

April 15, 2016 Double Tee Collapse at the Miami-Dade College West Campus Parking Garage, Doral, FL

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Report

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Background

In 2012, the parking garage under construction at the Miami-Dade College (MDC) in Doral, Florida, partially collapsed killing four workers. MDC decided to demolish the remaining standing structure of the parking garage, and build a new structure. On April 15, 2016, during the construction of the replacement garage, an incident occurred during the placement of precast double tees (double tee #392 and #393) on the fourth level of the new parking garage. A plan view of the fourth level is shown in Figure 1 which indicates the location of the collapse. Miami-Dade Fire Rescue immediately responded and the two workers involved in the incident were treated on site before being transported to the hospital. Compliance officers from the Occupational Safety and Health Administration's Fort Lauderdale Area Office visited the site to inspect the damage and gather relevant information. The collapsed precast double tee beams are shown in Figure 2.

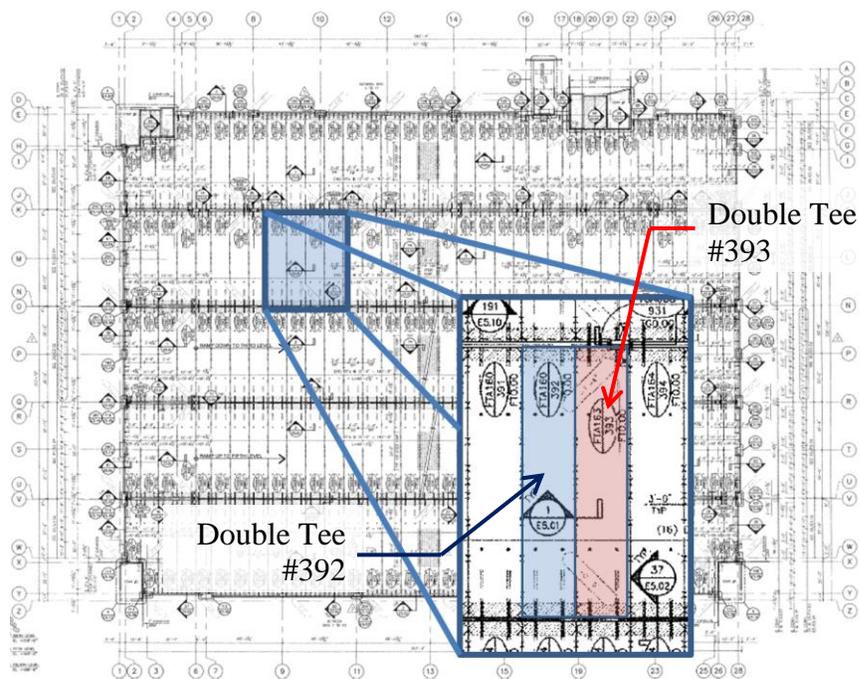


Figure 1. Plan View of Miami-Dade College West Campus Parking Garage



Figure 2. Collapsed Precast Double Tee Beams

The Regional Administrator, Region IV asked the Directorate of Construction (DOC) in the OSHA National Office to provide engineering assistance to determine the cause of the collapse. A structural engineer from DOC visited the site to examine the collapsed precast double tee beams and to obtain relevant information pertaining to the construction of the parking garage. Interviews were held with construction personnel and employees.

The following were the key participants in the project:

1. Owner: Miami-Dade College (MDC) of Doral, FL
2. Design/Build Contractor: Haskell Architects and Engineers (Haskell) of Jacksonville, FL
3. Inspections: NOVA Engineering and Environmental Consultants (NOVA)
4. Structural Engineer of Record: DDA Engineers P.A. (DDA) of Miami, FL
5. Construction Quality Assurance: NV5 of Miami Lakes, FL
6. Precast Fabricator: Metromont of Greenville, SC
7. Erectors: Pre-Con Construction, Inc. (Pre-Con) of Tampa, FL

8. Structural Engineer of Precast Members: Blue Ridge Design, Inc. (BRD) of
Winchester, VA

The Project

In 2016, construction began for a new parking garage for 2,026 vehicles. MDC awarded a design-build contract to Haskell. Haskell prepared the overall plan for the garage and retained DDA as its structural engineer. Haskell contracted with Metromont to design and fabricate individual precast pieces, transport them to the site, and to erect them.

