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Strengthening and Rehabilitation of Structures

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Abstract: The deterioration of Reinforced Cement Concrete (RCC) structures over time due to environmental, structural, and material degradation poses significant safety concerns. Many buildings are constructed without adequate design considerations, resulting in the need for structural strengthening and rehabilitation. This paper presents a case study on the repair and strengthening of an overhead water tank at Market Yard, Karad Municipal Council, Karad. Various retrofitting techniques, including ferrocement lining, epoxy grouting, waterproofing, and column jacketing, were utilized to restore the structural integrity and extend the service life of the tank. The study highlights the systematic approach followed in identifying damages, selecting appropriate rehabilitation techniques, and executing repairs effectively.

Keywords: Rehabilitation, Repairs, Retrofitting, Epoxy.

I. INTRODUCTION

Concrete structures are prone to deterioration due to multiple factors such as poor workmanship, environmental exposure, seismic activity, and inadequate maintenance. The overhead water tank at Market Yard, Karad Municipal Council, experienced structural distress, leading to cracks, leakage, and reduced strength. Strengthening such structures is crucial to prevent catastrophic failure and to ensure their continued usability.

Rehabilitation involves a comprehensive process of evaluating structural damages and applying corrective measures to restore and enhance the structure's durability. Retrofitting techniques are implemented to reinforce existing elements and improve resistance to external forces. The objective of this case study is to explore the methodologies adopted for repairing and rehabilitating the overhead water tank.

II. OBJECTIVES

- To assess the structural integrity and identify major defects in the overhead water tank.
- To implement suitable strengthening techniques such as ferrocement lining, epoxy grouting, and column jacketing.
- To enhance the durability and service life of the tank using advanced repair materials and methodologies.
- To analyze the cost-effectiveness and sustainability of the rehabilitation process.

III. METHODOLOGY

The methodology adopted in this study includes the following steps:

- **Inspection & Assessment** - Conducting visual inspections and non-destructive testing (NDT) to determine structural defects.
- **Planning & Design** - Identifying appropriate rehabilitation techniques based on structural analysis.
- **Execution** - Systematic implementation of repair techniques such as dismantling, ferrocement lining, and waterproofing.
- **Quality Control** - Monitoring and testing materials to ensure durability and effectiveness.
- **Final Evaluation** - Conducting post-repair inspections and performance analysis.

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1. **Flowchart of Methodology:**

Start → Structural Inspection & NDT → Identification of Defects → Selection of Repair Techniques →Dismantling & Surface Preparation → Application of Repair Techniques → Quality Control & Testing →Final Evaluation & Report → End

IV. REHABILITATION TECHNIQUES

A. REPAIRS AND STRENGTHENING METHODS

2. **Dismantling** - The collapsed top dome was carefully removed.
3. **Surface Preparation** - Plaster was removed from the interior and exterior tank walls, conical portions, and bottom dome ring beam.
4. **Joint Treatment** - Construction joints were opened, and general cleaning was performed.
5. **New RCC Work (Ferrocement)** - A new roof dome and walkway slab were constructed.
6. **Ferrocement Lining** - The interior of the tank walls and bottom dome was lined with ferrocement.
7. **Concrete Jacketing** - The columns were jacketed to enhance structural strength.
8. **Waterproofing** - A flexible membrane waterproofing system was applied.
9. **Grouting Techniques:**
   - Cementitious grouting for construction joint reinforcement.
   - Epoxy grouting for structural crack repairs.
10. **Anti-Corrosive Treatment** - Exposed reinforcement bars received corrosion protection treatments.
11. **Replastering and Repair Work** - Polymer-modified mortar was used for replastering staircase, ring beam, and bracing.
12. **Protective Coating** - The entire structure was coated with cement-based and polymer-based protective coatings.

V. SPECIFICATIONS FOR REPAIRS

1 Chipping and Surface Preparation

- Removal of loose concrete using an electrically operated chisel.
- Cleaning of corroded reinforcement using wire brushes and emery paper.

2 Additional Reinforcement Provision

- Additional steel bars were provided where reinforcement loss exceeded 20%.
- Lapping or anchorage with epoxy grout was implemented to restore structural integrity.

3 Corrosion Protection

- Application of epoxy-based coatings to reinforcement bars.
- Use of migrating corrosion inhibitors to prevent future corrosion.

4 Crack Injection Treatment

- Low-viscosity epoxy resin was injected into shear and tensile cracks.
- Injection was performed under controlled pressure using specialized equipment.

5 Waterproofing System

- Application of polymer-modified cementitious coatings for water resistance.
- Flexible membrane system to prevent leakage in tank walls and dome.

VI. CASE STUDY: OVERHEAD WATER TANK REPAIR FOR KARAD MUNICIPALITY

The overhead water tank required extensive repairs at an estimated cost of Rs. 11,64,800. The following steps were executed:

1. **Repair Process Steps:**
1. **Dismantling:** Removal of collapsed top dome.
2. **Primary Preparation:** Removing plaster from inside and outside of tank wall, conical portion, bottom dome ring beam, walkway, etc.
3. **Opening construction joints** from inside and outside for better bonding.
4. **General Cleaning:** Clearing debris and preparing surfaces for repair.
5. **New RCC Work (Ferrocement):** Roof dome and walkway slab reconstructed.
6. **Ferrocement Lining:** Applied to tank walls and bottom dome interior.
7. **Concrete Jacketing:** Strengthening of columns.
8. **Waterproofing Treatment:** Application of flexible membrane system.

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9. **Strengthening by Cementitious Grouting:** Grouting construction joints for reinforcement.
10. **Special Strengthening by Epoxy Grouting:** Injecting epoxy through nozzles into cracks.
11. **Anti-Corrosive Treatment:** Protection for exposed reinforcement.
12. **Corrosion Inhibitor Treatment:** Application to exposed concrete elements.
13. **Re-plastering Work:** Strengthening staircases, ring beams, and bracing using polymer-modified mortar.
14. **Protective Coating:** Application of Monopole 456 to dome and walkway slab.
15. **Foundation Testing:** Exposure and NDT analysis for additional reinforcement if necessary.

2. **Experimental Work:**

- Non-destructive testing (NDT) to assess material properties.
- Compressive strength tests on repair mortar.
- Injection grouting trials to ensure effectiveness in crack sealing.
- Waterproofing application trials for durability assessment.

Photo Gallery

Image of Water Tank at A Market Yard, For Karad Municipal Council Karad.

VII. CONCLUSION

1. Structural components such as columns are vulnerable and require strengthening to support additional live loads.
2. Traditional strengthening methods like steel jacketing have limitations due to increased dead load and corrosion issues.
3. Advanced materials like Fiber Reinforced Polymer (FRP) offer superior strength without significant weight increase.
4. Ferrocement technology provides an effective alternative for rehabilitating structural elements.
5. Further research and development in retrofitting methods can improve cost-effectiveness and efficiency in structural rehabilitation projects.

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