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Evaluation of Moisture-Related Defects in Older Buildings Using Infrared Thermography (IRT) and Selection of Cost-Effective Waterproofing Solutions

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Abstract: ***Old buildings are particularly susceptible to waterproofing problems, leading to moisture ingress and potential structural damage. This research investigates the critical role of identifying these defects for timely intervention. Among various methods, Infrared Thermography (IRT) emerges as a powerful tool for non-invasive inspections. The study utilizes a FLIR C2 camera to effectively pinpoint moisture ingress and other structural issues that could compromise the building's integrity if left unaddressed. Following the IRT inspections, a comparative cost analysis is conducted to evaluate different advanced waterproofing techniques for both slabs and walls. This analysis aims to identify the most cost-effective solutions for these crucial building components. The findings highlight the importance of IRT as an advanced diagnostic tool for ensuring the longevity of aging structures. Furthermore, the research offers practical recommendations for cost-effective waterproofing solutions, promoting the preservation of these buildings.***

Keywords: Infrared Thermography (IRT), Waterproofing Techniques, Leakage Detection, Building defects

1. Introduction

Waterproofing serves as a critical line of defence for buildings, safeguarding their structural integrity from the damaging effects of water infiltration. This protection becomes even more essential for older structures, where concrete, a ubiquitous construction material, has endured decades of exposure to the elements. While concrete offers substantial strength, prolonged water contact can lead to a weakening of the material through cracking and shrinkage. Effective waterproofing solutions are therefore paramount to ensuring the longevity of these aging structures.

Over time, the original waterproofing systems in older buildings can deteriorate, compromising their ability to prevent water ingress. This infiltration can exacerbate existing problems like cracks and water seepage, leading to a cascade of detrimental consequences. Potential issues arising from inadequate waterproofing include structural damage, a decline in the building's aesthetics, and the need for costly repairs. Preserving the historical and architectural value of these structures is of utmost importance; however, a lack of clear guidelines and plans for proper waterproofing work can hinder effective maintenance practices. This research addresses the critical need for improved methods in waterproofing older buildings. Our study focuses on two key areas:

Defect Identification: We investigate the effectiveness of Infrared Thermography (IRT) as a non-invasive method for pinpointing structural defects related to moisture ingress in older buildings. This technique offers a valuable tool for gaining a comprehensive understanding of potential problems before implementing waterproofing measures.

Cost-Effective Solutions: We conduct a comparative analysis of various modern waterproofing techniques, specifically evaluating their cost-effectiveness when applied to older structures. Analyzing and comparing costs associated with different solutions will help in selecting the most practical and affordable approach for each unique situation.

The findings from this research will provide valuable insights and practical recommendations for building owners, engineers, and professionals involved in the maintenance and preservation of aging structures. By employing IRT for accurate defect identification and selecting the most cost-effective waterproofing solutions, we can ensure the longevity and integrity of these historical and architectural treasures.

2. Identifying Structural Defects with Infrared Thermography

2.1 Infrared Thermography

Infrared Thermography (IRT) is a modern, non-destructive technique used to examine buildings. IRT cameras capture temperature variations on a building's surface, allowing for measurements from both the interior and exterior. This technology offers valuable applications in building inspection, including: Visualizing energy losses, Detecting missing or faulty insulation, Identifying air leaks, Locating moisture in insulation, roofs, and walls, Finding water infiltration in flat roofs. IRT is also used in building conservation to identify hidden features or degradation within a structure.

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2.2 Equipment

The IRT inspection utilized a FLIR C2 thermal camera. Emissivity is a material property that influences the accuracy of temperature readings in IRT. It represents an object's efficiency in emitting thermal radiation compared to a perfect blackbody. Ranging from 0 to 1 (0 being a perfect reflector and 1 being a perfect emitter), emissivity values are considered during data analysis for various materials like:

Table 1: Emissivity coefficient of Different Materials

Material	*Emissivity (ε)*
Brick	0.90-0.93
Water	0.96
Concrete	0.91-0.94
Plaster	0.90-0.96

Figure 1: FLIR C2 Thermal Camera.

2.3 Experimental Procedure

This section details the three-step experimental procedure employed for defect detection in a 75-year-old civil and environmental engineering building of Veermata Jijabai Technological Institute, (VJTI) Mumbai using Infrared Thermography (IRT).

1) Site Selection: The initial step involved selecting appropriate locations for IRT inspection. Priority was given to areas exhibiting a higher likelihood of moisture-related defects, including, Walls adjacent to bathrooms, a common location for moisture accumulation and potential mold growth. Areas with a documented history of leaks or water damage like slab areas. These areas were chosen based on their susceptibility to moisture ingress and the potential consequences for the building structure.
2) Thermogram Acquisition: The second step involved capturing thermal images (thermograms) of the selected locations. Passive thermography was utilized during this process, relying on the natural thermal radiation emitted by the building surface rather than an artificial heat source. For instance, sunlight served as the natural heat source during roof inspections.

