September 1, 2015 Collapse of a Steel Building during Erection at Bryant University, Smithfield, RI

U.S. Department of Labor
Occupational Safety and Health Administration
Directorate of Construction

February 2016
Report

September 1, 2015 Collapse of a Steel Building during Erection at Bryant University, Smithfield, RI

February 2016

Report prepared by
Gopal Menon, P.E.
Office of Engineering Services
Directorate of Construction

Contributions to this report by
Thomas R. Braile
Compliance Safety & Health Officer
Providence Area Office
<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>5</td>
</tr>
<tr>
<td>The Project</td>
<td>5</td>
</tr>
<tr>
<td>The Incident</td>
<td>8</td>
</tr>
<tr>
<td>Discussion</td>
<td>10</td>
</tr>
<tr>
<td>Conclusion</td>
<td>16</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 1  Building Plan
Figure 2  End wall and section at gridline 2
Figure 3  Manufacturer’s recommendation for first bay framing and subsequent erection
Figure 4  After the collapse
Figure 5  After the collapse
Figure 6  Extract from Erection Guide drawings (R3 and R4 of Construction details)
Figure 7  From Contractor’s Erection Plan
Figure 8  Locations of Concrete Dead-men and disconnected Cables
Figure 9  Before collapse
Figure 10  Before collapse
Figure 11  Frame at gridline 3 and dead-men on the south side
Figure 12  Erection Guide listing the erection sequence
Figure 13  Erection Guide listing the erection sequence
Background

On September 1, 2015 at about 8:15 a.m. an athletic building under construction at Bryant University collapsed, injuring six construction workers. The crumpled steel was scattered across the site. The proposed indoor practice facility, a pre-engineered metal frame building, was 430 ft. x 192 ft. The building was 430 feet long consisting of multiple bays, with a bay length of approximately 25 feet each. Approximately 9 bays were already erected to varying degrees of completion and at the time of the incident, the crew was in the process of erecting and plumbing the frames.

The Occupational Safety and Health Administration’s (OSHA) Region I Administrator asked the Directorate of Construction (DOC) in OSHA’s National Office in Washington, D.C., to provide technical assistance in a causal determination, and to provide engineering assistance to the Providence Area Office in its investigation. DOC reviewed the documents submitted by the Area Office, but did not visit the site. The following is our report based on a review of the photographs and the documents provided by the Area Office.

The Project

The pre-engineered metal building was 430 feet long, 192 feet wide with an eve height of 32 feet. The frames had a span of 192 feet and the spacing between the frames varied from 20 feet to 25 feet, see Fig. 1 and 2. The location of the project site is Bryant University, 1150 Dougles Turnpike, Smithfield, RI 02917. The general contractor (GC) was A/Z Corporation of North Stonington, CT, and the subcontractor retained by the general contractor to erect the steel was Barnes Buildings and Management Group Inc. (Barnes), 96 Prospect Hill Drive, North Weymouth, MA 02191. The contract called for Barnes to erect steel framework, siding and a roof for the building, among other things. Barnes, the contractor, was using a custom-engineered metal building system manufactured by Metallic Building Company (Metallic), of Houston, TX. Metallic provided erection drawings to the GC.
September 1, 2015 Collapse of a Steel Building during Erection at Bryant University, Smithfield, RI

Fig. 1 – Building Plan
Fig. 2 – End wall and section at gridline 2
The Incident
Barnes started erecting the frames from the north side moving towards the south. As per the construction document and industry practice, the builder/erector was responsible for the stability and integrity of the structure during erection. Metallic was responsible for the structural adequacy and integrity of the building after the erection was completed. The erection sequence and procedures were provided in the drawing by Metallic as a guide and recommendation; however, the erector was responsible for the final selection of methods and means. The details provided in the drawing were the manufacturer’s recommended procedures. Metallic recommended that initially one “braced bay” be completed 100% say between column lines 3 and 4, with all permanent connections, and placement of girts and purlins. All subsequent frames would then be tied to this completed “framed bay” to provide lateral stability to the subsequent frames during erection, see Fig. 3 (from erection guide drawing R3), which recommends that the erection should begin with a “braced bay” and one bay should be completed before erecting the subsequent frames.

Barnes however, decided to provide three braces on the north side and three braces on the south side attached to concrete dead-men and the roof girders of the first frame. This method could provide additional flexibility to the erector to plumb and align the frames. The cables would resist tension due to the application of lateral load in either direction.

Approximately nine frames were already erected when the incident happened. With the first frame braced by the cables, workers were in the process of erecting and plumbing the subsequent frames. Nine workers were exposed and six of them were injured with the collapse of the building. All nine workers exposed were working on the roof or inside the building. Four Metal Built employees working directly for Barnes were standing on the top of the frame installing the purlins. Two Barnes employees were working from boom lifts, while two others were working on the ground underneath the frame, and the foreman was operating a construction forklift, called Lull, when the building collapsed to the north (see Figs. 4 and 5). All four workers standing on top of the cross member frame and the two employees working from the telescoping boom lift basket had to be transported to the hospital for treatment and/or evaluation. Three other workers were able to walk away from the collapsed building with only minor injuries.
September 1, 2015 Collapse of a Steel Building during Erection at Bryant University, Smithfield, RI

Fig. 3 – Manufacturer’s recommendation for first bay framing and subsequent erection
(From drawing R3, see Appendix)
Discussion

The manufacturer’s erection plan included written instructions explaining the recommended steps for erecting the structure. Also, the drawing states that the contractor is responsible for the erection.