Metromont has several manufacturing facilities to produce precast concrete members. Metromont retained BRD to perform structural design of the individual precast elements, and to prepare shop drawings for the purposes of fabrication. All documents and drawings were sent to Metromont, DDA, and Haskell for their review.

Metromont contracted with Pre-Con to erect the precast concrete garage. MDC retained NOVA to perform a threshold inspection as per Florida regulations as an independent inspection and testing laboratory. Haskell retained NV5 to conduct compaction, concrete, grouting and welding tests. Figure 3 is an organization chart for the project.

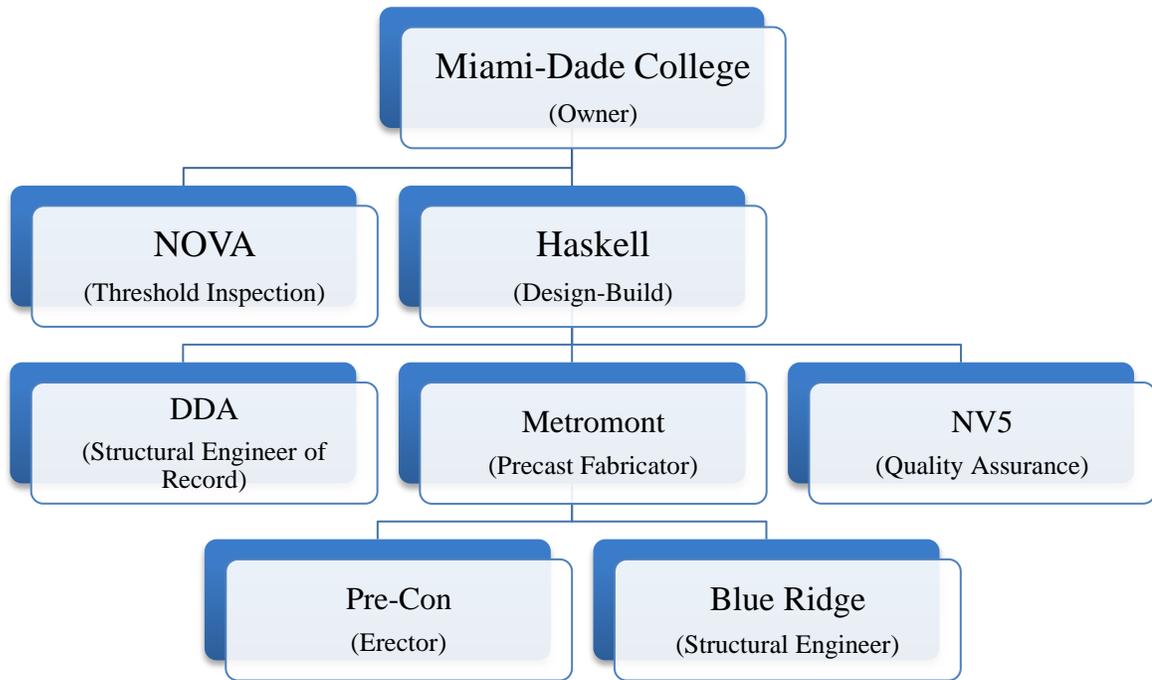


Figure 3. Project Organization Chart

Analysis and Discussion

At the onset of the project, discussions were held between Metomont, Pre-Con, and Haskell regarding the erection sequence for the parking garage. It was decided that initially only two bays, K-N and N-Q, would be erected between the column lines 6 through 14. This area is shown in Figure 4. Accordingly, wall panels were erected along column lines Q and N after which precast double tees were placed at the second through the sixth level. The double tees rested on wall panels at both the north and south ends. At a few locations, it was discovered that the tee flanges were misaligned due to fabrication and erection tolerances; therefore, the flanges of some tee members were not level with the adjacent tee flange and proper welds between the tee flanges could not be made. Although it is a common practice to shim beams to facilitate adjustment, fabrication issues required an unusually high number of adjustments. Shims were placed under the stems of the affected double tees. The shims were placed by jacking up the stems of the tees from the lower level.

