Construction Study

Theory

Significant changes were made to the Athletic Center in the Structural Redesign and Daylighting Study sections of this report. Not only do they have considerable effects on the design of the structural system and building façade, but they affect the construction methods and management approaches as well. Two construction management issues were discovered during the redesign of the perimeter diagrid lateral system. They are:

1) Truss loading sequence
   The new perimeter truss design incorporates both tension and compression columns as a means of carrying gravity loads. The deformations between adjacent tension and compression columns are incompatible, and large vertical displacement differences occur. This incompatibility presents curtain wall installation problems. A sequencing study was performed to resolve this issue.

2) Site layout
   In the original diagrid design, large sections of the diagrid were meant to be prefabricated and delivered to site for erection directly from the truck. With the new precast curtain wall design, additional space must be provided for panel layout. A site layout plan was developed to better manage the tight site constraints.

The goal of this construction study was to consider these issues and to make informed, logical decisions on each one to better manage the construction of the Athletic Center. Doing this not only strengthened the planning aspects of construction, but justified the changes to the structural and architectural systems as well.

Solution

Truss loading sequence

In order to fully address the issue of column deformation compatibility, it is necessary to understand the reasons why such a problem occurs. A clear visualization of the load path and deformations is important. Load is carried from the tension columns in the spans up to the perimeter truss. The truss carries the load horizontally to the larger compression columns, where it is all brought down to the foundation. As for deformations, consider the diagram in Figure 38. Suppose the bottom of the compression column deflects Δ_1. Disregarding load from the floors acting directly on the column itself, the top of the compression column will deflect approximately $5\Delta_1$. Disregarding truss sag as well, the top of the tension column will be the same, $5\Delta_1$. Finally, the bottom of the tension column will deflect an additional Δ_2, for a total of $5\Delta_1+\Delta_2$. This is many times larger than the bottom of the compression column. Consider the heavily loaded column in the northeast corner of the building. Its deflection at Level 500 is 0.088", while its deflection at Level 900 is 0.650". This is a 740% increase. The tension column next to it deflects 1.676" at Level 500. This means there is a 1.588" difference between the adjacent columns at Level 500 over a distance of 27'. Such a difference causes problems of alignment and joint stability between precast panel and window sections.

