FDA OC/ORA Office Building

Silver Spring, MD

Thesis Proposal

Adam Love

Structural Option

AE Consultant: Dr. Hanagan

December 15th, 2009

Table of Contents

Executive Summary

The proposed thesis will include a feasibility study with the design of progressive collapse beams to include the design of post-tensioning. It is intended to redesign the lateral system to include the existing shear walls and the addition of exterior moment resisting frames. The exterior moment resisting frames are going to be designed with post tension beams to increase the capacity with a smaller cross section. The exterior beams must also meet progressive collapse standards, provided post tension design is acceptable for progressive collapse design. The purpose of this thesis is to learn the concepts of progressive collapse design as well is integrating post tension design into the design of progressive collapse elements.

An advanced computer modeling techniques will be used to model the FDA OC/ORA Office building. Using ETABS and ADAPT to model various parts of the lateral system, and the building diaphragm the models can be used to determine the characteristics of the building under various loads. ETABS will be used to model the entire building to development the lateral system responses under loading. An ADAPT model will be researched and developed to model the building's post tension members.

The impact on the cost and schedule of the overall project will be performed to determine the feasibility of the change in the lateral systems. The scheduling changes that would involve the additional construction time for the jacking of the post tension strands will be considered and compared to the existing system.

Also an architecture study of the building façade will be performed to revaluate the façade with architecture precast panels. The benefits of using precast panels are quality control, construction time. The change to precast panels would most likely increase the lead time but also increase construction time as well as quality control on the construction site.

Introduction

Starting the fifth phase of the consolidation efforts by the FDA, the OC/ ORA Office building plans to move the Office of Commissioner (OC), Office of Regulatory Affairs (ORA) Office building to the White Oak Campus. On the site of the former US Navy facility at the Federal Research Center- Naval Ordnance Laboratory, the OC/ ORA Office Building sits on the southern end, and forms its shape around the existing buildings.

Forming an S shaped building, the 500,000 S.F. office building was laid out and designed to mirror the existing buildings on the site and to form a unique face of the campus from the main drive off of New Hampshire Ave. Broken up into two buildings with four wings, Building 31 is comprised of Wing A, and Building 32 is comprised of wings B through D (Figure 1)

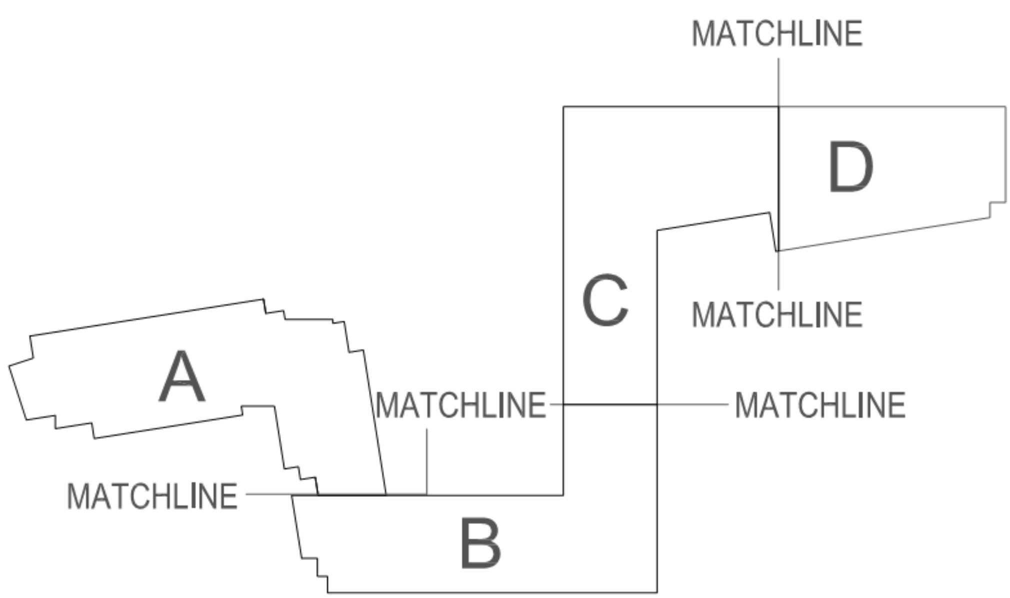


Figure 1: Key Plan

Structural System

Foundation:

The foundation of the building is separated into two categories. Spread footings that bear on undisturbed soil or spread footings that sit on a number of Geopiers. Schnabel Engineering conducted soil test to determine the bearing capacities of the soils. Where 95% compaction could not be met the use of Geopiers or vibropiers was recommended.

