3.0 Breadth Work — Integration of Structural System and Constructability

3.1 Overview

The Philadelphia School District chose to relocate in an existing building instead of building a new facility. A concern with moving into an existing building is constructing the new building systems within it. All building systems must be integrated with the existing structure. The first topic to be explored is structural compatibility. The weight of the system to be constructed should be checked against what the existing structural system can withstand. Modifications may be needed in order to fit the new equipment in the building or on the roof.

The second topic to be discussed is constructability. Since 440 North Broad is an existing building there are boundaries as to how equipment can be moved inside the building and once inside, how it can be moved around within the building. Heavy equipment like cranes may need to be positioned and the surrounding areas must be considered when locating the crane.

The mechanical system recommendation was to install a DOAS/Radiant system with a water cooled centrifugal chiller and a gas-fired boiler. This requires placing a chiller and a cooling tower on the roof. The structural system will be checked and a constructability study will be completed.

3.2 Structural Analysis

The existing structural system consists of 5 inch slab on deck with steel columns and girders. The existing mechanical system required a cooling tower at 44,000 pounds (lbs) to be placed on the roof. The designers used column extensions for one central bay and built a new exterior concrete slab about 4 feet above the roof. The cooling tower sits on another slab which lies on top of the addition floor. The mechanical system recommendation requires two new rooftop packaged chillers in addition to the existing cooling tower. Because the existing design using column extensions works for the cooling tower, the same design will be modeled for the chillers. The original building was a printing facility which had floors designed for 125 PSF. Because the building is now being used as office space the live load will be assumed to be 80 PSF so that corridors can be placed at any location. A dead load of 75 will be assumed due to a 5" normal weight concrete slab and MEP loads on the floor.

This structural analysis will include modeling the bay that will be affected by the mechanical equipment in SAP2000 and in RAM, two structural modeling programs. The reason for using two different programs will be explained further on. It is required of the structural system to be able to take the load of the new rooftop chillers each weighing 70,000 lbs. They will take up a total area of 15 by 8 square feet. A typical bay in the School District of Philadelphia Administration Headquarters is 25 feet by 25 feet. The proposal is to build another floor above a central bay away from the cooling tower, Figure 3.2A. Like mentioned before, this is not what the cooling tower lies on—it is another slab which is on top of the new floor. The top slab is 24 by 18 feet, red in Figure 3.2B and was modeled in SAP so that the reactions can be found and placed on the model in RAM. This was done by placing pins at each point labeled 1-8 in Figure 3.2B and by placing a distributed load over the area of the slab.

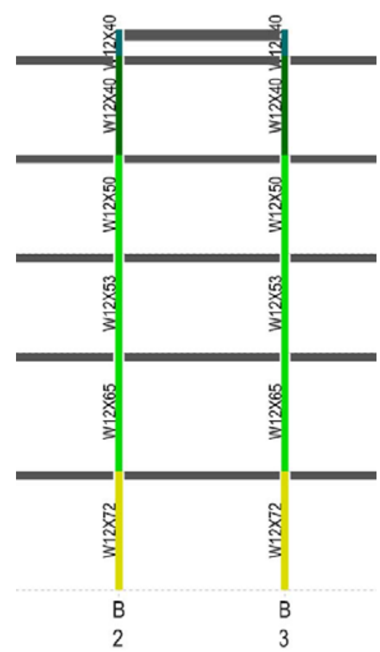

Figure 3.2A. Column Section with New Floor

Distributed Load = 70,000 lbs x 2 ÷ (24' x 18') = 324 PSF

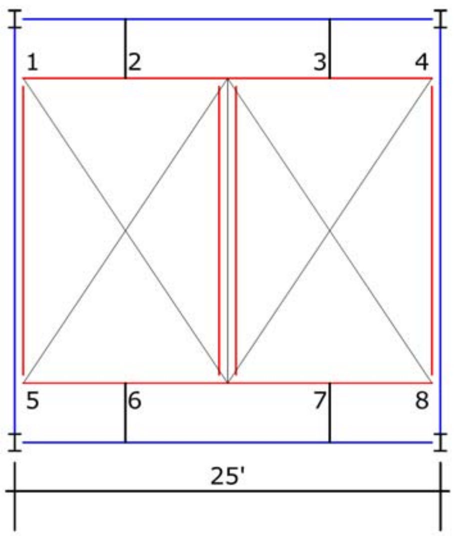

Figure 3.2B. New Mechanical Floor Above Roof.

This gave the reaction of 1 KIP at points 2, 3, 6, and 7 and 136.2 KIPS at points 1, 4, 5, and 8. The deflection can be seen on the next page. The 136.2 KIP loads were converted to a line load acting from points 1 to 5 and from points 4 to 8.

