Gateway Plaza
Wilmington, DE
January 16, 2006

Elizabeth Hostutler
Structural Option
Advisor: Linda Hanagan

Senior Thesis Proposal:
Framing Redesign Using Post-tensioned Concrete

EXECUTIVE SUMMARY

Gateway Plaza is a 15-story office tower located in Wilmington, DE. The Gensler design, financed by the Buccini/Pollin Group, will be the first new building constructed in the Central Business District in 15 years and one of the few office towers with a glazed curtain wall façade. In addition to 387,000 ft^2 of rentable office space Gateway Plaza will offer the city, the site will also be host to a 5-story parking garage in its rear.

The building sits on clusters of drilled pier foundations which penetrate up to 70', down to bedrock. The superstructure of Gateway Plaza is composite steel with an typical floor-floor height of 13'-6". A variety of concentrically braced steel frames, located mainly in the rear of the building, resist lateral loads transferred by the rigid diaphragm. The most structurally challenging feature of Gateway Plaza is its 52'x36' bays. Preserving this open layout of the office is a major concern for the architect.

The goal of the thesis project will be to redesign the entire building with concrete. Columns will be transformed to cast-in-place concrete, and floor systems will now be post-tensioned flat slabs. To resist the lateral loads, concrete shear-walls will be implemented. The idea behind the redesign is to determine a different system that will decrease the floor depth while preserving the 52' spans. The purpose of this work is to become more familiar with the design of post-tensioned slabs and the implications they may have on a design.

In addition to a structural redesign of Gateway Plaza, several outside topics will be researched and discussed to determine what implications they will have on the design of the structural system. First, a construction management study will be performed to determine a new construction schedule based on the different tasks and trades that must be accounted for using a post-tensioned system compared to a composite steel system. Second, a mechanical study will be conducted to determine if a more efficient duct layout can be achieved. Consequently, if efficiency can be gained, a new, smaller fan shall be selected.

This project will be performed in steps and completed and presented to a panel of faculty jurors at the end of the Spring Semester.

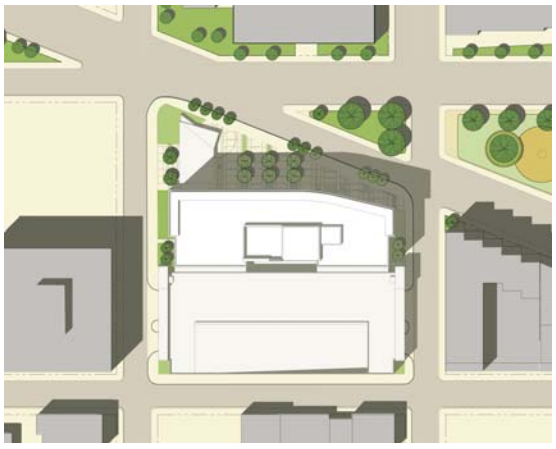
BUILDING INTRODUCTION

Gateway Plaza is the first new office tower being built in the Central Business District of Wilmington, Delaware in over 15 years. The $52 million complex is being built on the site of a former parking lot located at 500 Delaware Ave. By filling in a flat lot, the building will provide continuity to the entrance to the city.

The key team players in the design and construction of Gateway Plaza include:

- **Owner/Developer**: Buccini/Pollin Group
- **Architect**: Gensler
- **Construction Manager**: Gilbane
- **Engineers**
  - *Structural*: O'Donnell Nacarrato & MacIntosh
  - *MEP*: BALA Consulting Engineers
  - *Civil*: Landmark Engineering
  - *Geotech*: Duffield Associates