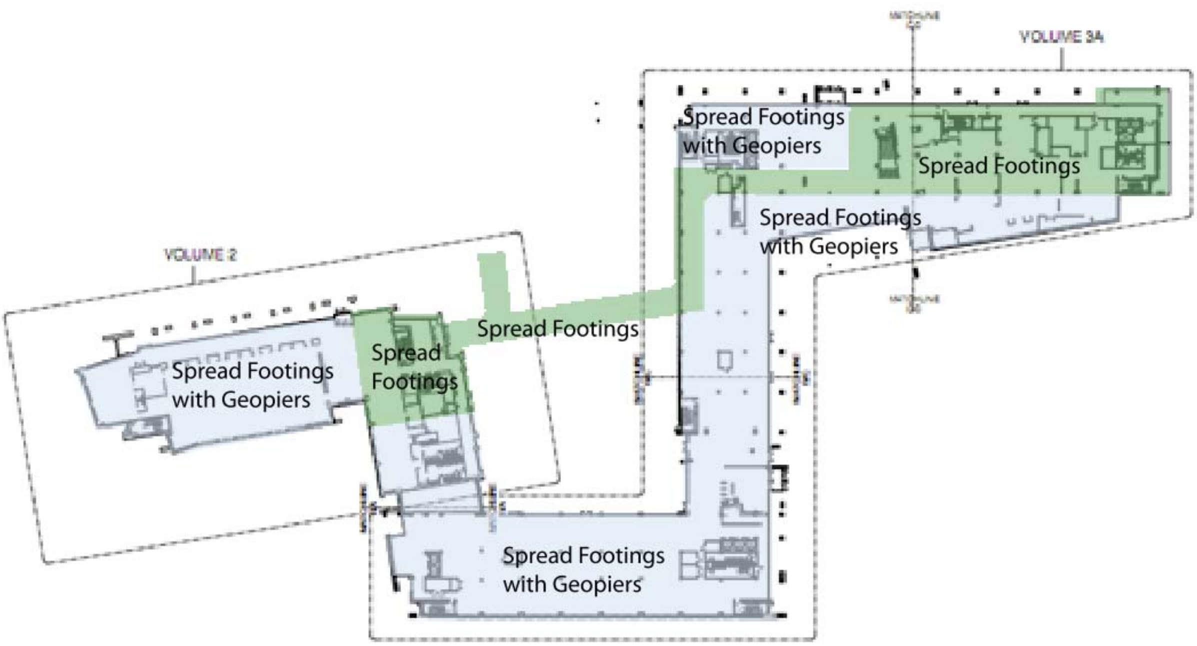


Figure 2: Foundation Key

For non-basement areas of Building 31 (Wing A), the western and central wings (Wings B and C) of Building 32, and the non-basement areas of Wing D, deep existing fill is expected within the majority of the buildings footprint. Geopiers are to be used in these areas to provide adequate bearing capacity (Figure 2). Geopiers use the concept of over consolidation to increase the soils bearing capacity. The 30 inch diameter Geopeirs should reach a depth of at least 10 feet. A detail of the typical spread footing with Geopiers is shown in Figure 3.

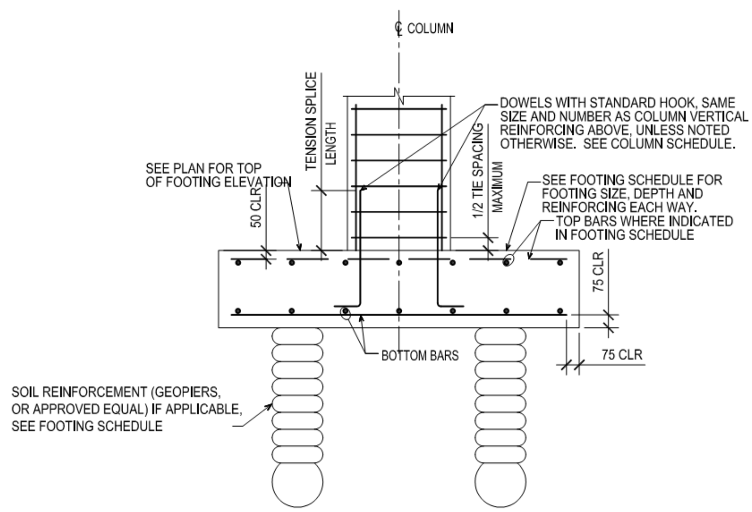


Figure 3: Typical Geopier Foundation Detail

For the basement level of Building 31 (Wing A), the basement level of Wing D of Building 32, and the underground tunnels, the foundations reach a sufficient depth where the bearing capacities on the spread footings are adequate (Figure 2).

Normal weight concrete was designed to be used with all the spread footings of the foundations. With a unit weight of 2350 kg/m^3 (147 pcf), the concrete has a 28 day strength of 28 MPa (4061 psi) concrete. A water to cement ratio of .48 is specified along with only 1% maximum chloride content.

Schnabel Engineering recommended the use minimum safe bearing capacities at the different locations of the foundation system. Where spread footings bear on undisturbed soil a bearing capacity of 192 kPa (4010 psf) was estimated. Beneath the spread footings of Wing A, where Geopiers were used, the estimated bearing capacity is 192 kPa (4010 psf). In the sections of Building 32 where Geopiers were used, a bearing capacity of 287 kPa (5994 psf) was estimated.

Floor System:

Building 31:

Building 31 utilizes a one way slab floor system for the majority of the buildings layout. The typical one way slab construction is an 8.07 inch thick slab with 5.91 inch drop panels, unless noted differently on the drawings. On the first three floors of Wing A there is a large open assembly space, and prevents any typical bay spacing. However, on the fourth floor the typical bay spacing is 21.85' x 26.74' to 19.685' x 19.685'.

Resistance to progressive collapse was designed into the exterior reinforced beams of building 31. Typical progressive collapse beam sizes range from 23.62" x 42.32" to 18.11" x 35.43". The interior beams on Building 31 are reinforced concrete beams with typical sizes of 18.11" x 35.43" to 18.11" x 23.62".

A large assembly pace on the first floor of Wing A is open up through the third floor. On the fourth floor framing level, post tension transfer girders were designed to support the column loads above the fourth floor and transfer the load to the foundation (Figure 4). The post tension transfer girders are 35.43" x 70.89" and have a post tension strand force of 4540 kN.

