28	28	36	36	33.00	28		
C26	Top	46	46	34	42	44	44	42.67	46	47	Distort Edge Of The Column
	Bottom	52	42	42	46	40	44	44.33	48		
C27	Top	40	38	40	40	30	42	38.33	36	43.25	NILL
	Bottom	42	42	54	40	48	50	46.00	50.5		
C28	Top	44	40	40	44	42	40	41.67	44	46	NILL
	Bottom	40	40	50	46	44	44	44.00	48		
C29	Top	38	38	40	36	40	42	39.00	38	37	NILL
	Bottom	40	36	32	38	42	42	38.33	36		
C30	Top	42	44	42	48	54	60	48.33	54.5	51.25	NILL
	Bottom	44	42	48	44	44	44	44.33	48		
C31	Top	38	40	36	38	42	38	38.67	38	47.25	Severe Cracks &Exposure Of R/F
	Bottom	42	44	46	54	60	50	49.33	56.5		
C32	Top	50	44	40	46	44	48	45.33	50	53.2	NILL
	Bottom	48	56	50	50	46	44	49.00	56.4		
C33	Top	34	34	32	32	32	36	33.33	28	31	Small Amount Of Cracks
	Bottom	32	34	32	40	40	46	37.33	34		
C34	Top	40	36	36	32	38	44	37.67	36	39	NILL
	Bottom	40	40	42	42	42	42	41.33	42		
C35	Top	44	40	38	42	40	40	40.67	42	38	Mild Honeycombing & Cracks
	Bottom	40	38	38	32	36	36	36.67	34		

Column No	Position	Rebound Number						Avg Rebound Number	Compressive Strength	Avg Comp. Strength	Remark
		1	2	3	4	5	6				
C36	Top	34	38	32	32	36	40	35.33	32	30	severe honeycombing
	Bottom	30	36	36	32	34	32	33.33	28		
C37	Top	46	46	50	48	34	42	44.33	48	43	R/F Exposed at bottom
	Bottom	44	32	42	36	44	36	39.00	38		
C38	Top	32	36	30	34	40	38	35.00	32	40	NILL
	Bottom	42	52	42	42	48	40	44.33	48		
C39	Top	42	42	42	44	64	48	47.00	52	50	NILL
	Bottom	42	44	46	46	48	38	44.00	48		
C40	Top	38	38	42	38	40	40	39.33	38	44	NILL
	Bottom	42	40	42	52	48	46	45.00	50		
C41	Top	50	40	36	38	40	40	40.67	42	40	Distort edge of the column
	Bottom	40	40	36	38	40	40	39.00	38		
C42	Top	48	38	38	48	38	52	43.67	48	47	NILL
	Bottom	52	44	42	42	44	34	43.00	46		
C43	Top	48	44	44	44	26	40	41.00	42	43	NILL
	Bottom	48	46	42	28	32	54	41.67	44		
C44	Top	00	00	00	00	00	00	0.00	0	20	Mild honeycombing
	Bottom	40	42	40	40	40	40	40.33	40		
C45	Top	44	44	34	40	38	44	40.67	42	38	NILL
	Bottom	40	32	34	40	46	30	37.00	34		
C46	Top	44	36	46	44	36	30	39.33	38	44	severe cracks due to weather
	Bottom	40	30	42	60	36	60	44.67	50		
C47	Top	60	44	54	56	52	48	52.33	62	61	Distort edge of the column
	Bottom	48	48	48	46	48	60	49.67	60		
C48	Top	42	44	52	40	46	46	45.00	50	55.25	Distort edge of the column
	Bottom	46	56	50	54	42	56	50.67	60.5		
C49	Top	42	42	40	44	56	44	44.67	50	50	NILL
	Bottom	40	50	48	48	44	42	45.33	50		
C50	Top	34	34	36	42	38	30	35.67	32	31	NILL
	Bottom	34	36	34	34	32	34	34.00	30		
C51	Top	42	44	50	44	50	32	43.67	48	54.25	Distort edge of the column
	Bottom	50	42	54	62	50	48	51.00	60.5		
C52	Top	52	34	50	48	54	54	48.67	56.4	58.45	NILL
	Bottom	56	40	44	56	54	54	50.67	60.5		
C53	Top	44	38	48	38	56	38	43.67	48	42	NILL
	Bottom	34	38	38	38	40	42	38.33	36		

