5th International Conference
"Computational Mechanics and Virtual Engineering"
COMEC 2013
24- 25 October 2013, Braşov, Romania

RESEARCHES REGARDING THE CAUSES OF DEGRADATION OF ROOF SYSTEMS

E. Badiu[1], Gh. Brătucu[1]
[1] Transilvania University of Brasov, Brasov, ROMANIA, ed@cebb.net

Abstract: *Roofing system durability is the result of many parameters, such as, but not limited to: local climate, local temperature which is correctly considered a result of changes in solar radiation, wind, rain, and other environmental influences. Other factors, such as the use or physical abuse to which the system will be exposed, are requirements mandated by the specific building in question.*
Keywords: *degradation, durability, roof system*

1. INTRODUCTION

Contrary to popular opinion, the maintenance-free roof system is a misnomer. All types of roofs require a certain level of attention. In fact, from the moment of installation, the roofing system undergoes continuous deterioration. Extreme temperature fluctuations as well as snow, ice, hail and wind prevail upon the roofing surface. In short, the elements are the biggest deterrents to the roof system over its service life. Traffic on the roof and the installation of mechanical and other equipment can also cause physical damage that could lead to roofing failures.
There are a number of complex, systematic variables that cause distress in roofing systems. Rational planning for repair and replacement is necessary. It is important to note that distress of roof systems is not linear. The function of each system is defined in distinct terms, not on a continuum. If a roofing system's performance reaches a point of failure, its function and aging process change dramatically. From that point on, problems are not static, self-correlating, or reversible. A split in a roofing membrane amounts to an immediate failure to protect the building structure and its contents, as does a flashing failure, detachment due to wind forces, mechanical damage by man, or any change in the protective function of the roofing membrane [5].

2. STRUCTURAL PROBLEMS DUE TO THE DECK MOVEMENT

The type and stability of the deck are critical to the performance of the roof. Decks that are too light or that deflect contribute to excessive tensile forces upon the roof that can induce a form of cyclical fatigue stress that will eventually lead to the splitting of properly manufactured components of a roof system.
The stability of the deck can be affected by many factors, such as exposure to moisture, improper attachment of the deck to the structural supports, lack of proper joint spacing, inadequate structural support and the use of weaker or improper decks [5].

3. STRUCTURAL PROBLEMS DUE TO LACK OF VENTILATION

The most common problems caused by poor roof ventilation are due to two factors, heat and moisture [2].
The lack of proper ventilation can lead to excessive heat and moisture build-up which can adversely affect the short-term performance as well as the long term performance. Over time, excessive heat and moisture can lead to premature aging resulting in hardening of the coating asphalt, visible cracking, or fine, alligator-type cracking and the eventual splitting or cracking of the roof system components.

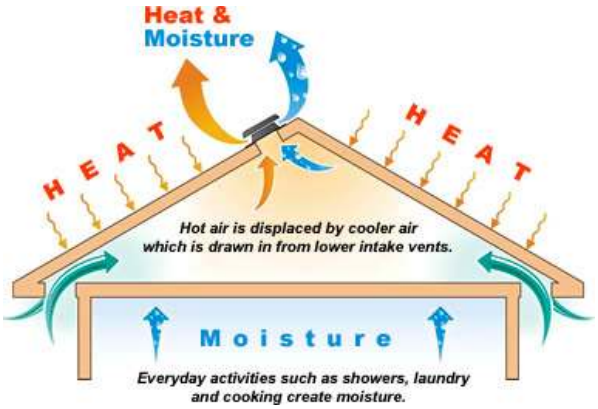

Figure 1: Problems caused by poor roof ventilation [2]

Trapped moisture and heat can lead to the following common problems:
Mold & Mildew: A humid environment is the perfect place for mold or mildew to form. Mold can ruin stored items in the attic and cause health problems.
Rust: Rust can begin to form on metal components like nails or other critical fasteners. Overtime it can rust the heads off of nails or cause plumbing or venting straps to fail.
Sagging or Spongy Decking: When excessive moisture begins seep into the roof decking it can begin to dissolve the adhesives which hold them together and cause it to warp, sag between rafters or feel spongy when walked on. This can become a danger for anyone on the roof.
Roofing System Deterioration: Not only can excessive heat and moisture ruin roof decking, it can also reduce the life of the underlayment and shingles themselves. Cracking shingles or premature loss of granules can be signs of improper roof ventilation.
Air Conditioner Replacement & Expenses: As heat builds in the attic, air conditioners must work extra hard to keep the air inside the home cool. This undue stress on the unit can reduce its life and increase energy costs.
Frost: Similar to how sitting in a cold car on a winter day will cause frost to form on the windows, the same can occur in a poorly vented attic. As the attic cools and warms with the day, frost formed inside the attic can melt and drip onto the ceiling.
Ice Dams: Ice dams can form at the edge of a roof where trapped warm air can melt snow on the roof that then freezes as it cools. As the snow continues to freeze, melt and refreeze it creates a barrier, or dam preventing water from running off the roof. Once dammed, water and ice can creep back up under the shingles and underlayment resulting in leaks.
Proper ventilation and the use of added insulation can help mitigate this melting and freezing process and eliminate ice dams [2].