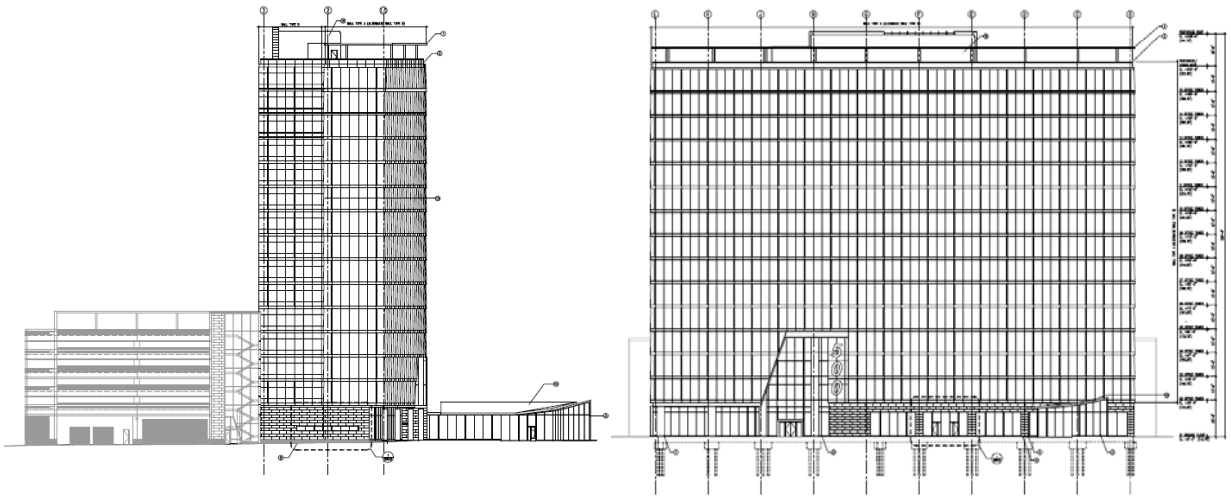
With 15 stories, Gateway Plaza tops out at 210'-6". The tower will provide the city with 387,000 ft^2 of rentable office space and the 5-story rear parking garage holds 600 parking spaces for building employees. The ground level will be a public plaza complete with a U.S. Post Office, WSFS Branch Bank, café, and lobby space for the tower above. The remaining 14 stories will be tenant fit-out office spaces. Additionally, a mechanical penthouse will be located on the roof and disguised with a screen wall it and a crowning element along the perimeter of the roof.



The glass curtain wall façade of Gateway Plaza will be the first of its kind in the CBD and will offer tenants views of the city and Delaware River. The site is in the shape of a trapezoid with Delaware Ave. running along the angled, North edge. The building's footprint embraces this shape with a café protruding from the North-West corner of the office tower. The café helps creates an outdoor plaza which will serve as a small gathering space for the public.

Ground was broken in July 2005 and the building's long awaited arrival is slated for December 2006.