Line Load = 136.2 KIP x 2 ÷ 18' = 15.13 KIP per LF

This would be worst case scenario at full load design. These reactions were then put on the RAM model, Figure 3.2C. The model was ran using the dead and live loads assumed per floor and these point and line loads.

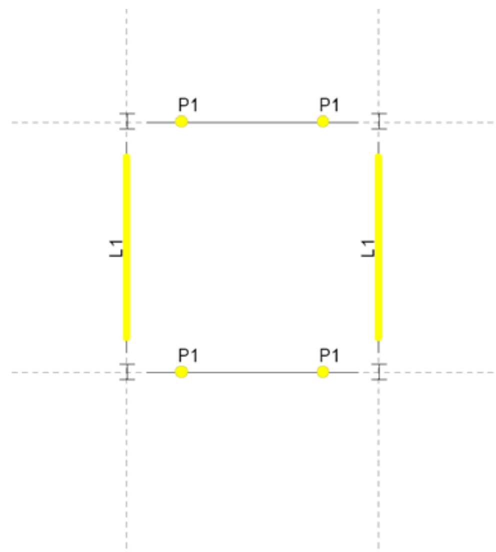

Figure 3.2C. Loads on Beams.

The output can be seen on the next page. If the beams and the columns on the top and bottom floors of the existing building are the same size or larger than the ones given in the RAM model, then the same design for the existing cooling tower can be used to design a new floor for a chiller for the DOAS/Radiant system. The existing column extensions for the cooling tower are W12x40 and the first floor columns are W12x72. The existing beams are HSS20x12x12 and HSS12x6x1/2. The beams were set in the RAM program and it was allowed to calculate the column sizes. The results from RAM show that the column sizes needed for this structural renovation coincide with what is in the building currently. The framing plan also coincides with the W16s currently in the building. See Appendix C for the beam design calculations

3.2.1 SAP Results

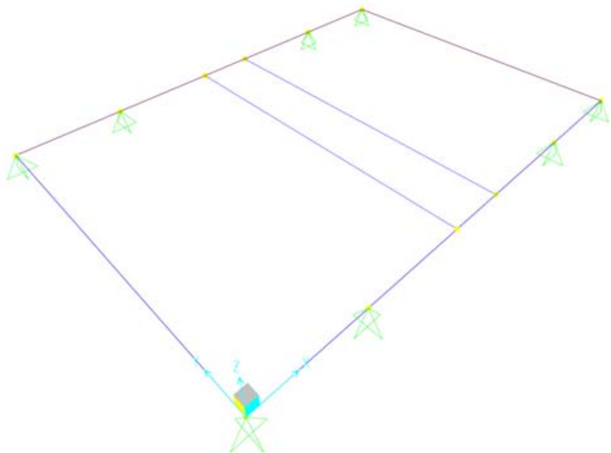

Figure 3.2D. Top Slab without Deflection.

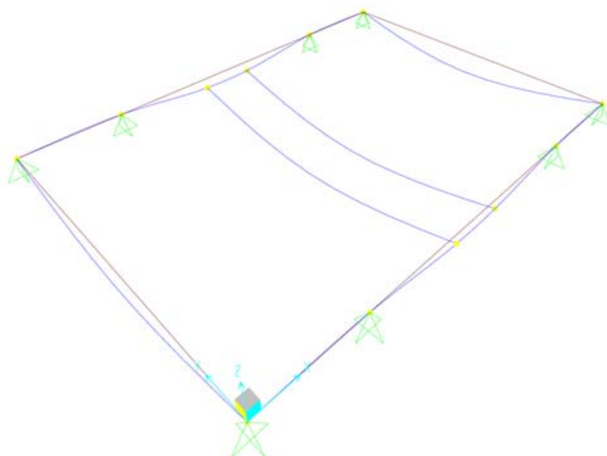

Figure 3.2E. Top Slab with Deflection.

3.2.2 RAM Results

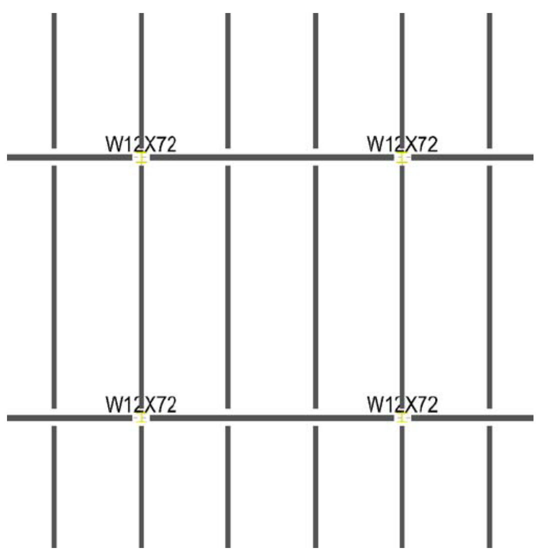

Figure 3.2F. First Floor Columns.