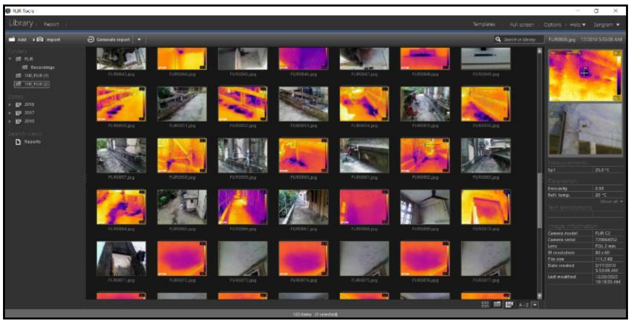

Figure 2: Main Screen of FLIR Tool showing all thermograms

3) Data Analysis: Following thermogram acquisition, the captured images were transferred to a computer for post-processing and analysis using specialized software like FLIR Tools. The software facilitated the following tasks:

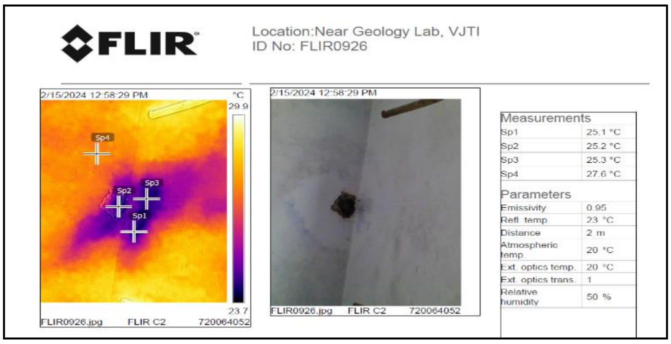

Figure 3: Reports Generated By FLIR Tool

Visual Inspection: Identification of areas on the thermogram exhibiting temperature variations. These variations could potentially indicate the presence of underlying defects. In general, darker violet colors signify areas with higher moisture content, potentially revealing hidden moisture problems within the building structure.

Temperature Measurement: Precise temperature determination at specific points within the thermogram. This aided in pinpointing the extent of moisture infiltration within the building element under inspection. Through these analytical steps, the IRT data was interpreted to identify potential moisture-related defects within the building's structure.

2.4 Observed Defects

The IRT inspection conducted at Veermata Jijabai Technological Institute, Mumbai, revealed several key observations concerning potential moisture-related defects within the building structure. These observations focused on dampness, leakages, and moisture accumulation.

1) Dampness and Moisture:

The presence of dampness can lead to a cascade of secondary problems within a building. The excess moisture creates a favorable environment for mold growth, which can pose health risks and contribute to "sick building syndrome." Dampness can also deteriorate plaster, paint, and wallpaper, leading to aesthetic and structural issues. Additionally, water stains, salt deposits, and mold growth can mar surfaces and compromise their integrity. Figures 4 and 5 illustrate examples of moisture accumulation identified through IRT.

In these figures, violet color concentrations indicate areas with higher moisture content compared to the surrounding pink areas. Figure 4 depicts moisture accumulation creating dampness marks on a wall near the Geology Lab, while Figure 5 showcases similar moisture accumulation on a slab near the Structural Department.

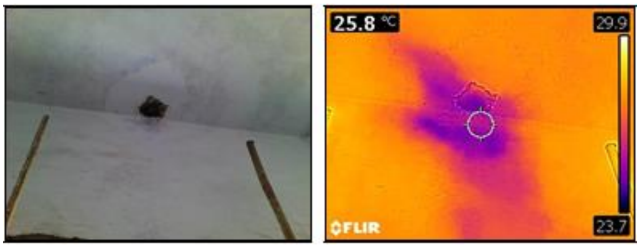

Figure 4: IRT Inspection near Geology Lab Showing Moisture Accumulation and Dampness marks on the slab

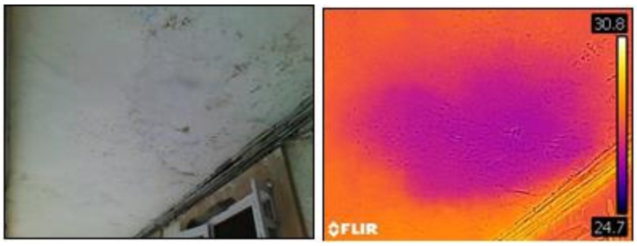

Figure 5: Moisture Accumulation and Dampness on Slab near Structural Department

2) Leakages:

