FDA OC/ORA Office Building

Silver Spring, MD

Thesis Proposal

Adam Love

Structural Option

AE Consultant: Dr. Hanagan

January 25th, 2010

Table of Contents

Executive Summary ... 3
Introduction ... 4
Structural System ... 5
  Foundation: ... 5
  Floor System: ... 7
    Building 31: ... 7
    Building 32: ... 9
  Columns ... 10
  Lateral System ... 10
Proposal ... 15
  Proposed Thesis ... 15
  Graduate Course Integration ... 16
Breadth Options ... 16
  Breadth Study 1: In-Depth Cost and Schedule Impacts of Depth ... 16
  Breadth Study 2: MEP Coordination Breadth ... 16
  Breadth Study 2 Alternate: Lighting Study of Conference Room ... 17
Tasks and Tools ... 18
Schedule ... 19
Conclusion ... 20

Executive Summary

The FDA OC/ORA Office Building is designed as a reinforced concrete structure with a two-way flat slab for the gravity system. This thesis proposes to pursue the development of Progressive Collapse Design and implement that design to the FDA OC/ORA Building. The office building will be redesigned using a steel superstructure.

The gravity system will be redesigned using a typical steel on metal deck flooring system. Beams and girders will be designed using AISC Steel Manual Thirteenth Edition, the gravity loads were determined in the second technical report using ASCE 07-05. The lateral loads were be recalculated using the new building weight, and the lateral system will be redesigned. The lateral system will be composed of braced frames at the two elevator cores, and exterior moment resisting frames.

The gravity system will be designed as a typical steel on metal deck flooring system, and after the initial design is completed the critical members will be re-evaluated using the standards for progressive collapse design. Progressive collapse design assumes the loss of a primary structural element and with redistribution of forces, no other structural losses occur. A main contributing factor to the resistance of progressive collapse is the connections. The design of connections that meet the requirements for progressive collapse will be implemented as a part of the master's integration for this thesis.

The impact on the cost and schedule of the overall project will be performed to determine the feasibility of the change in the structural systems. The scheduling changes that would involve the additional construction time for erecting the steel and additional lead time to order the steel. The increased complexity with the connections will also increase the cost of the steel system when compared to the concrete monolithic design.

Using the existing ceiling height, and re-evaluating the existing MEP through a section of the building. The intent is to redesign the MEP passing through a section to account for the added depth of the gravity system without impacting the architecture of the office building.

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)

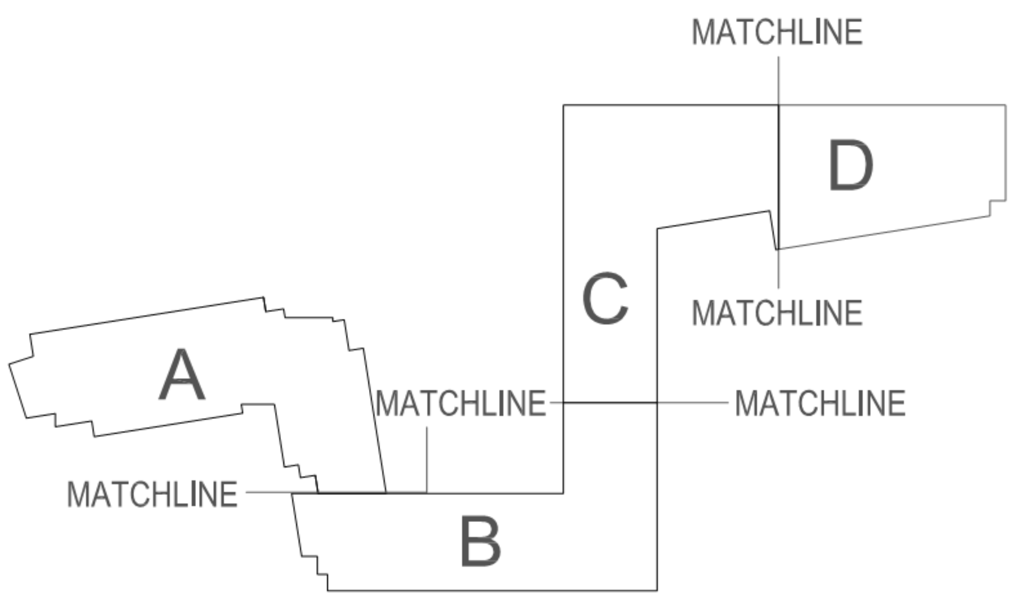


Figure 1: Key Plan

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.

