PROJECT PROPOSAL

ORCHARD PLAZA

AE SENIOR THESIS

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EXECUTIVE SUMMARY

Orchard Plaza is a six story office building with street level retail on the ground and first level. The building is located in southwestern Pennsylvania on the corner of two streets in an urban environment. Completed in 2006, Orchard Plaza is also a LEED Certified building.

The structural system elements include a foundation of caissons, grade beams, and slabs on grade. The site of Orchard building slopes upward from the ground floor on the eastern side to the first level on the western side. Because of this difference in grade, a concrete retaining wall is found along the western half of the building. The gravity system comprises of a system of W-shape beams, girders, and columns that carry all vertical loads to the caissons. The lateral resisting system is composed of six eccentrically braced steel frames that are evenly distributed to resist both North-South and East-West forces.

The façade is composed of four major materials. At its base, Orchard Plaza is wrapped in a limestone veneer that extends up to the second or third level. Next, red-orange brick veneer is found between levels two and five. The sixth level is wrapped in sleek metal paneling, proving a modern crown to the building. All glazing is green in color and gives the building a very contemporary appearance.

PURPOSE

The purpose of this document is to provide a detailed overview of the existing Orchard Plaza structure as well as propose an alternative lateral and façade system that is anticipated to lower fabrication costs of the lateral system as well as bring even more daylighting into an already open office floor plan.

BUILDING INTRODUCTION

OVERVIEW

Construction of Orchard Plaza was completed in December 2006 and is located twenty miles southwest of Pittsburgh in Cannonsburg, Pennsylvania. The building comprises of six floors and is of modern design that incorporates both masonry and brick facades and square green glass windows and curtain walls. All six floors follow an identical L-shaped plan as seen in the typical plan below.

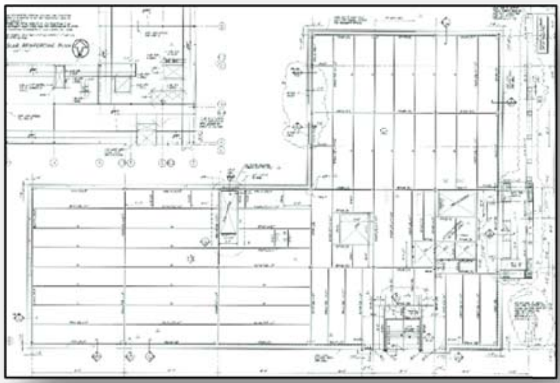


Photo credit: millcraftinv.com

STRUCTURAL DETAILS

FOUNDATION

The foundation for Orchard Plaza consists of a series of grade beams that rest on a total of forty-one caissons. Slabs on grade of varying thicknesses form the first floor with expansion joints at structural gridlines and column bases. Details of each foundation element can be seen below.

CAISSONS

Caissons ranging from thirty to seventy-six inches in diameter secure the columns to the soil. The caisson notes specify that the caisson depth must extend a minimum of one foot into limestone bedrock. Longitudinal rebar extends a minimum of ten feet below the top of each caisson.

Caisson caps serve as column base plate bolt anchors. Their height varies per column. Details of caissons and caisson caps can be seen in Figures 1 and 2 respectively.

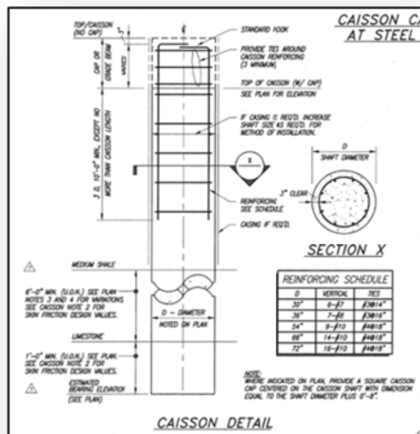


Figure 1: Caisson Detail – S0.00

Courtesy of STRADA

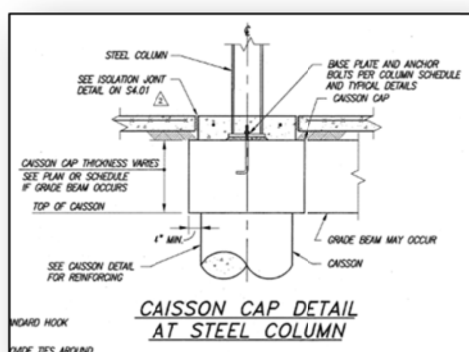


Figure 2: Caisson Cap Detail –S0.00

Courtesy of STRADA

GRADE BEAMS & SLABS ON GRADE

Grade beams of widths varying from eighteen to thirty-two inches and depths up to three feet provide a grid of foundation between most columns. Slabs on grade with expansion joints between grade beams and slabs on grade and between adjacent slabs compose the first floor (ground floor) of the building. Figure 3 shows the interaction of the grade beams with the caisson caps/column bases and the slabs on grade.

Figure 4 shows an example of the relationship of expansion joints to the slabs on grade, grade beams, and column bases.

