# STRUCTURAL MONITORING OF ELEVATED WATER TANK USING NON - DESTRUCTIVE TECHNIQUE

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*Abstract* — In present investigation the structural monitoring of elevated tank is performed considering non – destructive testing, the visual inspection is firstly done in elevated water situated in boring road patna, the different apparatus are used to identify the weaker zones in elevated water tank, those are half cell potentiometer for corrosion investigation, rebound hammer for surface hardness, profometer for strength of structure. The testing is performed and results obtained during structural monitoring are further recommended for retrofitting of elevated water tank in its different zone i.e. columns, upper dome and beams of elevated water tank structure.
Keywords— *Non – destructive testing, elevated concrete water tank , retrofitting.*

## I INTRODUCTION

Corrosion of the reinforcement and earthquakes are the main issues that might cause these structures to fail [Natarajan et al. 2009]. Direct observation had demonstrated that the columns and beams often sustain damage. There have been few studies that have concentrated on the seismic behaviour, analysis, and construction of elevated tanks. Elevated tanks were weak points in previous earthquakes and their seismic behaviour was unfavourable, causing damage owing to the lack of seismic protection. The members' declines and rising stress levels are the key causes of the collapse. Firefighting, repair, maintenance, and other emergency responses may be hampered by the breakdown of these vital structures [Shakib and Omidinasab, 2011]. In order to meet demand, reinforced concrete (RC) overhead reservoirs are regarded as vital services in many cities. After that, an analysis using SAP 2000 is performed to determine the current seismic needs taking into account IS 1893. Once the root cause of the collapse has been identified via inquiry, several retrofitting techniques are used to reinforce the building. Their safety record during powerful earthquakes is highly concerning. This study's main goals are to evaluate the current situation and refit the damaged ESR that already exists. The state of the structure was discovered by Condition Index (CI) employing several Nondestructive Testing (NDT) techniques for future use. After an earthquake, they shouldn't break down so that household and firefighting demands can be met. Retrofitting historic buildings to increase their strength is therefore important and necessary. Many methods have been developed and put to use to enhance the seismic behaviour of these structures.

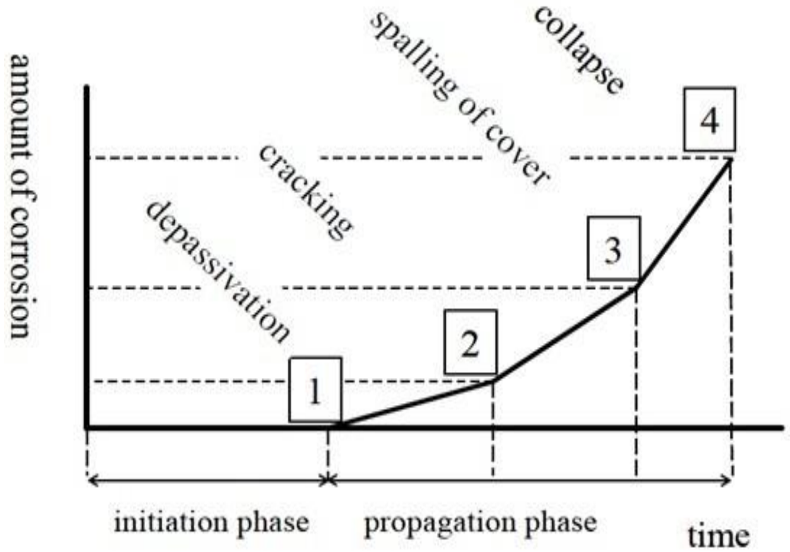



**Figure 1:** Various Stages in the Development of Reinforcement Corrosion in Concrete.

## II Types of Corrosion

- Low temperature and high temperature.
- Dry corrosion and wet corrosion.
- Water line attack concentration cells, Galvanic corrosion
- Uniform corrosion
- Hydrogen cracking, stress corrosion and embrittlement corrosion
- fatigue
- Atmospheric corrosion
- Dealloying, Dezincification
- Pitting
- Erosion corrosion
- Fretting
- Corrosion fatigue
- Cavitation

## III. RETROFITTING AND REPAIRS

Since earthquakes are the most damaging and disruptive of all natural disasters, they have also made it necessary to increase the present safety standards in buildings. To understand why some popular and outdated design philosophies, like soft-story structures, are no longer suitable for long for earthquake resistant construction, consider how seismic demands are rising daily, all over the world. Several already-existing structures were examined, planned, and detailed in accordance with the recommendations of the relevant codes. Many additional considerations are taken into account when choosing a retrofitting technique, and a few of the reasons for this have been mentioned below. Because these structures frequently fall short of the current seismic standards, reinforcing and upgrading them is crucial [Bhattacharjee, 2016]. Retrofitting is one of the finest ways to protect deteriorated structures against future natural disasters and potential earthquakes. Structures need to be strengthened and retrofitted as they age if they were not built properly to account for different loads, which will increase their strength and lifespan.

