Rehabilitation of Structural Members

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***Abstract*—In this project non destructive leakage detection method is adopted to detect early leaks that are not possible to detect through visual examination. The purpose of this work is to increase the durability of the building, avoid damages and minimize the energy consumption in repairing of water leaks on building. The leakage detection methods done are focused on cost effectiveness. The leak detection method uses infrared sensors to detect the water leaks in structural members. The temperature variation gives a colour change and thus the leaks are detected. The solution for water leak is prescribed. The sealing material is tested for water proofing property by impermeability test and it is applied on the existing damaged structure and the source of water leak is thus arrested. Thus the leak is sealed and the life of structural member is increased.**

Index Terms— Non destructive detection, leakage detection, sealing materials, *EFVM*

I.INTRODUCTION

There are many different household problems that can be procrastinated. However, a roof leak repair should take the highest priority on your list of home maintenance issues. Roofing leaks can develop for a variety of reasons: improper roof installation, wind or storm damage, and lack of maintenance. Most homeowners think a leaky roof is just a structural problem, but it can actually pose many more safety and even health risks. Constant water intrusion will eventually work down from the attic area to the very foundation of the house, causing plenty of costly damage on the way. Buildings often have flat roofs, which are notoriously prone to leakage. In fact, 40% of flat roofs develop serious problems within one year of installation and this leakage passes to the joints of the beam, then to column, then entire structure till foundation. Flat roofs are everywhere. Flat roofs are expensive to install ($4 to $6 per SF or more for a new roof) and replacement roofs can cost as much as $8 to $10 per square foot when disposal costs of the old roof are included.

Roofs are often ignored as part of the building maintenance plan. The roof only gets attention when it makes itself known, and the only time that happens is when it leaks. Forty-five percent (45%) of all new roofs develop serious problems within one year of installation.

The National Roofing Contractors Association estimates that the sources of the problems are due to:

1. 50% - Poor workmanship
2. 20% - Poor design
3. 15% - Poor maintenance
4. 10% - Material failures

Flat roofs are highly susceptible to leaks and water damage. Once a leak begins, it will saturate the insulation beneath it, diminishing the R-value of the ceiling's insulation and adding unneeded heating and cooling costs to a building. The leak should be detected at an early stage where the building maintenance has a great part. The major problem associated with leaks is spreading of the moisture to the entire area and so the extent of the damage caused. The leaks become detectable as discoloration of visible parts of the structural members or noticeable accumulations of water at the rooftops. Failure to detect and repair such a leak will result in loss of insulation, efficiency and deterioration of roof support materials. The losses from premature roof failure run into the billions of dollars every year. These dollars are lost, and are not available to support or extend business operations. The primary costs associated with roof failures include the following:

Excessive energy consumption due to reduced insulating value of wet insulation Losses due to water leakage into the building, resulting in problems ranging from minor nuisances to catastrophic and life-threatening situations. Leaking roofs can cause total building outages when water invades electrical switch gear and critical production equipment. Damage to the roof membrane and the structural roof components caused by trapped moisture in the roof assembly. There are numerous accounts of people being seriously injured or killed when they fall through a flat roof because the roof lost structural integrity due to water damage. Loss of salvage value of the roof insulation at the time of membrane replacement because it has become wet.

When hidden leaks go undetected, the problem threatens property values, your utility costs increase, and repairs become more costly. Small punctures, membrane splits or mechanical damage to waterproofing membrane result in wet insulation, mold, and costly interior damage. Leaks can go unnoticed and the water exit location might not correspond with the point of entry. Thus leak detection is an important criterion.

