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Inspection and Maintenance of Flat Roofs

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Please note

The roof constitutes a vitally important part of any building, but as methods of controlling interior environments have improved its role has become less conspicuous in separating inside from outside conditions. This is particularly true of flat roofs, which are not generally visible and escape attention. Often it is not until a water leak occurs that the need for repair is recognized. By that time extensive damage may have been done to the roof and to the building below it.

A roof has three main functions: (1) To keep water out; a water-shedding or waterproofing system must completely cover the roof to ensure that there is absolutely no point at which water can enter the building below. (2) To restrict the flow of heat; effective thermal insulation should cover the entire roof. (3) To provide a deck-structural system that will ensure a stable base for the roof covering and support both the continuous and transitory loads applied to it.

Two types of flat roofing system are used. In the conventional system, the deck may be covered with a vapour barrier to which insulation is adhered. The main waterproof membrane is placed uppermost and often protected by a gravel layer. In the protected membrane roofing system the main waterproof membrane is placed on the deck, the thermal insulation on top of it and covered by paint, gravel, paving stones, concrete or earth for protective or other reasons (**CBD 150**).

Waterproofing System

The waterproofing system in any roof comprises three interrelated elements: roof membranes, seals and flashings. By far the largest part of the roof is covered by the membrane. It must be terminated, however, wherever stacks, air ducts, access ports, skylights, drains or other building elements penetrate it, as well as at the edge of the roof or where it abuts a higher portion of the building. At such breaks, protection is provided by either a waterproof seal or a flashing. The first is a waterproof joint between the membrane and an adjacent waterproof element. The second diverts water away from an opening in the roof system but, like shingles on a sloped roof, is not sealed to the adjacent component. The two components can move in relation to one another without producing mutual stresses.

In inspection and maintenance, the uniqueness and importance of each of the three elements must be recognized. The seals and flashing cover a very small fraction of the roof area, but the majority of roof leaks occur when they fail and they must be carefully inspected so that their integrity can be maintained.

Where there are parapets round the roof or higher adjacent walls the roof system may not cover all possible points of water entry. Failure of the coping to divert water, percolation through the parapet or wall components or, in some cases, failure of roofing at a higher level allows water to flow down the interior of the wall into the roof in question. Although these areas are not properly part of the roof, they constitute a part of the topside waterproofing system. Their contribution to leakage is indistinguishable from that of the roof as far as the occupants are concerned. All will be attributed to "that leaky roof."

Local failure of insulation may lead to condensation on the lower surface of the roof deck. Failure on a large scale results in a substantial increase in heat transmission, leading to higher heating bills in winter or increased air-conditioning requirements in summer. The failure of insulation produces results much less obvious than failure of the waterproofing system. Nevertheless, the cost is high. For example, if an insulated roof were designed to have a "U" value of 0.067 Btu/hr ft^2 F, the total annual heat loss per 100 sq ft would be about 1.6M Btu (million British thermal units). If the thermal insulation were damaged, for example by water, so that the U value of the roof were increased to 0.17 Btu/hr ft^2 F, the heat loss would increase to 4.1M Btu/yr, or by 2-1/2M Btu/yr. At a cost for usable heat of $3 per M Btu this represents an increase in heating cost of about $7.50 per year for each 100 sq ft of roofing.

Roof Inspection and Maintenance Program

In setting up an inspection and maintenance program, the owner has two basic options: to have the work done under contract with a qualified inspection agency or to set up an in-house program. In the latter case personnel will have to be properly trained and given a mandate to carry out the work plus the time and funds necessary for it. Cost estimates range from about 3 to 7 cents per square foot per year. Those selected should have a knowledge of roofing, recognize the purpose of the roof and the stresses to which it is subjected, types of roof failure, test procedures and suitable remedies. It is beyond the scope of this Digest to give details of the various tests and test methods available, but general guidelines are offered for an inspection and maintenance program. Such a program should be initiated as early in the life of the building as possible.

1. If a new building is to be constructed, the person charged with inspection and maintenance should be fully familiar with the plans so that errors can he detected and corrected at the design stage.
2. Details of construction and weather conditions, including sketches and photographs of as-built details, should be documented and filed. Membrane and insulation moisture content should be tested and recorded. The temperature of the bitumen should be measured, both in the kettle and as it leaves the spreader; and its viscosity should be measured before heating and as it is placed on the roof.
3. Even if the roof has already been built, possibly years before, efforts should be made to accumulate details of construction from the building specifications, discussion with the roofer or anyone involved in the construction, and through inspection.
4. A plan of the roof should show all details, i.e., flashings, roof penetrations, materials and deck-structure. To assist in identifying such locations, the roof should be divided into a grid pattern, for example, 10-ft squares. Permanent marks might be placed on adjacent walls and parapets to facilitate the use of such a system.

These procedures should ensure that no items are missed in the inspection and will provide a permanent record that can be used to evaluate roof performance and facilitate cost analysis. Both will be valuable when decisions are to be made about major repairs and future construction.

5. During the post-construction period the floor immediately below the roof should be inspected for any evidence of roof leakage, which may be evidenced by water dripping or staining or by damage to walls well below the roof line. The under side of the deck should be inspected for cracks since they may affect the roofing above or indicate that structural strength has been impaired. Rusted steel decks may also be suspect. Condensation on the under surface of the deck or other component may be the result of high humidity in the building or faulty roof insulation.
6. Efflorescence on exterior walls is often caused by moisture originating inside the building but it may be caused by a roof leak.
7. The membrane of a conventional system is often covered by gravel. A stiff push broom can be used to remove it from suspect areas and for spot checks. In the protected membrane system the membrane is covered by insulation, usually held in place by the gravel or paving stones. If the insulation is not bonded to it, it can be lifted off, but otherwise visual inspection is virtually impossible. Forms of membrane damage include splits, blisters, ridging, slippage and various forms of membrane movement:

    In conventional roofs *splits* often follow insulation joints or originate at a point of weakness such as a corner or roof penetration or at joints in metal flashing to which the membrane is bonded. Water-damaged insulation should be replaced and the area re-roofed, preferably leaving a strip unbonded for about 6 in. on either side of the split so that further movement will not cause another one.