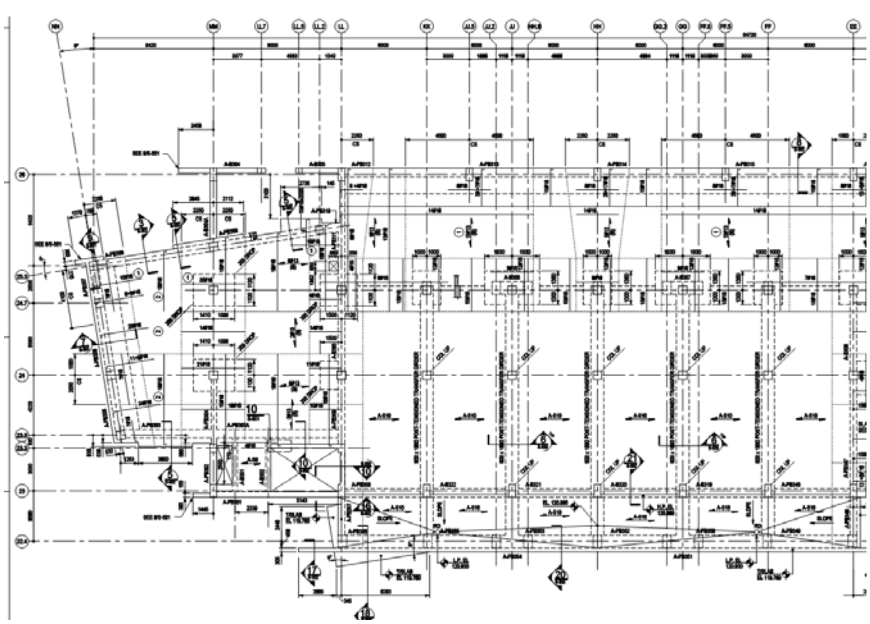


Figure 4: Framing Flan for Post Tension Transfer Girders

An atrium is provided between Wing A and Wing B that is primarily a steel superstructure with lightweight concrete on metal deck (Figure 5). The walkways over the atrium connecting the two wings are cast in place lightweight concrete on steel metal deck. The rib height on the metal deck is 50 mm with an additional 83 mm of concrete above. Supporting the walkway is W360 x 32.9 steel beams that frame into W360 x 32.9 girders with a shear connection. On the Wing A side of the atrium the girders site on an L152x152x9.5 that is attached to the concrete beam in Wing A. On the Wing B side on the atrium, an expansion joint is place, so the girders rest on a sliding connection that is connected to a beam in Wing B (Figure 6 and 7).

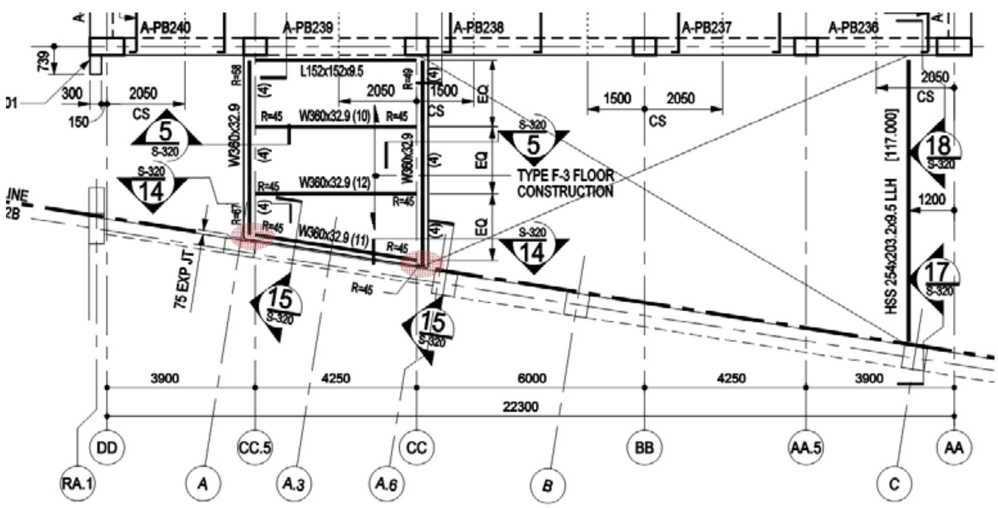


Figure 5: Wing A Atrium

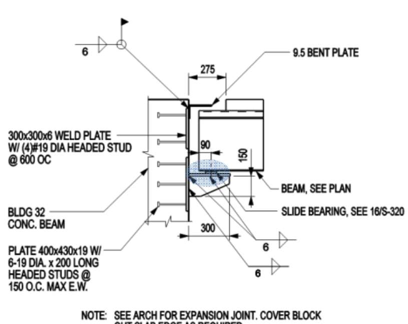


Figure 6: Expansion Joint Detail (Red)

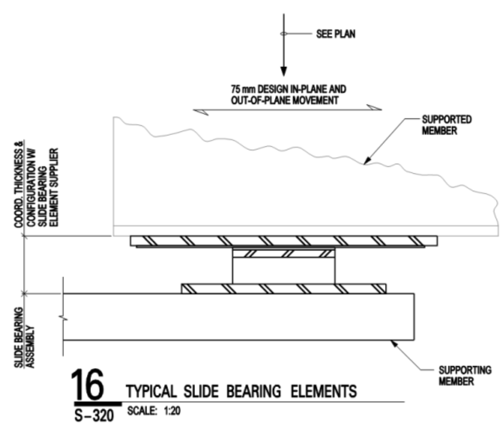


Figure 7: Expansion Joint Detail (Red)

Building 32:

Building 32 utilizes a two way flat slab system for the majority of the building's floor system. A 5.91" thick slab on grade is provided for the ground level and the basement levels of the building. The two-way flat slab is typically 9.449" thick with a 7.09" thick drop panel, unless noted differently on the structural drawings. The typical interior bay spacing for Building 32 is 29.528' x 19.685', and the typical exterior bay spacing of 27.559' x 29.528', figure 8 shows the typical layout of the bays.

