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Effective Management and Maintenance of Old Educational Infrastructure using Non-Destructive Testing and Automation in Estimation

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Abstract: ***Infrastructure, the backbone of a developing nation, heavily relies on Reinforced Cement Concrete (RCC) for its construction. While RCC structures have a designated lifespan (50 years for buildings, 80-100 years for bridges and dams according to IS 456). The longevity of a RCC structure depends on proper and timely maintenance. This research addresses the challenges of managing an 85-year-old college building. A thorough survey identified various forms of structural distress and their root causes. Subsequently, repair methodologies were developed based on PWD SSR guidelines. To improve efficiency, an automated data entry sheet was created to streamline cost estimation. The effectiveness of the repair strategy was validated through non-destructive testing. This research offers a cost-effective and time-saving solution for maintaining aging infrastructure. The combination of the automated data entry sheet and the repair methodology paves the way for efficient upkeep of existing structures.***

Keywords: Rehabilitation of structure, building repair, NDT, Repair estimate, building maintenance.

1. Introduction

As the development of a nation progresses, it witnesses immense boost in infrastructure. The RCC structures which are being constructed are prone to defects and distress with the passage of time. With an expected lifespan of 80 years, RCC structures require a vigorous maintenance procedure so as to sustain the effects of ageing and environmental impact.
When it particularly comes to an educational structure, the need of proper maintenance increases by multi folds as it is a very important aspect of society with a large number of occupants at a particular time. It is very important to identify the defects and distress at right time to avoid further deterioration of the infrastructure. The research deals with the distress and their probable causes. Once the defects are identified, a proper repair methodology has to be identified and followed. The validation of repair methodology was done with the help of Non-Destructive Testing.

While planning for maintenance of an educational structure, many factors come into picture. The first and foremost is budget, it is always seen that an educational infrastructure depends on the funding provided to it, and many of the times, the project activities are done in phases. Planning and execution of maintenance activities in phases becomes a tedious job. This gives rise to need of an automated sheet which helps in ease of drafting BOQ which in turn is easy to divide the project in phases.

The automation of bill of quantity sheet will result in time saving and effective maintenance of infrastructure. The cost effectiveness will be seen in terms of savings in requirement of expert staff for maintenance of structure.

2. Non-Destructive Testing

As the age of concrete increases, the inner pore structure along with the strength of concrete deteriorates. The existing quality of concrete in the RCC structural member can be assessed by Non-Destructive testing (NDT). The NDT enables assessment of material without causing damage to the structure. The 2 prevailing NDT methodologies used in this research are Rebound Hammer Test and Ultrasonic Pulse Velocity (UPV) Test.

3. Methodology

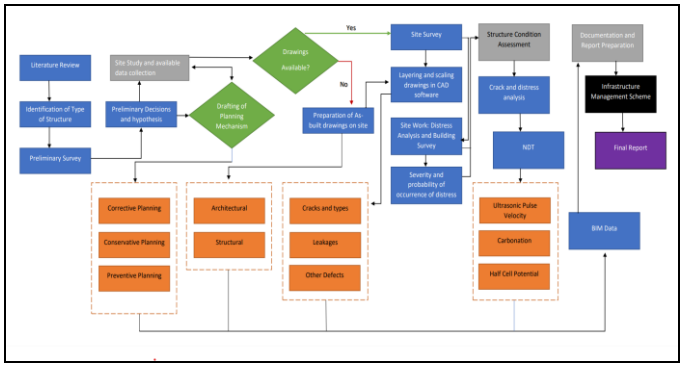

Figure 1: Methodology

Site Survey: The process of planning of maintenance of educational infrastructure shall always start with a site survey to identify the distress.

Distress Mapping: This process consists of marking the distress on a piece of drawing so that the maintenance engineer can understand and make a bill of quantities for repairs.

Non-Destructive Testing: NDT to be performed for assessing the extent of deterioration and properties of RCC structural elements.

Automated BOQ: As the scale of infrastructure increases, the complexity of BOQ will also increase. For effectiveness of maintenance, an automated sheet was developed for estimation of repair quantity.

Filters and report: Different filters can be used to determine the BOQ for different phases. A report for planning of maintenance schedule has to be prepared.

4. Result and Discussion

Distress Survey:
Entire structure was surveyed visually and all the distress were recorded by photographs. The probable cause of distress was found out. This helped in determining the repair methodology for the distressed RCC member.