    Blisters are of two main types. Blueberry or pin blisters, often caused by moisture in the roof system, occur in the pour coat and may expose the felt to weather action. Additional gravel or white gravel may help or the area may need to be recoated and regravelled. Larger blisters caused by moisture and air occur between felt plies or at the membrane-insulation interface. They should be opened, dried, the membrane rebonded and reinforced with more membrane or glass fabric and mastic, and regravelled with light-coloured or white gravel.

    In protected membrane systems blisters may occur at the deck-membrane interface. They may be caused by water vapour or solvent vapour and air, or often by the sun's heating the unprotected membrane before the insulation is placed. If small, i.e., pin blisters, they can probably be ignored. If the membrane is a liquid-applied type intended to have full bonding, they should be repaired.

    Ridges sometimes occur in conventional roofs, usually over insulation joints. In time, these may crack open so that there may be no alternative to replacing the roof.

    Migration, in which progressive movement of the membrane takes place in one or both directions, can occur on conventional flat roofs. It contributes to ridging and splitting, piles membrane up against roof projections, and may tear flashings and counterflashings. It is probably caused by thermal forces and a poor bonding of the roof components to the deck. A cure at the post-construction stage is difficult and repeated patching of the affected components and attempts to reduce the thermal effects may be the only available course of action.

    Slippage of membranes on conventional, sloping roofs is evidenced by exposed bitumen on higher parts of the roof and piling up of felts on lower ones. It is produced by bitumen having too low a viscosity for the slope and is likely to occur in warm weather when roof temperatures may reach 70°C or more. Viscosity of the bitumen may increase with age enough to stabilize it. Alternatively, it may be possible by some mechanism to secure the membrane to the insulation, which is quite probably stable, or to the deck. It can also occur in protected membrane roofs if the slope and top-surface loading combine to produce a sufficiently high shear stress in the membrane, even though membrane temperatures will probably not exceed 35°C. Blocking, secured to the deck, may be required to prevent it.

    Alligatoring on conventional roof membranes is caused by shrinkage cracking of the top surface bitumen. Eventually it will expose the felts to weathering damage.

Gravel scouring by high winds or water exposes conventional roofing membranes to the weather. It frequently occurs at roof corners but may take place on any area of high local wind speed. If detected at an early stage, flood coating and regravelling will correct the problem, but if the felts are damaged and curled, replacement may be necessary. On protected membrane roofs, insulation will be exposed to the sun if the gravel cover is lost. In both types of roof, larger gravel or even paving stones may be used to prevent its recurrence.

Paint coatings deteriorate due to sun, water or mechanical damage and need periodic maintenance.

8. There are many types of insulation with different thermal and physical properties. Some foam plastic insulations and some types of membrane may be damaged by solvent coming from other components or spilled on the roof. Where the damage is caused by incompatible construction materials it should be evident soon after the roof has been built.

   Wet insulation is difficult to detect externally, but condensation on the under surface of the deck may indicate it. On the upper surface, physical damage from water may produce sponginess or settlement of the membrane.

9. Failure of seals around drains, projecting pipes or other interruptions can be produced by membrane movement or aging. As such failure is sometimes obscure and very difficult to detect, careful inspection is needed.

   Pitch pots or mastic pans are going out of favour because of their unreliability. Aging of the sealant material or movement of the penetrating component may cause failure of the seal and require renewal of the material.

   Skylights are often constructed so that the light has to be sealed to the base, and failure of this seal results in leakage into the building. This may require a special gasket or caulking, but it must be done with the proper material to be successful.

10. Through-the-wall or cap flashings provide excellent protection against the flow of water from above. Counterflashings may be set into reglets with lead wedges and sealed with a caulking compound. If the seal fails because of aging or component movement, it should be removed, the flashing secured and the sealant renewed because water moving down the wall can flow behind the counterflashing and into the roof or building. Any damage to the counterflashing that allows water to leak through must be remedied, for example, popped rivets, corrosion, bending.

    Base flashing should extend high enough to prevent backflow of water over it. Membrane migration may draw it downward or tear it, or if it has not been properly supported by the cant strip it may be punctured. If exposed because of poor design or loss of protective cover, it may be aged by the sun.

11. As water is a major cause of roof deterioration it should be drained away as quickly as possible. Inspection should ensure that drains are not plugged. If the water ponds because drains are too high, pumps can be used to remove it or, in extreme cases, new drains provided at low points.

Concluding Remarks

Flat roofs are made up of rather fragile materials subject to a host of stresses from man and weather that can result in serious problems. The program of inspection and maintenance suggested in this Digest can help to prevent roofing failures or permit repairs to be carried out at an early stage. The benefits are obvious. Replacement of a roof that has failed or requires extensive repairs is not only expensive but also highly inconvenient for those occupying the space beneath.

A variety of devices can be employed to make inspections more effective. Nuclear moisture meters, electrical resistance meters, and infrared photography can detect wet insulation; infrared thermometers can measure bitumen temperature; devices are available for checking bitumen viscosity; and chemicals that fluoresce in ultra violet light can be helpful in locating roof leaks.