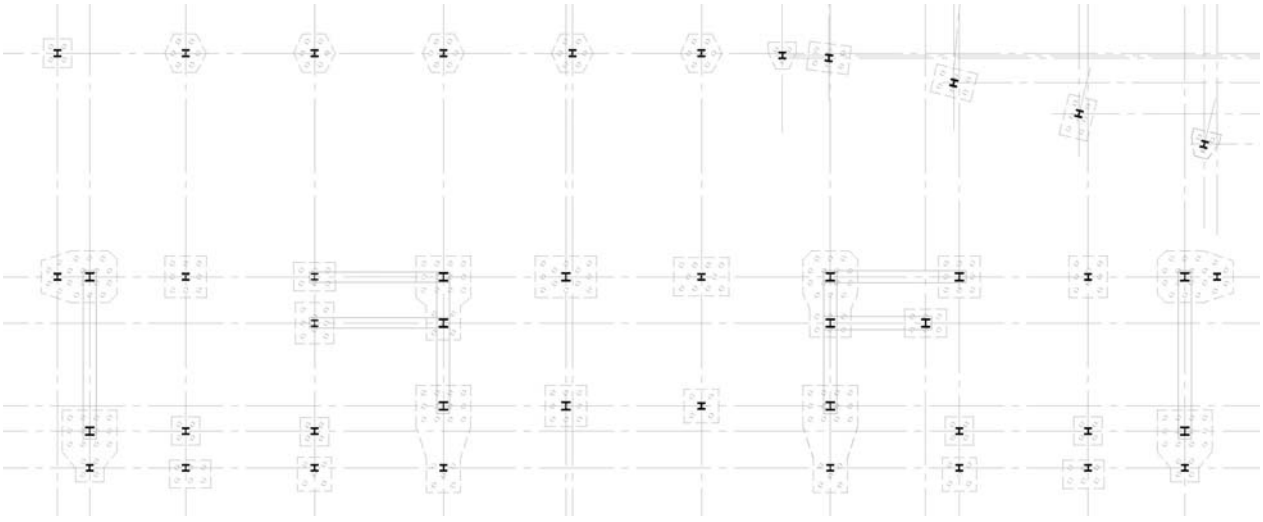
Structure



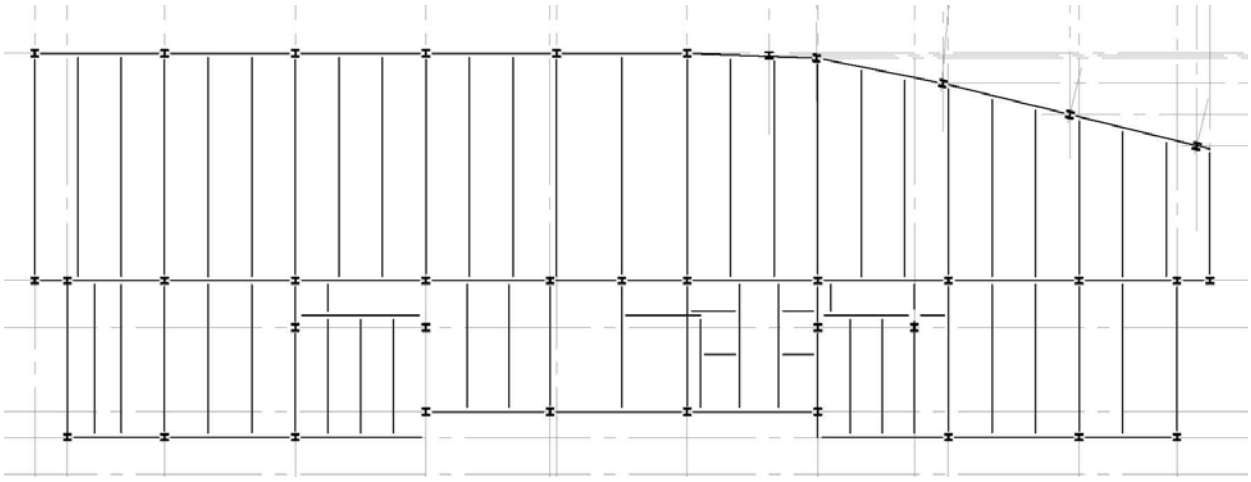
Foundations: The foundation of Gateway Plaza uses clusters of auger-cast, drilled piles to support column loads. The piles are 12" in diameter and use high strength concrete to develop 120 tons of bearing capacity. Most of the piles are drilled 70' down to bedrock through sandy-silt and silt, typical of a city located on a river. Grade beams span the pile caps on the entire building's perimeter, and a 5" slab on grade span the grade beams in much of the foundation.

The office tower's steel columns sit on pile caps that are typically 60" thick and vary in shape. The columns from the lateral load resisting system generally sit on clusters of 18 piles where those from the gravity system sit on clusters of 12. The larger foundations under the lateral frames are to resist the overturning moment from wind and seismic loading. The pile clusters in the office tower are on a 30'x52' grid on the north side and a 30'x35' grid on the south side.

The picture below illustrates the location of the foundations as well as the size and geometry of the piles and pile-caps.

