

## Structural Assessment of Silo Structure Using NDT Technics

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### ABSTRACT

Repairing silos has been increasingly important in recent years, with considerable awareness among storage bins, Civil Engineers, and Consultants dealing with the issue of structural repairs and rehabilitation. Until the end of the nineteenth century, silos were built all over the world using "Load Bearing" constructions. Throughout the late nineteenth century, early storage silos, largely used by farmers for bulk storage of maize, were erected using wood, brick, stone or galvanised steel, with height constraints. The utilisation of locally accessible materials and expertise was the fundamental driving factor underlying the design and construction of these buildings. Steel and concrete silos are widely used in industry today to store ash, coal, lime, aggregate, and other materials. Engineers faced a problem in meeting the need for contemporary high-rise silos with high storage capacity and R.C.C. design procedures of great quality, where suitable technique and monitoring during construction were lacking. Later in the twentieth century, the entire design idea had to be altered from "Load Bearing Structure" to "R.C.C. Framed Structure" with contemporary design and construction concept, with use of Indian standard code. In the early twentieth century, the use of concrete in the construction of storage silos revolutionised the industry and spread the usage of storage silos beyond the farm.

### I.

#### INTRODUCTION

Silos are employed by a good range of industries to store bulk solids in quantities starting from some tones to hundreds or thousands of tones. The term silo includes all sorts of particulate solids storage structure that may preferably be stated as a bin, hopper, grain tank or bunker. They will be constructed of steel or reinforced concrete and should discharge by gravity flow

or by mechanical means. They can be supported on columns, load bearing skirts, or they may be hung from floors.

Some causes of failure of RCC Silo" s.

- Failure due to structural design.
- Failure due to maintenance.
- Failure due to construction error.

Storage silos are cylindrical structures, typically 3 to 27 meter in diameter and 10 to 90 meters in height with slip and jump from concrete silos being the larger diameter and taller silos. Bunker silo are trenches, usually with concrete walls, that are filled and packed with tractor.

### II.

#### LITERATURE REVIEW

[1] Nikhil L. Jagtap, Prof. PR Mehetre, in this project, the status of the existing structure was evaluated using NDTs and an additional structure was prepared. The building was designed over 40 years ago to meet the state of the art, but not today. The research project will support and improve the performance of existing models so that they can perform well when exposed to additional products. This job includes non-destructive testing of existing equipment / determining the load and time bearing capacity of the structure before and after extension, process improvement, R.C.C. of the existing process. This project continued to support the existing structure with different reinforcement techniques and to examine the performance of the existing structure after retrofitting.

[2] Namitha R. Jain, Mr. K.N. Vishwanath is used in non-destructive testing (NDT) techniques for health assessment. A structure is an assembly of bearing elements that can safely transfer the load to the base. Their main and most important feature is the durability of the fabric they are used in. As we all know, stone is a monolithic material used for construction. Therefore, the strength of the stones used must be "known" before the comparison begins. These different methods and techniques are called NDT. In recent years, new non-

destructive methods have become established that can be used to evaluate existing models, but methods for conventional analysis have not yet been established. Therefore, the aim of this study is to examine the validity, effectiveness, efficiency, challenges, and limitations of NDT. The damaged concrete in the foundation, basement and floor will return to its original form and meet the expectation after a successful evaluation by an experienced organization under the supervision of experienced personnel.

[3] Pascal et al. (2003) performed a destructive and non-destructive test using different concrete mixes with cube strengths ranging from 30 to 150 MPa to determine the relationship between strength and weakness, such as impact velocity, rotary hammer, tensile, and probe penetration. . road together.

[4] Almir and Protasio (2000) examined the relationship between the compressive strength of concrete and measured the strength using the NDT method, and also proposed tensile, pin drilling and UPV for the evaluation of sexual strength. [5] Rens and Kim (2007), Inspection of steel bridge using various NDT methods such as visual inspection, impact hammer, Schmidt hammer and UPV test, NDT results were used for area detection and local damage testing. Like compressive strength, chloride test and magnetic cover meters are commonly used to estimate the coating of rebar.