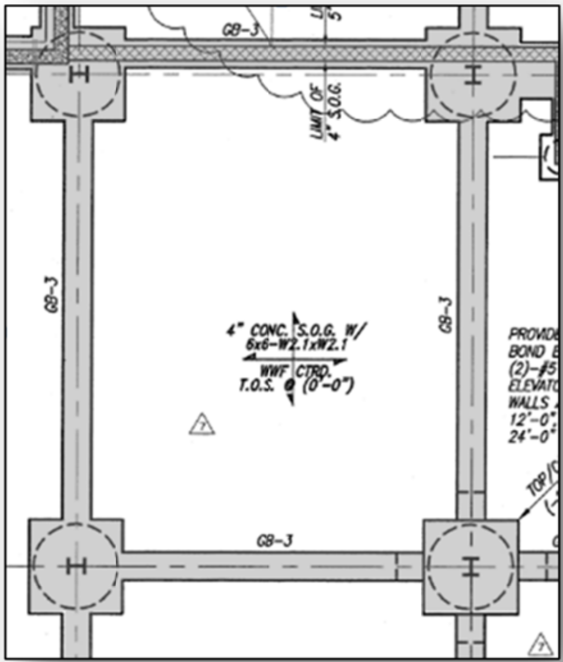


Figure 3: Grade Beams – S1.00

Courtesy of STRADA

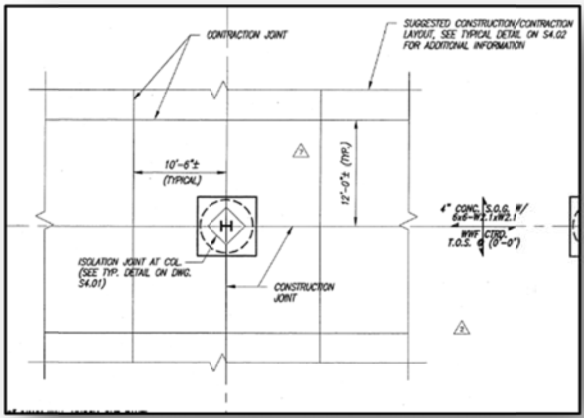


Figure 4: Expansion Joints – S1.00

Courtesy of STRADA

SLAB REINFORCING

Slabs on grade are reinforced with welded wire fabric placed between one and one and one-half inches below the top of the slab. Special reinforcing rebar is added around slab openings as seen in Figure 5. Rebar extends multiple feet beyond the slab opening edge and is accompanied by a diagonal bar at opening corners.

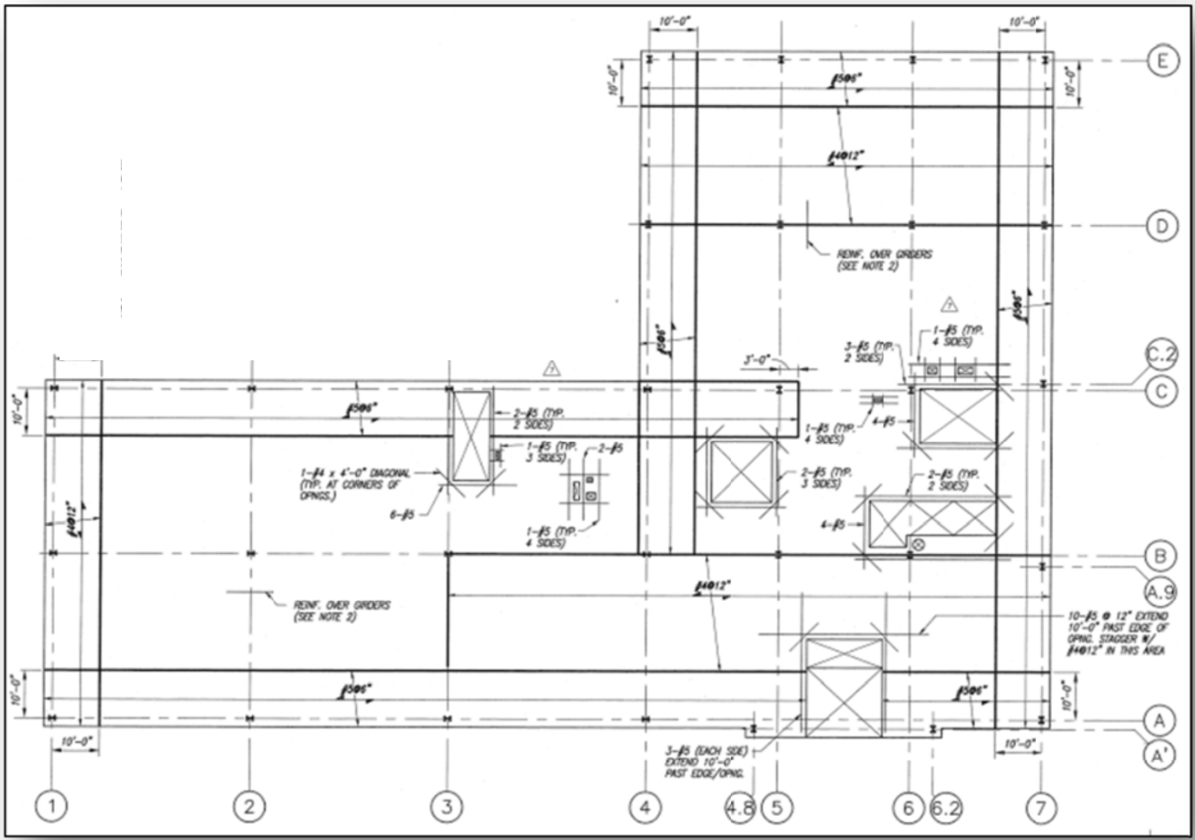


Figure 5: Slab Reinforcing Plan – S1.01

Courtesy of STRADA

FOUNDATION WALL

Due to the grade change over the building's site, there is a one story change in elevation over the site beginning on the western side at the first floor and raising up to the second floor on the eastern side. In order to accommodate this change while maintaining the entire first floor for usable space, a cast-in-place concrete wall is used on the north, east, and south exterior walls. The location of this wall is highlighted in green below in Figure 6.