- When only gravity loads are included in the analysis and design of the structures.
- When seismic zone maps, norms of practise, and standards are not promptly updated.
- When a structure's present seismic code requirements are not met despite an increase in loading class brought on by a change in usage.
- When a structure's ability to withstand material and structural degradation reduces and it can no longer support the demands of today's loads.
- When there is a lack of engineering expertise, poor planning, and subpar building.

## IV. OBJECTIVES

1. To study the nondestructive testing approach based experimental method to find the condition index of ESRs.
2. To develop a methodology, for field surveys and condition assessment of existing ESR.
3. To undertake a case study of field condition monitoring of deteriorated ESR.
4. After finding condition ranking of the existing structure the loss of cross-sectional area due to corrosion and then present-day seismic requirements will be found out as per different revision of IS 1893.
5. After knowing seismic requirement and CI decision will be taken whether retrofitting is required or not.
6. Various retrofitting methods will be adopted for improving the drift capacity and flexural capacity of the structure.
7. To address some of the critical issues of the seismic response of the retrofitted structure concerning drift ratio, base shear, time period, displacement, velocity and acceleration.

## V. METHODOLOGY

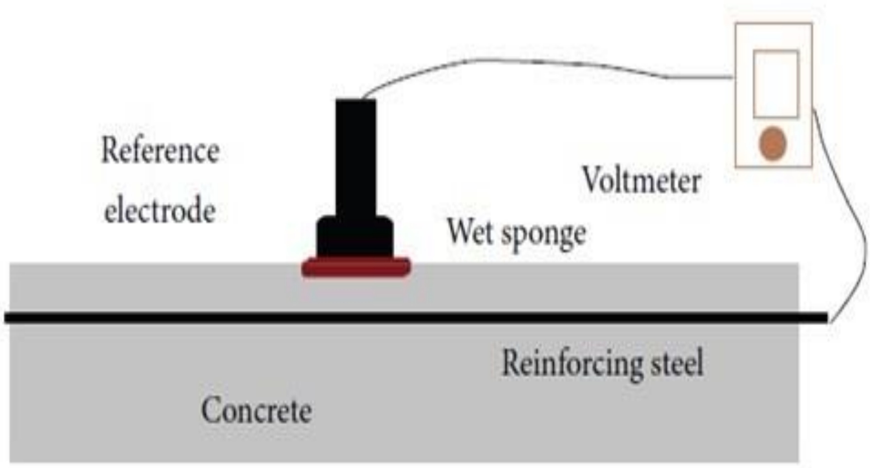
### ➢ CORROSION INVESTIGATION

**Visual Investigation**

- Authentication of the correctness of the original drawings. If drawings are not available then determination of basic ESR information.
- Classification of the most important alterations not shown on the original construction documents.
- Finding of visible structural and non-structural damage.
- Observations on quality of construction, the condition of soil and the foundation.
- Photographs at crucial locations with documentation of existing conditions.

### ➢ Half-cell Potential Measurement Method

| Percentage Chance of Corrosion Activity | Potential Level (mV) |
|---|---|
| 10% | Less than-200 |
| Uncertain | -200to-350 |
| 90% | -350to-500 |
| 95% | Above-500 |




## VI. RESULTS

**Table 4.1: Salient Features of Patna boring road elevated water tank ESR**

| Sr. No | Features | Description |
|---|---|---|
| 1 | Period of construction | 1975-76 |
| 2 | Location | At. Patna boring road elevated water tank, Bihar |
| 3 | Owned and maintained | Municipal Corporation, Bihar. |
| 4 | Total period of use | 40 yrs. |
| 5 | Utility of water tank | Yes |
| 6 | Capacity | 75,000 liters |
| 7 | Staging height | 10.5 m |

| | | |
|---|---|---|
| 8 | Column shape | Circular |
| 9 | Bracing levels | Two stage |
| 10 | Number of column | 6 |
| 11 | Structure/Geometry of tank | Tank with top spherical dome, cylindrical/ vertical wall,conical dome and bottom flat |