Distress: Structural cracks on beams and columns	Probable Cause: Corrosion of reinforcement bars.
	

Figure 2: Distress Photographs


Figure 3: Distress Photographs


Figure 4: Distress Photographs

Automated Estimate Sheet:

Distress	Possible Cause	Repair Methodology Activities	PWD SSR No.
De-bonded Concrete	De-bonding of concrete cover due to possible corrosion of reinforcement bars	- Scaffolding - Removing of Rich mix concrete - Structural Repairs - Grouting - Bond Coat - Anti Carbonation System - Paint	- 46.42 - 46.13 - 47.01 - 47.02 - 47.16 - 47.19 - 36.21
Structural Crack	Severe corrosion of reinforcement bars	- Scaffolding - Removing of Rich mix concrete - Structural Repairs - Grouting - Bond Coat - Anti Carbonation System - Paint	- 46.42 - 46.13 - 47.01 - 47.02 - 47.16 - 47.19 - 36.21
Spalling	Spalling of concrete due to extensive corrosion of reinforcement bars and possible leakage in vicinity.	- Scaffolding - Structural Repairs - Bond Coat - Anti Carbonation System - Paint - Removal of Loose Rust	- 46.42 - 47.01 - 47.16 - 47.19 - 36.21
Leakage	Damaged waterproofing allowing water to seep through.	- Removal of existing waterproofing layer - New waterproofing layer	- 46.14 - 31.04
Vegetation Growth	Growth of vegetation due to seepage of water resulting in roots damaging core structure of concrete	· Removal of vegetation by means of acid and treating it with cementitious grouts.	- 46.58

Figure 5: Distress and repair methodology summary in automated sheet

Frontend data means the data which user/engineer will input. The input sheet of this automated sheet is very simple to understand and has a user-friendly interface. The data sheet has predefined dropdowns which are just to be selected and then the data can be added by the user. The following data are taken by the sheet:

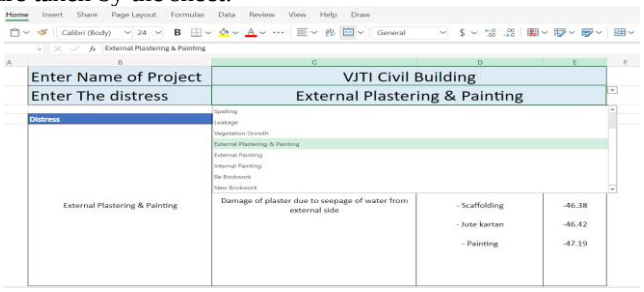

Figure 7: Frontend interface.

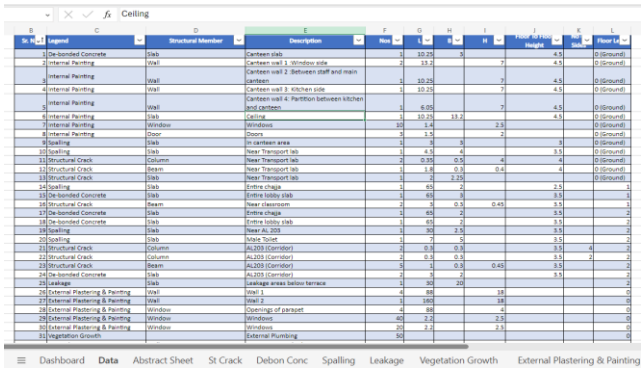

Figure 8: Frontend interface.

The backend data of the sheet formulates and calculates the measurements for the user input data. The backend system also understands the input of the engineer and segregates the required activities of the repairs in respective measurement sheets. Illustrating the detailed steps of the data in backend of the automated sheet.

Abstract Sheet Civil Work							
Total Project Amount						₹ 14,875,727.64	
Sr. No.	Qty	SSR Item	Description of Work	Rate	Unit	Amount	Type of Work
1	10850	46.42	Providing and fixing double scaffolding system (cup lock type) on the exterior side of building/structure, including additional rows of scaffolding in stepped manner as per requirement of site, made with 40mm dia M.S. tube, placed 1.5 metre centre to centre, horizontal & vertical tubes joint with cup & lock system with M.S. Tubes, M.S. tube challis, M.S. clamps and staircase system in the scaffolding for working platform etc. and maintaining it in a serviceable condition for execution of work of cleaning and/ or pointing and/ or applying chemical and removing it thereafter. The scaffolding system shall be stiffened with bracings, runners, connecting with the building etc,	279	Sqm	₹ 3,027,150.00	Enabling Works