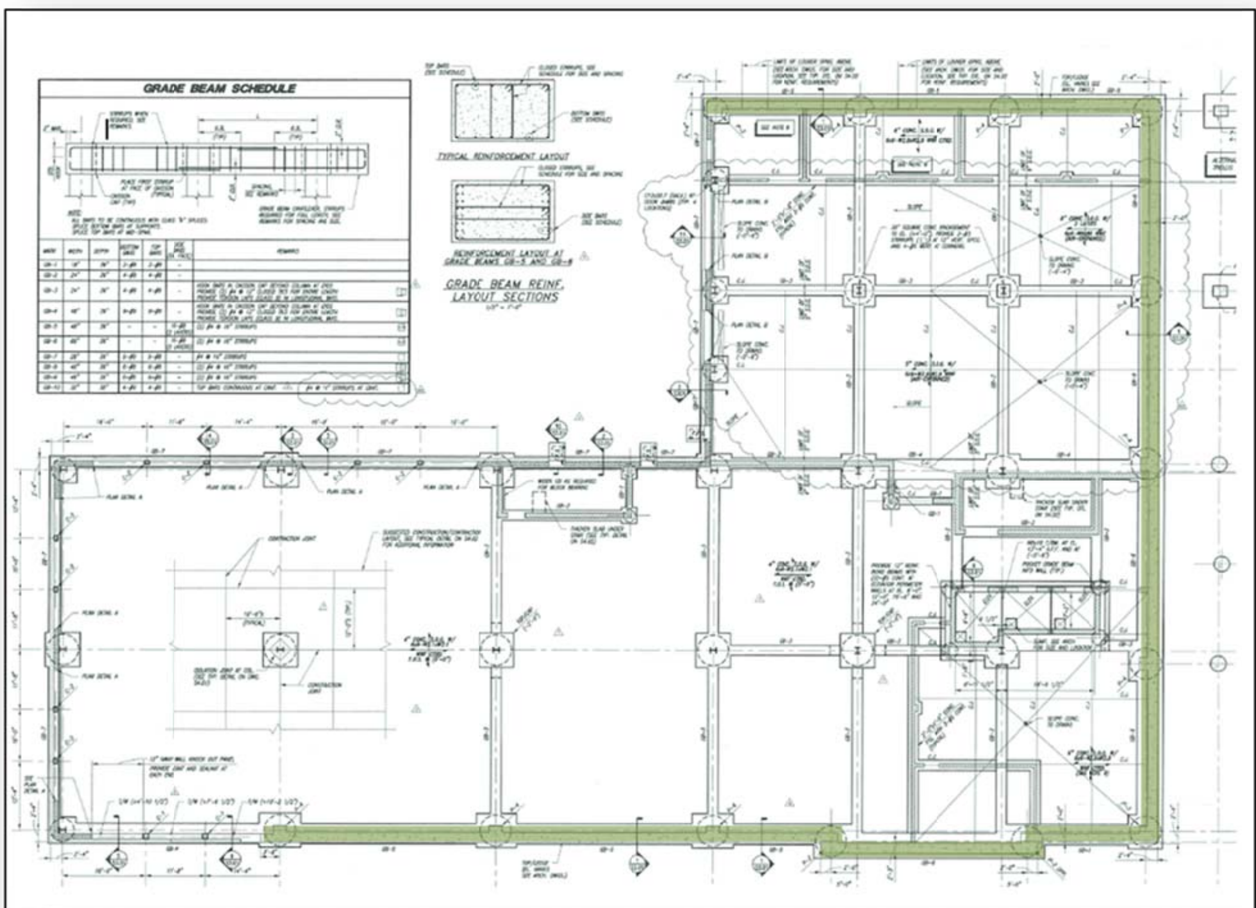


Figure 6: Foundation Plan – S1.00

Courtesy of STRADA

FLOOR FRAMING & TYPICAL BAYS

Typical floor framing consists of beams and girder construction of varying sizes. Figure 7 shows a typical beam and girder layout for the first floor. Floors two through six follow a very similar design. Beams range in size from W16x31 to W21x44 while girders vary from W24x68 to W 30x99 with exceptions for both beams and girders surrounding floor openings .