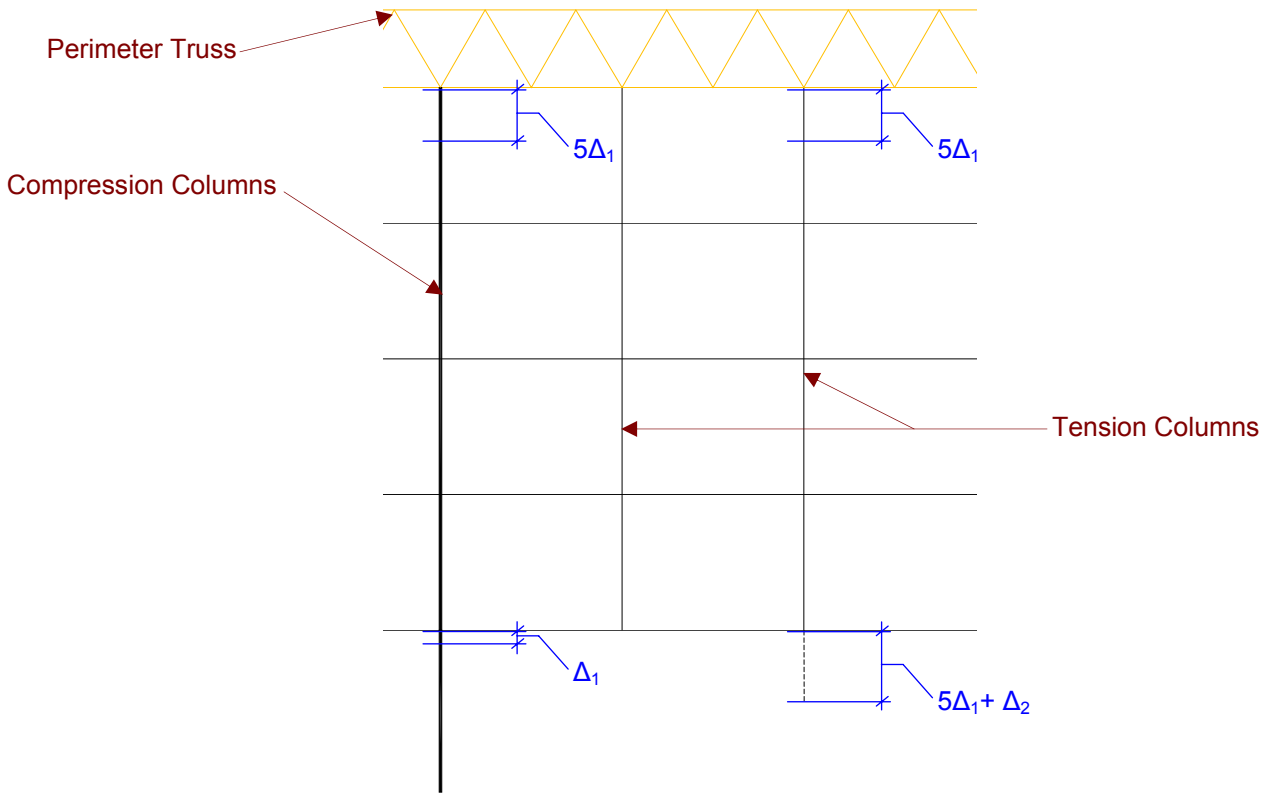

Figure 38: Column deformation incompatibility

There are three ways this issue can be resolved:

- Change the section sizes of the columns to limit the deformations or make them more compatible with each other. This is a not a very economical choice at all and should be disregarded except in extreme circumstances.

- Tension column lengths can be designed initially shorter than required to account for deflection. This is analogous to cambering a beam before loading. Unfortunately, this method causes concrete slab pouring problems. The lower slabs will continue to deflect as upper levels are loaded.

- Construction sequence can be controlled so that deflection change is minimized. Consider two options, installing the curtain wall from the bottom up and from the top down. The relative deflections were found for each level as the structure was loaded in either direction. The results are shown below in Tables 27a and 27b.

	Levels loaded				Total	Total after installation
Level	500	500-600	500-700	500-800		
800	1Δ	1Δ	1Δ	1Δ	4Δ	0
700	2Δ	2Δ	2Δ	1Δ	7Δ	1Δ
600	3Δ	3Δ	2Δ	1Δ	9Δ	3Δ
500	4Δ	3Δ	2Δ	1Δ	10Δ	6Δ

Table 27a: Bottom up sequence

	Levels loaded				Total	Total after installation
Level	500	500-600	500-700	500-800		
800	1Δ	1Δ	1Δ	1Δ	4Δ	3Δ
700	1Δ	2Δ	2Δ	2Δ	7Δ	4Δ
600	1Δ	2Δ	3Δ	3Δ	9Δ	3Δ
500	1Δ	2Δ	3Δ	4Δ	10Δ	0

Table 27b: Top down sequence

The bottom up sequence results in a maximum relative deflection of 6Δ after installation. The top down sequence produces the same overall deflections; however its maximum relative deflection after installation is only 4Δ. Therefore, it is advantageous to install the curtain wall from the top down. In a traditional building this is an unusual situation, however it is not only possible but logical to perform such a construction sequence.

Site layout

The use of precast concrete panels requires more careful planning of site layout. Because the panels are not lifted directly from the truck, they take up space on a limited job site. Figure 39 shows the general layout of the site plan.

