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Detection And Analysis of Structural Leakage Using Thermal Imaging Techniques

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***Abstract*—Structural leakage is a common problem in buildings. It can cause damage to walls, roofs, and foundations. If not detected early, leakage may lead to mold growth, structural weakness, and high repair costs. Traditional methods of detecting leakage are often time-consuming and may require breaking parts of the structure. Thermal imaging techniques provide a non-destructive and efficient way to detect hidden leakage. This paper explains the basic concept of thermal imaging, how it works, and how it can be used to detect structural leakage. The advantages, limitations, and practical applications of this method are also discussed in simple language.**

***Index Terms*—Thermal camera, inspection, Temperature, Leakage.**

I. INTRODUCTION

Structural leakage refers to the unwanted entry of water into building components such as walls, roofs, ceilings, and floors. Leakage can happen due to cracks, poor construction, aging materials, or damaged waterproofing systems.
Water leakage is dangerous because it can:
Damage building materials, Reduce the strength of structures, Cause mold and fungal growth, increase maintenance costs, Create unhealthy indoor conditions
In earlier days, leakage detection was done by visual inspection or by breaking walls to find the source. These methods are not always accurate and may damage the structure further. With modern technology, thermal imaging has become an effective method to detect hidden moisture and leakage without destroying the structure.

II. BASIC CONCEPT OF THERMAL IMAGING

Thermal imaging is a technique that detects heat (infrared radiation) emitted by objects. Every object with temperature above absolute zero emits infrared radiation. This radiation cannot be seen by human eyes, but it can be detected by a special device called a thermal camera.
A thermal camera converts infrared radiation into a visible image called a thermograph. In this image:
Warm areas appear in bright colors like red, yellow, or white.
Cool areas appear in dark colors like blue or purple.
Moisture and water affect temperature distribution in building materials. Wet areas usually have different thermal properties compared to dry areas. Because of this difference, leakage areas can be identified using thermal imaging.

III. PRINCIPLE OF LEAKAGE DETECTION USING THERMAL IMAGING

When water enters a wall or roof, it changes the thermal behavior of that area. Water has higher heat capacity than dry materials. This means wet areas heat up and cool down more slowly than dry areas.
There are two main principles used in thermal leakage detection:

3.1. Temperature Difference

Moist areas show a temperature difference compared to surrounding dry areas. For example:
During the daytime, wet areas may appear cooler because evaporation removes heat.
During nighttime, wet areas may remain warmer because they release stored heat slowly.
These temperature differences help identify leakage zones.

3.2. Evaporative Cooling

When water evaporates from a surface, it absorbs heat from that surface. This makes the area cooler. A thermal camera can easily detect these cooler spots.

IV. EQUIPMENT USED

The main equipment used for structural leakage detection is a thermal imaging camera. Some well-known manufacturers include companies like FLIR Systems, which produce advanced infrared cameras for building inspection.

4.1. Thermal Camera
A thermal camera consists of:
Infrared detector, Lens, Display screen
Image processing systemThe camera captures infrared radiation and displays it as a color image.

Figure 1 Thermal Camera Image

Figure 1. Shows BOSCH Company Thermal camera image which I use in my thesis.

4.2. Home Inspector Pro
A software where thermal data scan and give result based on temperature variation

V. METHODOLOGY FOR LEAKAGE DETECTION

The following steps are generally followed during thermal inspection:

Step 1: Preparation
Choose the right time for inspection (early morning or evening is ideal).
Ensure there is enough temperature difference between wet and dry areas.

Step 2: Scanning
Scan walls, roofs, ceilings, and floors using the thermal camera.
Move the camera slowly and steadily.
Observe color differences on the screen.

Step 3: Identifying Abnormal Areas
Look for unusual cold or hot spots.
Compare with surrounding areas.

Step 4: Verification
Use a moisture meter to confirm moisture presence.
Check visually for cracks or damaged waterproofing.

Step 5: Documentation
Capture thermal images.
Record location & temperature readings.
Prepare a simple inspection report.

VI. APPLICATIONS OF THERMAL IMAGING IN STRUCTURAL LEAKAGE

Thermal imaging is widely used in different types of buildings:

6.1. Residential Buildings
Detect roof leakage, identify damp walls Check plumbing

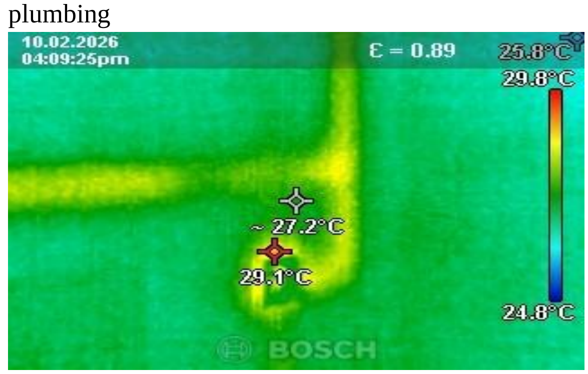

Figure 2 Conceal line Image Using Thermal Camera

Figure 3 Shows Water Tap Leakage

6.2. Commercial Buildings
Inspect large roof areas
Detect hidden moisture in ceilings
Prevent structural damage

6.3. Historical Buildings
Old buildings require careful inspection without causing damage. Thermal imaging is useful because it is non-destructive.
For example, heritage conservation projects supported by organizations like UNESCO often use non-invasive techniques such as thermal imaging to protect historical structures.

