A Method to Detect and Locate Roof Leaks Using Conductive Tapes

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ABSTRACT

Undetected roof leaks and the subsequent deterioration are considered the greatest cause of premature roof failure. This paper describes a method whereby a leak locating grid of conductors is placed on the top of a roof membrane to detect and localize leaks to within an area defined by the grid spacing.

The method is particularly useful for roof designs that incorporate a waterproofing membrane under a green roof, wear-course or topping slab where direct inspection of the roof membrane is difficult or impossible. A top-of-membrane grid system can provide an accurate and cost effective method to monitor and maintain a wide range of covered roof types and sizes. The initial mock-up testing as well as examples of subsequent field installations is provided.

INTRODUCTION

The failure to detect, identify and correct minor roof deterioration and leakage in the earliest stages is considered the greatest cause of premature roof failure [3, 6]. This is particularly true of roofing materials applied on low-slope or flat roofs. Costly roofing problems are often the result of design deficiencies or faulty application of the roof system. Even when properly designed and applied, all roofing materials deteriorate from exposure to the weather at rates determined largely by the kind of material and the conditions of exposure. Roof designs that incorporate a waterproofing membrane under a green roof, wear-course, or topping slab greatly exacerbate the problem of locating leaks [8, 9, and 10].

Flood testing at time of construction [4] is sometimes specified to test roof membranes. The test is difficult to do and often inconclusive. The national roofing contractor associations in both Canada [5] and the US do not support this practice.

Several methods [1] have been used in attempting to locate roof leaks after they have occurred. Electric capacitance meters identify leaks using an alternating current signal to measure dielectric constant changes in the roofing material as a result of moisture below the membrane. Infrared cameras allow technicians to scan roof surfaces for temperature differentials that signify moist areas through changes in thermal conductivity or evaporation. Electric field vector mapping uses a wire loop around the perimeter of the roof surface to introduce an electric potential between the structural deck and a selected roof area which is sprayed with water. The electric field potential caused by a conductive path to any roof membrane damage is then traced to the breach using a voltmeter and a pair of probes. These methods are usually employed to assist in locating roof leaks after costly water damage has occurred.

Moisture detection sensors [7] can also be placed under the roof membrane to detect the presence of moisture; however several roof designs incorporate membranes that are directly adhered to the roof deck thereby limiting the placement and effectiveness of this type of moisture sensor application.

This paper describes a method whereby a leak locating grid of conductors is placed on top of a protected roof membrane to detect and localize leaks to within an area defined by the grid spacing. The method has particular application for inverted, covered and green roofs [2] where the membrane is fully adhered. The mock-up and testing of this application was supported by and carried out at the training facilities of the Roofing Contractors Association of British Columbia (RCABC).

METHOD

During construction, a flat two-conductor peel-and-stick grid tape is installed on top of a roof membrane to provide conductance testing between the top of the membrane and the roof deck. During a leak test, a measuring voltage is applied between the detection conductors and the roof deck. Any water path between the detection conductors and a damage site will result in a leakage current from the roof deck to the detection conductors through the insulating membrane. For potentially corrosive environments, a small cathodic protection current is applied between the tape conductors and earth ground to inhibit corrosion. In the most severe environments stainless steel conductors can be used.

The individual conductors are electrically connected at one end to a switching and measuring system whereby an isolated fault current to ground measurement can be made. In operation, a selected conductor is switched to act as the input of a current sensor, and an electric potential is applied between the selected conductor and the roof deck ground. As illustrated in Figure 1, the adjacent grid conductors that read a high leakage current to ground through the water path identify the grid section with a membrane breach.