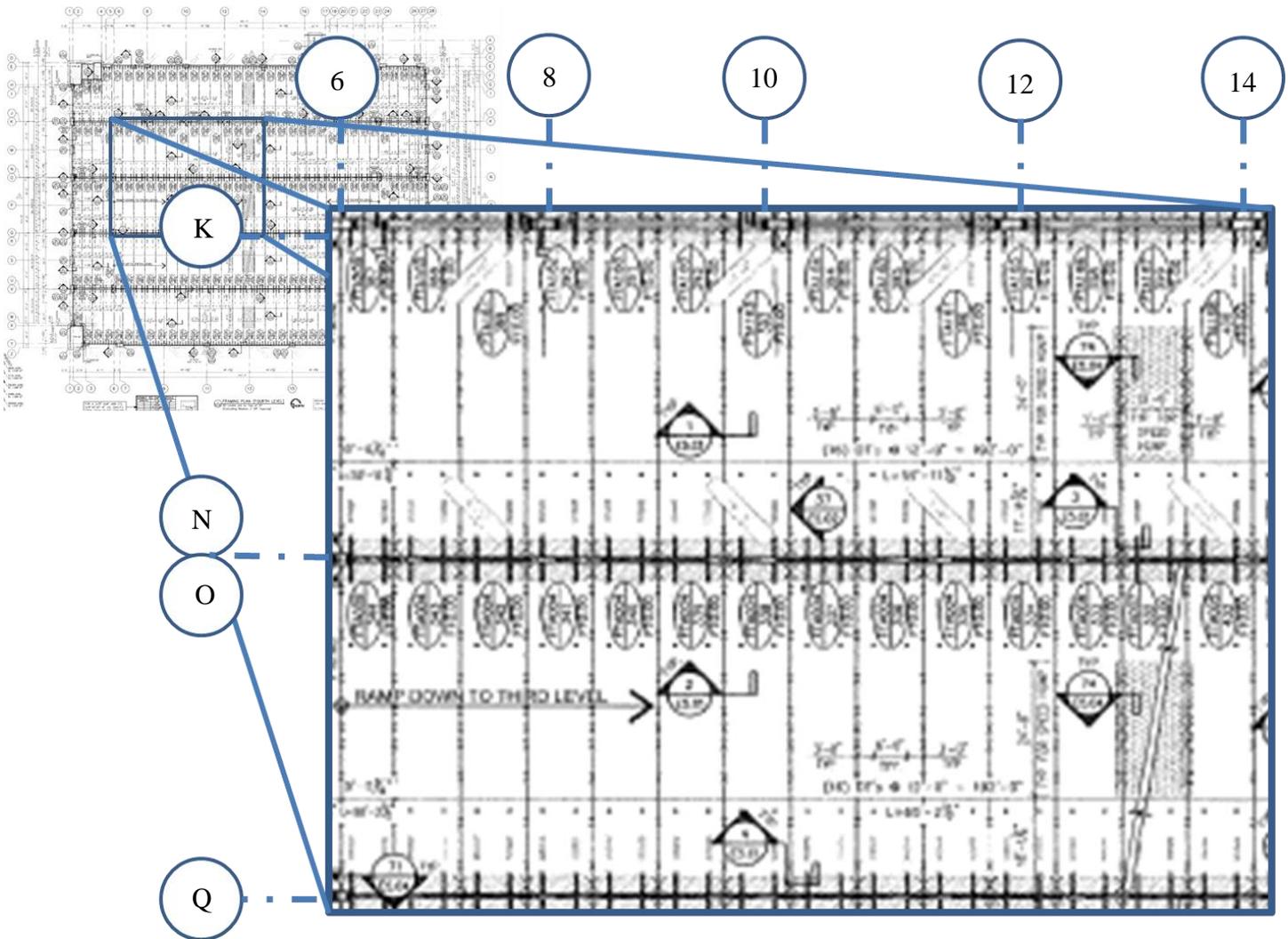


Figure 4. Fourth Level Floor Plan

After all the precast tees were placed between bays K and N from column lines 6 through 14 from the second to the fourth floor, erection moved to the adjoining bay of N-Q. First, precast columns were erected on column line Q. Second, inverted tee beams along column line Q were placed followed by the placement of double tees on the second and third floors. As was the case between bays K and N, adjustments were needed to align the flanges of the tees. All adjustments of the tee elevations were made by placing shims under the stems of the affected tees. The stems of the tees, however, were not jacked up from the lower level as was the case in the previous bay between lines K and N, but by raising the tees with a crane.

On April 15, 2016, Pre-Con completed the third level between bays N and Q by erecting the three remaining double tees, and then proceeded to work on the fourth level. First, inverted tee beams were placed between column lines 6 through 14 with all connections completely welded to the column inserts. Second, double tees were placed by supporting them on inverted tee beams on the north end and on wall panels on the south end. The direction of erection for the double tees was from west to east. Three double tees marked 387, 388, and 389 were placed between column lines 6 and 8. Then, four tees marked 390 through 393 were placed sequentially between column lines 8 and 10. When the double tee marked 393 was placed, it was observed that the southeast flange of the double tee marked 392 was slightly lower than the corresponding flange of the double tee marked 393. The need, therefore, arose to place a shim under the southeast stem of the tee marked 392 to align it with the flange of 393. The crane was already released from the double tee marked 393. The connector asked the crane operator to lower the hooks near the southeast corner of the tee marked 392 to make the necessary adjustments. The crane operator lowered all four hooks near the southeast corner. Then the connector placed one of the four hooks into the lifting insert. The connector instructed the crane operator to raise the stem no more than $\frac{1}{2}$ to $\frac{3}{4}$ inch, just enough to place a shim under the southeast stem of the double tee marked 392. The shim was installed and the double tee was lowered into place. The connector removed the hook from the insert and instructed the crane operator to “boom up, load up.” As stated earlier, there were four hooks hanging loose in the immediate vicinity of the insert. Suddenly, as the crane began to raise the hooks, one of

the hooks caught the insert, as shown in Figure 5, and the double tee began to rise along with the hooks. To the horror of the welder and the connector, who screamed on the radio to the crane operator to lower the hooks, the crane operator continued to raise the hooks, causing double tees 392 and 393 to collapse. The welder and the connector were injured in the collapse of the double tees.