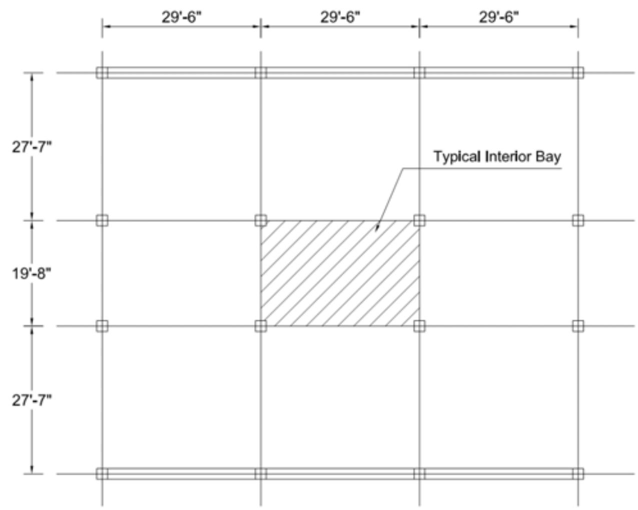


Figure 8: Building 32 Wing B Typical Bay Layout

Resistance to progressive collapse was designed into the exterior reinforced concrete beams of building 32. Typical progressive collapse beam sizes ranging from 23.62" x 40.95" to 15.75" x 40.95".

Atriums are provided between Wings B and C, and between wings C and D. The floor system for the atriums is a cast in place lightweight concrete on metal deck. The rib height on the metal deck is 1.97" with an additional 2.52" of concrete above. Supporting the walkways are W150 x 30 steel beams that frame into W610 x 217 girders with a shear connections. Expansion joints at the Intersections of the wings are provided and sliding connections are required at the atrium walkways.

Columns

Typical reinforced concrete columns were designed for the FDA OC/ ORA Office Building. Designed as the primary gravity system, the typical sizes of the columns are 600mm x 600mm, 900mm x 600mm, and 600 mm diameter. Various types of columns are provided ranging from square columns, rectangular columns and circular columns (Figure 9). The concrete for the columns is a normal weight concrete with 28 day strength of 28 MPa (4061 psi). The slab and the beams are monolithic with the columns forming a continuous system.

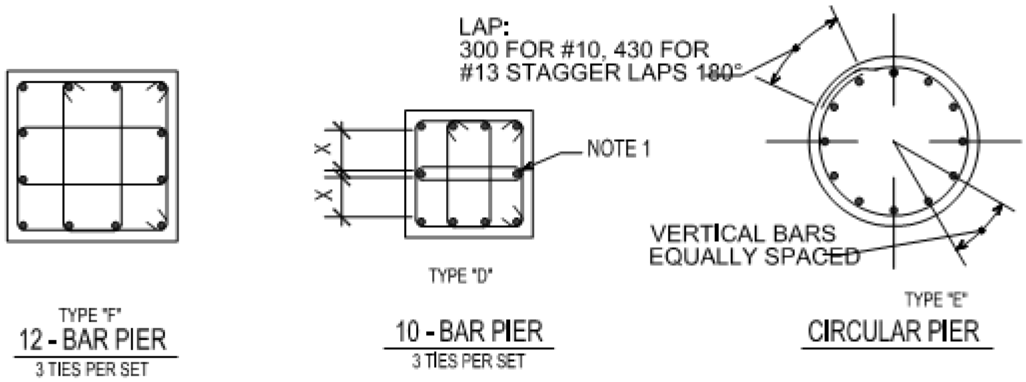


Figure 9: Typical Column Details

Lateral System

Ordinary reinforced concrete shear walls were design for the primary lateral resisting system. The typical shear wall has #16 at 300mm (#5 at 11.82 inches) for both vertical and horizontal reinforcement with 13 #16 (13 #5) for the end zone reinforcement and #13 ties at 300mm (#5 ties at 11.81 inches) for the vertical reinforcement (Figure 10 and 11).

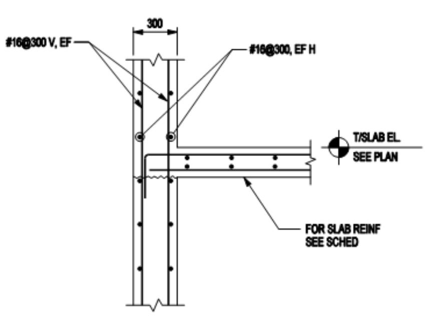


Figure 10: Shear Wall Detail

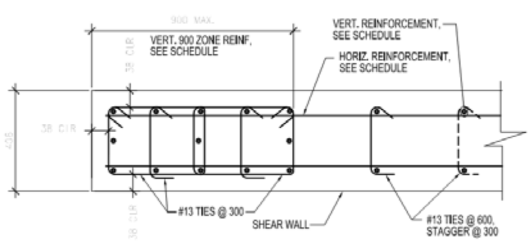


Figure 11: Shear Wall End Zone

Shear walls are provided around each elevator core and the stair shaft of Wing A. Wings B through D provide shear walls around each elevator core; Figures 16 through 19 shows the location of the shears walls in each wing, shown in red. At the intersection of each wing, in the atriums, slide bearing connections are provided at the expansion joints, shown in blue. These connections allow each wing's lateral systems to act independently of the other wing.