Leakages within a building can have significant consequences. Water ingress can damage building materials, create conditions for mold and decay, and compromise the structural integrity over time. Common signs of leaks include water stains on walls and ceilings, damaged finishes like paint or wallpaper, and visible water marks. Figures 6 and 7 showcase the impact of leakages detected through IRT. In both figures, blue color concentrations on the thermal images indicate areas with a temperature pattern consistent with water infiltration. Figure 6 highlights a leakage from a damaged plumbing joint near the Structural Department, while Figure 7 reveals a possible entry point for water casing leakage near the Exam Section (First Floor). The distinct blue coloration in these figures aids in visually pinpointing the affected areas, allowing for targeted repair efforts.

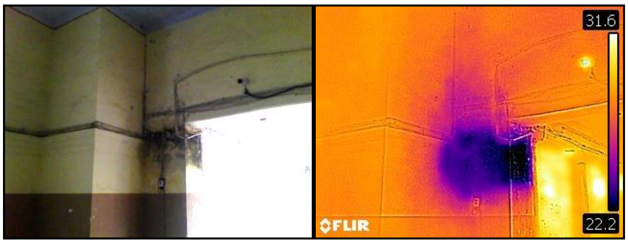

Figure 6: Infrared Detection of Leakage on wall from Damaged Plumbing Joint near Structural Department

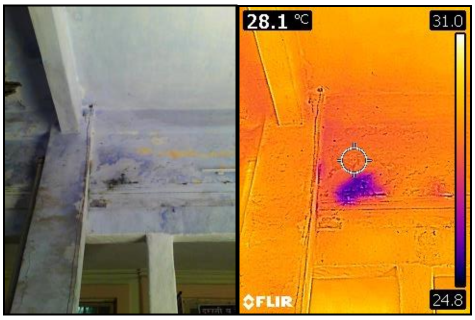

Figure 7: Possible Entry Point of Water Casing Leakage near Exam Section (First Floor)

3. Result and Discussion

Building on the IRT inspection results, targeted waterproofing solutions can be chosen for walls and slabs. Areas with minor moisture issues on walls, identified by IRT, can be effectively addressed with Elastomeric Waterproofing. Similarly, IRT data guides the selection of waterproofing for slabs. Slabs with minimal moisture concerns can be treated with flexible acrylic polymer modified cementitious coatings. By pinpointing the specific defects, IRT facilitates the selection of cost-effective solutions for each unique area within the building envelope.

3.1 Cost Analysis Acrylic Polymer Modified Cementitious Waterproofing:

This section focuses specifically on the cost comparison of acrylic polymer modified cementitious waterproofing products for slab works. The analysis is presented in the following bar graph:

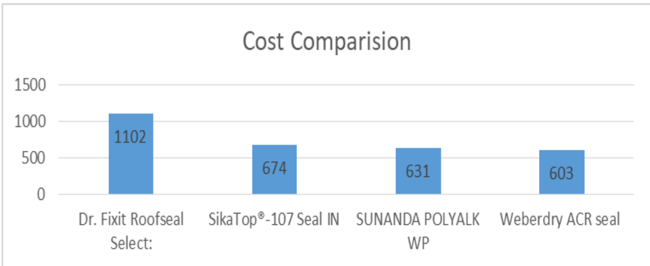

Figure 8: Bar Graph showing the comparison between the Acrylic Polymer Modified Cementitious Waterproofing

As evident from the graph, the total costs associated with different products vary. Dr. Fixit Roofseal Select exhibits the highest cost at Rs. 1102 per square meter, followed by SikaTop®-107 Seal IN (Rs. 674), SUNANDA POLYALK WP (Rs. 631), and Weberdry ACR seal (Rs. 603).

3.2 Cost Analysis Elastomeric Waterproofing for Walls:

The following bar graph illustrates the cost variations between different elastomeric waterproofing products for wall surfaces:

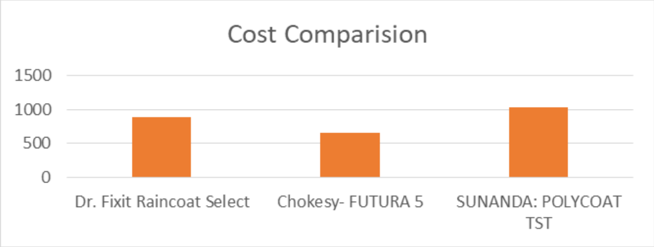

Figure 9: Bar Graph showing the comparison between the elastomeric waterproofing products for wall surface

As depicted in the graph, the total costs associated with these elastomeric products differ. Dr. Fixit Raincoat Select is priced at Rs. 887 per square meter, followed by CHOKSEY FUTURA 5 at Rs. 652, and SUNANDA POLYCOAT TST at Rs. 1031, highlighting the most expensive option in this comparison.