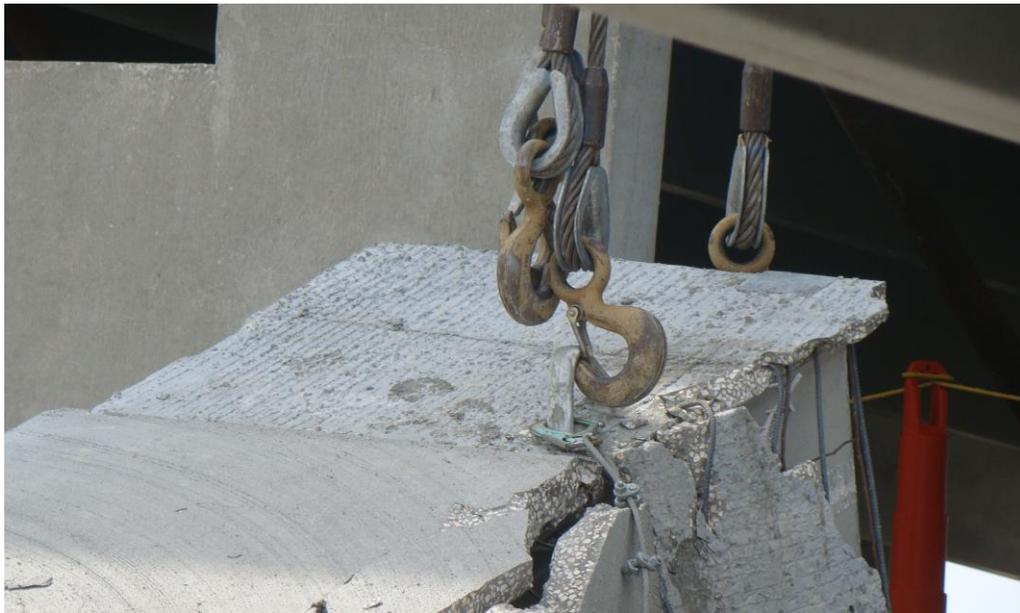


Figure 5. Hoisting Hook Inadvertently Caught on Insert

Another contribution to the April 15, 2016 incident was the fact that the contractor did not provide welds in accordance with the instructions in the general notes. If the double tee had been properly welded at each end as required by the construction documents, then the crane operator might have noticed the tension developing in the hoisting hooks and stopped the crane's operation before the beams collapsed. The erection instructions are listed on Sheet E0.12 of the BRD drawing package prepared for Metromont. The relevant section of the erection instructions is shown in Figure 6 and the instructions pertaining to the double tees are highlighted. The erection notes clearly required that **all** end connections and a minimum of two flange connections on each end be made before the release of the crane.

However, Detail A on the same sheet conflicts with the erection instructions. Detail A is shown in Figure 7 and conflicts with the erection instructions in the following ways:

1. End connections are missing in the “Fully Welded” zone. According to the erection notes all end connections must be made before the member is released from the crane.
2. End connections are missing in the “In Progress” zone. Again, according to the erection notes all end connections must be made before the member is released from the crane.
3. More than one double tee is shown in the “Not Welded” zone. The erection notes stipulate that the end and two flange connections at each end must be made before the crane releases the member. Therefore, only 1 double tee can be in the “Not Welded” zone at a time. Once the required welded connections are made to release the crane, the double tee is then classified within the “In Progress” zone.
4. The highlighted text in Detail A contradicts the welding instructions described in the general notes. The highlighted text requires a minimum of one connection to a supporting member at each end of the tee while the erection procedure instructions require two connections. Furthermore, the highlighted text reference to joint connections is vague and unclear.

