METAL WAREHOUSE ROOF COLLAPSE INVESTIGATION

Sarah Moriarty, Brandon Loiselle, Marco Gioioso, Alex Croteau
Sponsor: Simpson Gumpertz & Heger
Faculty Advisor: Dr. Ray Cook

ABSTRACT

The project embodied by this presentation is an investigation of a roof collapse on a metal warehouse. The investigation was done by University of New Hampshire students as their senior design project. The project team worked collaboratively with Simpson, Gumpertz and Heger. The warehouse being investigated was built in 1981 and is in Kingston, Massachusetts. The collapse occurred along the east side of the building abutting the new section of the warehouse.

The project began with a virtual site investigation. Because the collapse occurred in 2009 the only option for the senior project group was a virtual investigation. The virtual investigation consisted of a slideshow, along with the assistance of SG&H. Two site investigations occurred in which ideas/potential modes of collapse were highlighted. After the virtual investigations, the project team brainstormed multiple theories.

The next portion entailed analysis to prove that the suspected mode of failure did in fact cause collapse. To begin, a model was created. Using a variety of information, SG&H sourced documents, codebooks and historical data, the best representation of the structure was produced. The expected loads were then generated by using NOAA weather data for snow loads and the assumption made by the group.

ANALYISIS MODEL

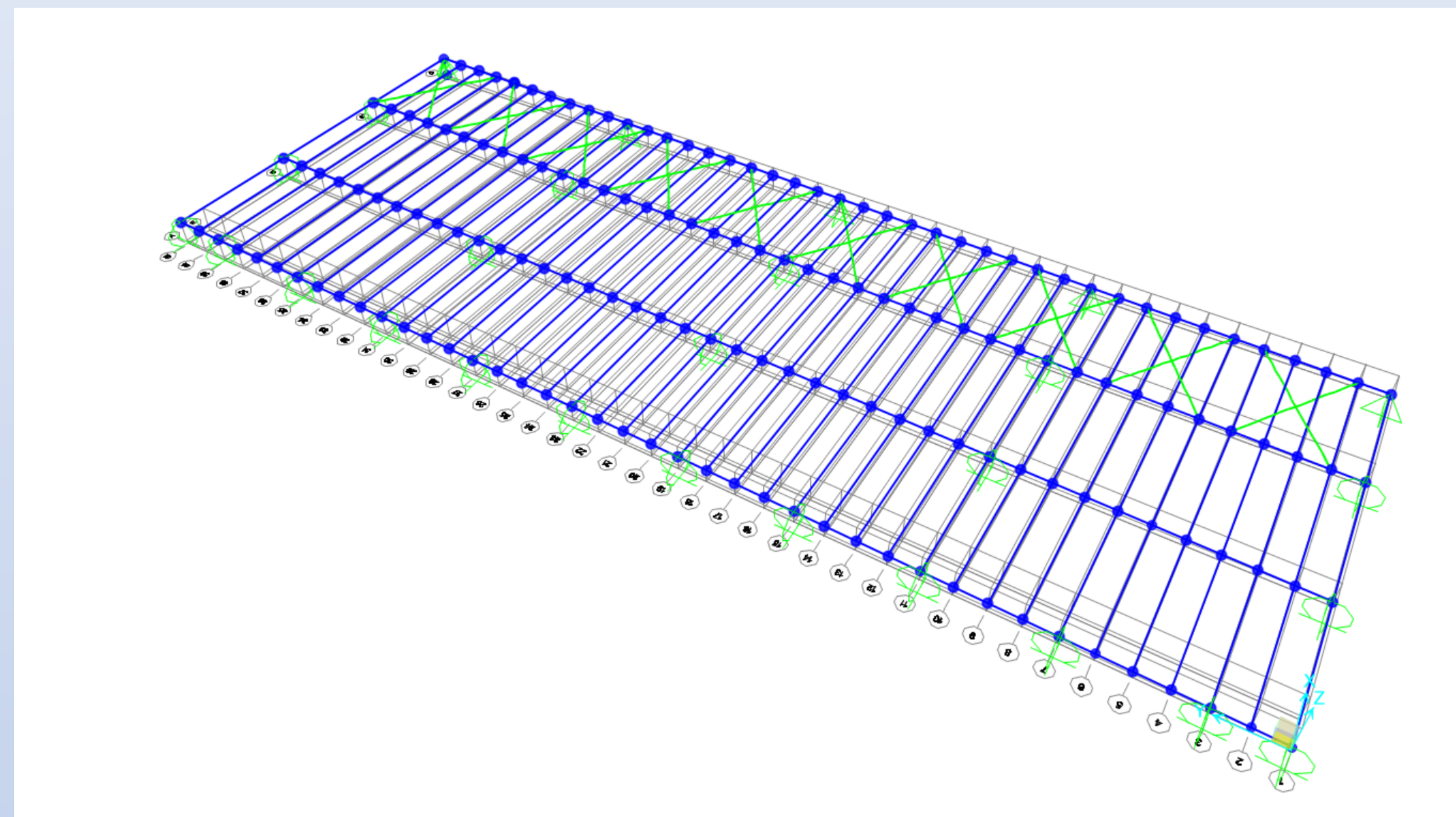

Figure 1: SAP 2000 Analytical Model

CONCLUSION

Failure Theories

Snow Load and Potential Ponding
Contractor-Engineer Discrepancies
Roof Leakage
Additional Mechanical Units on Roof
Dynamic Loading

Leading Theory

Ultimately, it was determined that there was an excess snow load shoveled onto the original, lower roof. In the investigation, it was also determined that the roof purlins were the most likely failure members. In conjunction with a potential flaw in construction, excessive snow load was hypothesized to be the reason for collapse.

