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Strength Assessment and Restoration of RC Structures by Structural Health Monitoring Techniques

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ABSTRACT

In effect, concrete is broadly used as a building material due to the fact of its excessive strength-cost ratio in many applications. Concrete constructions are commonly predicted to supply bother free provider in the course of its meant design life. However, these expectations are not realized in many constructions due to the fact of structural deficiency, material deterioration, unanticipated over loadings or physical harm and for that reason Civil structures like buildings, dams, bridges etc are subjected to non-stop deterioration over the years. This extent of damage or deterioration appreciably depends on the great of substances and workmanship at each the building stage. The deterioration of constructions can be a end result of a range of factors inclusive of furnace damage, frost action, chemical attack, corrosion of steel and so forth at some stage in the lifestyles span of the structure. The investigation of soundness is for this reason imperative for discovering the current serviceability of the structure and its scope for future developments or for the change in its utilization. Such an investigation can be carried out the usage of the following methods: a) Visual examination b) Non Destructive Testing c) Partial Destructive Testing. Besides, it turns into imperative for buildings hit with the aid of an earthquake, a bomb blast or any different calamity. In general, Soundness estimation to be executed for constructions which are crossed over 15 years of age.

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1. INTRODUCTION

In effect, concrete is broadly used as a building material due to the fact of its excessive strength-cost ratio in many applications. Concrete constructions are commonly predicted to supply bother free provider in the course of its meant design life. However, these expectations are not realized in many constructions due to the fact of structural deficiency, material deterioration, unanticipated over loadings or physical harm and for that reason Civil structures like buildings, dams, bridges etc are subjected to non-stop deterioration over the years. This extent of damage or deterioration appreciably depends on the great of substances and workmanship at each the building stage. The deterioration of constructions can be a end result of a range of factors inclusive of furnace damage, frost action, chemical attack, corrosion of steel and so forth at some stage in the lifestyles span of the structure. The investigation of soundness is for this reason imperative for discovering the current serviceability of the structure and its scope for future developments or for the change in its utilization. Such an investigation can be carried out the usage of the following methods: a) Visual examination b) Non Destructive Testing c) Partial Destructive Testing. Besides, it turns into imperative for buildings hit with the aid of an earthquake, a bomb blast or any different calamity. In general, Soundness estimation to be executed for constructions which are crossed over 15 years of age.

2. METHODOLOGY

2.1. VISUAL INSPECTION OR FIELD CONDITION SURVEY

- **Cracks:** The types and width of the cracks have to be recorded. If a crack is believed to be active, a reveal may be mounted to document any movement.
- **Joints:** The configurations and stipulations of all joints must be recorded alongside with any noted deficiencies.
- **Delamination:** Areas of delamination must be identified by way of type and their depth recorded.
- **Spalling:** Locations, depths and condition of spall need to be recorded.
- **Water Infiltration**: Signs of water infiltration must be documented, alongside with whether or not the leaks had been energetic at the time of the survey. Infiltration associated with rust staining or efflorescence ought to be identified accordingly.
- **Exposed steel**: The extent and circumstance of exposed steel need to be documented.
- **Corrosion:** Noted corrosion may consist of surface staining due to corrosion of the embedded metal and floor installed components.
- **Structural Distress:** Possible warning signs of structural misery encompass excessive deflection, shear cracking, tension sector cracking, radial cracking at columns, etc.
- **Organics:** Organic rely growing on concrete surfaces is frequently indicative of excess moisture. Both the

moisture and organic boom can deteriorate the concrete. Organic boom can also additionally dim harm to the concrete. The areas must be cautiously reviewed for signs and symptoms of concrete distress.

2.2. Quality of concrete from Rebound Values Comparative Hardness

Table: 2.1 Quality of concrete from Rebound Values Comparative Hardness

Average Rebound	Quality of concrete
>40	Very good
30-40	Good
20-30	Fair
<20	Poor and/or delaminated
0	Very poor and/or delaminated

The results of rebound hammer are significantly influenced by several factors such as,

- Smoothness of test surface.
- Size, shape, and rigidity of the specimen.
- Age of the specimen.
- Surface and internal moisture conditions of the concrete.
- Type of coarse aggregate.
- Type of cement.
- Carbonation of concrete surface.