### III. METHODOLOGY

1. To carry out visual inspection of silo and collect the details of structure with the help of structural drawings.
2. Carry out following test on structure.
  - a) Ultrasonic Pulse velocity Test (UPV Test).
  - b) Rebound Hammer Test.
3. To prepare surface for test.

#### A. Ultrasonic pulse velocity test

The test is based on IS: 13311 (part 1)-1992 to measure the quality of concrete by ultrasonic pulse emission method. The principle of the test is to measure the propagation time of the ultrasonic pulse from the test stone of the model. Stone density, uniformity, homogeneity etc. Speed can be achieved when the angles are good.

#### INTERPRETATION OF RESULTS

Uniformity of stone quality, presence or absence of scars, cracks and segregation etc. it is indicative of the quality of the stone, so the degree of work can be evaluated using rules. These rules, given below, have turned into concrete structures in the context of the ultrasonic pulse report.

Table No.1: -UPV Test Result Calculation.

Pulse velocity (km/sec)	Concrete Quality
Above 4.5	Excellent
3.5 to 4.5	Good
3.0 to 3.5	Medium
Below 3.0	Doubtful

#### B. Rebound Hammer Test

The Schmidt hammer is a tool used to measure the strength (mainly hardness and resistance to penetration) of concrete. The hammer measures the rotation of the spring-loaded mass against the surface of the sample. The last hammer hit the stone with a special force. The rebound depends on the hardness of the stone and is measured by the material. The compressive strength of concrete can be determined from the conversion table according to the return value. Interpretation of results The hammer reading on the gauge is calibrated for horizontal impact (at the surface) by the hammer manufacturer to indicate compressive strength. When used in other projects, the appropriate treatment provided by the manufacturer should be considered.



Table No.2: - Half-cell potentiometer test with recoil hammer results calculated

Average Rebound Number	Quality of Concrete
>40	Very good
30 to 40	Good layer
20 to 30	Fair
<20	Poor Concrete

Half-cell capacity testing is a very important method for measuring the severity of corrosion activity in concrete structures, half-cell capacity testing techniques usually involve measuring the capacity of the metal line (usually copper/sulphate) connected to the half of the cell. . on the surface of the water.

Table No.3: - Corrosion risk for different readings.

Sr. No.	Half-cell (mv) relative to Cu-Cu sulphate	% chance of corrosion activity
1	Less than -200	10%
2	Between -200 to -350	50% (uncertain)
3	Above-350	90%



Fig No.1: - Rebound Hammer Test



Fig 2: - Half Cell test

#### IV. RESULTS

##### Ultrasonic pulse velocity test

Table No.4 : - UPV Test Results

Sr. No.	Description	Type of Methods	No. of points	Transit Time (T) in Micro Seconds	Path Length (L) in mm	Velocity $V = L/T$ in Km/Sec	Corrected Factor Reading	Remarks
<b>At 1.0 Meter Level</b>								
1	East Side	Indirect	4	90	200	2.22	3.22	Medium
			4	198.5	400	2.02	3.02	Medium
			4	334.6	600	1.79	2.79	Doubtful
2	East-South side		4	91.2	200	2.19	3.19	Medium
			4	192.5	400	2.08	3.08	Medium

		Indirect	4	345.6	600	1.74	2.74	Doubtful
3	South Side	Indirect	4	112.3	200	1.78	2.78	Doubtful
			4	189.3	400	2.11	3.11	Medium
			4	356.3	600	1.68	2.68	Doubtful
4	South west side	Indirect	4	110.8	200	1.81	2.81	Doubtful
			4	176.3	400	2.27	3.27	Medium
			4	380.1	600	1.58	2.58	Doubtful
5	West Side	Indirect	4	111.8	200	1.79	2.79	Doubtful
			4	201.9	400	1.98	2.98	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
6	West North Side	Indirect	4	101.5	200	1.97	2.97	Doubtful
			4	211.5	400	1.89	2.89	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
7	North Side	Indirect	4	111.8	200	1.79	2.79	Doubtful
			4	206.1	400	1.94	2.94	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
<b>At 4.0 Meter Level</b>								
1	East Side	Indirect	4	101.3	200	1.97	2.97	Doubtful