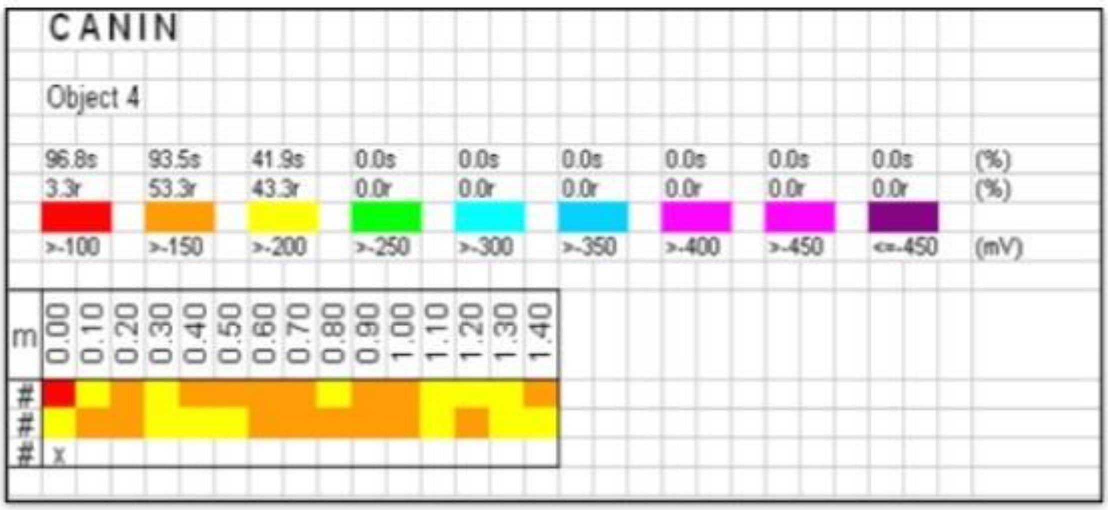



**Figure 4.8: Corrosion Mapping of Beam B1 of Patna boring road elevated water tank ESR**

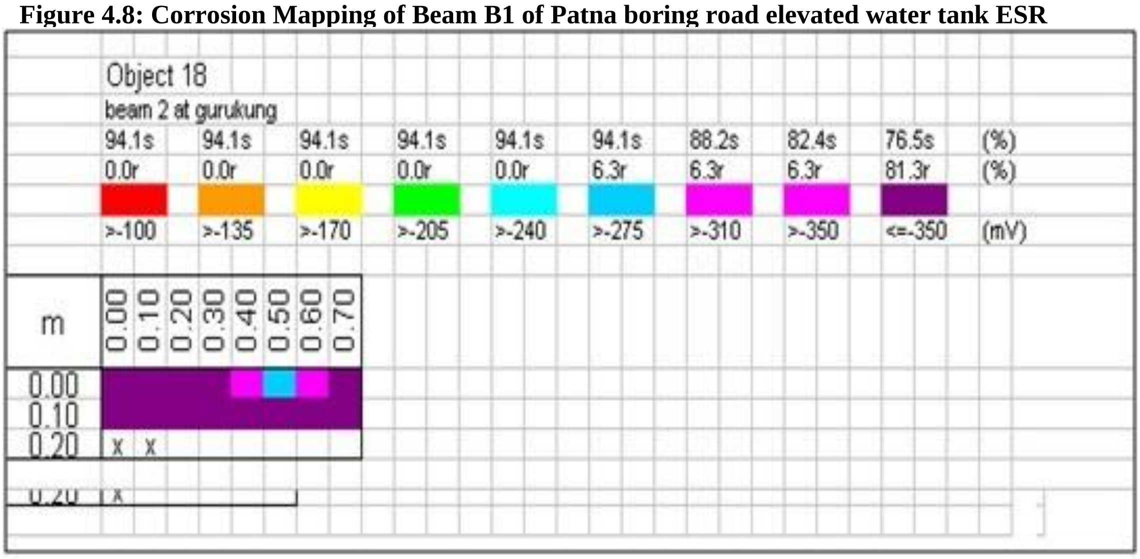