Fig.1. Image showing damages occurred in roof and wall due to water leakage

In our paper we researched and studied the working principle of two different methods to detect leakage in structural member. The two methods are Electric Field Vector Mapping (EFVM) and Infrared thermal detection. EFVM is a low-voltage test method that creates an electrical potential difference between a non-conductive membrane surface and conductive structural deck or substrate, which is earthed or grounded. Developed by ILD Germany in the early 1990s, EFVM quickly became a valuable tool for leak investigations on existing systems. An infrared inspection of your roof can detect evidence of latent moisture within your roof cavities and it can determine the potential for ice dams, plugged drains, and water retention that may cause roof damage and/or leakage which could lead to serious damage to your living area if not detected on-time. The solution for the leakage is also prescribed. The water proof material used is tested for its quality through impermeability test. The tested and verified material is used for sealing the leakage in the study area. Thus the leakage in structural member is detected and sealed.

I. STUDY ON LEAKAGE DETECTION METHODOLOGY

If there are water stains that extend across ceilings or run down walls, the cause is probably a roof leak. Tracking down the leak is the hard part. There are various conventional methodologies that are being followed in detection of roof leak. Though there exist various methods in leakage detection, selection of the suitable method is the important part. The selected method must be economical, easy in carrying out the detection, accuracy, etc.

A. EFVM

This method is useful for detecting leaks on larger roof areas, provided the membrane is an electrical insulator. This method utilizes the insulation property in combination with the fact that water is a relatively good electrical conductor. But it has serious issues of grounding in concrete.

B. Working Principle of EFVM

An electric field is created by applying water on the surface of the membrane and using the water as a conductive medium. The EFVM equipment delivers a low voltage pulsating electrical charge between the non-conductive waterproofing membrane and the conductive structural deck. A watertight membrane will isolate the potential difference, while breaches in the membrane will cause an electrical connection to occur. The inspectors read the directional flow of the current with a potentiometer to locate the point of entry with pinpoint accuracy. The EFVM technicians then complete the test by conducting a visual inspection of all wall junctions, perimeter details, and membrane penetrations. All breaches are numbered to allow for repairs by the water proofers onsite and are retested to confirm water tightness. Small electrical pulses are directed onto the membrane. The electricity searches for a ground connection. If the membrane is watertight, the electricity is isolated and does not find a ground connection. If the membrane is not watertight, the toward positive poles.

A. Small electrical pulses are directed onto the membrane. The electricity searches for a ground connection.

B. If the membrane is watertight, the electricity is isolated and does not find a ground connection.

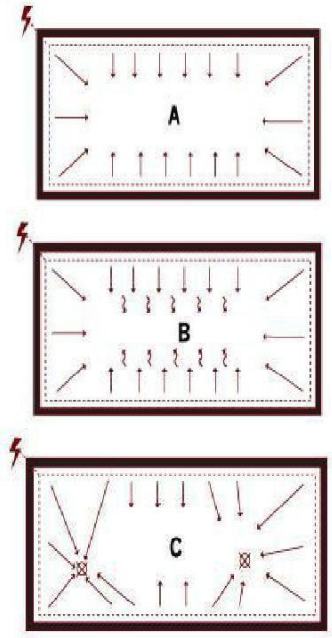

Fig. 1. PRINCIPLE OF EFVM

C. If the membrane is not watertight, the electricity makes a ground connection and is pulled toward positiveve poles.

Fig.2. EFVM testing for leakage in roof

II. IR LEAKAGE DETECTOR

This is the method in which the IR rays produced by the body is received by the IR receiver and based on the temperature increase or decrease with reference to the reference temperature, the leaks in the members can be detected. An infrared inspection of your roof can detect evidence of latent moisture within your roof cavities and it can determine the potential for ice dams, plugged drains, and water retention that may cause roof damage and/or leakage which could lead to serious damage to your living area if not detected on-time. By infrared roof evaluation you can save a bundle (in the long run) by knowing if certain roof sections need minor repair now to avoid major repair or replacement later, or to simply determine if the whole entire roof needs to be replaced in the not-so-distant future. Thermal imaging can give you the existing roof information in a nice neat visual package. This roof looks great visually, but a major moisture build-up detected utilizing infrared camera

