



AMERICAN
STRUCTUREPOINT
INC.

CASE STUDY

BARN COLLAPSE; WHEN EXPERIENCE IS NOT ON YOUR SIDE

In the world of construction, reputations are often built and promoted based not on what you have done, but how long you have done it. Many construction contractors are quick to declare they have been in the construction industry for more than 20 years or have been building structures since they were in high school. While great construction experience and longevity is something of which to be proud, it is not the exclusive indicator of a great contractor or a worthy resume.

Scores of relatively small construction projects are christened every day across the country, and the industry greatly contributes to many sectors of our economy. The sheer volume of start-up construction companies is a testament to the need for these services. However, some contractors perform the required tasks “because that’s the way I have always done it” instead of knowing exactly why a task is performed or the required details of the task. This empirical form of construction works most of the time. Only when something goes wrong are we reminded the construction industry should be founded in proven engineering principles and not labor output.



The forensic structural engineers at American Structurepoint were retained to determine the cause of the collapse of an agricultural barn under construction and identify possible subrogation opportunities. The owner of the barn was using the services of a construction company owned by his longtime friend. Expectedly, the contractor quickly claimed to be well seasoned in the field with decades of experience. There is no doubt he has completed numerous successful construction projects for many happy customers.



Even though the collapse of the barn occurred during an atypical November thunderstorm, a brief view of the barn collapse debris revealed the mode of failure was not solely the result of elevated wind speeds. According to the National Weather Service, the moderately severe storm produced a maximum sustained wind speed of 36 mph and maximum wind gusts up to 45 mph from the west, as recorded approximately 10 miles southeast of the property in rural northeast Indiana. These wind speeds are common in the region and are typically achieved several times each year.



The rectangular barn was approximately 40 feet by 80 feet (long dimension in the east-west direction) and was constructed of common wood framing with wood roof trusses supported by wood stud walls that stood on short concrete foundation walls. The wood-framed barn was situated in an open field and was approximately 70 percent complete at the time of the collapse, lacking wall siding and approximately 25 percent of the metal roofing.

Based on the configuration of the collapsed debris, the walls and roof trusses fell approximately 15 feet directly to the east, appearing to be pushed over by the westerly wind. The system of roof trusses contained sufficient bracing and remained relatively undamaged as the building rotated and collapsed. The 40-foot east and west walls were generally still intact after falling over to the east. In a domino effect, the individual studs of the 80-foot-long north and south walls were laid over in the plane of the walls. In general, the wall studs were relatively undamaged as they lay on the ground following the collapse.

Viewing a collapse of this nature, the forensic engineer should always inquire about how the structure was braced. Based on information provided by the contractor and our observations while systematically sifting through the collapse debris, each wall was

braced by two wood 2x4's in the plane of the wall. The braces were orientated from the top corners down toward the base of the wall at an angle of approximately 45 degrees. The 20-foot-long wall braces were nailed to the adjacent wall studs at both ends of the brace and periodically along the length of the brace. Nail spacing of the braces was inconsistent and varied from 32 inches up to 13 feet. The braces at the west side of the long north and south walls were fractured near the middle of the braces. The fractures were consistent with the braces buckling in compression. No nails were located in the vicinity of the fracture. The braces located at the east end of the long north and south walls were not significantly damaged as the nails were pulled from the structural members, which was consistent with the braces being loaded in tension, as expected.



While the completed structure would have likely performed better during the moderate wind event, it is the construction contractor's responsibility to ensure a building is structurally stable throughout the construction process. However, our forensic study revealed the 2x4 in-plane wall bracing with periodic nailing did not have the structural capacity to resist the horizontal loads from the moderate wind speeds that were sustained. This mode of failure is substantiated by the observation of bracing that was buckled and fractured in compression at the west end of the building and the tensile failure of the bracing at the east end of the building.

In this type of construction, horizontal loads such as wind forces are solely resisted by the critical in-plane wall bracing of the walls parallel to the direction of the wind. The in-plane braces maintain the rectangular shape of the wall and transmit the applied

horizontal forces to the foundation. In the case of westerly winds being resisted by the braces in the north and south walls, compressive forces develop in the bracing at the west end of the walls and tensile forces develop in the bracing at the east end of the walls. The resistance capacity of the braces is dependent on many factors, including the material, width, depth, and length of the brace element, as well as how and where the brace is nailed to the adjacent wall studs. The frequency of nailing of the braces is crucial to the resistance capacity of long and relatively flimsy 2x4 braces. In effect, the wall studs brace the braces. Nailing a compression brace to each adjacent wall stud ensures a high compressive stress can be resisted by the brace before it fails. Not nailing



a compression brace to each adjacent wall stud significantly reduces its capacity to the point where the long and flimsy brace easily kicks out of plane and buckles in compression as was observed. When the compression braces suddenly fail, the entire wind load must be resisted by the tension braces. In this case, the entire wind load that was transferred to the tension braces resulted in failure of the connection between the tension braces and the wall studs.

In summary, the American Structurepoint forensic structural engineers determined the collapse of the barn was primarily due to the contractor's inadequate bracing of the structure during construction. Specifically, the combination of the size and nailing pattern of the in-plane braces of the north and south walls did not provide sufficient resistance to horizontal movement of the structure during construction. It is the forensic structural engineers' opinion that proper construction bracing of the structure would have been able to resist the moderate and expected wind speeds that were recorded near the property. The contractor placed the wall braces in the correct location, which is likely how he has done throughout his career. However, without fully understanding how the braces work and what details are needed to get the performance he expected, the contractor made a critical omission that significantly contributed to the collapse of the agricultural barn.

Since 1966, clients in the property and liability claims industry have trusted American Structurepoint as their single source for forensic engineering investigations. For more information, please contact Darwin Acord at 765.438.3174, or dacord@structurepoint.com. You can also visit our website to learn more at www.structurepoint.com/investigative.