Metallic erection drawing (E1- Cover Sheet) states:

Building Erection - The Builder/Contractor is responsible for all erection of the steel and associated work in compliance with the Metal Building Manufacturers drawings. Temporary supports, such as temporary guys, braces, false work or other elements required for erection will be determined, furnished and installed by the erector (AISC Code of Standard Practice Sept 86 Section 7.9.1) (Mar 05 Section 7.10.3) (CSA/SS16-09 Section 29)

The Erection Guide drawing from Metallic states that the contractor is responsible for temporary bracing. These drawings also provide the recommended sequence of erection. Selected text from Erection Guide drawings R3 and R4 are listed in Fig. 6. First bay framing details from drawing R3 is already shown in Fig. 3, above.
The contractor chose not to follow the manufacturer’s recommended procedures for first constructing a single “framed bay” with all permanent connections before erecting additional framework. The contractor did not install the permanent cross-bracing as recommended by the manufacturer. The contractor did not provide any calculations to support the adequacy of the temporary bracing.

As discussed earlier, the contractor, Barnes, used a series of concrete dead-men and temporary support cables to the first frame erected, to maintain the stability of the structure during...
construction. The contractor’s steel erection plan called for temporary cable bracing to the first mainframe at three equally spaced locations, attached to (2) 2500# dead-men on either side of the rafter, for a total of twelve dead-men, see Fig. 7. However, in reality, the contractor provided temporary cables at three locations on the rafter, and the cable was attached to one dead-man at six locations (three each on north side and south side of the rafter). In addition, the contractor placed 2500# dead-man in front of these dead-men at five locations, thus 11 dead-men were used, with the cable connected to the rear dead-man, see Fig. 8.

![Fig. 7 – From Contractor’s Erection Plan](image)

Barnes assigned a foreman to this project, who assigned all duties to employees as they worked on or around the building being constructed. The foreman had a copy of the manufacturer’s erection plan at the site and he was aware of the requirement for temporary bracings. Barnes was a certified erector of Metallic Buildings, and was familiar with Metallic erection guidance for these types of buildings. Barnes, however, decided to adopt a different bracing technique.

Figs. 8 to 11 show the bracing and concrete dead-men details provided by the contractor. The number and location of concrete dead-men at the site is shown in Fig. 8. The frame at gridline 3 was braced to the 2,500 pound dead-men on the north and south side. At the gridline G, on the north side, a single dead-man weighing 3,400 pounds was used, see Fig. 8.
On the day of the incident for some reason, the cable connected to the south-side dead-men at gridline C and G were disconnected, leaving only one cable attached to the dead-men only at gridline E, see Figs. 8 and 11.

Fig. 8 – Shows locations of Concrete Dead-men and disconnected Cables
On the north side, all three cables remained connected to the dead-men. The contractor did not reconnect the cables on the south side before resuming the erection of the frames. The crews began to plumb the frames and in the process, as is usual in steel erection, applied force on the structure. In the process, the structure collapsed to the ground towards the north. The cable at the south side at grid line E pulled the dead-men towards the north, about 20 feet, before getting hung up in a piece of equipment that was in front of it. The north side support cables were still attached to the frame and to the dead-men. The cables attached to the dead-men remained intact. The cables were not solid members like pipes or tubes and, therefore, could only resist tension and not compression. If the applied forces are in the northern direction, the only cable providing any stability was the south cable on column line E; also the dead-men were not dug into the dirt but rather they were placed directly on the dirt. Therefore, the passive soil pressure of the concrete dead-men could not be depended upon to resist the lateral load. Therefore, only the frictional force could be considered. If the coefficient of friction between concrete and soil is considered as 0.3, the block could only resist $0.3 \times 5000 = 1,500$ pounds, if the cables were along the horizontal axis of the dead-men. However, due to the sloping cable from the top of the frame down to the concrete dead-men and assuming an angle of 45 degrees (see Figs. 8 and 11), it could only resist approximately 1,150 pounds. If all three cables were left intact, it would have taken a force of approximately 3,450 pounds.
With the building’s collapse, some of the anchor bolts snapped above the concrete, some snapped from inside the concrete, and other anchor bolts stayed intact and snapped from the steel base plate. The anchor bolts did not pull through.

To determine the mechanical properties of the structural steel members and anchor bolts, tensile test specimens were machined from selected plates and anchor bolts. The specimens were subjected to tensile testing in accordance with ASTM Specification A-370 by a third party. The results of the tensile testing indicated that the mechanical properties of the anchor bolts and structural plates used in the fabrication and installation of the columns were typical of the specified and/or anticipated material grades.
Conclusion

1. The contractor was responsible for ensuring the stability of the structure during erection. The contractor failed to maintain the stability of the building during erection due to inadequate bracings. Thus, the contractor violated OSHA standard 29 CFR 1926.754(a) that states “Structural stability shall be maintained at all times during the erection process.”

2. The contractor neither followed the manufacturer’s recommended erection procedure nor provided adequate bracing during erection. The contractor’s erection plan was flawed. There were no calculations to support the erection plan developed by the contractor.

3. The contractor used a series of concrete dead-men and temporary support cables to maintain the stability of the structure during construction. Unfortunately, the contractor disconnected the temporary support cables and continued with the erection, thereby rendering the structure unstable. Thus the contractor was negligent during the erection.
APPENDIX

(Erection Guide drawings R3 and R4 from manufacturer drawing)
Fig. 13 – Erection Guide listing the erection sequence