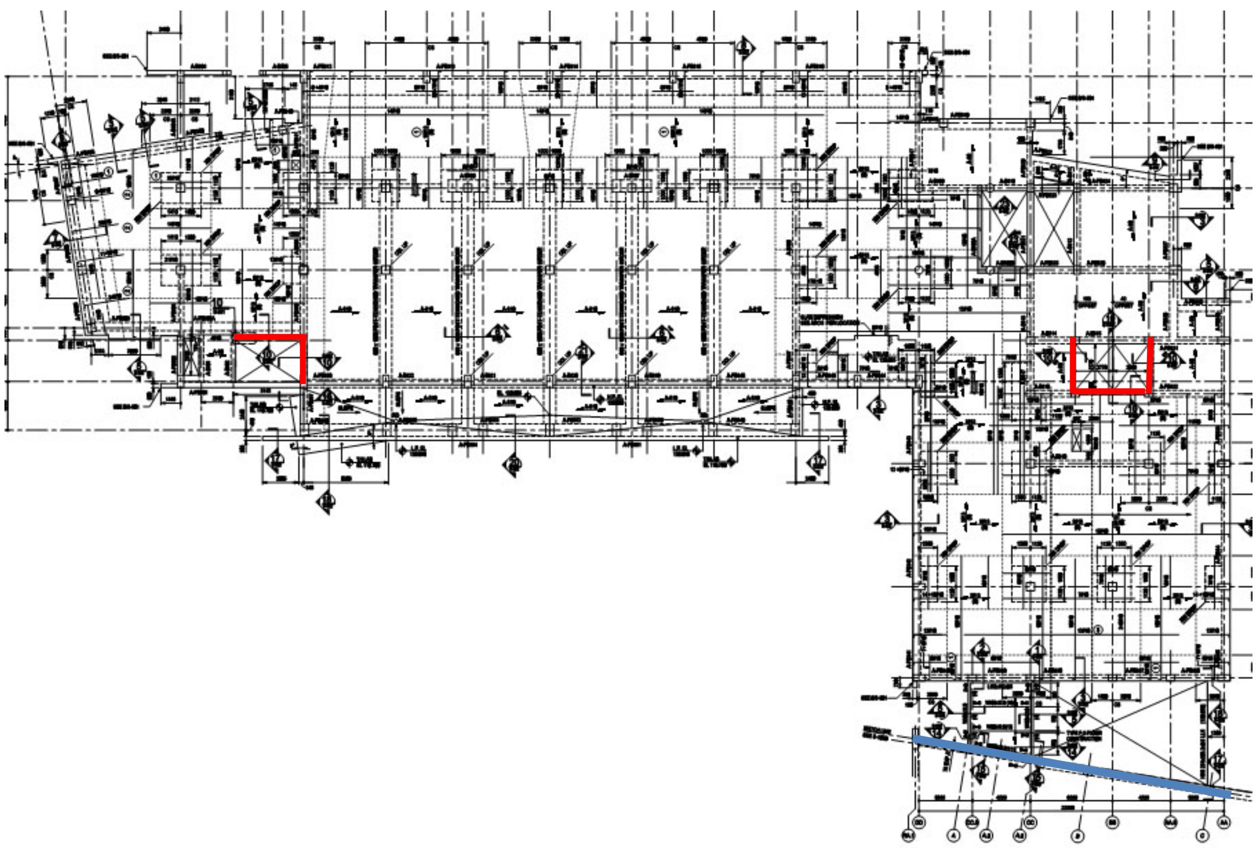


Figure 12: Shears Walls of Wing A

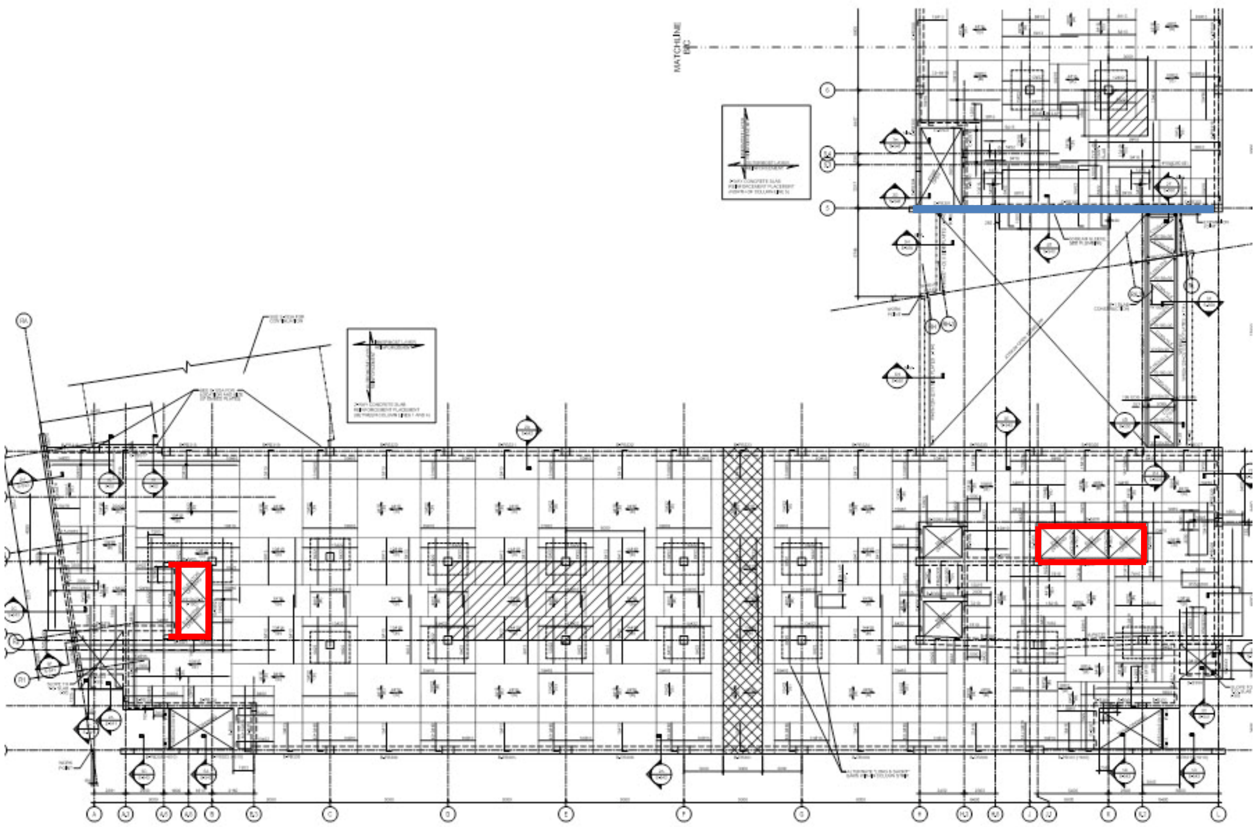


Figure 13: Shear Walls of Wing B

Thesis Proposal

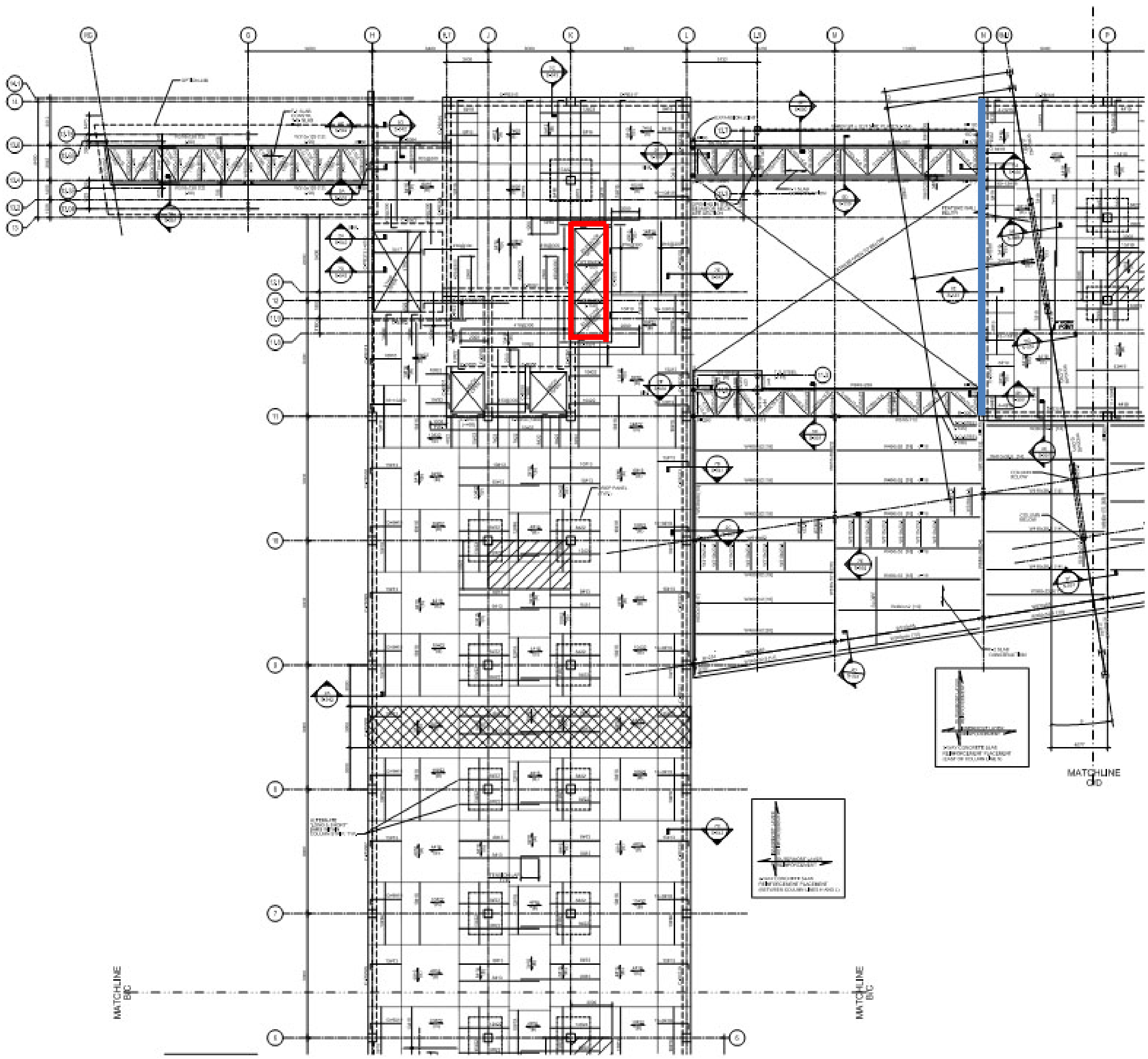


Figure 14: Shear Walls of Wing C

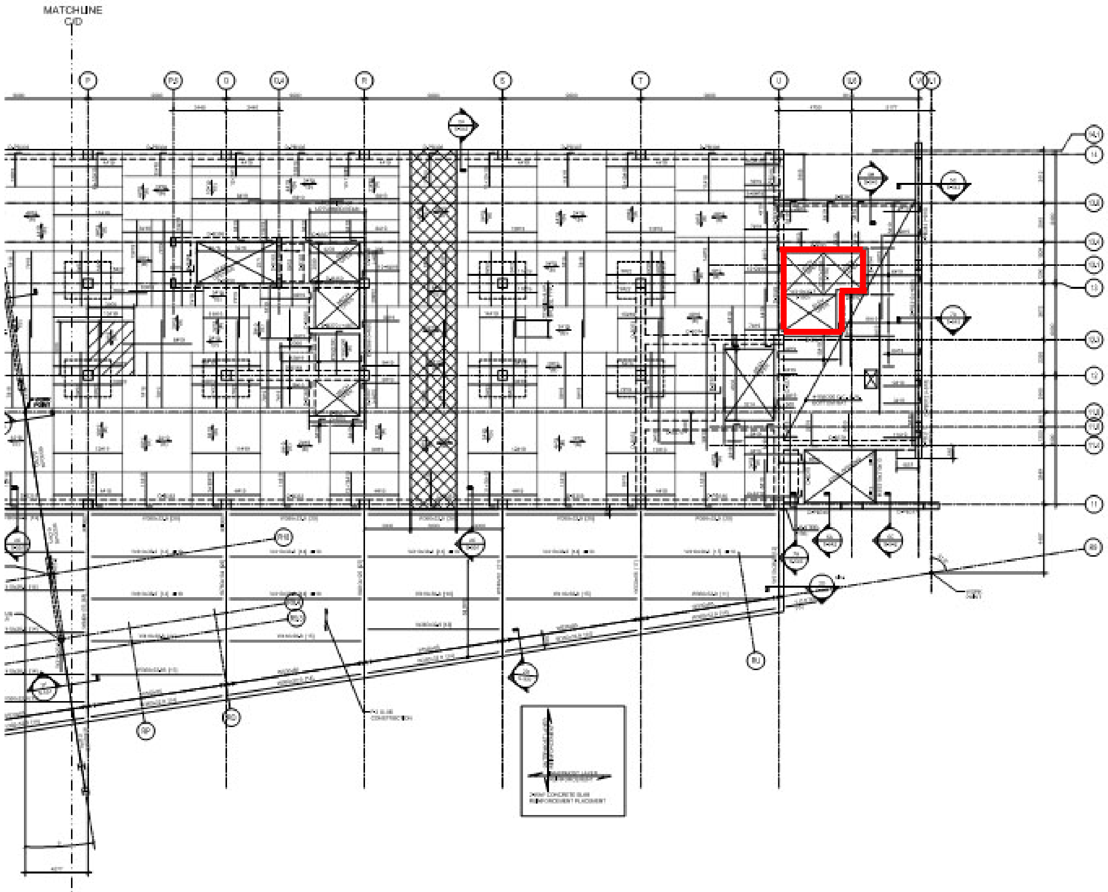


Figure 15: Shear Walls of Wing D

Proposal

Problem Statement

The FDA OC/ORA Office Building is comprised of four wings, the main focus of the preceding reports dealt with the gravity and lateral systems of Wing B. Wing B uses typical concrete shear walls as the main lateral load resisting system. The shear walls are located around the two elevator cores that are in Wing B. During Technical Report 3 it was determined that under seismic loads in the N-S Direction the deflection in the shear walls would exceed the 6 inch distance for the expansion Joints. These deflections were obtained from 2D models of each shear wall, to determine the true deflection of the building diaphragm a 3D model will be created.

Problem Solution

The FDA OC/ORA Office Building utilizes a two way flat slab system with perimeter beams. In an effort to address the deflection concerns of the shear walls, the perimeter beams and columns are going to be redesigned as moment resisting frames. The redistribution of lateral forces and additional lateral stiffness provided by the moment resisting frames, along with the existing shears walls will be evaluated.