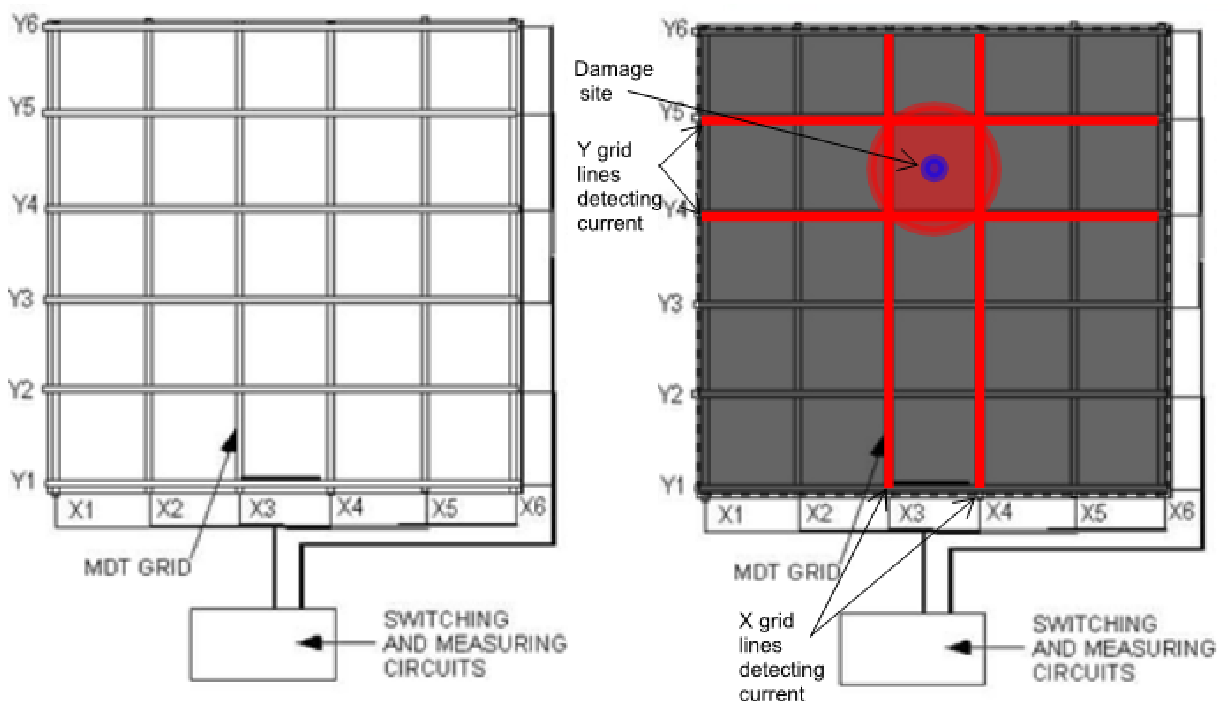

Figure 1: Basic measuring circuit and illustration of membrane breach locate.

A moisture leakage path through the roof membrane will usually cause any selected grid conductor to measure some level of leakage current. To avoid stray current that can create significant error in the membrane breach location survey, all detection conductors *not* selected for current measurement are connected to a special guard circuit. The guard circuit forms an electric shield between the selected conductor and any other current leakage sites beyond the conductors immediately adjacent to the selected conductor. This eliminates stray current errors and makes this method feasible.

EXPERIMENTAL RESULTS

Initial tests of the membrane leak locate method were carried out on the roof membrane above a parking garage under construction. The membrane is hot fluid-applied rubberized asphalt with a covering protection board. As shown in Figure 2, a four foot-by-four foot moisture detection tape grid was placed over a 16 foot square section of the roof membrane. The conductor ends were spliced to connecting cables and terminated on a switching box. A 150K ohm membrane fault level was made in the area bounded by the X3-X4 and Y1-Y2 grid locations. The area was wetted down, the measurement system energized and the individual grid tape leakage currents were measured.

As illustrated in Figure 2, the measured currents are drawn on the X and Y axis with the Z (or vertical) axis showing the current magnitudes at each grid line. Current maximums occur at the Y1 and Y2 grid lines on the Y axis and the X1 and X2 grid lines on the X axis which encloses the damage site.

