Reliability Study of RCC Elements of Sugar Mill

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Abstract- **Preliminary assessment can be executed using Rapid Visual Screening i.e. by visual observation notes with standard format sheets having dimensions, physical changes visually seen, photo and basic input to decide for in depth survey using appropriate NDT scheme. Basic environmental features which can affect health of structure should be recorded in addition to other inputs e.g. repair history, reasons for distressed condition if known by interaction with local people. New technologies option in rehabilitation is based on the assessment of the respective structure. Nondestructive testing was performed to evaluate the integrity of damaged concrete structures. Rebound hammer can be used to find hardness of the concrete structure surface, and its strength is related using inbuilt calibration curve in the instrument. 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. In some cases it is also possible to check the quality of workmanship and structural integrity by the ability to detect voids, cracking and delamination.**

For new structures, the principal applications are likely to be for quality control or the resolution of doubts about the quality of materials or construction. The testing of existing structures is usually related to an assessment of structural integrity or adequacy.

***Keywords*— Sugar Mill, Rebound Hammer, Beam, Column, Foundation**

I. INTRODUCTION

Concrete is a strong handy building material that has found favor amongst the Civil Engineers due to ease of production and capability of being molded into any shape and size. Its quality, performance and behavior depend upon its constituents and the method of production. In the earlier times the period when most of the old RCC structures were built, the emphasis was primarily on the 28 days strength of the concrete. Little was known about the long-term behavior of concrete i.e., durability, as the earlier versions of IS 456:1978 was silent on this aspect. Though environmental factors or exposure conditions were known to cause damage to concrete, but many of the places are free from pollution and far away from the sea, the environmental factors were not considered for these types of structures.

Non-destructive testing (NDT) finds prominence in quality assurance of construction industry. It has great potential in investigation and repairs to various types of structures. Simple NDT techniques can be used to identify weak areas in concrete, which can be suitably repaired. Non-destructive testing is defined as testing that causes no structurally significant damage to concrete. It does not impair the intended performance of the element or member under investigation. NDT has the ability to determine the strength and durability of critical construction without damaging them and test can be carried out on site.

NDT is becoming popular now a day as no damage occurs in structures while testing. It gives rapid assessment of existing condition of structure it is used for wide range of objectives as discussed before. NDT includes testing right from visual inspection to the advanced techniques available for the testing of structures. NDT is applied not only in quality control and routine inspection but also in diagnostic investigations.

II. METHODS ADOPTED FOR NDT

(a) *Rebound Hammer Test*

The Schmidt Rebound Hammer measures the hardness of material at the surface by the rebound of hammer mass after an elastic impact against the surface. The mass is released from a standard pre-compressed spring thus having a fixed amount of energy. Principle of this test is that the rebound of the elastic mass depends on the hardness of the surface upon which it impinges. Energy is lost on impact due to localized crushing and internal friction within the body of the concrete. This internal friction is the function of the elastic properties of concrete constituents. Rebound Number is the distance traveled by the mass after the elastic impact expressed as a percentage of original distance. This gives a measure or indication of hardness and an estimate of the strength of concrete. There are several factors other than concrete strength that influence rebound hammer test results, including surface smoothness and finish, moisture content, coarse aggregate type, and the presence of carbonation.

Although rebound hammers can be used to estimate concrete strength, the rebound numbers must be correlated with the compressive strength of molded specimens or cores taken from the structure.

However, within certain constraints, the empirical correlation provided by one of the researcher Facaoaru (MINT, 2006), is:

$$\mathbf{K = a\ Nb} \qquad \text{(a)}$$

where N: rebound index; K: compressive strength; a and b are constants depending on moisture content of concrete and dosage of cement, age of concrete, and in special cases, the type of cement.

The estimated error in this method is +30%. Again, the calibration equation (2.1) is valid for a particular type of cement, aggregates used, moisture content, & age of specimen. (Deshpande, 2004).

III. PROBLEM STATEMENT

New Sugar Mill site consisted of two sections i.e. Sugar-Co-Gen Section & Distillery Section. In both sections few the structures are made of steel sections with RCC foundation. Some are made as water retaining structures. The Executing Agency i.e. Rajasthan State Road Development Construction Corporation Ltd, Sri GangaNagar proposes to ascertain the uniformity & quality of the whole project.

Quality of Concrete of the Structure: - The mix design report conducted in 2014 and approved. In the mix design report value of parameter K is taken as 1.64, stating that not more than 5 % of results are expected to fall below fck. The proportion recommended is 0.43:1.01:1.58:2.92. The report clearly mentions the use of admixtures.