4. PROBLEMS RELATED TO MANUFACTURING OF ROOFING MATERIALS

Materials used in roof construction vary in cost, design and longevity. The style of the residence or building, the desired color, and economic and ecological factors drive the selection of roofing materials. Understanding the variables of the numerous materials available for roof construction provides a clearer selection process. Whether choosing green (ecologically friendly) or choosing historically correct roofing, options for materials used in roof construction open new possibilities in the 21st Century.
Asphalt Shingles. The variety of colors and the range in price from inexpensive 3-tab (three sections per unit) shingle to a more costly durable asphalt shingle remain popular. Easily repaired, petroleum-based asphalt shingles are environmentally unfriendly since they seldom get recycled and usually end up in landfills. Hot weather scars this roofing material while moss and mildew form during its short life span of 15 to 30 years [3].
Glass fiber-reinforced asphalt shingles are the predominant roof material used to cover steep-slope roof systems in the United States and Canada. Many variations of this product are available, including three-tab and laminated shingles. Field performance of glass fiber-reinforced asphalt shingles ranges from outstanding to poor; deck conditions, wind, snow and ice, and extreme heat may shorten shingles' service life. Installation methods and fastening patterns may also affect field performance. A predominant field performance issue with glass fiber shingles is cracking. The cracking pattern on a three-tab shingle may be diagonal, vertical, horizontal or a meandering combination of the above. The mechanical and thermal loads a roof shingle experiences are many; extreme heat, large temperature swings, high winds, deck warpage and heavy rainfall are the primary agents loading a shingle. The sealant used to hold down the exposed lower portion of a shingle is vital to preventing

wind uplift. If the sealant is too hard and not ductile, it prevents expansion of the shingle during extreme heat. Sealant location is also critical; applications of sealant that are close together prevent movement. Wider distribution allows for more gage length. Selfsealing turns multiple individual shingles into a unit. This will cause stress concentration to occur during temperature swings if nonuniform attachment is present either in the sealant or nailing. The performance of glass fiber-reinforced shingles has been studied and reviewed by many authors, including Cash, Ribble, et al., Noone and Blanchard, and Terrenzio, et al. Shingle cracking has been specifically addressed by Cash, Datta, et. al., Noone and Blanchard, Phillips, et.al., and Shiao. Although temperature extremes certainly occur on roofs, Rose and Cash have demonstrated that attic ventilation alone cannot control or significantly affect shingle temperatures. These authors separately concluded from field studies and mathematic models that attic ventilation is limited in controlling shingle temperature. Cash has shown that color has more effect on shingle temperature during solar load than attic ventilation. The measurement of a shingle's ability to resist cracking or splitting has been debated heavily [1].

Metal roofs are great for any type of roof and are ideal in forested, moss prone, or heavy precipitation areas. Typically manufactured from steel, aluminum or copper, metal roofing offers homeowners the chance to choose from a multitude of colors and textures. Standing-seam steel roofing is the most popular residential metal roofing today. The term standing-seam describes the upturned edge of one metal panel that connects it to adjacent sections, creating distinctive vertical lines and a trendy historical look. But metal roofs can also be made to resemble wood shakes, clay tiles, shingles, and Victorian metal tiles. Aluminum or coated steel is formed into individual shingles or tiles, or into modular panels four feet long that mimic a row of shingles or tiles. Metal roofs are durable, fire retardant and almost maintenance-free. They are also energy efficient. Research by the Florida Solar Energy Center showed that metal absorbed 34% less heat than asphalt shingles, and homeowners switching to metal roofing reported saving up to 20% on their energy bills. Metal roofs typically have solar reflectance values between 0.50 and 0.70 but their overall efficiency is reduced by their low emittance levels, which means they trap solar radiation and don't emit the heat. They perform better when combined with a polymeric coating that helps to offset the low emittance of the metal. These coatings, which are similar to paint, can be factory-applied. It can be manufactured in long panels, or in smaller pieces that more closely resemble tiles or shingles. The sound of rain on a metal roof, which some homeowners find unacceptable, can be reduced with the use of a foam underlayment. The cost of metal roofing is initially higher than that of composition shingles, but it has a longer life cycle and can significantly lower heating and air conditioning costs, making a metal roof a very good investment. Furthermore, metal roofs are made from recycled metals (60% or higher), so they provide an environmentally friendly option. The reduced weight is of particular importance in high seismic zones where roofs can experience severe vertical and horizontal forces during an earthquake. The lightweight metal roof significantly reduces the chances of catastrophic failure or collapse of the roof structure during a massive quake. It is also fire resistant, making it suitable for use in fire-prone areas, and can result in reductions in the cost of insurance coverage. Metal roofs are virtually maintenance-free. Periodic rinsing with a hose or pressure washer can help keep the surface clean and free of corrosive residue, such as bird droppings and acid rain. Although metal roofs can be walked on, care should be taken when walking on a roof with deep shake and tile profiles, to prevent damage to the contour of the ridges [4].