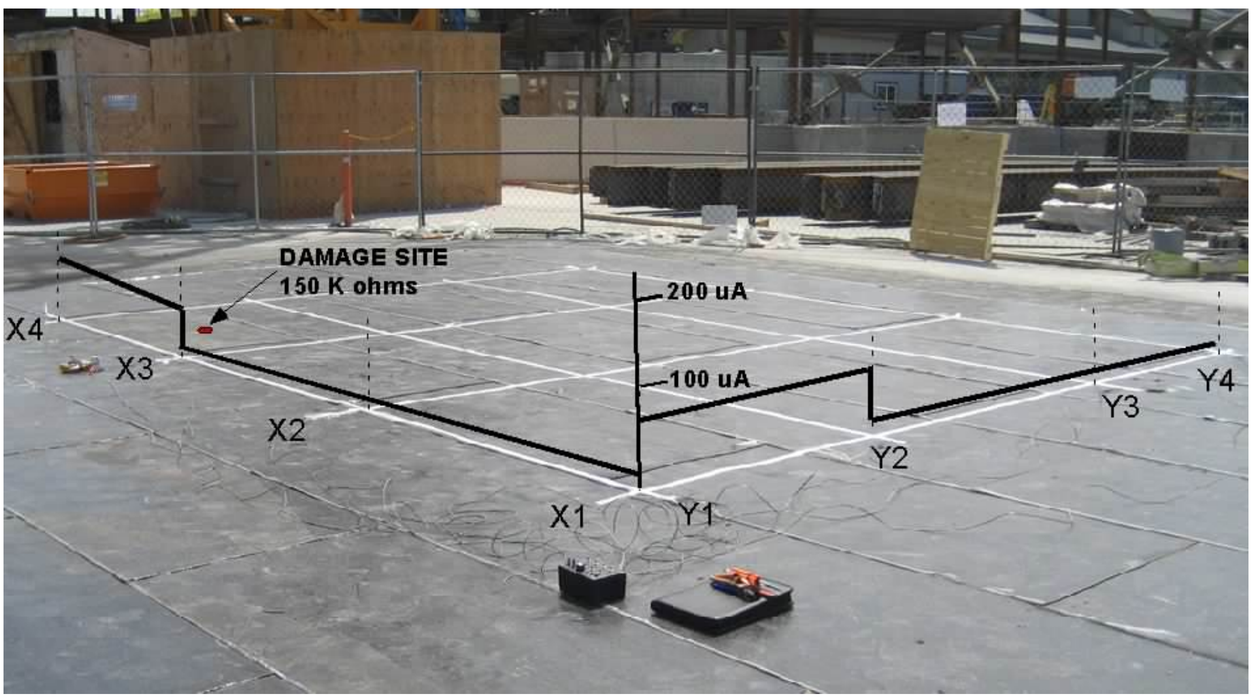

Figure 2: Leak locate test set-up on parking garage roof membrane

Mock-up tests were then carried out at RCABC using a grid of detection tape conductors installed on top of a TPO roof membrane that was laid over a concrete deck (Figure 3). Six strips of detection tape conductors were placed on top of the membrane in both X and Y directions. Connecting cables from the grid conductors were terminated on a manual switch box to allow scanning of the individual conductors for leakage current while placing all other conductors in a guard circuit arrangement. Controlled defects were then made in the membrane and the entire surface wetted. Electric conductance tests were then carried out to evaluate the effectiveness of the fault locate method.

