## C22 Review and Analysis of a Bowstring Wood Truss Roof Collapse During a Snow Event

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After attending this presentation, attendees will be introduced to a case where roof trusses in a renovated building collapsed at the time of an ice and snow event. The investigation into the cause of the collapse and the recommendation for remediation will be described.

____This presentation will impact the forensic science community by illustrating the necessity of a proper and reasonable structural engineer review and evaluation of existing building conditions prior to a renovation project.

____Distress often develops in individual truss members during normal load service because of the cumulative damage effects of the long-term loadings over the structure's life. Overstress issues due to inadequate allowances for accumulations of rain or drifting snow need to be reviewed and properly addressed when investigating bowstring roof trusses.

A building was affected by an ice and snow event, which occurred during a recent winter season. During the 1998/99 timeframe, a single story prior use supermarket was renovated, upgraded, and enlarged as a medical and professional office building. The construction type of the original structure consisted of brick masonry bearing walls supporting heavy timber bowstring profile wood trusses. These trusses supported conventional wood framing bearing on the truss top chords, with ceiling joists supported by the truss bottom chords.

During the course of the significant winter precipitation event, three of the trusses located towards the middle of the original building section structurally failed and began to collapse. These roof trusses, which remained in place, were found to have had long term deflections, thereby causing some of the bottom chord split ring connectors to develop significant gaps between the connectors and the bottom chord elements.

Significant additional structural loadings were placed on the existing truss system as a result of the building renovation. A new roof profile created new snow drift zones adjacent to the intersection of a new rear two-story area and the existing bowstring truss roof as well as at new valleys on either side of a new semicircular entrance. Given the uniform profile of the bowstring trusses prior to the alterations, the existing bowstring wood trusses were not designed to support the additional loading created at the new snow drift zones.

The minimum due diligence of the design team, including the architect and structural engineer of record, during the modification of the existing building profile included taking into account any new additional loads. This required the design team to complete a detailed structural review of the existing building system. This structural review was not properly performed during the 1998/99 renovation work, and as a result additional loads and snow drift profiles were added to the existing roof without any structural reinforcement or alteration.

Based on computer analysis of a typical truss loading after the renovation project, some truss members had significant overloading stresses that exceeded those allowable under the uniform snow load, unbalanced snow load, and drifted snow load cases. Based on the analysis, the trusses were found to be significantly overloaded under the maximum anticipated service loads, as defined by the 2000 edition of the International Building Code and the ASCE-7 Subcode. In addition, top chord shear stresses were found to exceed allowable stresses, and the four longest diagonal struts were found to be too slender for the compressive forces.

Based upon field observations, evaluation, and follow-up structural analysis, it was confirmed that long term wood deterioration, shrinkage, and movement of the southern bottom chord ends must have occurred, thereby permitting the southern wall to shift outward and the roof trusses to move downward under the additional loading caused by uneven snow drifting. The trusses required strengthening in place by increasing the tensile capacity of the bottom chords, the shear capacity of the top chords at panel points, and the area of the slender diagonals.

Given that a proper structural survey and inventory was not completed prior to the building alterations, significant areas of concern during the renovation design phase were neglected. These renovation design omissions led to the collapse during the winter storm events.

A proper and complete structural evaluation of the bowstring wood truss framing system prior to the structural and building renovation program would have determined the scope of the structural deficiencies, and the overstress of the bowstring truss members then could have been addressed from a structural engineering standpoint. Given that far more severe storm events occurred prior to the renovation and collapse, it is reasonable to conclude that the renovation was made without the proper and expected structural engineering review and evaluation of the existing bowstring wood trusses.

**Bowstring Wood Trusses, Snow Load, Structural Analysis**

 ** Presenting Author*