**Figure 4.9: Corrosion Mapping of Beam B2 of Patna boring road elevated water tank ESR**

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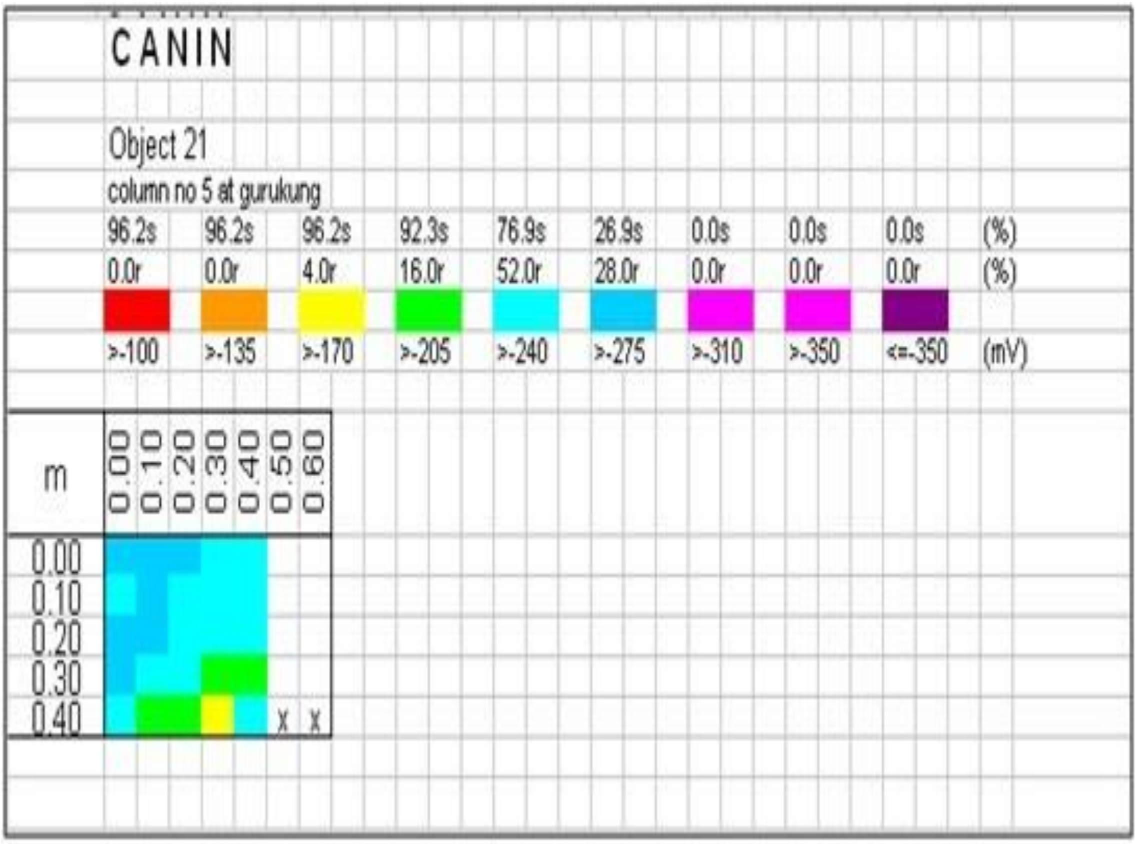