Site Testing aspect: - It was submitted by the client the data regarding test carried out at the site i.e. photocopy of the register where other tests are also mentioned. It clearly shows that the grade of concrete M20/M25/M30 is used in construction. The NDT tests were carried out by at the lab house of sugar mill. Rebound Hammer test results show a value of 50/44/41 MPa with rebound hammer no as 42/40/39 in horizontal position & dry condition. The tests were carried out as per IS 13311 part I & II: 1992.

IV. OBJECTIVE OF NONDESTRUCTIVE INVESTIGATION

Schmidt Rebound hammer readings SN 1-56 & 1-35 for both sections were observed related to surface hardness of the Concrete and its strength is related using inbuilt calibration curve in the instrument. The strength with rebound hammer number not necessarily truly indicative of its compressive strength to the extent shown, these have to be corrected for different factors but it does give comparison of surface hardness for quality of concrete, Refer IS 13311 pt II.

To assess the existing quality, integrity and allowable compressive strength of concrete in the raft, beam, column and foundation and super structure element which can be utilized for overall structural safety. Besides, in case of any inadequacy in the concrete quality being revealed, suitable remedial measures can also be suggested.

V. NDT RESULTS

Non Destructive Test results are given below on the randomly selected elements accessed easily on the structure.

TABLE I

Rebound Hammer Assessment in Sugar-Co-Gen Section at New Sugar Mill Kaminpura SriGanganagar

Structure Member/	Concrete Grade	Observation**				
		Min	Max	SD	R	f_{ck}
Cane Carrier-Chopper	M-20	33	43	3.5	38.8	40.3
Fiberizer	M-20	30	39	3.4	33.8	31.5
Vertical Crystalliser	M-20	30	44	5.2	32.7	32.9
Mill House Floor (VD)	M-20	32	36	1.6	34.2	32
Mill House Wall S side	M-20	25	35	3.8	29	25
Mill House Wall N side	M-20	26	37	4.8	31	26.7
Sugar House-Hopper	M-20	30	33	1.2	31.7	27.8
Sugar House-ID	M-20	28	35	2.9	31.7	27.8
Sugar House-FBD	M-20	25	38	4.2	32	28.4
Floor outside Power House Near Towards SY (VD)	M-30	34	43	3.5	36.5	36.1
Floor outside Power House RO tank (VD)	M-30	30	37	2.7	34.3	32.3
Switch Yard Found Un finished	M-20	27	35	2.7	32.2	28.7
Tubro Alternator GF	M-25	29	37	3.3	33.3	30.6
Power House Column	M-25	32	38	2.5	35.3	34.1
Power House Beam GF	M-25	29	34	1.8	29.3	28.8
Power House Beam 8.5 m Level	M-25	30	34	1.5	31.3	27.3
Turbine base pedestal 8.5 m level	M-25	36	47	4.8	40.5	43.4
Boiler Foundation	M-20	25	36	4	30.2	25.3
Boiler Foundation	M-20	33	42	3.4	39.2	40.9
Boiler- ID Fan	M-20	28	34	2.5	30.5	25.9
Boiler- ESP	M-20	33	40	2.3	36.3	35.8
Clarifier	M-20	28	34	2.1	30.3	25.6
Lime Sulphur House	M-20	24	33	3.7	29.3	24
Lime Sulphur House(Plastered)	M-20	26	31	2.1	28.2	22.1
Chimney Sugar	M-20	32	37	2.1	34.3	32.3
CPU Wall	M-25	30	42	4.6	32.8	29.8
CPU area Floor	M-25	37	29	2.5	37.3	26.2
CPU – SBD Wall	M-25	25	32	1.5	29.3	28.6
ETP Wall	M-25	37	43	2.1	39.2	40.9
ETP – SBD Wall	M-25	37	42	2.7	37.2	27.5
ETP –Clarifier	M-25	33	38	1.9	35.3	34.1
Spray Pond	M-20	22	38	5	30.3	25.6
Hot Water Channel Wall	M-20	33	28	2.7	29.3	22.7
Cold Water Channel Wall	M-20	29	27	1.2	28.5	22.5
RO Tank	M-20	27	39	5.1	31.5	27.5
DM Tank	M-20	26	34	2.8	29.3	23.5
Sugar Godown	M-20	25	35	3.7	29	23.5