The lateral systems will be re-evaluated to be composed of the typical concrete shear walls at the elevator cores and concrete moment resisting frames at the exterior of the building. It is also important to note that the office building is designed for resistance of progressive collapse. The addition of lateral loads to the perimeter beams will have to be designed to meet progressive collapse requirements. The main purpose of the redesign of the lateral system is to gain further knowledge in the design of structures with the resistance to progressive collapse.

The first step in the redesign of the lateral system is to redistribute the lateral loads determined by ASCE 7-05 to the existing concrete shear walls and the proposed concrete moment resisting frames. The concrete moment frames will be designed using the Gravity and Lateral Loads obtained from ASCE 7-05, using the critical load case to design the perimeter beams and columns. Once a preliminary design is obtained, the deflection requirements will be checked. Provided the deflection criteria are met, the design of the moment frames for the requirements of progressive collapse will be researched and carried out. As a proposed method to design for progressive collapse, the design of post tension progressive collapse beams will be researched in a feasibility study. If the study determines that post tension design is adequate for progressive collapse requirements, the exterior moment resisting frames will be designed with post-tensioning. Alternately if the study yields post tension does not meet the requirements for progressive collapses the moment frames will be redesigned using reinforce concrete. Both methods will provide the detailed analysis and design of structures to resist progressive collapse.

Graduate Course Integration

Using a comprehensive 3D model to determine the actual drift of the building will be compared to the individual drift of the shear walls that were obtained from Technical Report 3. ETABS will be used to model two separate buildings. The first, 3D model of the existing concrete shear walls and the building diaphragm, this model will be used to determine the actual drift of the building, and compare it to the deflection requirements. The second model will be similar to the first, but incorporate the exterior moment resisting frames into the lateral resisting system. Provided the post tension research provides promising results, the use of post tension modeling software will be used to design the post tensioning for the exterior moment resisting frames. The ETABS model will also be used to aid if the analysis and design of the exterior moment frames to resist progressive collapse.

Breadth Options

Breadth Study 1: In-Depth Cost and Schedule Impacts of Depth

The first breadth study was chosen with its connection to the structural depth. The proposed changes to the lateral system with post tension design will have an impact on the scheduling on construction. The scheduling changes that would involve the additional construction time for the jacking of the post tension strands. A cost comparison of the existing structural system to the proposed changes will be made to the lateral system. Once the scheduling impact and the cost changes are considered, the feasibility of redesigning the progressive collapse beams as post tension beams will be evaluated.