Figure 7: First Floor Framing Plan – S1.01

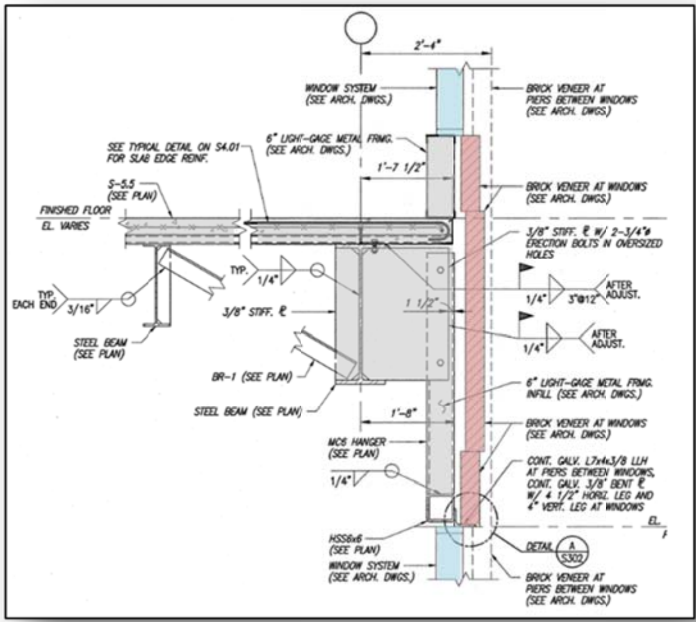
Courtesy of STRADA

35' x 42' Bay area coverage

35' x 28' Bay area coverage

FLOOR SYSTEM DETAILS

Floors two through five utilize a composite decking system comprised of normal weight concrete, two inch 18 gauge composite decking, and welded wire framing placed one inch from the top of the slab. Where exterior brick veneer requires support, deeper beams run the length of the exterior with 3/8" plate welded perpendicular to of the beam. A system of HSS tubing, shims, and angle form the brick veneer support while an angle brace runs up to the beam behind (Figure 8) or is joined directly with a double angle connection (Figure 9). Similar connections are done for masonry veneer facades on the lower floors. Some exterior edges also include small cantilevers.



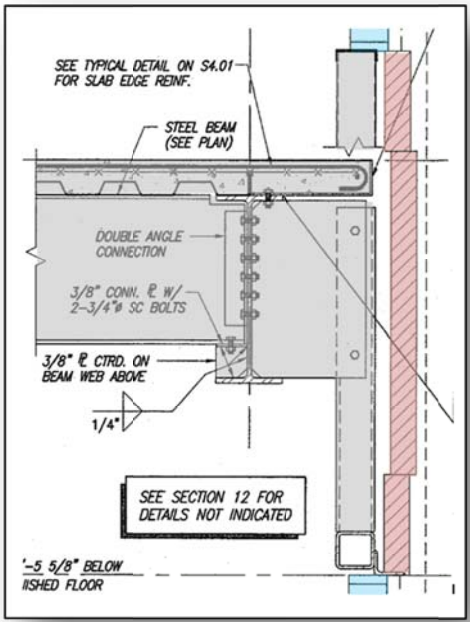


Figure 8:

Floor to Exterior connection with brace – S3.02

Courtesy of STRADA

Figure 9:

Floor to Exterior connection– S3.02

Courtesy of STRADA

COLUMNS

All columns rest on caissons or grade beams as described earlier. Column base plates are typically mounted to caissons with four anchor bolts as shown in gray in Figure 10. Additional base plates and anchor bolts are added are added for any base joints with the lateral system (shown in blue in Figure 11).

Column splices occur four feet above the floor slab of the first, third, and fifth floor unless required to be at a different height to avoid brace connections. Base columns range from W14x99 on the exterior to W14x257 on the interior. See Appendix A for column schedule.

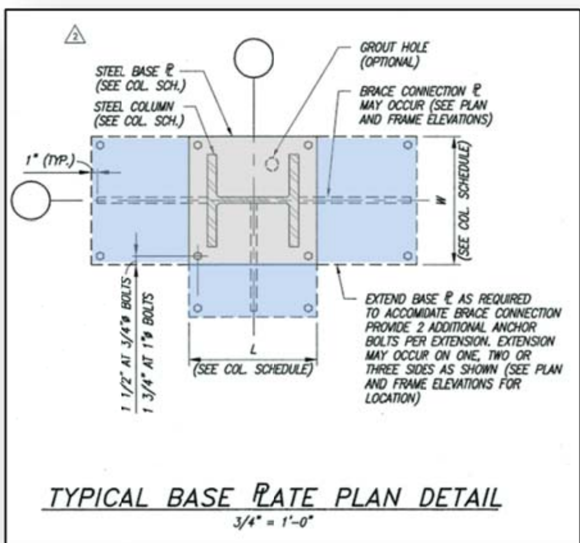


Figure 10:

Typical Base Place Elevation – S2.02

Courtesy of STRADA

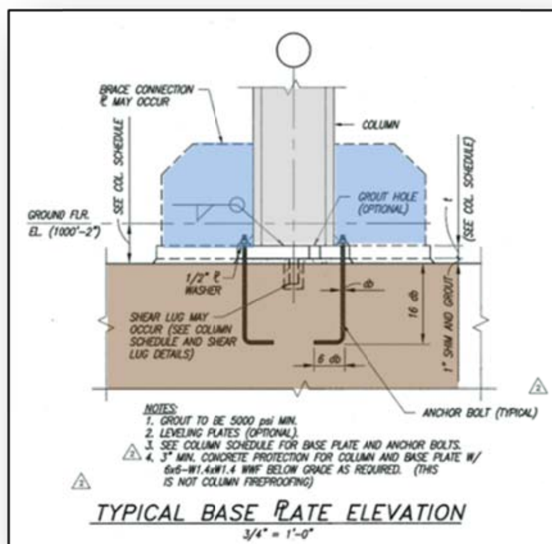


Figure 11:

Typical Base Place Plan Detail – S2.02

Courtesy of STRADA

GRAVITY LOADS

A complete estimate of the building's gravity loads can be found in Appendix A

Dead Loads	
Description	**Load (psf)**
Ceiling + Misc. Mechanical	15
Roofing	11
Exterior Walls (Exterior Surface Area)	56
Floor Slab - Level 1	72
Floor Slab - Levels 2-6	66

Live Loads	
Description	**Load (psf)**
Lobbies & Corridors	100
Office Areas	80
Main Corridors Above Ground Level	80
Electrical & Mechanical Rooms	200
Stairs & Landings	100
Light Storage	125
General File Areas	175
Heavy Storage	250
Roof Live Load	30

Snow Loads	
Description	**Value**
Ground Snow Load P_g	25 psf
Flat-Roof Snow Load P_f	18 psf
Snow Exposure Factor C_e	1
Snow Importance Factor I_e	1
Thermal Factor	1
Wind Directionality Factor K_d	0.85

LATERAL SYSTEM

The primary lateral load resisting elements are moment frames formed from W-shape beams and HSS tubing. The location of all moment framing elements is shown in blue in Figure 12 below. The orientation of these frames is distributed evenly between the north-south and east-west direction to adequately accommodate lateral loading from any direction.

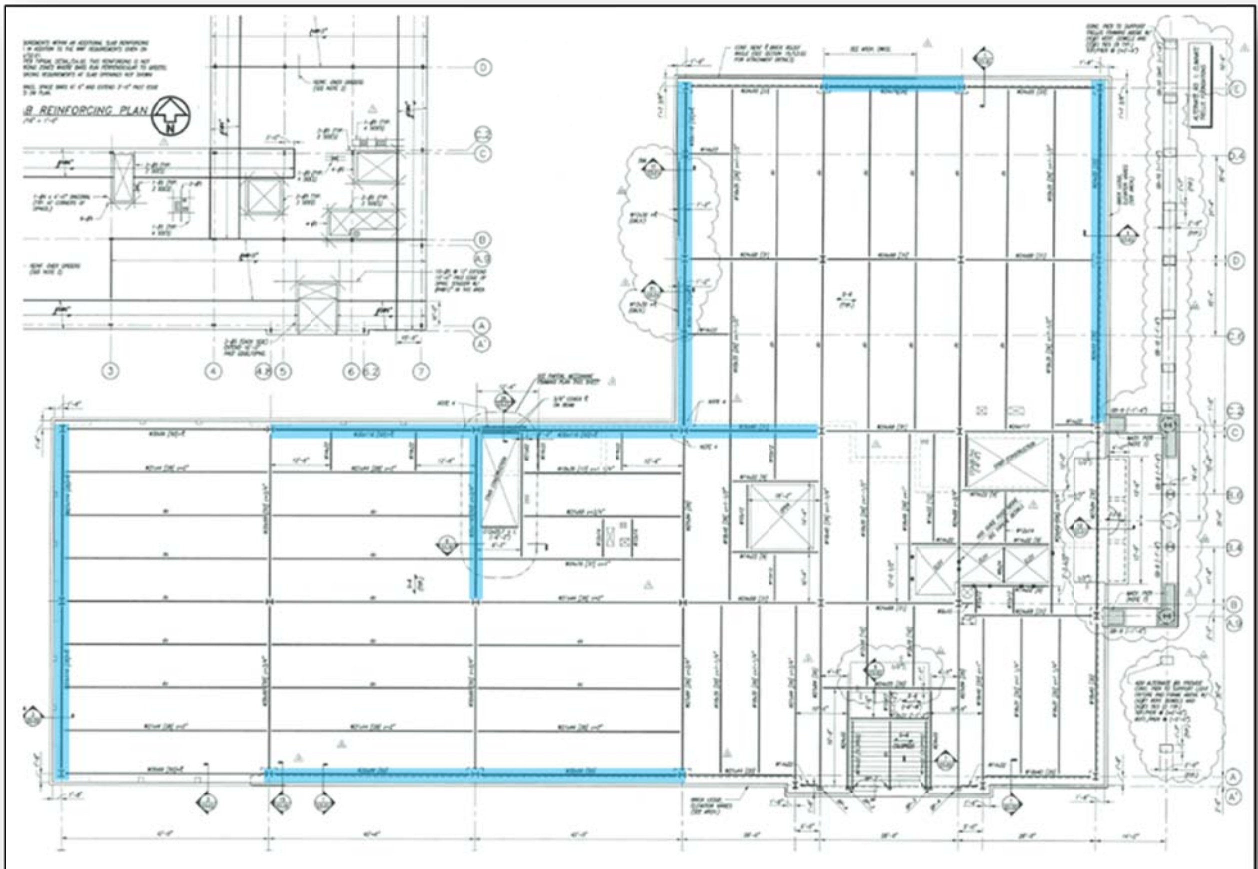


Figure 12: First Floor Framing – S1.01

Courtesy of STRADA

Lateral frame connections are characterized by welded plates at both ends of the HSS tube, shown in purple, and are welded to columns and girders as seen in Figure 14 below. This connection requires a significant amount of prefabricated welding and field welding. Stiffener plates must also be added on both sides girder webs at the upper connection of the HSS tube and respective connection plate.