2.3. Risk of Corrosion against the Potential Difference Readings

Table:2.2 Risk of Corrosion against the Potential Difference Readings

Potential difference levels (mV)	Chance of re-bar being corroded
less than –500	visible evidence of corrosion
-350 to -500	95%
-200 to -350	50%
More than -200	5%

3. NON DESTRUCTIVE TEST RESULTS AND DISCUSSION

Fig.3.1 Image of the Water Tank

The Water tank was constructed in the year 1985.The capacity of Water tank was 15000 litres. The water tank is rested on four Columns, where columns are connected by Braces of size 250mmx250mm.

Fig.3.2 Image of Spalled Column of the Water Tank

Fig.3.3 Image of the Spalled Brace of the Water Tank

3.1. Tests Conducted on Water Tank

Fig.3.4 Half Cell Potential Difference Test being conducted on Column of the Water Tank

4. RESULT OF THE TEST CONDUCTED

4.1. Test Result for Half Cell Potential Difference

Table 4.1 Result for Half Cell Potential Difference Test Conducted at column and Braces of the Water tank

Member	Point 1 (in mV)	Point 2 (in mV)	Point 3 (in mV)	Average (in mV)	Probability of Corrosion
Column 1	-460	-420	-397	-426	90%
Column 2	-405	-426	-415	-415	90%
Column 3	-396	-411	-387	-398	90%
Column 4	-368	-391	-361	-367	90%

Member	Point 1 (in mV)	Point 2 (in mV)	Average (in mV)	Probability of Corrosion
Brace 1	-370	-352	-361	90%
Brace 2	-341	-384	-363	90%
Brace 3	-297	-325	-311	Uncertain
Brace 4	-347	-381	-364	90%

4.2. Test Result for Rebound Hammer

Table 4.2 Result for Rebound Hammer Test conducted at the column and Braces

S. No	Concrete Member	Rebound Number	α Degree with Horizontal, in degrees	Average Rebound number
1.	Column 1	27	0	26.00
		25	0	
		26	0	
2.	Column 2	24	0	22.33
		21	0	
		22	0	
3.	Column 3	21	0	22.67
		24	0	
		23	0	
4.	Column 4	27	0	27.33
		29	0	
		26	0	
5.	Brace 1	25	0	24.67
		23	0	
		26	0	
6.	Brace 2	26	0	23.67
		28	0	
		27	0	
7.	Brace 3	24	0	25.33
		27	0	
		25	0	
8.	Brace 4	23	0	23.33
		26	0	
		21	0	

4.3. Tests conducted on Ration Shop Building in Kenjanur

Fig 4.1 Half Cell Potential Difference test being conducted on the Ration Shop building

4.4. Test Result for Half Cell Potential Difference

Table 4.4 Result for Half Cell Potential Difference Test Conducted on Ration Shop

Member Plinth Beam	Half Cell potential Difference between Reinforcement and Concrete in mV
Point 1	-223
Point 2	-209
Point 3	-159
Point 4	-169
Point 5	-185
Point 6	-168
Point 7	-207
Point 8	-185
Point 9	-221
Average	-192

Member-Main Roof	Half Cell potential Difference between Reinforcement and Concrete in mV
Point 1	-271
Point 2	-307
Point 3	-289
Point 4	-321
Point 5	-332
Point 6	-296
Point 7	-281
Point 8	-312
Point 9	-290
Point 10	-312
Point 11	-261
Point 12	293
Average	-298

4.5. Test Result of Rebound Hammer Test

Table 4.5 Result for Rebound Hammer test conducted on Staff Quarters

S. No	Concrete Member	Rebound Number	α Degree with Horizontal, in degrees	Average Rebound number
1.	Sunshade 1	17	90	16.00
		15	90	
		18	90	
		14	90	
2.	Sunshade 2	28	90	26.00
		23	90	
		25	90	
		27	90	
3.	Main Roof slab	32	90	33.00
		35	90	
		30	90	
		37	90	
		31	90	
		36	90	
		34	90	
		30	90	
		38	90	
		36	90	
		29	90	
		31	90	
4.	Water tank Slab	28	90	28.00
		31	90	
		25	90	
5.	Portico Slab	34	90	34.00
		36	90	

5. CONCLUSION

After carrying out the NDT tests in the selected project areas we found that the water tank at Sunnambukarayur was in poor condition. Its structural members were corroded to 90% it becomes unfit for use, while the Ration shop building at Kenjanur and Staff quarters at Bhavanisagar are in good condition but some minor defects had been mitigated. The damages located in the Ration shop and staff quarters can be rectified by adopting suitable repairing techniques. The suitable repairing techniques for rectifying the minor damages in the structures had been suggested.

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