Column No	Position	Rebound Number						Average Rebound Number	Compressive Strength using Graph	Average Compressive Strength	Remark
		1	2	3	4	5	6				
C54	Top	42	50	38	44	38	38	41.67	44	48.25	NILL
	Bottom	34	44	50	48	54	52	47.00	52.5		
C55	Top	38	42	46	42	42	44	42.33	44	45	NILL
	Bottom	42	42	42	42	44	44	42.67	46		
C56	Top	36	44	42	48	42	46	43.00	46	43	Mild honeycombing
	Bottom	40	40	42	40	38	42	40.33	40		
C57	Top	30	32	32	36	36	32	33.00	28	31	Moderate honeycombing
	Bottom	40	34	38	32	46	30	36.67	34		
C58	Top	32	34	34	36	32	34	33.67	30	33	NILL
	Bottom	36	40	40	34	36	42	38.00	36		
C59	Top	34	36	42	38	36	36	37.00	34	38	NILL
	Bottom	44	42	42	38	38	40	40.67	42		
C60	Top	38	40	40	44	38	48	41.33	42	39	Tree near bottom of column
	Bottom	40	40	40	38	30	38	37.67	36		
C61	Top	40	36	44	40	42	48	41.67	44	42	NILL
	Bottom	36	40	40	42	40	44	40.33	40		
C62	Top	40	40	50	42	40	40	42.00	44	47.25	NILL
	Bottom	48	48	46	38	52	44	46.00	50.5		
C63	Top	40	40	38	38	50	40	41.00	42	44	NILL
	Bottom	46	44	42	44	40	40	42.67	46		
C64	Top	32	32	34	38	34	36	34.33	30.5	31.25	NILL
	Bottom	38	40	36	32	38	32	36.00	32		
C65	Top	40	38	38	34	40	42	38.67	38	37	NILL
	Bottom	38	38	42	38	34	40	38.33	36		
C66	Top	40	40	36	42	42	44	40.67	42	43	NILL
	Bottom	42	44	42	40	40	46	42.33	44		
C67	Top	40	38	38	36	40	40	38.67	38	38	NILL
	Bottom	36	40	42	40	36	42	39.33	38		
C68	Top	44	46	44	46	48	38	44.33	48	45	Mild honeycombing
	Bottom	40	44	44	34	40	42	40.67	42		
C69	Top	42	40	40	40	38	38	39.67	40	40	NILL
	Bottom	40	38	50	36	40	34	39.67	40		
C70	Top	34	34	38	50	40	56	42.00	44	39	NILL
	Bottom	36	36	40	38	36	36	37.00	34		
C71	Top	40	38	40	42	44	40	40.67	42	42	Mild honeycombing
	Bottom	42	42	40	38	44	42	41.33	42		

Column No	Position	Rebound Number						Average Rebound Number	Compressive Strength	Average Compressive Strength	Remark
		1	2	3	4	5	6				
C72	Top	54	44	38	54	50	46	47.67	54.5	41	NILL
	Bottom	60	64	48	62	64	54	58.67	66.5		
C73	Top	40	50	52	60	32	52	47.66	54.5	41	NILL
	Bottom	60	50	60	54	60	60	57.33	64.5		
C74	Top	38	38	36	34	38	36	36.66	34	42	NILL
	Bottom	38	40	38	38	36	38	38	36		
C75	Top	40	44	44	40	42	48	43	46	55.5	NILL
	Bottom	44	48	46	48	44	42	45.33	50		
C76	Top	34	44	36	48	36	42	40	40	59.35	NILL
	Bottom	40	46	48	48	48	46	46	50.5		
C77	Top	44	46	42	48	42	46	44.66	50	44.25	R/F bars are out of column
	Bottom	50	42	44	42	48	40	44.33	48		

In general, the rebound number increases as the strength increases but it is also affected by a number of parameters. It is also pointed out that rebound indices are indicative of compressive strength of concrete to a limited depth from the surface.

4. CONCLUSION

As such, the estimation of strength of concrete by rebound hammer method cannot be held to be very accurate and probable accuracy of prediction of concrete strength in a structure is & 25 percent. If the concrete in a particular member has internal micro cracking, flaws or heterogeneity across the cross-section, rebound hammer indices will not indicate the same. Different types of aggregate used in concrete give different correlations between compressive strength and rebound numbers. The rebound hammer method is suitable only for close texture concrete. Open texture concrete typical of honeycombed concrete or no-fines concrete is unsuitable for this test. A wet surface will give rise to underestimation of the strength of concrete calibrated under dry conditions.

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