**Figure 4.10: Corrosion Mapping of Column C5 of Patna boring road elevated water tank ESR**

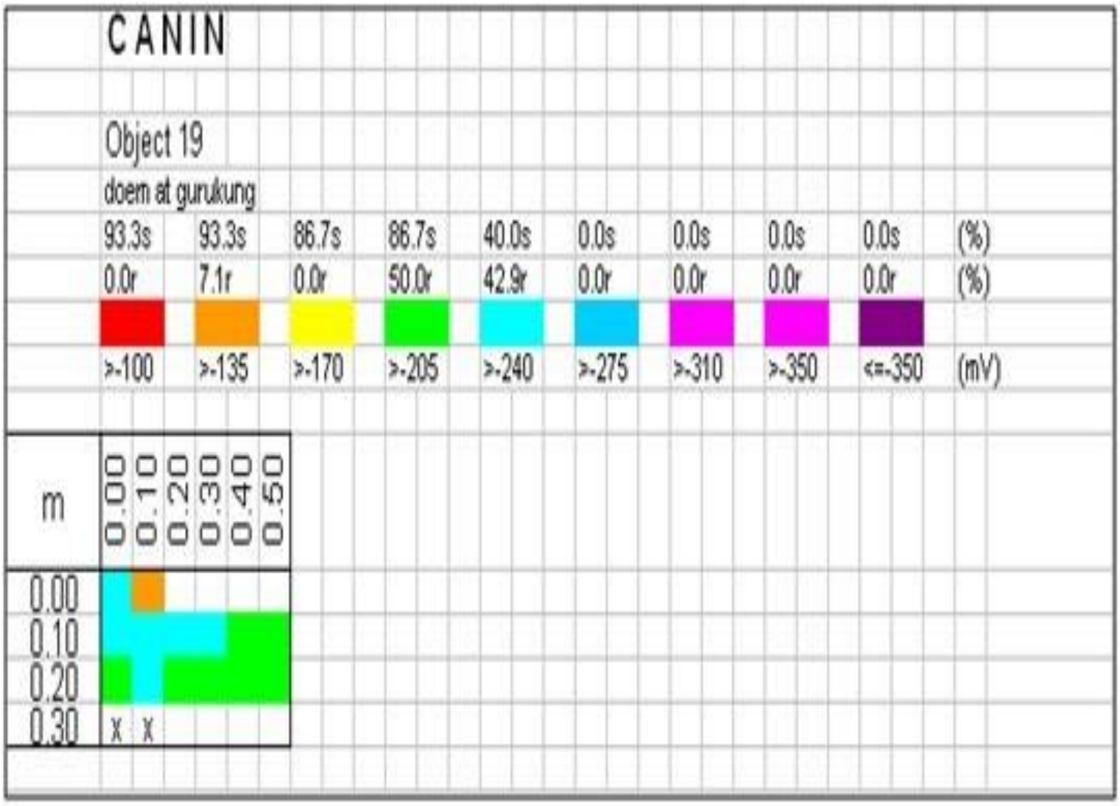



**Figure 4.11: Corrosion Mapping Top Dome of Patna boring road elevated water tank ESR**

## ➢ Profometer Test

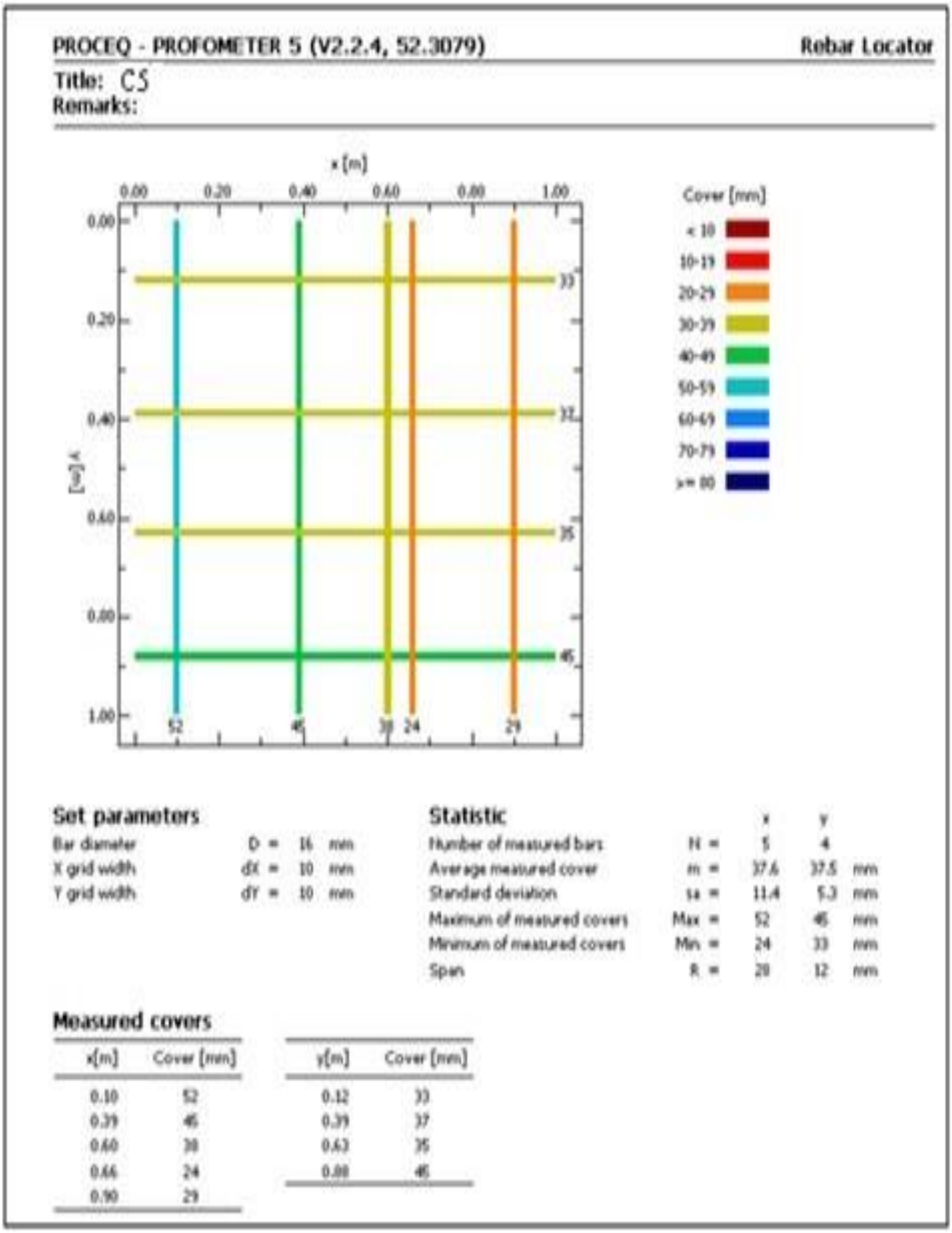
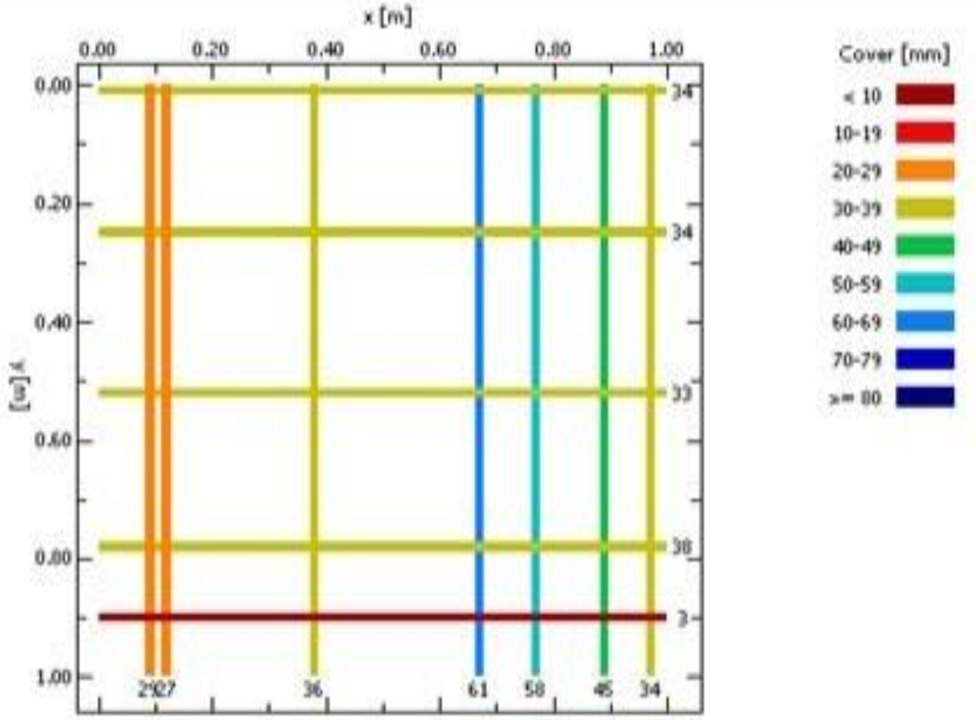



**Figure 4.13: Scanning Bars of Column C5 of Patna boring road elevated water tank ESR**

**Title:** COLUMN 3
**Remarks:**




**Set parameters**

| | | | |
|---|---|---|---|
| Bar diameter | D = | 16 | mm |
| X grid width | dX = | 10 | mm |
| Y grid width | dY = | 10 | mm |

**Statistic**

| | | x | y | |
|---|---|---|---|---|
| Number of measured bars | N = | 7 | 5 | |
| Average measured cover | m = | 41.4 | 28.4 | mm |
| Standard deviation | sa = | 13.6 | 14.3 | mm |
| Maximum of measured covers | Max = | 61 | 38 | mm |
| Minimum of measured covers | Min = | 27 | 3 | mm |
| Span | R = | 34 | 35 | mm |