			4	201.3	400	1.99	2.99	Doubtful
			4	361.2	600	1.66	2.66	Doubtful
2	East-South side	Indirect	4	91.2	200	2.19	3.19	Medium
			4	199.9	400	2.00	3.00	Medium
			4	360.9	600	1.66	2.66	Doubtful
3	South Side	Indirect	4	119.6	200	1.67	2.67	Doubtful
			4	203.3	400	1.97	2.97	Doubtful
			4	347.9	600	1.72	2.72	Doubtful
4	South west side	Indirect	4	111.9	200	1.79	2.79	Doubtful
			4	181.3	400	2.21	3.21	Medium
			4	381.9	600	1.57	2.57	Doubtful
5	West Side	Indirect	4	111.8	200	1.79	2.79	Doubtful
			4	201.9	400	1.98	2.98	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
6	West North Side	Indirect	4	101.5	200	1.97	2.97	Doubtful
			4	211.5	400	1.89	2.89	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
7	North Side	Indirect	4	116.9	200	1.71	2.71	Doubtful
			4	203.6	400	1.96	2.96	Doubtful
			4	363.3	600	1.65	2.65	Doubtful
8	North East		4	108.3	200	1.85	2.85	Doubtful

	Side	Indirect	4	230.6	400	1.73	2.73	Doubtful
			4	363.3	600	1.65	2.65	Doubtful
<b>At 7.0 Meter Level</b>								
1	East Side	Indirect	4	101.9	200	1.96	2.96	Doubtful
			4	201.3	400	1.99	2.99	Doubtful
			4	391.3	600	1.53	2.53	Doubtful
2	East-South side	Indirect	4	99.9	200	2.00	3.00	Doubtful
			4	206.3	400	1.94	2.94	Doubtful
			4	355.3	600	1.69	2.69	Doubtful
3	South Side	Indirect	4	132	200	1.52	2.52	Doubtful
			4	201.1	400	1.99	2.99	Doubtful
			4	358.3	600	1.67	2.67	Doubtful
4	South west side	Indirect	4	110.8	200	1.81	2.81	Doubtful
			4	176.3	400	2.27	3.27	Medium
			4	380.1	600	1.58	2.58	Doubtful
			4	111.8	200	1.79	2.79	Doubtful
			4	201.9	400	1.98	2.98	Doubtful
			4	369.9	600	1.62	2.62	Doubtful
			4	112.9	200	1.77	2.77	Doubtful
			4	222.3	400	1.80	2.80	Doubtful
			4	399.9	600	1.50	2.50	Doubtful
			4	111.8	200	1.79	2.79	Doubtful
			4	206.1	400	1.94	2.94	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
			4	111.8	200	1.79	2.79	Doubtful
			4	213.5	400	1.87	2.87	Doubtful
<b>At 10.0 Meter Level</b>								
1	East Side	Indirect	4	112.3	200	1.78	2.78	Doubtful
			4	209.9	400	1.91	2.91	Doubtful
			4	398.3	600	1.51	2.51	Doubtful
2	East-South side	Indirect	4	129.3	200	1.55	2.55	Doubtful
			4	240.3	400	1.66	2.66	Doubtful
			4	401.3	600	1.50	2.50	Doubtful
3	South Side		4	112.3	200	1.78	2.78	Doubtful
			4	189.3	400	2.11	3.11	Medium