Column						
Sugar Godown Floor – Middle	M-20	26	35	4	30.3	25.6
Sugar Godown Floor-- Exit Side	M-20	27	34	2.6	30	25.1
Admin Block Outer Column	M-20	39	48	3.5	43.5	49.1
Admin Block Inner Column	M-20	33	35	2.1	29.9	23.8
Guest House Column-1	M-20	33	38	1.8	35	33.5
Guest House Column-2	M-20	24	40	5.7	32.8	29.8
Bank Column	M-20	27	38	5.2	33.7	31.2
Canteen Column	M-20	30	41	3.9	35	33.5
Dispensary Column Plastered	M-20	24. 6	33	2.3	28.3	22.8
Lab Column Plastered Outer Corner	M-20	29	32	1.7	30.2	25.3
Ash Handling -1	M-20	30	36	2.1	33	30.1
Ash Handling – 2	M-20	29	38	3.8	34.8	33.2
Cooling Tower	M-20	33	39	2.6	36.5	36.1
Water Tank (Sump)	M-20	30	34	1.5	32.7	29.5
General Store	M-20	29	32	3.1	29.8	23.5
Workshop	M-20	31	40	3.4	34.2	32
Bagasse Yard	M-30	36	42	2.3	38.5	39.7
Bagasse Yard	M-30	31	38	2.3	34.8	33.2
Return Bagasse Carrier (RBC)	M-20	34	41	2.7	36.7	36.4

Min- Minimum, Max-Maximum, SD-Standard Deviation, R- Average Rebound, f_{ck}- Related Compressive strength

Table-II

Rebound Hammer Assessment in Distillery Section at New Sugar Mill Kaminpura SriGanganagar

Structure Member/	Concrete Grade	Observation**				
		Min	Max	SD	X	f_{ck}
Boiler	M-20	31	36	1.8	33.2	30.3
Turbo Alternator GF Column	M-25	36	45	3.8	41	44.3
Turbo Alternator GF Column	M-25	27	37	2.9	39.3	27.8
Turbo Alternator FF Column	M-25	34	38	1.8	35.3	34.1
Turbo Alternator Roof 6.5 m level	M-25	35	43	3	39.5	41.5
Turbo Alternator GP-2 Grouting 6.5 m level	M-25	34	43	3.5	38.5	39.7
Power House GF	M-25	27	32	2.1	36.6	27.2
Silos no-1	M-20	29	37	3.1	33.8	31.5
Silos no-2	M-20	42	45	1.1	44	50
Fermentation Tank	M-20	41	49	3	44	50.1
Distillation Process Column -no 1	M-20	29	36	2.3	32	28.4
Distillation Process Column no-2 (Plastered)	M-20	25	29	1.5	27.5	21.1
Alcohol Storage Column	M-20	29	40	4.1	34.3	32.3
Alcohol Storage Tank	M-20	35	43	3.3	39.5	41.5
CPU-Tank-1 wall	M-20	25	35	4.2	31.2	26.5
CPU-Tank-2 wall	M-20	23	25	4.3	29.7	23.7
CPU-Tank-SBD wall	M-20	27	35	3.1	30	25.1
Clarifier (Plastered)	M-20	24	32	2.7	29.2	23.3
WTP Wall	M-20	27	32	2.1	29.8	24.8
Spent Wash Tank-1, wall	M-20	32	37	2.1	34.3	32.3
Spent Wash Tank-2, wall	M-20	28	34	2.1	30.8	26.4
Chimney Distillery	M-25	35	42	2.7	39.2	40.8
Bio Composting Tank	M-20	26	32	1.5	29.5	23.2
Grain Storage Godown Column	M-20	29	37	2.9	31.3	27.3
Pipe Racks Near Evaporation	M-20	27	32	1.9	29.5	22.5
Pipe Racks Near Preclear	M-20	29	37	3.2	32	28.4
Bio-Composting Yard 100m Ch	M-30	31	37	2.6	34.7	32.9
Bio-Composting Yard 150m Ch	M-30	32	40	2.7	36.8	36.7
Bio-Composting Yard 200m Ch	M-30	32	39	2.7	34.5	32.6
Bio-Composting Yard 350m Ch	M-30	31	37	2.2	34.8	32.5
Bio-Mass Yard-Towers Bagasse Yard	M-30	30	36	2.1	33.7	31.2
Bio-Mass Yard-near Fuel Handling	M-30	28	29	4.5	34	31.8
Evaporation-Column	M-20	26	42	6.3	31	26.7
Zero Discharge Tank	M-20	32	35	1	33.5	30.9
Bio Gas Holder Shell Wall Plastered)	M-20	26	29	1.4	27.8	21.2

VI. SOME CITATIONS

With reference to IS 456-2000, Clause 16 Acceptance Criteria and Clause 16.1 for Compressive Strength, The Concrete shall be deemed to comply with the strength requirements when both the following conditions are met:-

The mean strength determined from any group of four consecutive test results complies with the appropriate limits in column 2 of table 11

Any individual test results complies with the appropriate limits in column 3 of table 11

Clause 16.3 Quantity of Concrete Represented by Strength Test Results

Clause 16.3 states ie the quantity represented by a group of four consecutive test results shall include the batches from which the first and last were taken together with all intervening results.