**Measured covers**

| x[m] | Cover [mm] |
|---|---|
| 0.09 | 29 |
| 0.12 | 27 |
| 0.38 | 36 |
| 0.67 | 61 |
| 0.77 | 58 |
| 0.89 | 45 |
| 0.97 | 34 |

| y[m] | Cover [mm] |
|---|---|
| 0.01 | 34 |
| 0.25 | 34 |
| 0.52 | 33 |
| 0.78 | 38 |
| 0.90 | 3 |

**Figure 4.14: Scanning Bars of Column C3 of Patna boring road elevated water tank ESR**

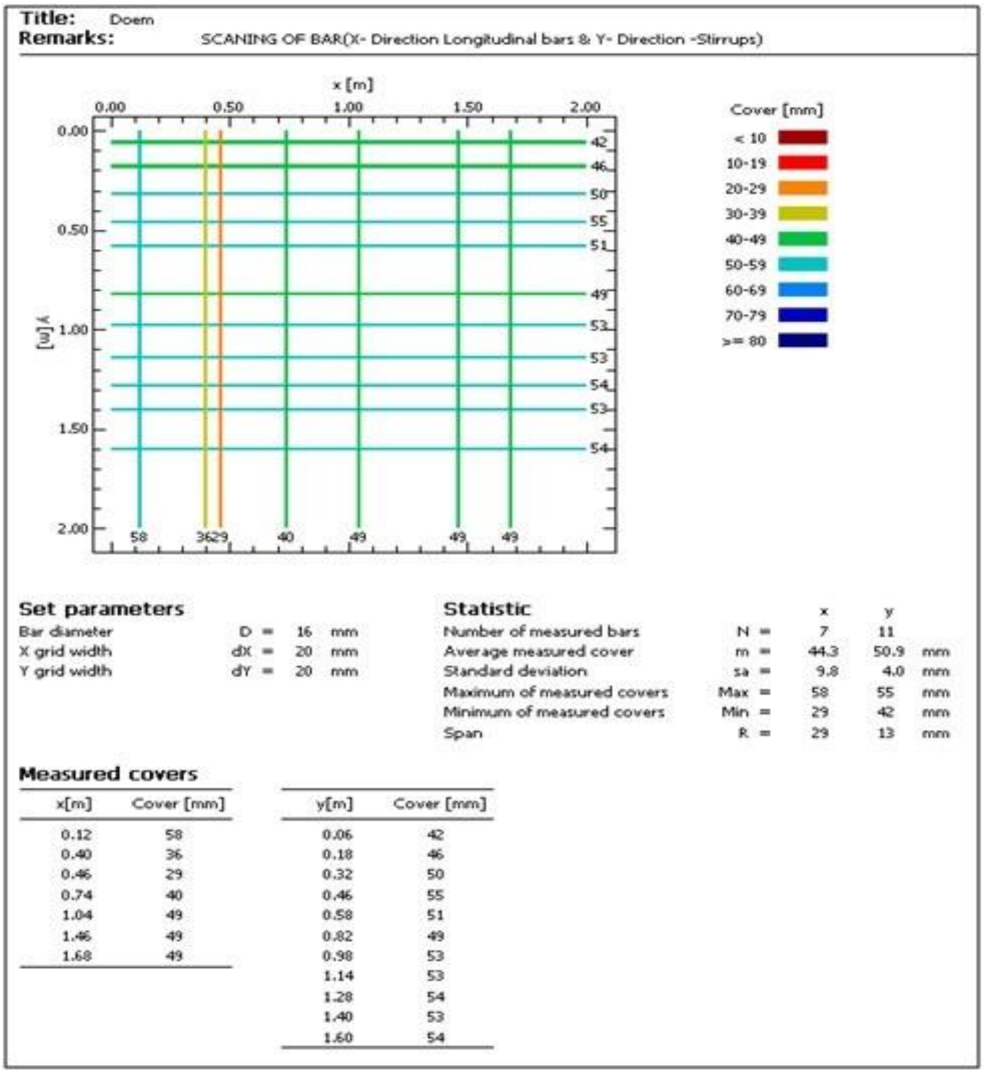



**Figure 4.15: Reinforcement Details in Water Tank Container of ReinforcedConcrete of Patna boring road elevated water tank ESR**