		Indirect	4	356.3	600	1.68	2.68	Doubtful
4	South west side	Indirect	4	110.8	200	1.81	2.81	Doubtful
			4	176.3	400	2.27	3.27	Medium
			4	380.1	600	1.58	2.58	Doubtful
5	West Side	Indirect	4	111.8	200	1.79	2.79	Doubtful
			4	201.9	400	1.98	2.98	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
6	West North Side	Indirect	4	101.5	200	1.97	2.97	Doubtful
			4	211.5	400	1.89	2.89	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
7	North Side	Indirect	4	111.8	200	1.79	2.79	Doubtful
			4	206.1	400	1.94	2.94	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
8	North East Side	Indirect	4	111.8	200	1.79	2.79	Doubtful
			4	213.5	400	1.87	2.87	Doubtful
			4	361.2	600	1.66	2.66	Doubtful
<b>At 13.0 Meter Level</b>								
1	East Side	Indirect	4	101.3	200	1.97	2.97	Doubtful
			4	201.3	400	1.99	2.99	Doubtful
			4	361.2	600	1.66	2.66	Doubtful
2	East-South side	Indirect	4	91.2	200	2.19	3.19	Doubtful
			4	199.9	400	2.00	3.00	Medium
			4	360.9	600	1.66	2.66	Doubtful
3	South Side	Indirect	4	119.6	200	1.67	2.67	Doubtful
			4	203.3	400	1.97	2.97	Doubtful
			4	347.9	600	1.72	2.72	Doubtful
4	South west side	Indirect	4	111.9	200	1.79	2.79	Doubtful
			4	181.3	400	2.21	3.21	Medium
			4	381.9	600	1.57	2.57	Doubtful
5	West Side	Indirect	4	111.8	200	1.79	2.79	Doubtful
			4	201.9	400	1.98	2.98	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
6	West North Side	Indirect	4	101.5	200	1.97	2.97	Doubtful
			4	211.5	400	1.89	2.89	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
7	North Side	Indirect	4	116.9	200	1.71	2.71	Doubtful
			4	203.6	400	1.96	2.96	Doubtful
			4	363.3	600	1.65	2.65	Doubtful
8	North East Side		4	108.3	200	1.85	2.85	Doubtful
			4	230.6	400	1.73	2.73	Doubtful

		Indirect	4	363.3	600	1.65	2.65	Doubtful
<b>At 16.0 Meter Level</b>								
1	East Side	Indirect	4	112.3	200	1.78	2.78	Doubtful
			4	209.9	400	1.91	2.91	Doubtful
			4	398.3	600	1.51	2.51	Doubtful
			4	129.3	200	1.55	2.55	Doubtful
			4	240.3	400	1.66	2.66	Doubtful
			4	401.3	600	1.50	2.50	Doubtful
			4	112.3	200	1.78	2.78	Doubtful
			4	189.3	400	2.11	3.11	
			4	356.3	600	1.68	2.68	Doubtful
			4	110.8	200	1.81	2.81	Doubtful
			4	176.3	400	2.27	3.27	Doubtful
			4	380.1	600	1.58	2.58	Doubtful
			4	111.8	200	1.79	2.79	Doubtful
			4	201.9	400	1.98	2.98	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
			4	101.5	200	1.97	2.97	Doubtful
			4	211.5	400	1.89	2.89	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
			4	111.8	200	1.79	2.79	Doubtful
			4	206.1	400	1.94	2.94	Doubtful
4	360.9	600	1.66	2.66	Doubtful			
4	111.8	200	1.79	2.79	Doubtful			
4	213.5	400	1.87	2.87	Doubtful			
4	361.2	600	1.66	2.66	Doubtful			
<b>At 19.0 Meter Level</b>								
1	East Side	Indirect	4	97.9	200	2.04	3.04	Medium
			4	198.5	400	2.02	3.02	Medium
			4	336.2	600	1.78	2.78	Doubtful
2	East-South side	Indirect	4	91.2	200	2.19	3.19	Medium
			4	201.6	400	1.98	2.98	Doubtful
			4	345.6	600	1.74	2.74	Doubtful
3	South Side	Indirect	4	112.3	200	1.78	2.78	Doubtful
			4	189.3	400	2.11	3.11	Medium
			4	356.3	600	1.68	2.68	Doubtful
4	South west side	Indirect	4	110.8	200	1.81	2.81	Doubtful
			4	176.3	400	2.27	3.27	Medium
			4	380.1	600	1.58	2.58	Doubtful
			4	111.8	200	1.79	2.79	Doubtful
			4	201.9	400	1.98	2.98	Doubtful
			4	360.9	600	1.66	2.66	Doubtful