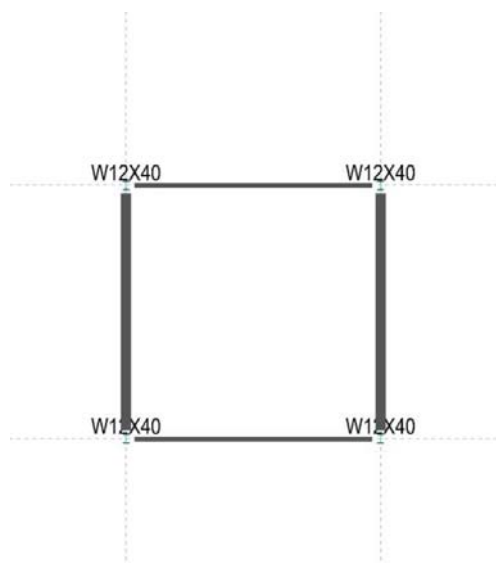

Figure 3.2G. New Floor Columns.

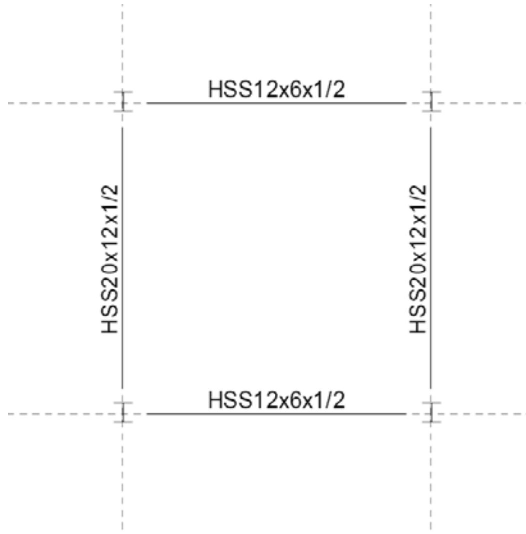

Figure 3.2H. New Floor Beams.

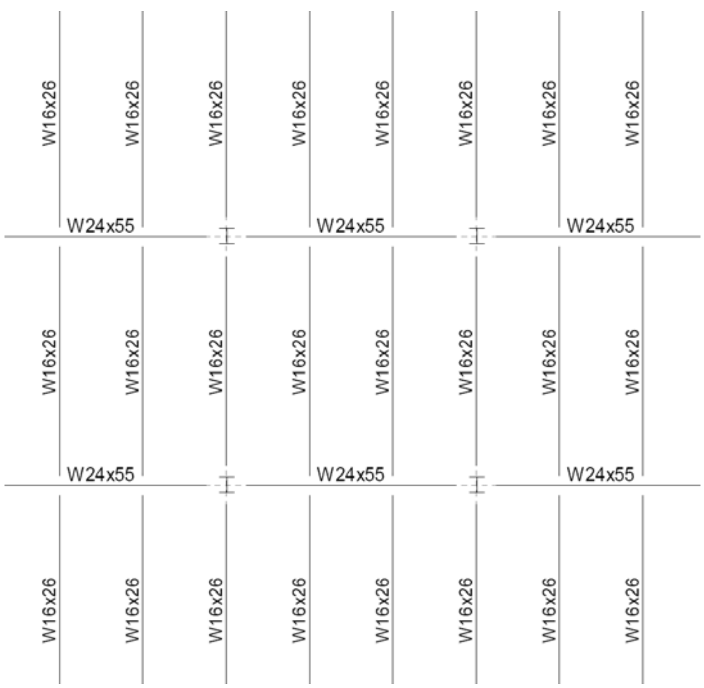

Figure 3.2I. Frame Plan

3.3 Constructability

This constructability study will include a sequence schedule and a site analysis. The sequence schedule will compare installing the VAV system compared to installing the DOAS/Radiant system. The site analysis will give locations of construction equipment and how it affects the surrounding neighborhood.

3.3.1 Sequence Schedule

The sequence schedule is appropriate for installing both the VAV and the DOAS/Radiant system. The expansive areas within the SDPAH accommodate having large lay down areas—areas where construction crews can keep material until it is time for them to install or build it. The spaces within the building are similar which allows for an even distribution of equipment and material.

