Analysis III: Beam Analysis for Structural Integrity

Introduction

The Wilkes-Barre/Scranton is a very unique building with its architecture. The entire building is has a gigantic sandstone wall that spans the entire length of the building. This wall starts from the lower entrance from the parking garage and runs all the way to the end of the terminal. The stones that are used are about 150 pounds each, and the wall reached to well over 40 feet in height in some areas. Navigating through the airport would be quite difficult if there were not any openings along this wall. The wall can not just stop for when an opening is needed either. The wall will continue overtop of the openings and will be supported by lintels to continue the pattern of the wall.

The sandstone wall has an interior CMU wall for supporting the large stones. The stones are tied into the CMU for any lateral support to prevent tipping and relief angles are found in the taller sections of the walls where the lintels can not support the weight of the wall. All of the openings in the wall have a prefabricated lintel that sits on a CMU pier on either side of the lintel. This case is true for all but one opening in the wall. The opening found in section two of the building, next to the freight elevator, does not have a prefabricated lintel, or CMU piers to bear the load from the stone clad lintel.

The lintel that is found in this area uses the supported floor slab beam as its source of support for the stones to hang off of. The supports for the stones are welded on to the beam through a series of long steel angles for the face of the walls and W/WT beams to attach the stones to the underside as well as support the steel angles. The stones are set in

place through steel pins on the face of the wall and embedded bolts for the under side to leave a smooth unflawed surface on the sandstone.

The issue that arises from this particular lintel is that when the HVAC system was roughed in and ducts were hung, the duct had to wrap around the same beam that would be holding up the lintel in this area. When the duct was installed the lintel was lowered by 10 inches and this caused some distress with the design of the wall and concerned the architect as well. This brings up the point of how to solve this problem effectively and regain the 10 inches that was lost in the original plans. The most logical way to solve this problem is to analyze the beam for having the duct punch through the web of the beam and not wrap around.

Beam Analysis

The beam that will undergo structural analysis will mainly focus on shearing issues of the beam. The beam that went under analysis is a W33 x 118 and is simply supported at each end. The beam is 44 feet in length and composed of A572-50 steel. There is a distributed load, which was found from the steel details, of 165 psf which equates to 990 pounds per foot. There is also a column that is supported by the beam for the roof and has a point load of 7.5 kips on the beam 11.75 feet from the right side. The load that comes from the lintel takes into account of the steel that has been welded on to the beam as well as the stones that will later be mounted on to the lintel. The load from the steel and the stones comes to 313.3 pounds per foot. The distributed loads were calculated and converted into point loads on the beam for analysis of a determinate structure. Determining the shear values of the beam where there are no shear forces working was almost in the middle of the beam in spite of the odd loading setup. The point where the shear is zero is 22’-4_11/16” from the left side of the beam in plan view. This position is frustrating because having a punch work most efficiently a punch would ideally go through the web of a beam where the shear is zero. But the location of where the shear is at it’s lowest is 18 feet away from where the ducts would normally travel.

The ducts are 9” in diameter and are located 3’-3” and 7’-4” from the left end of the beam. The shear in this area of the beam is at 24.5 kips at the 3’-3” punch and 19.18 kips at the 7’-4” punch. The beam will not be able to withstand this force if holes are cut into the web of the beam. The next best step is to re route the duct further along the beam where the duct can effectively punch through the beam with out risk of web shearing or buckling. Mentioned above, the point where the beam’s shear is equal to zero is at about 22’-5” from the left side of the beam. To avoid any critical failure the hole to punch through the beam will be placed here, using only one hole to prevent any excessive removal of the beam’s web. The duct will pass through one hole in the web and then branch off to the appropriate diffusers.

After talking with the structural engineer of the building, he supplied the information on this issue. When the problem arose on the job site the engineer analyzed the beam for the punches in the far left of the beam. Upon analysis the engineer found that the beam failed when the holes were cut through the web of the beam for the ducts. The lack calculations proving this point came down to a few issues. First of all not having a building model to use for personal analysis and load analysis made determining the loads of the building much more difficult than anticipated. Due to security issues obtaining the building model was not an option and only one section of the building could be obtained for analysis. Analyzing the calculations by hand with out the use of the model also proved to be very difficult for the lack of information and resources to provide empirical evidence. Even with the help of staff and classmates, a logical solution could not be found. The engineer did not save the calculations of the hole punches either because it was more for checking purpose and not an option to follow through with and try to fix. The simple solution was to lower the lintel, end of story.

Conclusion

The holes punched in the beam will actually cause more problems than anticipated. The failure of the beam where the two ducts originally were designated to punch through would fail the beam from what Highland Associates, the structural engineer on the project, determined. The holes that would be there did in fact have to high of a shear force that would cause failure of the beam. Making the hole in the center of the beam where the shear is equal to zero is a far better plan to locate the punch through the duct.

Placing the punch at the center of the beam is the best location to withstand the shear forces found with in the beam. The shear forces in the left end of the beam were above 19kips at one hole and 24kips at the other hole. The beams redistribution of the shear forces acting through that hole would fail the beam. The forces that would be affecting the hole at the center of the beam are less than 1000 pounds acting through that area. The shear forces that would be redistributed around the punch are around 500 pounds, that's 2 percent of what was being redistributed in the other planned holes. The beam can withstand this force and will not fail if a hole is cut there.

The analysis of the cost effectiveness of re routing the duct an additional twenty feet to punch through that duct will be covered in the HVAC analysis.