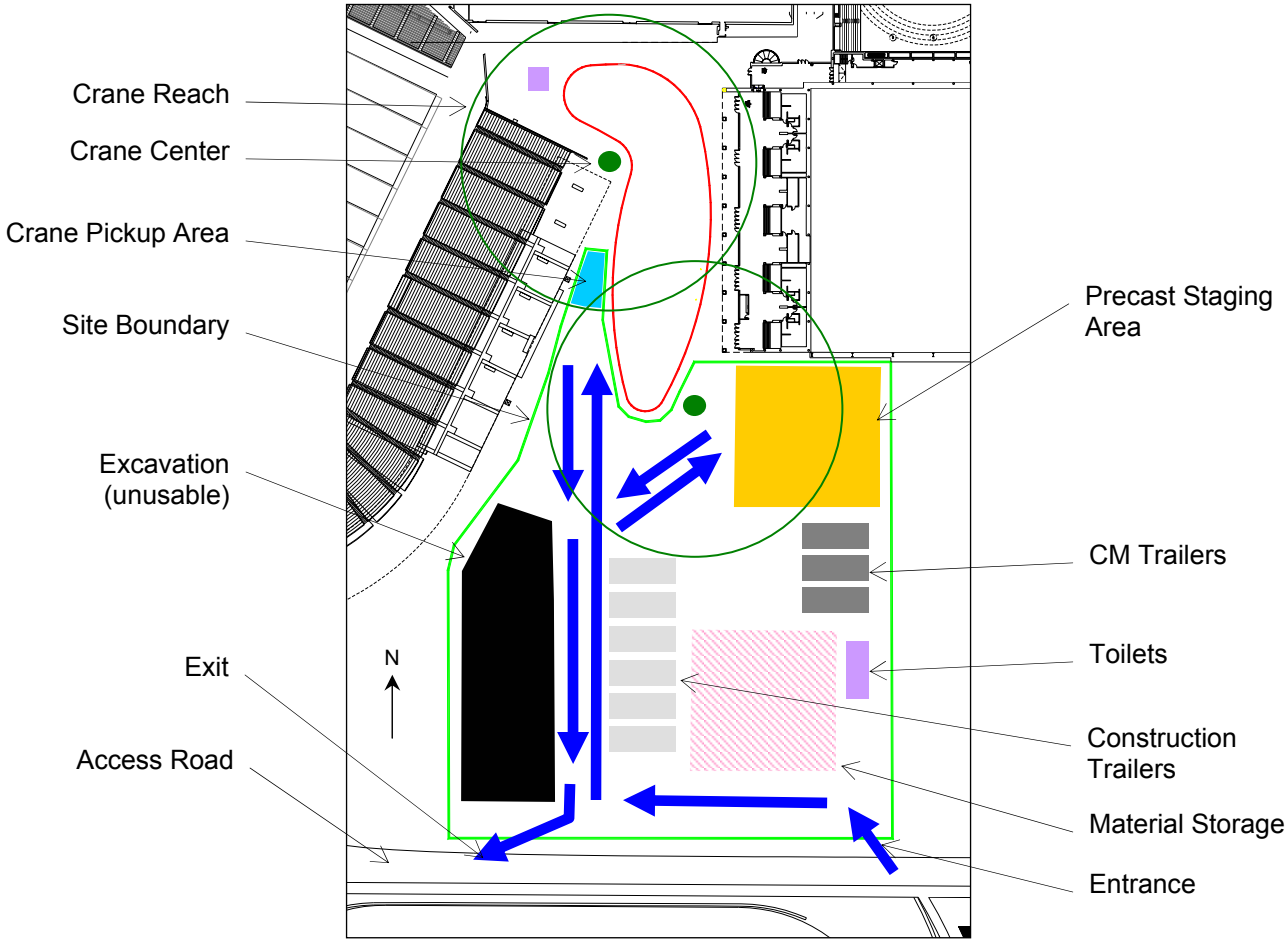

Figure 39: General site layout

The Athletic Center is outlined in red while the usable construction boundary is in green. An entrance and an exit at opposite sides of the site allow better traffic flow. Two cranes must be used in order to reach the entire building perimeter. The precast staging is tucked in the Northeast corner of the site. Toilets are located on both sides of the site.

In addition to the layout of the site, several other site planning issues are to be considered:

1) Site area lighting and street lighting shall be maintained throughout construction.
2) Power distribution shall be maintained throughout construction.
3) Fire department services and access shall be provided.
4) Surface storm drainage and sewer systems shall be provided.
5) Fall protection for all pedestrian areas adjacent to excavation shall be provided.
6) Pedestrian access through or around site shall be maintained.
7) Provide warning signage throughout site.
8) Do not interrupt nearby vehicular passageways.

Conclusions

It is clear from the problems considered above that modifying the structure and/or architecture of the Athletic Center impacts the planning and methodology of certain construction management procedures. Though the two considerations of truss loading sequence and site planning were not in-depth, they presented quick and simple solutions to the issues resulting from the structural redesign.