Each sequence in this schedule includes the construction for five different activities. The first activity is the construction of interior walls. The second set of activities includes the construction of the ceiling plenum. This is done by constructing the systems that are highest in the plenum first. The plumbing piping usually requires a fall for a certain length so this goes into the plenum first. The ductwork takes up a lot of space and is installed next. The sprinklers are installed after the ductwork but before the electrical equipment and lighting is installed last. The sequences will be laid out by wing of each floor.

Figure 3.3A. Sequence Numbering.

The first crew will move into space 1 and build the interior walls When they are finished they will move to space 2 (Part a, Figure 3.3B) and the plumbing crew will come in to space 1 to install plumbing lines. The ductwork crew will begin installation after the plumbers and so on and so forth. This is described visually in Figure 3.3B.

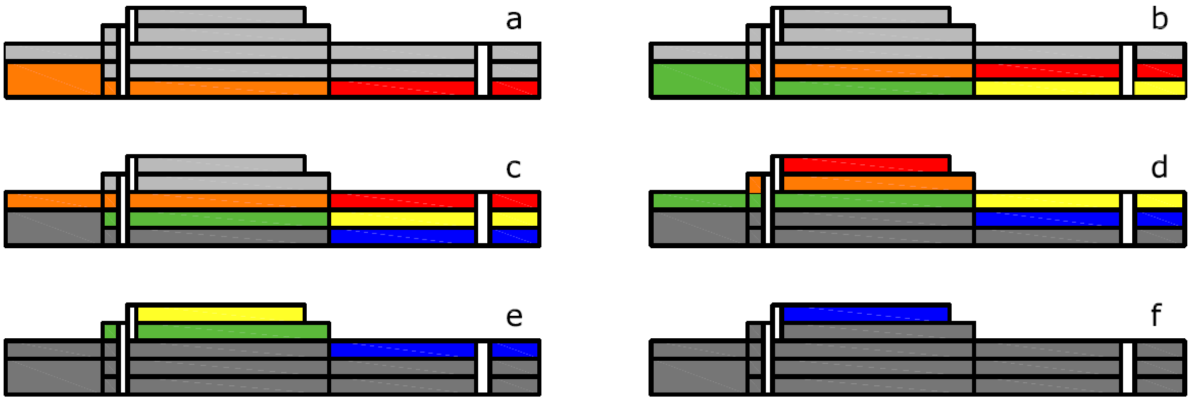

Figure 3.3B. Sequences Started and Finished.

For the VAV system, the ductwork will be assumed to take the longest time to install. From The weight of the galvanized steel ductwork was estimated to be 8 pounds per square foot at 0.2 inches thick. The estimate of the area of ductwork per sequence was taken from the mechanical construction documents and it was found that ductwork would take 35 days to install.

Installation of Ductwork		
Weight of Ductwork	500000	lbs
Total Daily Output	14250	lbs
Duration to Install	35	days

Figure 3.3C. VAV Critical Activity

Installation of Radiant Panels		
Length of Pipe	80000	ft
Total Daily Output	5250	lbs
Duration to Install	15	days

Figure 3.3D. Critical Activity

For the DOAS installation, each sequence will include the same activities as are included in the VAV installation, but with the addition of installing the radiant panels. The radiant panel installation will be included in the ductwork activity. The amount of ductwork included with the DOAS is minimal compared to that included in the VAV application. An assumption will be made that installing the radiant panels will take longer than the other activities—15 days. These activities were modeled using a scheduling program called Primavera. The ductwork and the radiant panels are on the critical path, meaning that if the crews installing this equipment falls behind schedule, it affects the activities after them as well (sprinklers and electrical), putting the whole project behind schedule. The VAV system was found to take 256 days, approximately 8 and ½ months. The radiant panel system was found to take 110 days to install the whole project, approximately 3 and 2/3 months.

3.3.2 Site Analysis

The existing site has many opportunities for easy construction. There are several freight elevators that can be used to move material from floor to floor within the building. Page 10 includes a table of all elevators located within the building. There are loading docks on the 15th Street side of the building where material can be brought into the building. There is a parking lot for Turner's construction office where a crane can be located (the red box). The crane would be necessary to move the chillers and cooling towers onto the roof of the building. The only issues with construction could be getting material into Philadelphia. The downtown location of the building and the tight streets that are around it could make it difficult for delivery trucks to get through. But once on site, construction crews have many paths they can use in order to move the system's equipment throughout the building.

Figure 3.3E. Site Analysis.