D7 Evaluating the Structural Failure of Wood Bowstring Trusses Under Heavy Snow Loading

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After attending this presentation, attendees will understand the factors which contributed to the cracking, structural failure, and/or partial collapse of several bowstring truss elements within a roof framing system, as well as the means and methods through which such a condition should be corrected to constitute safe occupancy of the building.

This presentation will impact the forensic science community by illustrating how uniform snow loads can negatively impact the structural integrity of roof framing members, particularly bowstring trusses, which are often subject to potential overstress under such conditions. This presentation also highlights the importance of thorough structural inspection and proper remediation methods, which can prevent buildings from experiencing complete structural failure of the roofing system.

During winter months, uniform or unbalanced roof snow loads can create stresses on the framing members of a roofing system; the weight of snow adds to the dead load of the system itself, supported by the members. This can lead to significant deflection and, over time, potential structural failure of these framing members. These conditions become more prone to occur as structural wood ages and experiences normal loading.

In this instance, the conditions experienced during the 2010/2011 winter season brought unusually cold temperatures for the Pennsylvania region, in addition to an increase in snowfall compared to preceding years. The unusual quantity of snow, in conjunction with lowered temperatures, led to the notable downward deflection and significant cracking in 6 of the 15 wood bowstring truss roof supports. These conditions were not localized to any particular roof area, rather they were widespread throughout various locations in the structure, furthering the evidence that these problems were caused by excessive snow loading across the roofing surface.

To properly remediate the damage to the trusses, and ensure the structural stability and safe occupancy of the building, computer analysis was performed using Rapid Interactive Structural Analysis for Two-Dimensional Planar Structures (RISA-2D) in order to evaluate the effects of varying live or dead loading conditions on a typical bowstring truss. These analyses found that under certain loading conditions, the bottom chords and web members of the bowstring trusses would experience twice the design stress for uniform snow loads, which could result in fracture, splitting, and possible structural failure of the trusses. Additionally, the presence of skylights within the building's roofing system were found to not only add to the dead load supported by select local trusses, but increase potential snow loading as a result of surrounding snow drift accumulation.

A structural remediation plan was detailed to properly reinforce and repair the bowstring trusses as needed, and thereby prepare the members to adequately support any snow loading during the impending winter season. It was recommended that tension reinforcements be added along the bottom chord of all members, in addition to the installation of reinforcement members along the lengths of the diagonal web members, which were determined to be insufficiently sized. The truss conditions also required the installation or replacement of bridging and diagonal bracing. Plans for adequate temporary shoring to prevent more significant damage or structural failure were also outlined, given that the initially installed temporary shoring was structurally inadequate to provide the support needed to prevent the roof framing system from experiencing failure during the upcoming winter season.

Bowstring, Failure, Snow

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