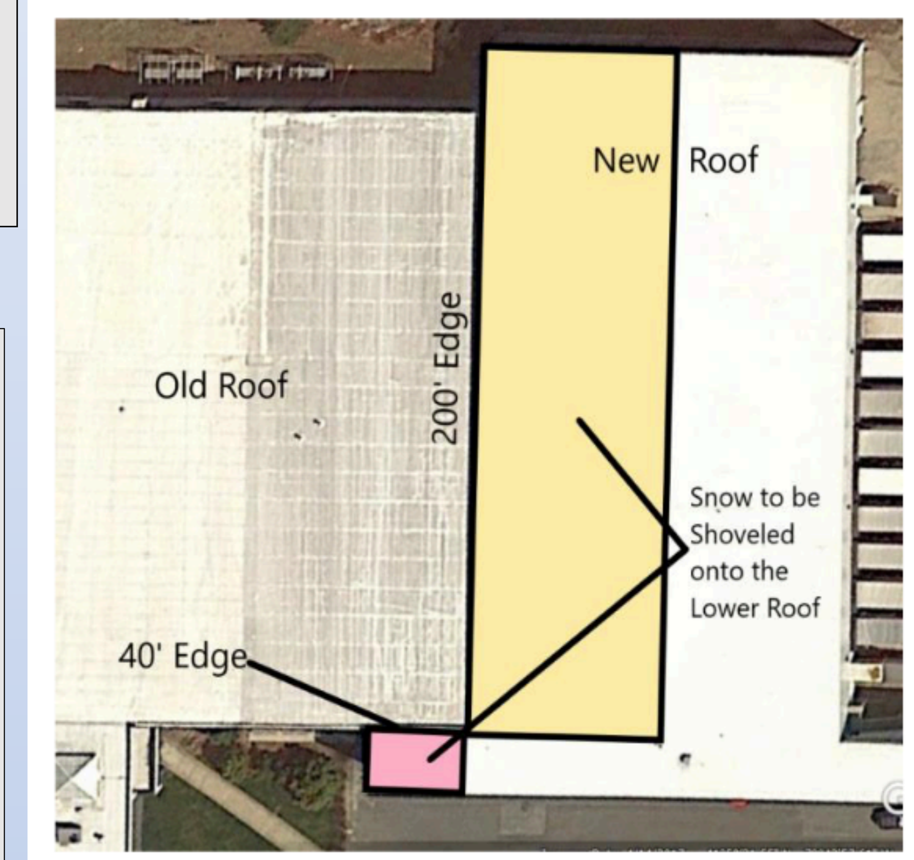

Figure 10: Sources of Additional Snow Load

IVESTIGATION SITE PHOTOS

These photos were taken by SG&H at their site visit and they were presented to the group so that we could investigate from those photos through a virtual walkthrough. Using these photos the group was able able to identify potential failure mechanisms. The group had to identify the most probable causes of collapse through closer analysis of the members and modeling.