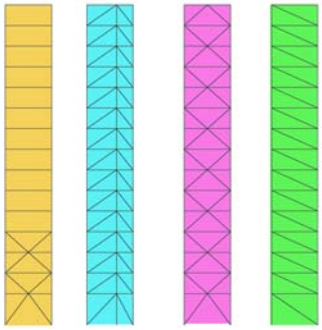


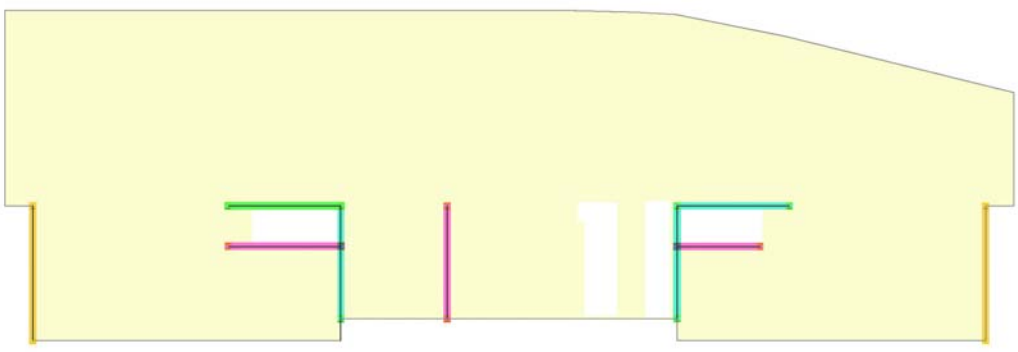
Superstructure: The composite steel framing in the office tower uses two grid systems: one orthogonal and one rotated. The grids are 30'x52' in the north half and 30'x36' in the south half. The rotated grid is an adaptation of the orthogonal grid, turned 14° clockwise from north, and is used to create the bowed surface on the northeast face. The columns are spliced every other floor or 27'. All framing members on the office floors use wide-flange shapes on A992, Gr. 50 steel where the framing of the penthouse and screen-wall on the roof use HSS tube shapes of A36 steel. All of the columns, in both the lateral and gravity systems, are W14 shapes of various sizes. The girders and beams range in size but are usually W18 or W27 shapes.



The 52'x30' bays introduce some unique challenges to the building's structural systems, and limit the type of building materials that can be used on this structure. The W27 members span 52' to preserve the open office layout. Structural slabs in the building are 3-1/4" lightweight concrete on 3" composite Lok-floor deck, which act as a rigid diaphragm to transmit lateral loads to the lateral resisting system.

Lateral System: The lateral system of Gateway Plaza uses a variety of concentrically braced steel frames to resist lateral loads. All of these frames are concentrated in the rear (South end) of the building to preserve the curtain wall façade's open view of the city from the front (North end) as well as preserve the open quality of the office space. There are five frames resisting the controlling wind loads in the y-direction, perpendicular to the long face of the building, and four frames in the x-direction, perpendicular to the short face of the building.



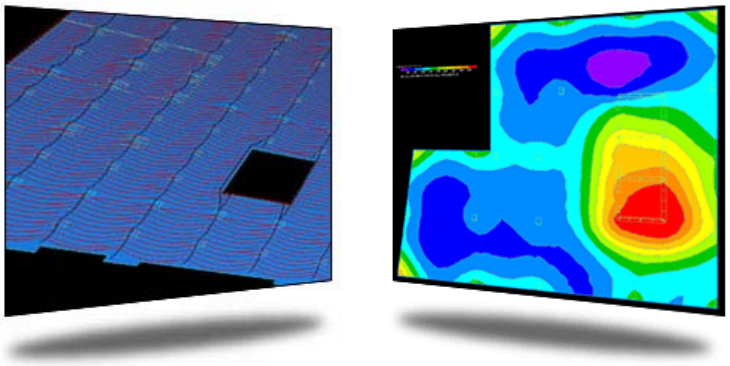


PROBLEM STATEMENT

An area for redesign was difficult to pinpoint with Gateway Plaza. After the research and analysis performed during Technical Assignments 1-3, it had been determined that the current structural systems--steel framing, concentrically braced frames, and deep foundations--were the best candidates given building type, local conditions and accepted practice. Though no feasible framing alternatives were found during research for Technical Report 2, further research and faculty consultation has suggested that a one-way post-tensioned concrete slab spanning post-tensioned beams with concrete shearwall construction will be worth redesigning. Though there are no height restrictions dictated by the architect or zoning ordinances, the post-tensioned system could save a significant amount of ceiling space and is worth researching. The purpose behind this redesign is to gain knowledge and experience in the design of post-tensioned concrete systems in buildings.

Proposed Problem Solution

As mentioned in the problem statement above, post-tensioned concrete slabs and beams will be designed to replace the current composite steel framing system. To transform the steel framing, cast in place concrete columns must be designed for transferring gravity loads to the foundation. To resist lateral, wind loads, concrete shearwalls will take the place of the concentrically braced steel frames.



Graphical output from RAM Conce*pt*., courtesy of RAM's website. These photos will be replaced by actual slabs in Gateway Plaza upon the completion of the proposal tasks.