Figure 9: Abstract estimate sheet output

Filtering output data:

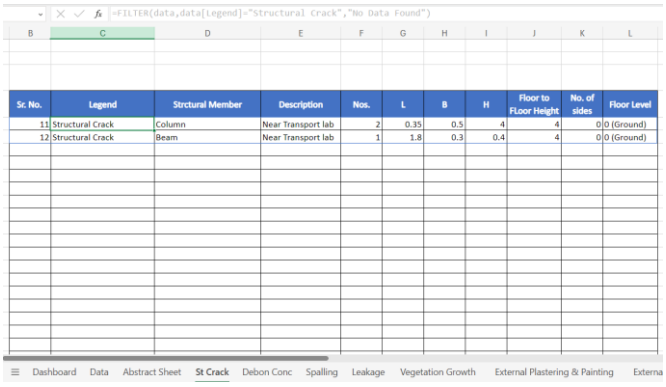

Figure 10: Filter function to enter the data sheet in its respective measurement sheet

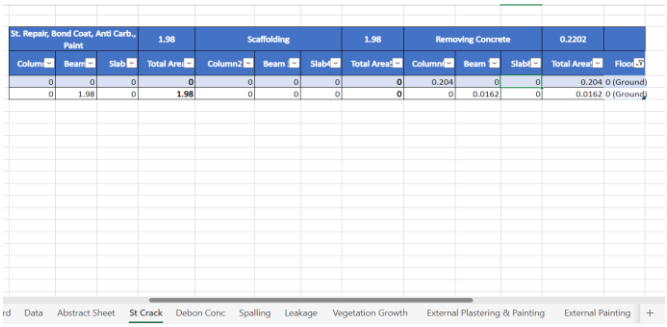

Figure 11: Updated measurement sheet after automation

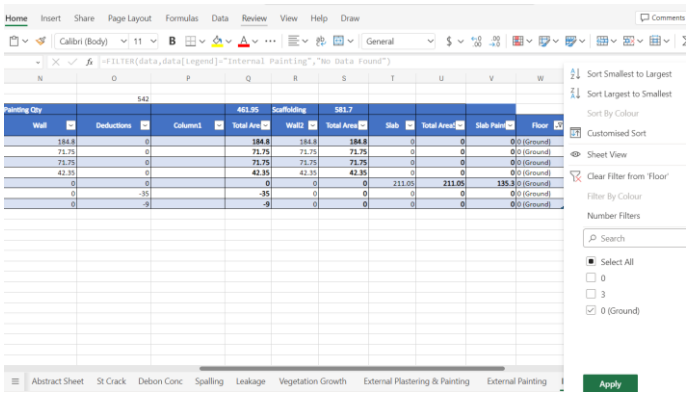

Figure 12: Filtered Painting measurement sheet (Ground Floor)

Repair methodology study:

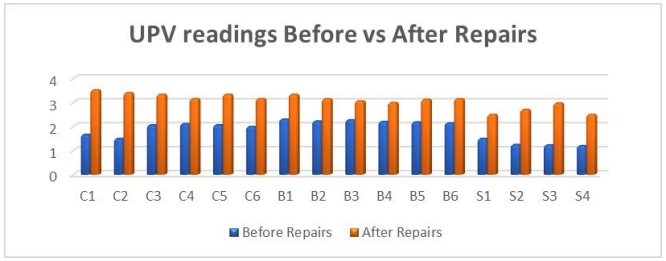

Figure 13: UPV readings before and after repairs on columns, beams and slabs

5. Future Scope

The sheet can be updated and used for any type of infrastructure. Especially this will be very useful in bridges and other complex infrastructure.

A software or an application can be made by using this data. This will result in effective maintenance of infrastructure using the latest technology and ease of planning.

This project can be implemented in major educational institutes for better planning of infrastructure management.

6. Conclusion

On the basis of assessment and Non-Destructive Testing, it was found out that there were structure related distresses on columns, beams and slabs in the pilot study area. The activities all together suggested to carry out rehabilitation works which includes chipping off loose plaster and concrete off the damaged elements, corrosion treatment for reinforcement bars, application of epoxy bond coat and then making up the section with polymer modified mortar, followed by plastering and painting.

There was an average increase of 200% in the UPV readings of columns, beams and slabs after the repairs. This indicated the effectiveness of the proposed repair methodology.

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