Breadth Study 2: Lighting Design of Atrium Space

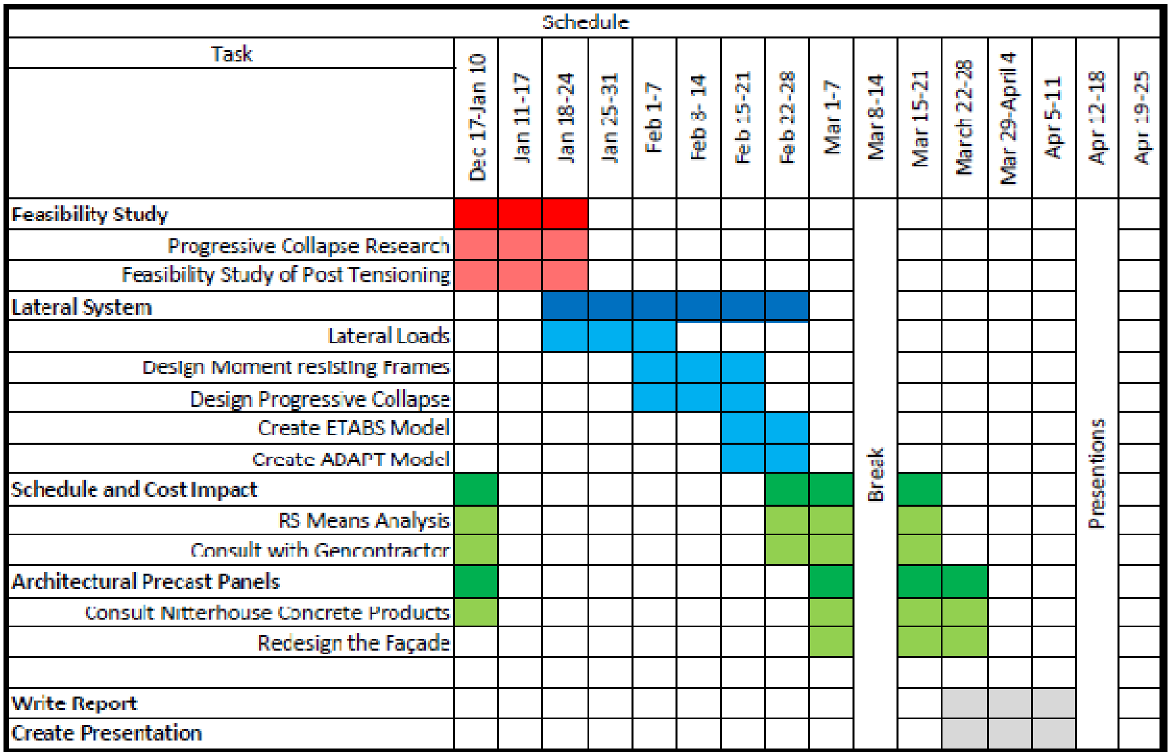
An architectural study of the building façade will be carried out for the second breadth. The façade is currently Brick with cmu backup; the proposed changes will incorporate Architectural precast panels. The change to precast panels would most likely increase the lead time but also increase construction time as well as quality control on the construction site.

Tasks and Tools

Listed below is a list of tasks to be accomplished in the research and development of the proposals as well as the required tools.

1. Feasibility Study
    - Research the requirements to be met for Progressive Collapse Design
    - Determine if Post-tensioning is adequate for perimeter beams and maintain progressive collapse requirements
2. Lateral System
    - Redistribute the Lateral loads from ASCE 7-05 to the existing lateral system and to the exterior moment resisting frames
    - Design the exterior moment resisting frames to account for the gravity loads and the lateral loads, as prescribed by the load combinations in ASCE 7-05
    - Design and detail the perimeter beams to meet progressive collapse requirements
    - Model the building in ETABS to check serviceability and strength requirements
    - Model the moment resisting frames in Adapt for post tension design
3. Scheduling Impact and Cost Analysis
    - Using RS Means to obtain a preliminary impact on impacts of redesign
    - Consult with the general contractor on the project team and subcontractors for a more detail cost analysis and scheduling impacts
4. Architectural Precast Panels
    - Consult with Nitterhouse Concrete Products for a scope of their products, lead times, and cost
    - Redesign the building façade to incorporate Architectural Precast Panels

Schedule


Schedule
Task
Dec 17-Jan 10
Jan 11-17
Jan 18-24
Jan 25-31
Feb 1-7
Feb 8- 14
Feb 15-21
Feb 22-28
Mar 1-7
Mar 8-14
Mar 15-21
March 22-28
Mar 29-April 4
Apr 5-11
Apr 12-18
Apr 19-25
Feasibility Study
Progressive Collapse Research
Feasibility Study of Post Tensioning
Lateral System
Lateral Loads
Design Moment resisting Frames
Design Progressive Collapse
Create ETABS Model
Create ADAPT Model
Schedule and Cost Impact
RS Means Analysis
Consult with Gencontractor
Architectural Precast Panels
Consult Nitterhouse Concrete Products
Redesign the Façade
Write Report
Create Presentation
Break
Presentions

Conclusion

The outcome from this thesis is hoped to be the design of progressive collapse members under lateral loading, while being designed with post tensioning. The feasibility study will determine whether Progressive collapse standards allow the design of members using post tension design. It was proposed to redesign the lateral system to include the existing shear walls and the addition of exterior moment resisting frames. The purpose of this thesis was to learn the concepts of progressive collapse design as well is integrating post tension design into the design of progressive collapse elements.

An advanced computer modeling techniques will be used to model the FDA OC/ORA Office building. ETABS is 3D structural modeling software that will be used to derive the lateral characteristics of the Wing B. The ADAPT software, once a model is developed will be used to aid in the design of progressive collapses member in the lateral system.

The changes to the lateral system will lead to other changes throughout the project. An in depth cost analysis and schedule impact study will be performed to determine the changes that are due to the change in the lateral system. The scheduling changes that would involve the additional construction time for the jacking of the post tension strands will be considered and compared to the existing system.

Architectural precast panels are being proposed to replace the existing façade. The benefits of using precast panels will increase quality control on the job site, and construction time of the project. However, it is import to note that the lead time for the precast panels will have to be considered into the project schedule.