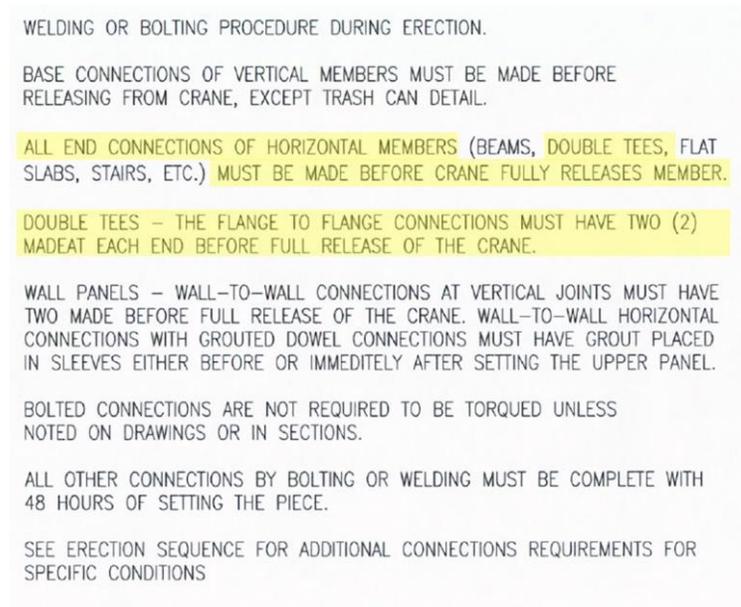


Figure 6. Erection Instructions, Sheet E0.12, Welding Procedure During Erection

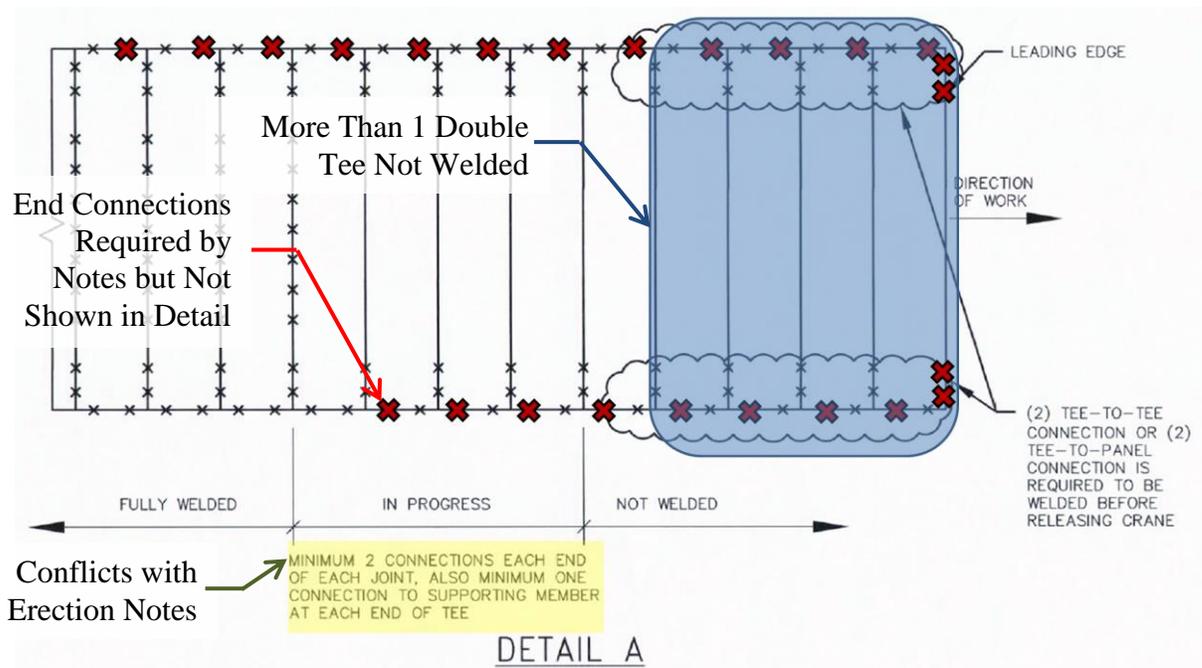


Figure 7. Sheet E0.12, Detail A Differences with Erection Instructions

The erector, Pre-Con, neither followed the welding procedure provided in the erection instructions nor the diagram shown in Detail A on Sheet E0.12. Field observations following the incident indicated that none of the double tees placed on the day of the incident on the fourth floor complied with the erection instructions on Sheet E0.12. Additionally, only two of the seven double tees placed on the day of the incident on the fourth floor agreed with the required end connections shown in Detail A. Furthermore, four of the double tees had either only 1 or none of the 4 required welded end connections, including the two members involved in the incident. Compliance with either the written erection instructions or Detail A could have reduced the likelihood of the incident.

Findings

1. The cause of the collapse of the double tees was the lack of adequate support during erection until permanent corrections were made.

2. Mixed and inappropriate audio signals were given to the crane operator which contributed to the collapse.
3. The quality control procedures of the precast fabricator, Metromont, as noted in site observations and interviews with the field erectors, resulted in misaligned precast double tee members. Although this fabrication oversight did not directly contribute to the collapse, these irregularities resulted in excessive shoring and field alterations to the members delivered to the construction site.
4. The structural engineer, Blue Ridge Design, produced a conflicting and confusing welding procedure for the erection of the double tees. The number of end connections that had to be in place before the crane released the member was unclear. In the erection notes, two end connections were required. However, a diagram showed that only one end connection was required. Furthermore, the diagram showed that multiple double tee members could be installed without proper end and flange weld connections in the “Not Welded” zone.
5. If the double tees had been properly secured, it is unlikely that multiple double tee members would have collapsed while shimming adjustments were being made to an adjacent member.

The erector, Pre-Con Construction, failed to properly weld the double tee ends and flange connections before releasing the crane, deviated from a safer method of shimming the double tees by using floor jacks instead of the crane, and neglected to follow standard procedures to ensure that the hoisting hooks were clear of the lifting inserts embedded into the double tees before booming up on the crane.