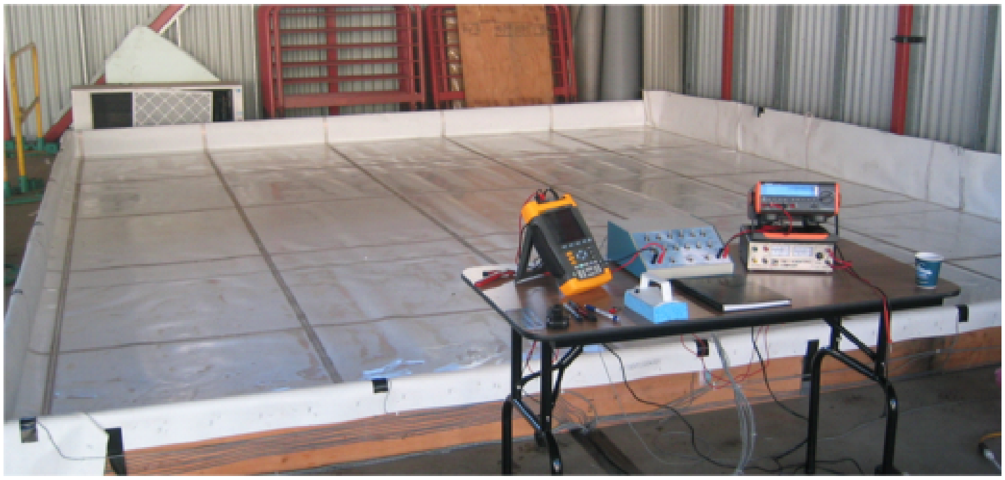

Figure 3: Photo of grid mock-up and lab test equipment used in initial evaluations

Several tests were performed in various locations, all with similar results. A typical conductance scan leak locate result is shown in Figure 3. Prior to creation of a damage site the site was wetted and tested for residual leakage. No leakage current was detected. A defect of approximately 1/8 inch in diameter was made in the area bounded by the X4-X5 and Y4-Y5 grid locations. The measurement system registered a total leakage current of 1.54 mA with an applied potential of 50V dc thereby giving a fault resistance through the membrane of 32.4 k ohms. The graphs in both X and Y directions show a distinct increase in leakage current on the X4, X5, Y4, and Y5 grid conductors, which corresponds to the fault area bounded by the grid coordinates.

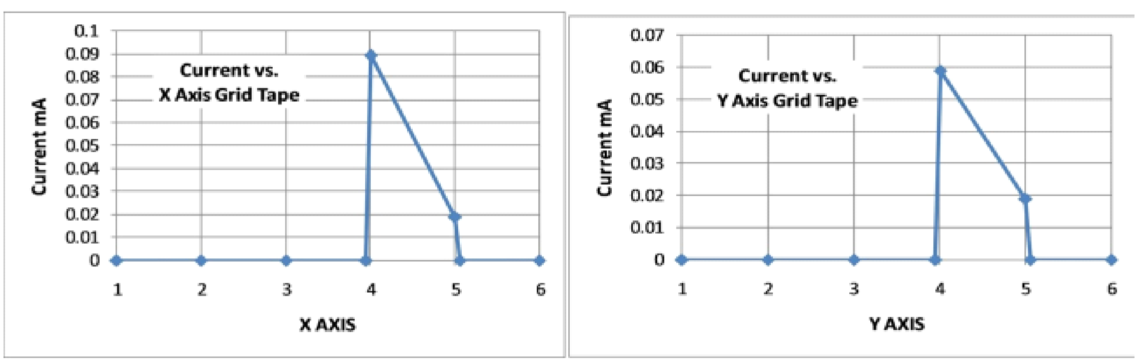

Figure 4: Graphs of measured grid-to-deck leakage currents in X and Y directions

FIELD INSTALLATIONS

Several successful installations have been carried out on over 1,500,000 square feet of waterproofing membrane on projects ranging from green roofs of several hundred square feet (Figure 5) to plaza decks and reservoir caps (Figure 6) of 270,000 square feet or more. Although not discussed in this paper, a quality control electric conductance membrane survey which uses the same measurement principal as the grid system is carried out to ensure that there are no membrane breaches prior to installation of the grid system. These systems have been deployed over the last few years with an increasing interest in application on inverted roof systems. In a few of the installations post-construction membrane leaks have been detected, located and repaired with minimum disruption of the overburden or green roof.

Figure 5. Leak locate grid installed on membrane of an intensive green roof system

Figure 6. Survey followed by leak locate grid installation on a large reservoir membrane

DISCUSSION

Leak-locate grid conductors installed on top of waterproof membranes, if monitored on a regular basis, can provide early detection and location of membrane damage. This method is particularly useful for roof designs that incorporate a fully adhered nonconductive waterproofing membrane under a green roof, wear-course or topping slab where direct inspection of the roof membrane is difficult or impossible. By performing a routine leak detection and locate procedure, membrane breaches can be quickly identified and localized to a grid size area. A top-of-membrane grid system provides an accurate and cost effective method to monitor and maintain a wide range of covered roof types and sizes.

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