4. Conclusion

This study investigated the effectiveness of Infrared Thermography (IRT) for identifying moisture-related defects in older buildings. A case study of Veermata Jijabai Technological Institute in Mumbai was presented, showcasing how IRT successfully pinpointed areas with potential leaks, dampness, and moisture accumulation within the building structure.

The analysis of the IRT data played a crucial role in guiding the selection of targeted waterproofing solutions. Elastomeric coatings emerged as a cost-effective option for addressing minor moisture issues on walls, while active leaks necessitated more robust and potentially more expensive solutions like liquid-applied membranes. Similarly, for slabs with minimal moisture concerns, flexible acrylic polymer modified cementitious coatings offered a cost-effective waterproofing approach.

This case study demonstrates the valuable role of IRT as a non-destructive technique for building defect detection. By facilitating the targeted selection of appropriate waterproofing interventions, IRT can contribute to cost-effective repairs and preventive maintenance strategies, ultimately enhancing the longevity and structural integrity of aging buildings.

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References

[1] Faqih, F., & Zayed, T. (2021). Defect-based building condition assessment. Building and Environment, 191, 107575. Elsevier. https://doi.org/10.1016/j.buildenv.2020.107575
[2] Lam, E. S. (2007). Water Seepage Problems in Multi-story Buildings. In Structures Congress 2007: New Horizons and Better Practices (pp. 1-9). ASCE.
[3] Muhammad, N. Z., Keyvanfar, A., Abd. Majid, M. Z., Shafaghat, A., & Mirza, J. (2015). Waterproof performance of concrete: A critical review on implemented approaches. Construction and Building Materials, 101, 80-90.Elsevier https://doi.org/10.1016/j.conbuildmat.2015.10.048
[4] Conceição, J., Poça, B., de Brito, J., Flores-Colen, I., & Castelo, A. (2018). Data Analysis of Inspection, Diagnosis, and Rehabilitation of Flat Roofs. Journal of Performance of Constructed Facilities, 33(1), ASCE. https://doi.org/10.1061/(ASCE)CF.1943-5509.0001252
[5] Kirimtat, A., & Krejcar, O. (2018). A review of infrared thermography for the investigation of building envelopes: Advances and prospects. Energy & Buildings, 176, 390-406. Elsevier. https://doi.org/10.1016/j.enbuild.2018.07.052
[6] Senarathne, H. N. Y., Asmone, A. S., & Chew, M. Y. L. (2023). Developing a Waterproofing Decision-Making Model for High-Rise Building Projects in the Tropics. Buildings, 13, 2328. MDPI https://doi.org/10.3390/buildings13092328
[7] Milovanović, B., & Banjad Pećur, I. (2016). Review of Active IR Thermography for Detection and Characterization of Defects in Reinforced Concrete. Journal of Imaging, 2(1), 11. MDPI https://doi.org/10.3390/jimaging2020011
[8] Mydin, M. A. O., Nawi, M. N. M., & Munaaim, M. A. C. (2017). Assessment of Waterproofing Failures in Concrete Buildings and Structures. Malaysian Construction Research Journal, MCRJ Special Issue Vol. 2, No. 2, 166-179.
[9] Sriravindrarajah, R., & Tran, E. (2018). Waterproofing Practices in Australia for Building Construction. MATEC Web of Conferences, 195, 01002. https://doi.org/10.1051/matecconf/201819501002
[10] Gomes, L. C. de F., Gomes, H. C., & Reis, E. D. (2023). Surface Waterproofing Techniques: A Case Study in Nova Lima, Brazil. Eng, 4, 1871-1890.MDPI https://doi.org/10.3390/eng4030106
[11] FLIR Systems, User's manual FLIR Tools/Tools+ (2017)
[12] FLIR Systems, FLIR Thermal Imaging Guidebook for Building and Renewable Energy Applications
[13] Sika India. (n.d.). Sika India | Sika India Private Ltd. Retrieved from https://ind.sika.com/
[14] Sunanda Global. (n.d.). Waterproofing Coatings - Sunanda Global. Retrieved from https://sunandaglobal.com/waterproofing-coatings/
[15] Dr. Fixit. (n.d.). Dr. Fixit - Waterproofing Solutions for Buildings and Structures. Retrieved from https://www.drfixit.co.in/
[16] Choksey Chemicals Pvt. Ltd. (n.d.). Choksey Chemicals. Retrieved from https://www.chokseychem.com/