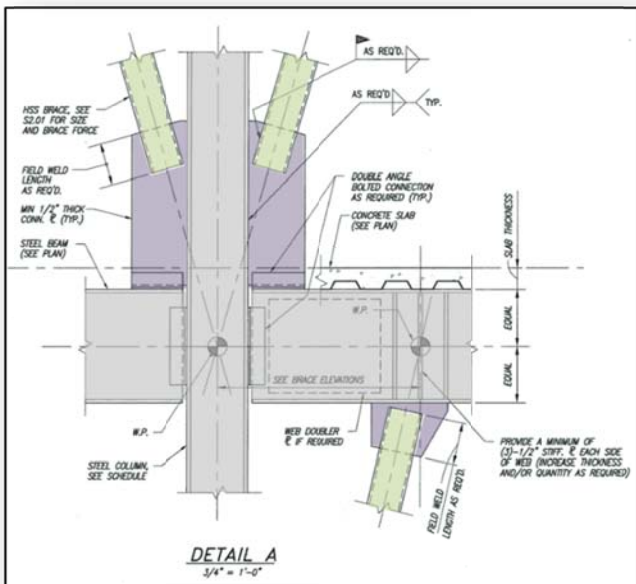


Figure 14: Interior Lateral Frame Joint– S2.02

Courtesy of STRADA

LOAD PATHS

This document will describe how the structure and its respective elements floor (live & dead), wind, earthquake, roof, snow and uplift loads. Diagrams of load paths are included for visual illustration while their respective design loads can be found in Appendix B.

ROOF LOADS

The roof is of typical flat beam and girder construction with 30psf live load minimum consideration. The roof includes three concrete pads for mechanical equipment and elevator housing which are highlighted in red in Figure 15 below. These additional loads require much larger beams and girders around the pads which then transfer the loads directly into interior columns uninterrupted into the foundation.

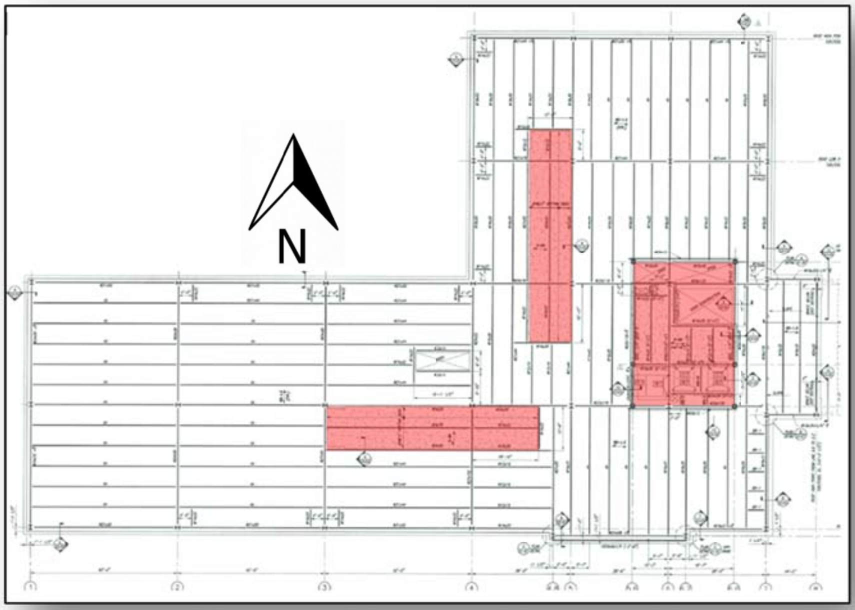


Figure 15: Roof Framing Plan – S1.07

Courtesy of STRADA

SNOW LOADS

Snow build-up is of primary concern around the rooftop equipment and under and canopies. Various snow loads were considered for this structure but have not been calculated in detail for this report. Specifics regarding snow load design can be found in Appendix B

WIND LOADS

The lateral moment frames constitute the majority of wind resistance framing in the building. It is expected that horizontal forces like those pictured with blue arrows below in Figure 19. The expected direction of forces on the base plates are shown with orange arrows. The frames are distributed, though not proven yet with calculations, appropriately so that most floor bays share at least one edge with one of the moment frames (See Figure 12). This layout provides for a more stable structure as there are no large areas without lateral resistance. Symmetry in the frames allows them to act equally effective regardless of wind direction (from left vs. from right in Figure 17).