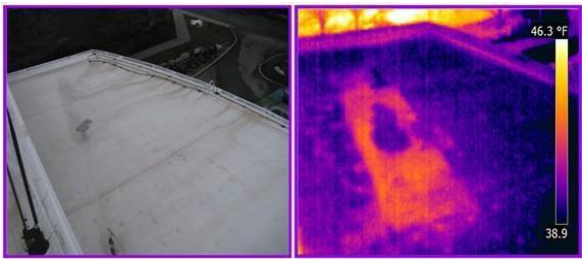

Fig.3. IR Imaging

During a home inspection, roof leaks are typically discovered by direct observations and then confirmed by utilizing moisture meters on the sheathing below. But if we detect a moist area and the roof sheathing is not visible from below (such as a finished cathedral ceiling or a ceiling below a living area) the exact area of the leak cannot be determined.
Then the floor must be protected from the falling debris and possibly requiring a scaffold system. Then once we pinpoint the problem area, minimum surface areas can be removed in order to make the necessary repairs. It is good to prefer to perform all exterior flat roof inspections in the early evening hours. In order to perform the infrared inspection correctly, we require solar heating of a hot sunny day to heat up the roof surface.. If water is actively seeping into the cavity of a roof surface, the dry roof insulation will cool much faster than the soggy wet roof insulation, making it possible for me to observe the thermal differences. Regularly scheduled infrared roof inspections will allow you to find moisture damage and water leaks that have not yet become apparent. This is the most cost-effective approach to any roof maintenance.

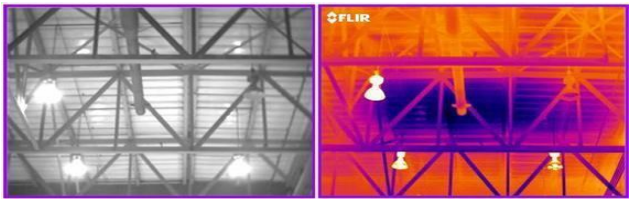

Fig.4. IR Imaging of Roof Truss

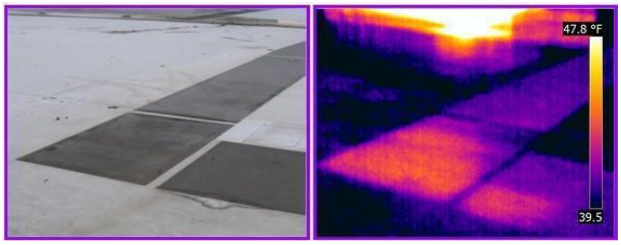

Fig.5. IR Imaging of roof leak

III. DESIGN OF THE EQUIPMENT

The equipment consists of a LED light, IR receiver, IC chip and a printed circuit assembly which consists of resisters, capacitors and transistors. All these are connected to a power supply which is the battery. The battery used is a 9V battery. The red and black wires form the positive and negative poles respectively. These wires are connected to the IR emitter and the LED light through 3pin (which includes the wire from the IR emitter that carries the information about the temperature to the IC) and 4pin (which includes wires from the IR emitter and the IC).It consists of one polarized capacitor of 33µF (i.e. the capacitor consists of positive and negative) and many non-polarized capacitors. The polarized capacitor is mainly for the steady power supply and other capacitors for noise filtering. The resisters are for the voltage drop and increase if the sensitivity of the device is adjusted.
Once the 9V battery is connected and the power button is switched on the device starts to temperature of the body to which the device is focused. So the power button is switched on and the IR receiver is focused to the body with respect to which the reference temperature is fixed by the device. The reference temperature is indicated by the green colour light from the light source. These commands are given by the IC. Now the device is moved throughout the place where the leakage has to be checked. The IR rays emitted by the body are continuously received by the IR receiver and the temperature change is constantly displayed in the LCD display. If the temperature reduces from the reference temperature, there will be an indication by means of the LED light i.e. it turns to blue colour. If the temperature of the body goes beyond the reference temperature, then the light turns to red colour. There are 3 forms of sensitivity i.e. the sensitivity of 1-degree change in temperature, 5-degree change in temperature and 10-degree change in temperature. There also a sensitivity adjustment in which there will be no LED light indication.