5. PROBLEMS RELATED TO APPLICATION/INSTALLATION

Roofing Contractors are a resource that always should to be valued and cultivated. Where defective design work contributes more than 50% of the roofing failures, defective workmanship accounts for about 30% of the roofing failures.

Most of these errors by contractors are due to ignorance about the consequences of their actions and absence or poor supervision. Skilled workers are usually supplemented with less experienced transient labor. Combining inexperienced workers, with inadequate supervision, with the emphasis on production rather than quality almost guarantees problems.

Among the most common problems are the following (which has often overlapped with matters of design):

Slope of the roof: Low slope roofs is that category, which includes generally weatherproof membrane types of roof systems installed on slopes of 14 degrees or less. Such roofing systems have a weatherproof cover or a single membrane that prevents water from entering the host structure.

Steep roof roofing is the categories that generally includes roofing discharging storm waters and are installed on slopes greater than 14 degrees. They are usually composed of individual parts or components installed shingles. These roof systems works with gravity to shed water from a place to another, ensuring drainage of roof surfaces.

Roof Drainage: The next critical step, after the selection of the roofing system appropriate for the climate and the occupancy of the building, is to make sure that the roof drains promptly. Roof areas that promptly drain last at least twice as long as areas that don't drain promptly.

Flashing Details at eaves and valley construction: Installation of a proper eave detail is always important, but in critical areas of high rainfall or where leaves, snow, ice, or where water dams are likely to accumulate on the roof. Installing a drip edge at the edge to protect the wood from possible damage is one of the most important conditions for a leak-free roof.
Flashing Details at roof penetrations and vertical walls: Key areas of concern other than eaves and valleys are flashing details on roof penetrations and vertical walls, especially those associated with chimneys and skylights.
Proper Nailing to Structural Substrate: Whenever mechanical fasteners are in contact with the membrane, some problems can be expected. Proper nailing/fastening is key to the roof's ability to stay in place. Nails/Fasteners must be installed per the manufacturer's installation.
There are specific repetitive elements; actions that might have been taken which might probably have prevented the failure from taking place, or at least minimized the event's impact [6].

6. CONCLUSION

- Roof systems are exposed to a variety of physical and chemical distress, which range from dramatic physical actions, such as wind forces, thermal loading, or mechanical damage, to slow, insidious chemical processes like photo-oxidation.
- The most common problems caused by poor roof ventilation are due to two factors, heat and moisture. The lack of proper ventilation can lead to excessive heat and moisture build-up which can adversely affect the short-term performance as well as the long term performance.
- The style of the residence or building, the desired color, and economic and ecological factors drive the selection of roofing materials. Understanding the variables of the numerous materials available for roof construction provides a clearer selection process.
- Roofing Contractors are a resource that always should to be valued and cultivated. Where defective design work contributes more than 50% of the roofing failures, defective workmanship accounts for about 30% of the roofing failures. Most of these errors by contractors are due to ignorance about the consequences of their actions and absence or poor supervision.

REFERENCES

[1] Dupuis R.M., The Effects of Moisture and Heat on the Tear Strength of Glass Fiber-Reinforced Asphalt Shingles, available at: http://docserver.nrca.net.
[2] http://www.trinityexteriorsinc.com.
[3] http://www.ehow.com.
[4] ***Green Affordable Housing Coalition Fact Sheet, No.18, p. 1-4, December 2005.
[5] www.buildings.com.
[6] www.roofingcontractor.com.