Method for Solution

In order to redesign the building using post-tensioned concrete slabs, research must initially be performed to gain knowledge in how to design such a system. By talking with students whose buildings use post-tensioned slabs and reading texts, a good deal of knowledge should be gained. Once a significant amount of information has been gathered, the office floors will be redesigned using loads obtained in Technical Report 1. The slabs will be designed in accordance with ACI 318-05 *Building Code Requirements for Reinforced Concrete*. Analysis for gravity loads will be completed using ADOSS. Once the slabs have been established, the other gravity framing elements (columns and edge beams) will be designed by hand and checked using PCA software. Finally, after the gravity system has been established the lateral system will be designed utilizing some of the current locations of braced frames. These lateral elements will be designed in accordance to ACI 318-05, Chapter 14 and checked using ETABS software.

Although a comprehensive post-tensioning design and analysis software is currently unavailable to Penn State students, consultation with faculty members for the possibility of purchasing RAM Conce*pt* has taken place.

Tasks and Tools

Research
- Gather information from peers and faculty.
- Review post-tensioned design documents.

Design Gravity System
- Design slabs, edge beams, and gravity columns by hand using ACI 318-05, Chapter 18.
- Verify designs using PCA software: ADOSS, PCA Col, and PCA Beams.

Build 3-D Model (Pending RAM Conce*pt* is purchased)
- Begin modeling gravity system in 3-D using RAM Conce*pt*.
- Input grid, gravity loads, gravity element layout.
- Resize foundations based on foundation loads.

Design Lateral System
- Verify lateral loads calculated in Technical Reports 1 & 3.
- Using Chapter 14, and referencing Chapter 21, in ACI 318, design shear walls for wind loads obtained in Technical Report 3.
- Further analyze using 3-D model built in RAM Conce*pt*.

Breadth Topic Research
- Consult peers and R.S. Means.
- Use Primavera to create a new schedule of tasks using the redesigned system.
- Re-route duct work and research a new fan.

Prepare for presentation
- Put together final report.
- Prepare Power Point slideshow for faculty presentation.

Present

Task	Week 1: 1/8-1/14	Week 2: 1/15-1/21	Week 3: 1/22-1/28	Week 4: 1/29-2/4	Week 5: 2/5-2/11	Week 6: 2/12-2/18	Week 7: 2/19-2/25	Week 8: 2/26-3/4	Week 9: 3/5-3/11	Week 10: 3/12-3/18	Week 11: 3/19-3/25	Week 12: 3/26-4/1	Week 13: 4/2-4/8	Week 14: 4/9-4/15	Week 15: 4/16-4/22	Week 16: 4/23-4/29
Research									SPRING BREAK							
Design Gravity System																
Build 3-D Model																
Design Lateral System																
Breadth Topic Research																
Presentation Preparation																
Present																
Review/Reflect																

BREADTH TOPICS

Two topics in non-structural disciplines will be studied during the redesign of the framing system of Gateway Plaza.

Construction Management: Since the post-tensioned concrete framing redesign will have a significant impact on scheduling, a detailed study of these changes will be performed. Using scheduling software, such as Primavera, a new schedule will be created and using estimating software, such as MC2, a new cost estimate will be compiled. The overall timetable, coordination of trades, and other factors will be considered in this study in order to determine the constructability of the redesign.

Mechanical: With the increased push in conserving energy, a smaller floor depth may allow for a more efficient layout of ductwork. Thus, new ductwork will be laid out and if possible, a new, smaller, fan will be selected. These changes are aimed at making the air circulation system more efficient. With the expected gain in efficiency, sustainability will be studied by comparing the new design with LEED standards.

CONCLUSIONS

At the conclusion of this semester's studies, a comprehensive understanding of all of the building systems in Gateway Plaza should be obtained. After having completed the existing conditions studies in the Fall Semester, a substantial amount of knowledge will be transferred to the Spring Semester when redesigns will begin. The redesign selected, a transformation from composite steel to post-tensioned concrete slabs and beams, will provide me with a great deal of knowledge that otherwise would have not been obtained during my collegiate studies. Post-tensioned concrete design is one of the most utilized structural systems in areas with height restrictions, and my studies will provide invaluable experience for entering the corporate world.

Additionally, the breadth work studies will provide a broader sense of the impact that structural design has on the other building systems. When these other systems are the most important aspects in a design, perhaps for LEED ratings, this understanding and how to better accommodate the other systems will make this experience invaluable.

By the end of the Spring Semester, I hope to have gained a better understanding of structural and all of the building systems.