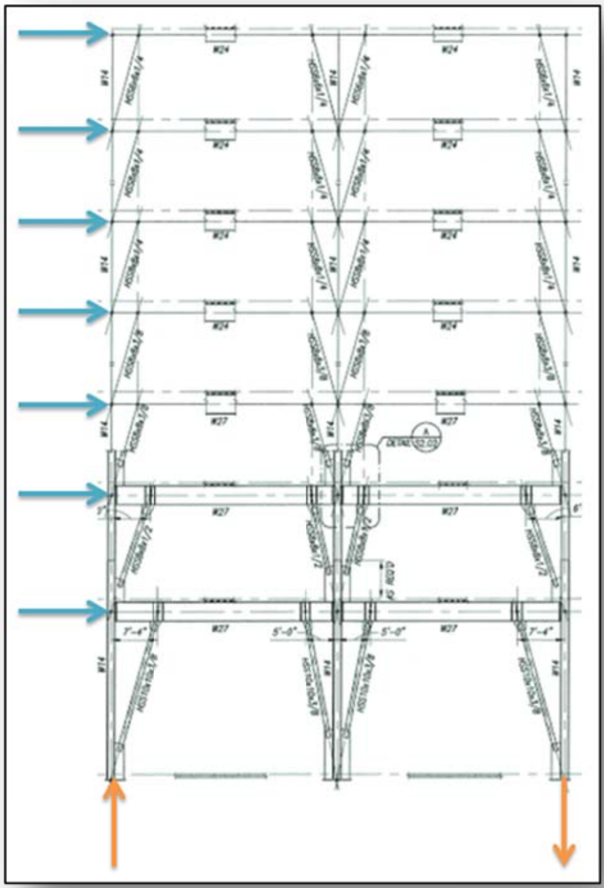


Figure 17: Line 1 Lateral Frame – S2.01

Courtesy of STRADA

PROBLEM STATEMENT

After analyzing the gravity system, lateral system, and loading factors the structure of Orchard Plaza was found to be acceptable under the codes used for design. Since no critical structural improvements are necessary, the structure will be modified for aesthetic and architectural enhancement and analyzed to ensure practicality and cost effectiveness.

The existing floor system is comprised of composite beams and girders. This system is very viable for material cost control and strength. One downside of this system is that mechanical and electrical systems must pass below the solid floor gravity system. This leaves a void of unused space between the floor decking and beams and girders. An additional dropped acoustic ceiling tile grid is hung below all the mechanical systems.

As mentioned in the structural overview, Orchard Plaza's existing lateral system is comprised of six main eccentrically braced frames. While structurally sufficient and an efficient use of steel, the frames are not as easy to construct as their counterparts, concentrically braced frames.

To mitigate some of these construction and space utilization concerns, alterations will need to be made to the existing gravity and lateral systems. It is believed that an alternate bracing method will be easier to install and lower in cost.

PROPOSED SOLUTION

A solution to the integration concern between the floor gravity system and the mechanical and electrical components is to use a joist system for the floor. Joists allow for ductwork and conduit to pass through the depth of the floor structure. This would be done in order to maximize space utilization and integration between floors. This should allow for the acoustic ceiling grid to be hung slightly higher, providing a more open workspace.

The gravity system will be modeled using the two typical bay sizes of 35′ x 42′ and 35′ x 28′ to determine if additional girders to control the depth of the joists. With the intention of raising the acoustic ceiling grid, controlling the depth of the joists is critical. The column layout is planned to remain the same as the existing structure but column sizes and strength will be analyzed and modified as necessary.

The lateral system will be changed to concentrically braced frames to increase stiffness. This increased stiffness will be used to help convert some of the two bay braced frames into one bay in order to decrease material and construction costs. Individual bays will be analyzed using RISA to compare structural effectiveness and full height frames will be analyzed in ETABS to determine overall drifts and deflections. The choice to use concentrically braced frames has aesthetic reasoning as well that is detailed in the architecture breadth.

BREADTHS

ARCHITECTURE

It is proposed that the existing and primarily masonry façade will be changed to a curtain wall. The existing structure was designed to provide an open workspace, so it seems logical to further provide an inviting work environment by utilizing a curtain wall system. This new system would also expose the lateral system. The proposed concentrically braced frames would provide a dramatic architectural feature. Integration of the curtain wall with the new floor joist system will also be considered.

DAYLIGHTING

With the introduction of a new curtain wall system and a much higher amount of daylight entering the space, an analysis will be performed to determine the natural light paths throughout the year and proposed systems to mitigate excess sunlight when necessary. Factors such as glazing type and shading devices, both active and passive, will be discussed. Once all factors influencing natural lighting on Orchard Plaza are researched, an ideal system will be proposed as well as details for integrating relevant systems into the space.

TASK LIST

Task 1- Redesign floor system and loading

- Use Vulcraft catalogue to size and specify joists using known load values
- Determine if additional girders are needed

Task 2 – Integration of MEP with new joists

- Research integration tools and techniques with joist systems
- Outline and detail integration of systems with joists
- Provide conceptual model of improved raised ceiling grid

Task 3 – Write up gravity system modifications in report

Task 4 – Redesign Lateral system

- Individual bay analysis in RISA
- Full frame comparison in ETABS
- Detail member selections