			4	101.5	200	1.97	2.97	Doubtful
			4	211.5	400	1.89	2.89	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
			4	111.8	200	1.79	2.79	Doubtful
			4	206.1	400	1.94	2.94	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
			4	111.8	200	1.79	2.79	Doubtful
			4	213.5	400	1.87	2.87	Doubtful
			4	361.2	600	1.66	2.66	Doubtful
<b>At 22.0 Meter Level</b>								
1	East Side	Indirect	4	101.3	200	1.97	2.97	Doubtful
			4	201.3	400	1.99	2.99	Doubtful
			4	361.2	600	1.66	2.66	Doubtful
2	East-South side	Indirect	4	91.2	200	2.19	3.19	Medium
			4	199.9	400	2.00	3.00	Medium
			4	360.9	600	1.66	2.66	Doubtful
3	South Side	Indirect	4	119.6	200	1.67	2.67	Doubtful
			4	203.3	400	1.97	2.97	Doubtful
			4	347.9	600	1.72	2.72	Doubtful
4	South west side	Indirect	4	111.9	200	1.79	2.79	Doubtful
			4	181.3	400	2.21	3.21	Medium
			4	381.9	600	1.57	2.57	Doubtful
5	West Side	Indirect	4	111.8	200	1.79	2.79	Doubtful
			4	201.9	400	1.98	2.98	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
6	West North Side	Indirect	4	101.5	200	1.97	2.97	Doubtful
			4	211.5	400	1.89	2.89	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
7	North Side	Indirect	4	116.9	200	1.71	2.71	Doubtful
			4	203.6	400	1.96	2.96	Doubtful
			4	363.3	600	1.65	2.65	Doubtful
			4	108.3	200	1.85	2.85	Doubtful
			4	230.6	400	1.73	2.73	Doubtful
			4	363.3	600	1.65	2.65	Doubtful
<b>At 25.0 Meter Level</b>								
1	East Side	Indirect	4	111.9	200	1.79	2.79	Doubtful
			4	203.3	400	1.97	2.97	Doubtful



			4	356.3	600	1.68	2.68	Doubtful
2	East-South side	Indirect	4	100.9	200	1.98	2.98	Doubtful
			4	202.1	400	1.98	2.98	Doubtful
			4	340.3	600	1.76	2.76	Doubtful
3	South Side	Indirect	4	121.3	200	1.65	2.65	Doubtful
			4	206.3	400	1.94	2.94	Doubtful
			4	360.1	600	1.67	2.67	Doubtful
4	South west side	Indirect	4	116.3	200	1.72	2.72	Doubtful
			4	176.3	400	2.27	3.27	Medium
			4	380.1	600	1.58	2.58	Doubtful
5	West Side	Indirect	4	111.8	200	1.79	2.79	Doubtful
			4	201.9	400	1.98	2.98	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
6	West North Side	Indirect	4	101.5	200	1.97	2.97	Doubtful
			4	211.5	400	1.89	2.89	Doubtful
			4	360.9	600	1.66	2.66	Doubtful
7	North Side	Indirect	4	112.9	200	1.77	2.77	Doubtful
			4	213.6	400	1.87	2.87	Doubtful
			4	362.9	600	1.65	2.65	Doubtful
8	North East Side	Indirect	4	111.8	200	1.79	2.79	Doubtful
			4	210.9	400	1.90	2.90	Doubtful
			4	366.9	600	1.64	2.64	Doubtful

#### A. Rebound Hammer Test

**Table No.5 : - Rebound Hammer Results**

	Particulars	Rebound No.	Average	Probable Compressive Strength (N/mm <sup>2</sup> )
<b>CEMENT SILO</b>				
	West South Side At 7.0 Mtr Level	40,42,42,3 8,48,42,42 ,36,38	41	46
	West South Side At 9.0 Mtr Level	38,40,42,4 2,34,36,48 ,32,46	40	44
	West South Side At 11.0 Mtr	42,38,36,3 8,28,44,42	36	37

	Level	,28,32		
	West South Side At 13.0 Mtr Level	28,32,22,2 6,42,26,24 ,32,34	30	27
	West South Side At 15.0 Mtr Level	28,32,44,4 2,48,24,26 ,28,30	34	34
	West South Side At 17.0Mtr Level	34,40,44,4 6,42,38,36 ,48,42	41	46
	West South Side At 22.0 Mtr Level	40,38,40,3 6,34,42,42 ,38,42	39	43
	West South Side At 24.0 Mtr Level	44,40,42,4 0,42,42,38 ,40,42	41	46