VII. ADVANTAGES OF THERMAL IMAGING TECHNIQUE

Thermal imaging offers many benefits:
Non-Destructive Method – No need to break walls or floors.
Fast Inspection – Large areas can be scanned quickly.
Accurate Detection – Identifies hidden moisture not visible to the eye.
Cost-Effective – Reduces unnecessary repair work.
Safe Method – No physical damage or risk during inspection.

VIII. LIMITATIONS OF THERMAL IMAGING

Although thermal imaging is very useful, it also has some limitations:
Environmental Conditions – Weather conditions affect results.
Requires Skilled Operator – Incorrect interpretation may lead to errors.
Initial Cost – Thermal cameras are expensive.
Surface Limitation – Deep internal leaks may not always be detected.
Therefore, thermal imaging should be combined with other inspection methods for best results.

IX. CASE STUDY EXAMPLE (SIMPLE EXPLANATION)

In a residential building, residents complained about damp patches on the ceiling. Visual inspection did not clearly show the source. A thermal inspection was conducted in the evening.
The thermal camera showed a cooler region on the ceiling compared to surrounding areas. After checking with a moisture meter, high moisture content was confirmed. Further inspection revealed a small crack in the roof waterproofing layer.
After repair, another thermal scan showed uniform temperature distribution. This confirmed that the leakage problem was solved.

X. SAFETY AND BEST PRACTICES

To get accurate results:
Avoid inspection during heavy rain.
Ensure proper calibration of the thermal camera.
Maintain proper distance while scanning.
Understand building material properties.
It is also important to follow building safety guidelines and inspection standards.

XI. FUTURE SCOPE

With improvement in technology, thermal cameras are becoming more advanced and affordable. Integration with:
Drones, Artificial intelligence, Data analysis software will make leakage detection faster and more accurate.
In the future, smart building systems may automatically detect moisture problems using thermal sensors.

XII. CONCLUSION, SUMMARY AND RESEARCH GAP

Structural leakage is a serious issue that can damage buildings and affect human health. Early detection is very important to avoid costly repairs and structural failure.
Thermal imaging techniques provide a modern, non-destructive, and efficient method for detecting hidden leakage. By identifying temperature differences caused by moisture, inspectors can locate leakage areas accurately.
Although this method has some limitations, it is highly effective when used properly and combined with other testing techniques. Therefore, thermal imaging is becoming an important tool in building inspection and maintenance.

Summary:
The studies collectively demonstrate that infrared thermography (IRT) is widely applied for detecting delamination, cracks, air leakage, moisture intrusion, roof leaks, pipeline leakage, and geotechnical fissures. Reviews by Ko Tomita & Michael Yit Lin Chew (2022), Gene F. Sirca Jr. & Hojjat Adeli (2018), and Elena Lucchi (2018) highlight influencing factors such as environmental conditions, material properties, and inspection protocols. Experimental works (e.g., Milad Mahmoodzadeh et al., 2020; Nan Ge & Guangzheng Peng, 2008) demonstrate practical leakage detection using pressure differentials and image processing. Recent studies integrate advanced filtering, drone imaging, BIM, and automation for improved detection accuracy. Overall, IRT proves to be a non-destructive, efficient diagnostic tool across infrastructure domains.

Research Gap:
Despite extensive applications, there is limited standardization of detection thresholds under varying environmental and operational conditions. Many studies focus on specific case scenarios (concrete, roofs, pipelines, slopes) with limited cross-domain validation or comparative benchmarking. Integration of IRT with AI-based automated defect quantification remains insufficiently explored in real-world large-scale infrastructure. Additionally, few studies address long-term monitoring reliability, uncertainty quantification, and performance comparison with other NDT techniques. A unified framework linking laboratory validation, field deployment, and decision-making models is still lacking.

REFERENCES

[1] K. Tomita and M. Y. L. Chew, “A review of infrared thermography for delamination detection on infrastructures and buildings,” 2022.
[2] M. Mahmoodzadeh, V. Gretka, S. Wong, T. Froese, and P. Mukhopadhyaya, “Evaluating patterns of building envelope air leakage with infrared thermography,” 2020.
[3] G. F. Sirca Jr. and H. Adeli, “Infrared thermography for detecting defects in concrete structures,” 2018.
[4] N. Ge and G. Peng, “A novel leakage detection and localization method based on infrared thermography,” 2008.
[5] E. Lucchi, “Applications of the infrared thermography in the energy audit of buildings: A review,” 2018.
[6] D. Zahradník, “Roof leak detection by thermography of as-built BIM,” 2022.
[7] C. Cheng, R. Na, and Z. Shen, “Thermographic Laplacian-pyramid filtering to enhance delamination detection in concrete structure,” 2019.
[8] J. Zhan and J. Peng, “Infrared thermography detection and thermal response analysis of loess landslide fissures,” 2025.
[9] D. Fernández Llorca, A. G. Lorente, C. Fernández, I. G. Daza, and M. A. Sotelo, “Automatic thermal leakage detection in building facades using laser and thermal images.”
[10] Jadin and Ghazali, “Systematic literature review and bibliometric analysis of pipeline monitoring and leakage detection techniques,” 2025.