Task 5 – Cost analysis of Gravity and Lateral systems

- Compare redesigned systems with existing and include in report

Task 6 – Write up lateral system modifications in report

Task 7 – Architectural Breadth

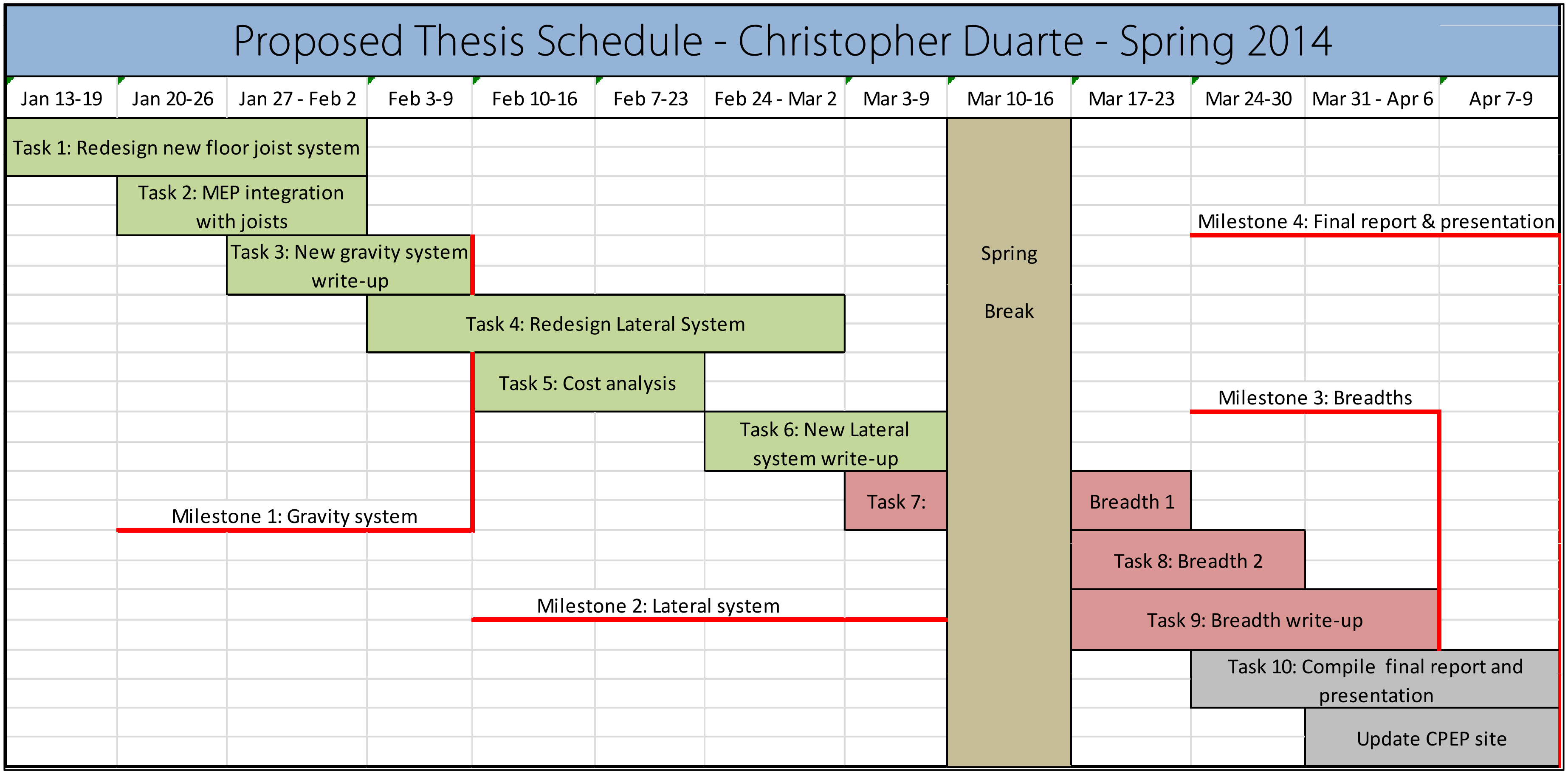
- Determine ideal curtain wall system
- Create model that shows the concentrically braced frames as new architectural features

Task 8 – Daylighting Breadth

- Analyze sun paths on building site
- Research and select best active and passive means of controlling daylight entering the workspace

Task 9 – Include Breadth topics in report including cost analysis

Task 10 – Compile Final report and presentation


Proposed Thesis Schedule - Christopher Duarte - Spring 2014
Jan 13-19
Jan 20-26
Jan 27 - Feb 2
Feb 3-9
Feb 10-16
Feb 7-23
Feb 24 - Mar 2
Mar 3-9
Mar 10-16
Mar 17-23
Mar 24-30
Mar 31 - Apr 6
Apr 7-9
Task 1: Redesign new floor joist system
Task 2: MEP integration with joists
Task 3: New gravity system write-up
Task 4: Redesign Lateral System
Task 5: Cost analysis
Task 6: New Lateral system write-up
Task 7:
Milestone 1: Gravity system
Milestone 2: Lateral system
Spring
Break
Breadth 1
Task 8: Breadth 2
Task 9: Breadth write-up
Task 10: Compile final report and presentation
Update CPEP site
Milestone 3: Breadths
Milestone 4: Final report & presentation

CONCLUSION

While the existing structure was found to be adequate, the proposed modifications look to reduce the complexities of the lateral system and stud installation of composite decking for a more modular system of joists and girders and simpler concentrically braced lateral system. By modifying the façade to a full curtain wall, the exposed lateral system will then become an architectural feature. With hopes of being able to integrate some MEP systems with the new joists, a higher ceiling will be achieved. The combination of the curtain wall and raised ceilings will add to an already enjoyable open workspace.