Clause 16.6 Concrete is liable to be rejected if it porous or honey combed, its placing has been interrupted without providing a proper construction joint, the reinforcement has

been displaced beyond the tolerances specified, or construction tolerances have been met, However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineers In charge.

Clause 17.3 Testing Clause 17.4.3, Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of cores is equal to at least 85 percent of the cube strength of the grade of concrete specified for the corresponding age and no individual core has a strength less than 75 percent.

VII. THE PURPOSE OF THE INSPECTION

The purpose of the inspection is to provide advice to a prospective or other interested party regarding the condition of the structure at the time of the inspection. The advice is limited to the reporting of the condition of the structure in accord with IS 456. This report is limited to (unless otherwise noted) the main structure on the site. This report is not intended as a certificate of compliance of the structure within the requirements of any act, regulation, and ordinance or by law, or, as a warranty or an insurance policy against problems developing with the building in the future.

Assumptions & Limitations-

- Any person who relies upon the contents of this report does so acknowledging that the following clauses, which define the Scope and Limitations of the inspection, form an integral part of the report.
- This NDT inspection is limited to those areas and sections of the structure fully accessible and visible to the Inspector at the time and on the date of Inspection.
- The inspection DID NOT include breaking apart, dismantling, removing or moving objects including, but not limited to, foliage, moldings, sparking membrane, appliances or personal possessions.
- Provisions of IS 13311 part I and part II 1992 applies in addition to provisions of IS 516 latest version applies. So far as mix design is concerns provisions of IS 10262 and SP 23 latest versions shall comply. Needless to say that Provisions of IS 456-2000 also applies.
- The visiting team DID NOT dig, gouge, force or perform any invasive procedures.
- Nothing contained in the Report implies that any inaccessible or partly inaccessible area(s) or section(s) of the structure being inspected by the Inspector on the date of the inspection were free from defects latent or otherwise.
- No responsibility can be accepted for defects which are latent or otherwise not reasonably detected on limited requirement.
- Durability of exposed finishes.
- Photographic evidence taken on the day of inspection is given as an example of the NDTs found to the structure for reporting purposes only. These photos within the report are to assist, and May not show all the tests and/or the areas noted on the day of inspection.
- Any person who relies upon the contents of this Report does so acknowledging that the above clauses, definitions and disclaimers that follow define the Scope and Limitations of the inspection and form an integral part of the report.
- Disclaimer of Liability: No liability shall be accepted on account of failure of the Report to notify any problems in any area(s) or section(s) of the subject structure physically inaccessible for testing purpose, or to which access for testing is denied by or to the visiting team (including but not limited to any area(s) or section(s) so specified by the Report.
- Disclaimer of Liability to Third Parties: This report is made solely for the use and benefit of the Client named on the front of this report. No liability or responsibility whatsoever, in contract or tort, is accepted to any third party who may rely on the Report wholly or in part. Any third party acting or relying on this Report, in whole or in part does so at their own risk.
- As requested in letter referred above of the party, care has been taken not dig out a core however combined method of Rebound hammer and Ultra Sonic Pulse Velocity meter were applied.

VIII. SUGGESTION

It is suggested that the construction should not be discontinued for so long time as it can hamper quality of construction. Other agencies can further deteriorate quality of materials used and part of the construction which has made the progress.

IX. RECOMMENDATIONS

All process should be including testing, witnessed by either the contractor or the agency owning the construction. The matter may be referred to a competent authority as per norms of NDMA considering Qualification and experience of the expert concerned. Ultimately onus lies on the agency owning the construction later on.

X. CONCLUSION

The quality of concrete in Sugar Mill construction is in general above satisfactory. Workmanship seems to be satisfactory in execution of the project. NDT test indicate in surface hardness. Rebound hammer readings with standard

deviation less than 5.0 show narrow range of data and uniform quality. Quality of concrete checked on un-plastered RC surface. At different point's narrow range of data of compressive strength with Rebound hammer show reliable results. Rebound hammer readings with standard deviation less than 5.0 show narrow range of data and uniform quality.

Unnecessary obstacles should be avoided. Looking to provisions of table 11 of IS 456-200 the case reported falls under individual category i.e. fck - 4 N/sq mm should be criteria for acceptance. So far as the citation quoted and visit at the site including other parameters, reported and generated, it is felt that there should not be an issue so far quality of Concrete is concerned.

XI. PHOTOGRAPHS

P1 RH Testing of Column Foundation

P 2 RH Testing of Foundation Block

P3 RH Testing of Un plastered Column

P4 RH Testing of Column

P5 RH Testing RCC Block

P6 RH Testing of Floor Slab

P7 RH Testing of Floor Slab

P8 RH Testing of Un-plaster Column Surface

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