### B. Half-cell Potential Meter Test

**Table No.6:** - Risk of Corrosion against Potential Difference Reading

Sr. No.	Particulars	Half Cell
1.	West Side At 2 Mtr Level	-239
		-242
		-244
2.	West Side At 4 Mtr Level	-236
		-227
		-226
3.	West Side At 6 Mtr Level	-221
		-244
		-220
4.	West Side At 8 Mtr Level	-234
		-222
		-199
		-311

### V. CONCLUSION

Results of Ultrasonic Pulse Rate Test (see IS 13311 Part 1 1992) from indirect method with maximum readings of 2.62 km/h and 3.16 km/h. The readings showed that the concrete quality was questionable in many places and moderate in a few places. RCC silos need to be repaired and strengthened by injection technique.

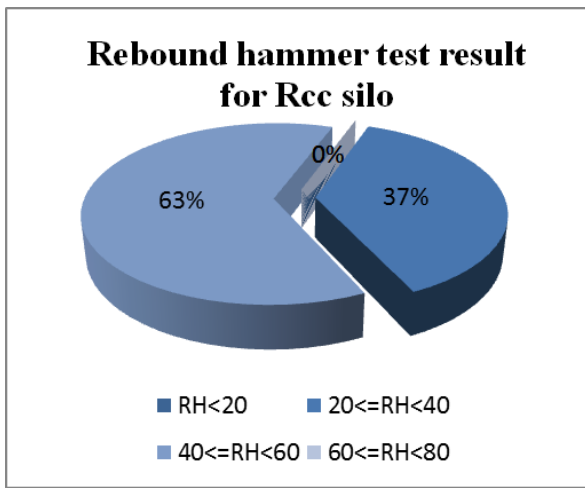


Fig.5 Rebound Hammer Test Result Cart

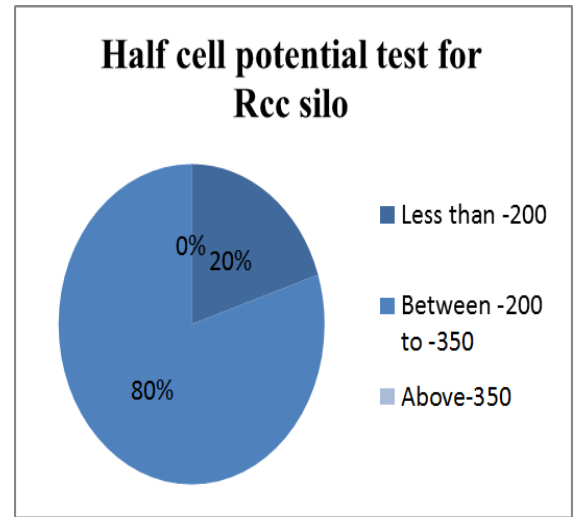
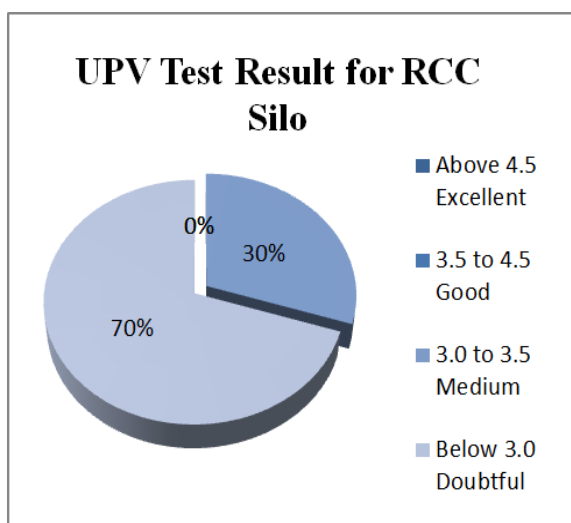


Fig.6 Half Cell Test Result Chart

B. Half cell capacity test for 50% corrosion in the silo. Remedial measures were taken to restore the silo, rust was removed using an antioxidant and the silo was restored.

A. Recoil Hammer Test The previous casing is made of grade M50 concrete and has been subjected to the rebound hammer test, which results in grades M27 to M46 concrete on each reading (see IS 13311 Part 1 1992). The concrete level is improved when using the grouting process.



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