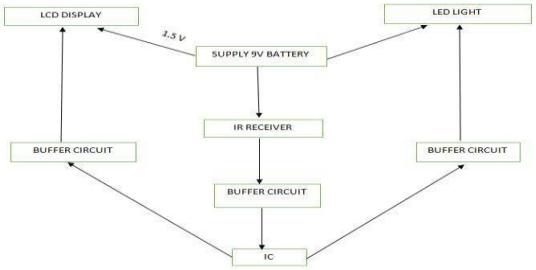

Fig. 6. Block diagram of detector equipment

A.Testing And Detection Of Leakage:

The device is focused to the place where the leakage detection has to be made. The sensitivity is adjusted. Based on the temperature and colour change the leakage can be confirmed.

Fig.7. IR testing for leakage in building

This method of test covers the procedure for determining the permeability to water of the concrete specimen, prepared by applying waterproofing compound on the top of the mould and by measuring the percolation of water through standard cylindrical specimen. A cube mould of 150X150mm is made. It is cured for 28 days..

IV. TESTING EQUIPMENT

A. Permeability Unit

The permeability unit shall consist of a specimen container ring of 100 mm diameter and 50 mm height held between a bottom plate and a water cell. The hydraulic head for testing

shall be obtained by connecting the unit to a compressor through a water pressure vessel. A pressure regulator and a pressure gauge shall be included between the compressor and water pressure vessel to indicate the test pressure. Water percolating through the specimen shall be collected in a container Figure. 5.3.3.a. and Figure. 5.3.3.b. give the details of an individual unit. The water cell shall be a 100 mm diameter brass cylinder and the top and bottom plates shall be either of brass or any other non-corroding metal. The connecting pipeline from the water cell to the water pressure vessel shall also be of non-corroding metal or of hard polythene. This requirement is necessary since the tests last over a number of days in which mild steel or allied materials will corrode and the rust formed will coat the top of the specimen and affect the permeability. The connection of units to the compressor shall be done by means of armoured heavy duty rubber hose. The water pressure vessel shall be made of galvanized steel and capable of withstanding the applied pressure with an adequate margin of safety.

B. Procedure For Test

The specimen shall be lightly wire brushed on either faces to remove Laitance, surface tines, etc. and washed. Later each of the specimen shall be fitted into the permeability ceil as shown in Figure.6. An initial pressure of about 0.05 N/mm^2 shall be applied to the water and from time to time the collecting container shall -be taken out and weighed to determine the rate of percolation. The rate of percolation will be comparatively high in the initial stages and will then become stabilized stage the pressure shall be increased again by 0.05 N/mm^2 and this procedure repeated until a final pressure of 0.2 N/mm^2 is reached. When a stable flow has been reached at this pressure, readings of the percolation shall be taken at fixed intervals of time for 8 h. The test shall be carried out at 27 ± 2°C. For each test three specimens shall be tested without the use of waterproofing compound, and three with the use of the waterproofing compound coated on top of it. If the average percolation (measured in millilitres of water) for the specimen incorporating the waterproofing compound is less than 50 percent of the average percolation in the case of the specimen without the waterproofing compound; the integral waterproofing compound under test shall be considered satisfactory.

VI. CONCLUSION

Thus the leakage areas were detected using the equipment. After which the sealant material was successfully tested using the impermeability test. The reports of the test are attached below. The detected leakage areas are then sealed using the sealant materials. The future research work is to be carried for the EFVM method. The applicability of EFVM method in Indian construction scenario is to be researched. This project is focused on the further study to be made on EFVM method and the current usability of IR equipment.

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