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Ventilation of Low Slope Roof Systems in Northern Climates

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Abstract

For over generations, multi residential (flats) buildings were constructed in North American with low slope roofs. The roof design included an interstial space of 1.5 to 2 meters between the ceiling and roof deck. This 'attic' space was typically vented via static air vents. The ceilings were typically constructed of plaster with little or no insulation. The roofing was typically asphalt or coal tar built up roofing applied directly to the roof deck. This simple ceiling to roof arrangement worked for centuries. In circa 1998, with the advent of mandated reflective roofs in several large North American cities, a simply workable design was changed, often with disastrous results. So that greater floor to ceiling heights could be attained, the 1.5 to 2 meter attic was reduced to .33 m or smaller. Plaster ceilings were changed to gypsum board. Fiberglass insulation with an ineffectual vapor barrier was installed at the ceiling, and often punctured by 'can' lights which allowed air transport of warm air, often containing moisture, into the attic cavity. With no attic ventilation, insulation on the roof deck, condensation accumulation on the attic structural elements to such a degree that, in many situations, resulted in the deterioration of the wood structural elements

This paper will review the importance of proper design with 'modern day' low slope roof systems with ceilings on the roof structure, and the role that venting, vapor retarders and roof color have on the success or failure of these roof systems. The author will review historical examples of recent failures and provide designers with recommendations for appropriate low slope residential roof system design.

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Keywords: Attic; conditioned air; vapor retarder; roof color

1. Introduction

Change is often not without unintended consequences and the issue of reflective roof surfaces in the North America is no exception. In the late 1990's cities in northern climates in the United States of America (USA) started to mandate the use of reflective roofs, more for politics, feel good, pseudo environmental reasons than sustainable, resilient and

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durable ones: It did more to lower the quality of buildings than enhance them. Furthermore, code and standard changes were made with no understanding of the result and no education to the architects of America.

While the resulting unintended consequences affected both commercial and residential buildings, it was the often catastrophic result on residential buildings that went untold and left homeowners with tens of thousands of dollars of corrective work.

2. History

As the large cities of America experience industrialization and required labor, their populations exploded. To house the labor migration row houses (3 to 4 story structures, often with a garden level unit of small width with 4 or more units, often constructed with only a meter width apart, block after block) and medium size apartment blocks were constructed: Most of these structures were wood frame, masonry veneer with low slope roof structures. The interior walls and ceilings were finished in cementitious plaster which provide a durable fire resistive finish. The plaster also performed as an effective air and vapor barrier, preventing interior conditioned air from penetrating into the non-insulated walls and ceilings, where it could condense within the walls and roof on cold climatic days.

Heating costs were low and little, if any, insulation was provided in the walls and roof. Roofs were composed of built up asphalt and coal tar, both smooth and aggregate surfaced. Attic spaces often 1.5m to 2.0m in height were vented via static vents. Any conditioned air that passed to the attic was able to dissipate through these static vents. This method of construction performed without significant attic condensation and the roof systems and roof structure performed for decades.

In the mid 1990's researchers at research institutes (theoretical researchers with no architectural, engineering, roofing, construction or practical building technology experience or knowledge) conducted research into the effects of minimizing solar gain through the roof via a reflective surface. Based on their algorithmic findings and recommendations (regardless of their validity) environmental groups used the concept to promote change. In 2001 the Mayor of Chicago introduced a new energy code with reflective roofing requirements and in 2008 the Chicago mayor adopted a new City of Chicago Energy Conservation Code with prescribed reflectance values. While the new code contained numerous positive enhancements, they included a requirement for the roof surface to be reflected. In this one code adoption, roof systems, such as coal tar pitch, that had performed for centuries were no longer permitted; roofing contractors went out of business and ultimately so did some roofing material manufacturers. All based on unproved and suspect research.

Architects were thus required to change roof covers from one of known ability to one with surface reflectivity. So they removed the multi-ply built up roof covers from their designs and just replaced the roof cover with a single ply reflective membrane (TPO, PVC and modified bitumen), without consideration of how roof systems perform over time and as a system. Within a year numerous 'phantom leaks' were being reported.

3. Result of Change

New construction roof system design of multi-story residences in urban centers in northern USA changed with less robust construction. Solid wythe masonry walls changed to wood metal stud and brick veneer. Insulation of walls and roofs was now added. Interior finishes moved from plaster to gypsum based board. And air conditioning and humidifying of heated interior air arrived. Architects used new materials without empirical experience and dealt with the consequence and 'learned as they went'.

Architects leaned towards tall floor to ceiling heights 3m plus over the standard 2.43m. With code restrictive height limitations, the desire for tall floor to ceilings lead to the reduction of the attic to that of the roof deck structural framing: Where the gypsum board was placed directly on the bottom side of the structural roof framing member. This