Figure 2: South View of Collapse

Figure 3: South View of Collapse

Figure 4: Interior View of Collapse

Figure 5: North View of Collapse

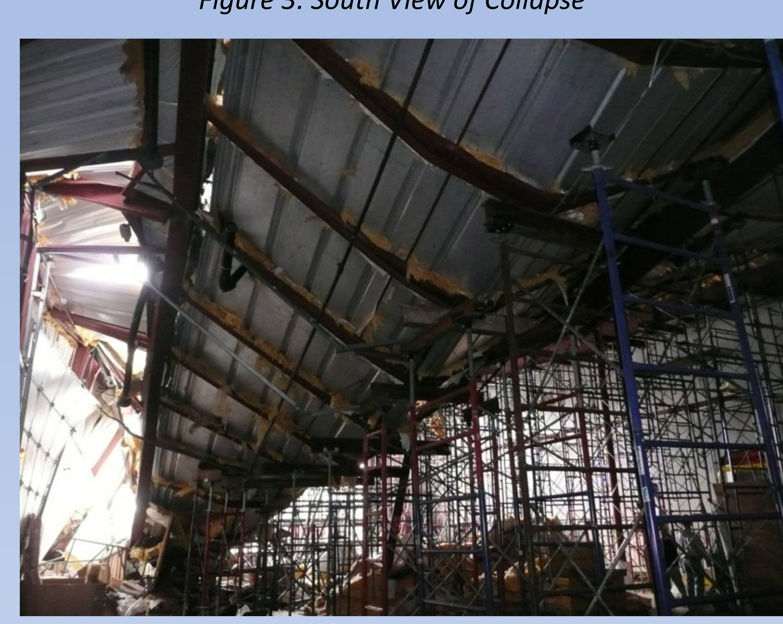

Figure 6: Interior South View of Collapse

Figure 7: Faulty Purlin Splice

LOADS

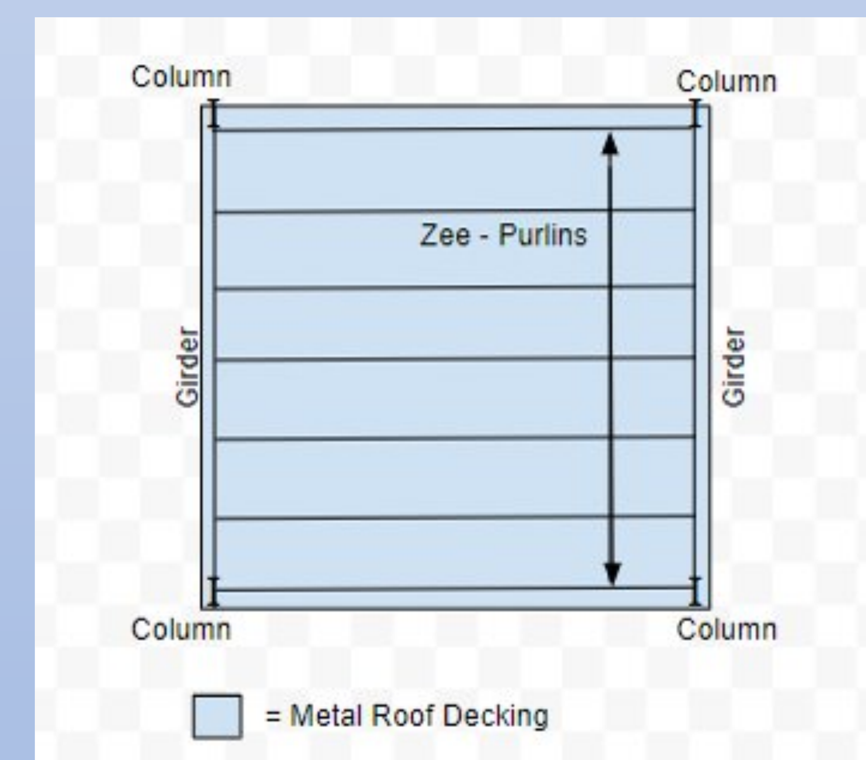

Figure 8: Load Path

Load Path
Load => Decking => Purlin => Girder => Column => Foundation => Soil

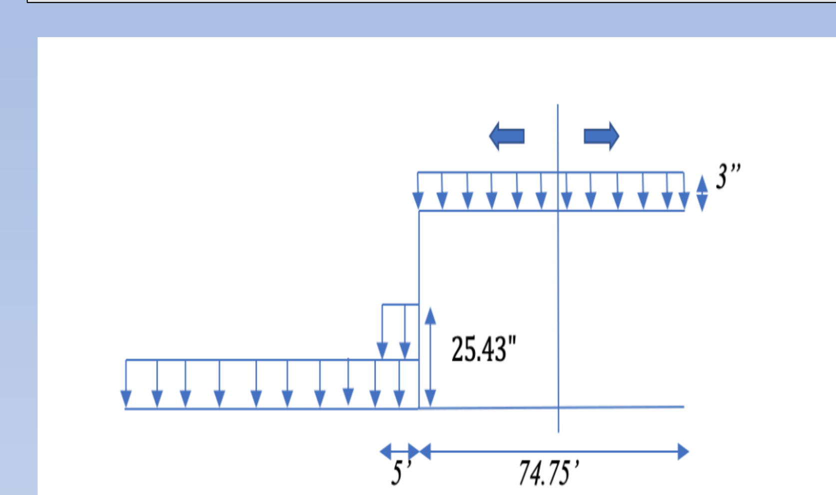

Figure 9: Distributed Snow Load

The design snow load was far lower than the snow load the roof experienced on January 7th. As shown in the table to the right, on average, three inches of snow would have a normal distributed load of 5 psf on the roof on any given section. The issue occurred when workers shoveled the snow into the condensed 5-foot section. Figure 9 shows how the volume of the section was calculated. The arrows indicate which way the snow was shoveled off. We assumed half would be shoveled onto the old roof and the other half was pushed off the other direction. If 3 inches fell onto the entire roof, about two feet of snow would end up in the 5-foot section indicated in Figure 9. This would add 42 psf to the roof when the design snow load was only 30 psf.

Load on Old Roof (psf)		
Cross Section	Normal (2 in.)	With Added Snow (17.95 in.)
Old Roof	3.34	x
New Roof	3.34	x
Section of Interest	3.34	29.92
Cross Section	Normal (3 in.)	With Added Snow (25.43 in.)
Old Roof	5	x
New Roof	5	x
Section of Interest	5	42.38
Cross Section	Normal (4 in.)	With Added Snow (47.85 in.)
Old Roof	6.6	x
New Roof	6.6	x
Section of Interest	6.6	79.75