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Wind performance evaluation of fully bonded roofing assemblies

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Abstract

Wind performance investigation is critical in the design of durable roofing assemblies. In North America, mainly two types of low slope roofs, conventional and inverted, are in practice depending on the placement of the membrane in the system. The present study focuses on the wind uplift performance of fully bonded single ply roofing assembly. Past studies focused on the wind uplift resistance evaluation of mechanically attached systems with different waterproofing membranes. However, no studies exist in the literature documenting the performance of fully bonded assembly (FBA). Recent field investigations of roof failures after major hurricanes indicated that these assemblies are equally susceptible to high wind events. The present study investigated three parameters that could influence the wind uplift performance of the FBA namely, curing time of the assembly, bonding strength between the membrane and insulation fastener plate and insulation thickness. The optimal curing time appears to be near 28 days, at which maximum adhesive bond is achieved between the membrane and the insulation facer. Use of metal fastener plates with smooth surface provides good bonding with the membrane compared to the plastic and textured plates, and thereby improves the wind uplift rating of FBA. Arranging the insulation in staggered fashion can minimize the airflow into the assembly and improve the wind uplift rating.

Keywords: Wind; Roofs; Uplift; Fasteners; Curing time; Loads; Dynamic test; Failure mode; Adhesive; Bond strength

1. Introduction

Wind performance investigation is critical in the design of durable roofing systems. Wind flow around buildings creates both negative and positive fluctuations over a roofing system. Negative pressure on exterior surface is created by the flow separation on the outside of the roof. Positive pressure, known as building internal pressure, is dependent on the location of dominant openings in the building. It is generated by the wind flow into the building and the temperature difference across the envelope. These pressures are dynamic and can be separated into static and fluctuating components. The static component is simply the mean pressure. The transient component occurs as a random process and its dominant frequencies depend on the frequency of the upstream wind and the geometry of the building. Thus the wind effect on roofing and its response is dynamic. Wind pressure distribution varies spatially over a roof and it can have high suction at the corner and perimeter, due to vortex flow and separations. Fig. 1 illustrates the pressure variation measured on a roofing assembly placed in a wind tunnel [4].

In North America, two main types of low slope roofs are in practice depending on the placement of the membrane in the assembly:

Conventional roofing assembly: The membrane is at the top of the insulation and is directly exposed to environmental elements. The conventional roofs may be either the single-ply roofing system (SPR) or a built up roofing system (BUR). Fig. 2 illustrates typical cross-section of a conventional roof assembly.

Inverted roofing assembly: It is also known as protected roofing assembly. The membrane is placed below the insulation and, thus is protected from environmental

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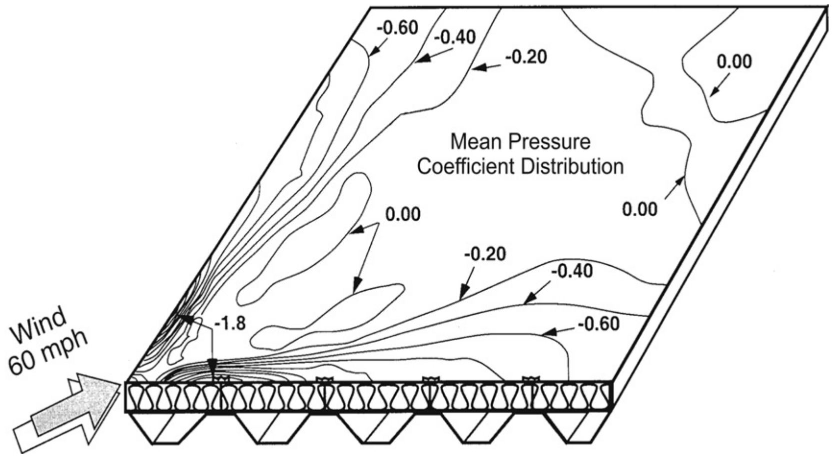

Fig. 1. Wind pressure distribution on a roof.

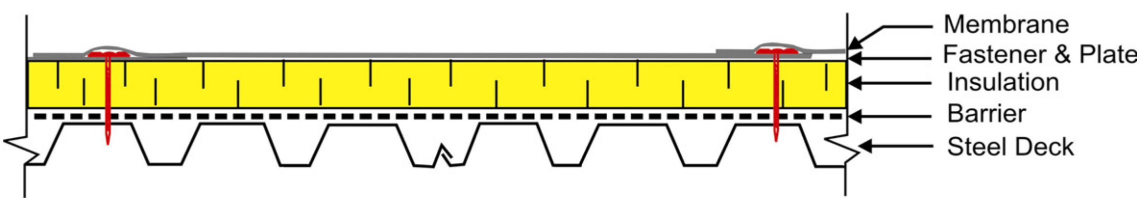

Fig. 2. Cross-section of typical conventional roofing assembly.

elements such as wind, rain, UV and temperature. Fig. 3 shows typical cross-section of an inverted roofing assembly.

Within the conventional single ply roofing assembly three types exist as follows:

Mechanically attached SPR: The membrane is attached to the structural substrate either along strips or at discrete points using fasteners. The attachments consist of the mechanical fasteners and plates or metal or polymer batten.

Fully bonded SPR: The membrane is adhered to the insulation by solvent or water-based adhesive or hot bitumen and the insulation is mechanically attached to the structural deck.

Loose laid SPR (ballasted configuration): The single-ply membrane is loose laid and held down by the weight of ballast or concrete pavers. However, at the building perimeters, the membrane is attached with the roof/wall junctions.

Figs. 4–6 show the typical cross sections of these roofing assemblies.

The present study focuses on the wind uplift performance of fully bonded single ply roofing assembly (Fig. 5). The fully bonded single-ply roofing assembly (here after abbreviated as FBA) comprises of following components: deck, barrier, insulation, fastener plate, fastener, adhesive and membrane. Wind-uplift resistance of FBA depends on several factors namely, on the application and bonding strength of the adhesive, bonding strength of the membrane with insulation and fastener plates, fastener density of the insulation board, insulation thickness, and curing time of the assembly.

Wind uplift resistance of the FBA is different from that of the mechanically attached systems (MAS). Fig. 7 illustrates the wind effects on the FBA. As seen in the figure, the entire roofing assembly acts as a composite unit though each roofing component offers a certain resistance to the wind uplift force. This can be illustrated through a force-resistance link diagram. All resistance links should remain

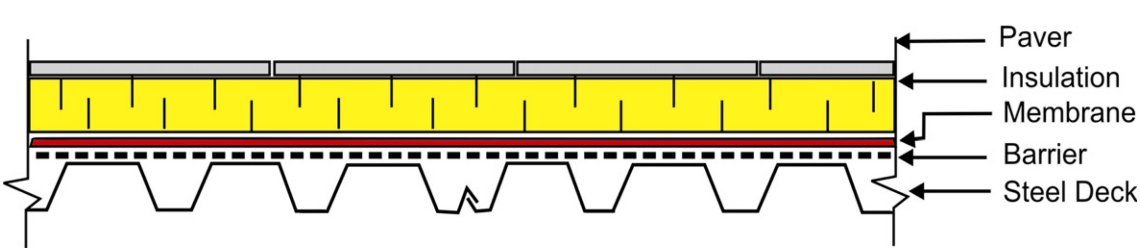

Fig. 3. Cross-section of typical inverted roofing assembly.