**Table 4.2: Results of Rebound Hammer Test of Patna boring road elevated water tank ESR**

| Sr. No | Location | Compressive Strength N/mm$^2$ | Surface Condition |
|---|---|---|---|
| 1 | C1 | 17 | Dry |
| 2 | C2 | 16.38 | Dry |
| 3 | C3 | 15.33 | Dry |
| 4 | C4 | 17.83 | Dry |
| 5 | C5 | 17 | Dry |
| 6 | C6 | 16.26 | Dry |
| 7 | B1 | 7 | Dry |
| 8 | B2 | 10.8 | Dry |
| 9 | B3 | 15 | Dry |
| 10 | B4 | 15.3 | Dry |
| 11 | B5 | 15 | Dry |
| 12 | B6 | 15.73 | Dry |
| 13 | B7 | 13.56 | Dry |
| 14 | Top dome and container | 17.5 | Dry |
| 15 | Stair case | 18.06 | Dry |

**Table 4.3: Percentage of Cross Sectional Area Loss of Patna boring road elevated water tank ESR**

| Sr. No. | Location | Diameter (mm) | | Area ($mm^2$) | | % of arealoss |
|---|---|---|---|---|---|---|
| | | Non- corroded | Corroded | Non- corroded | Corroded | |
| 1 | C1 | 16 | 12.05 | 201.06 | 114.04 | 43.27 |
| 2 | C2 | 16 | 12.36 | 201.06 | 119.98 | 40.32 |
| 3 | C3 | 16 | 12.55 | 201.06 | 123.7 | 38.47 |
| 4 | C4 | 16 | 12.33 | 201.06 | 199.4 | 40.61 |
| 5 | C5 | 16 | 13.1 | 201.06 | 134.78 | 32.96 |
| 6 | C6 | 16 | 11.9 | 201.06 | 111.22 | 44.68 |
| 7 | B1 | 16 | 12 | 201.06 | 113.1 | 43.75 |
| 8 | B2 | 16 | 12.05 | 201.06 | 114.04 | 43.27 |
| 9 | B3 | 16 | 13 | 201.06 | 132.73 | 33.98 |
| 10 | B4 | 16 | 12.25 | 201.06 | 117.86 | 41.38 |
| 11 | B5 | 16 | 12.65 | 201.06 | 125.68 | 37.49 |
| 12 | B6 | 16 | 12.66 | 201.06 | 125.88 | 37.39 |
| 13 | B7 | 16 | 14.1 | 201.06 | 156.14 | 22.34 |
| 14 | Top Dome | 16 | 13.6 | 201.06 | 145.26 | 27.75 |
| 15 | Water tank container | 16 | 12.9 | 201.06 | 130.7 | 35 |

**Table 4.6: Percentage of Cross Sectional Area Loss of Boring road patna ESR**

| Sr. No. | Location | Diameter (mm) | | Area ($mm^2$) | | % of arealoss |
|---|---|---|---|---|---|---|
| | | Non-corroded | Corroded | Non-corroded | Corroded | |
| 1 | C2 | 16 | 14.59 | 201.06 | 167.18 | 16.85 |
| 2 | B1 | 16 | 14.3 | 201.06 | 160.6 | 20.12 |
| 3 | Top dome and container | 16 | 14.9 | 201.06 | 174.36 | 13.27 |
| 4 | Stair case | 16 | 14.75 | 201.06 | 170.87 | 15.01 |

## CONCLUSION

- The results obtained from various tests, it can be concluded that boring road patna water tank is suffering severe damage due to carbonation, chloride attack, corrosion of reinforcements due to poor maintenance and inspections.
- The reinforcements of boring road patna water tank are highly corroded in columns, braces and domes.
- For the systematic investigation, a condition ranking procedure based on Analytical hierarchy process (AHP) has been proposed. DER rating technique is used to find out the condition ranking of elevated service reservoir at Boring road patna, NIT patna in Patna, Maharashtra, India.
- The condition index for RCC ESR at Boring road patna, is found to be CI =18.46 which implies that condition of the water tank is very poor and extensive deterioration and the water tank is barely functional.
- The RCC ESR at NIT patna is found to be CI =62.03 which implies that condition of the water tank is good, moderate deterioration occurred and function is still adequate. As per condition index recommendation, economic analysis of repair alternatives is recommended to determine appropriate action.

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