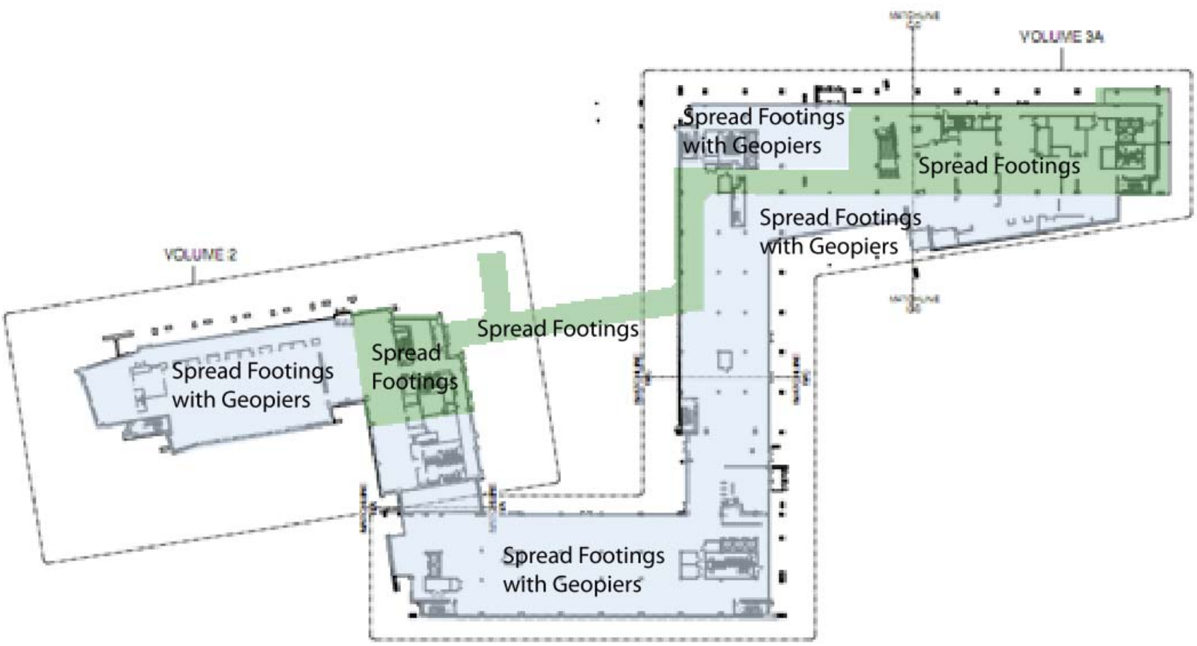


Figure 2: Foundation Key

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.

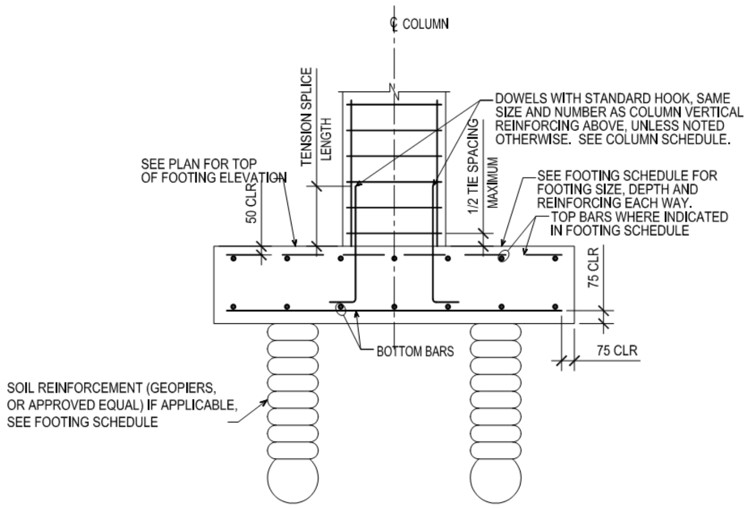


Figure 3: Typical Geopier Foundation Detail

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.

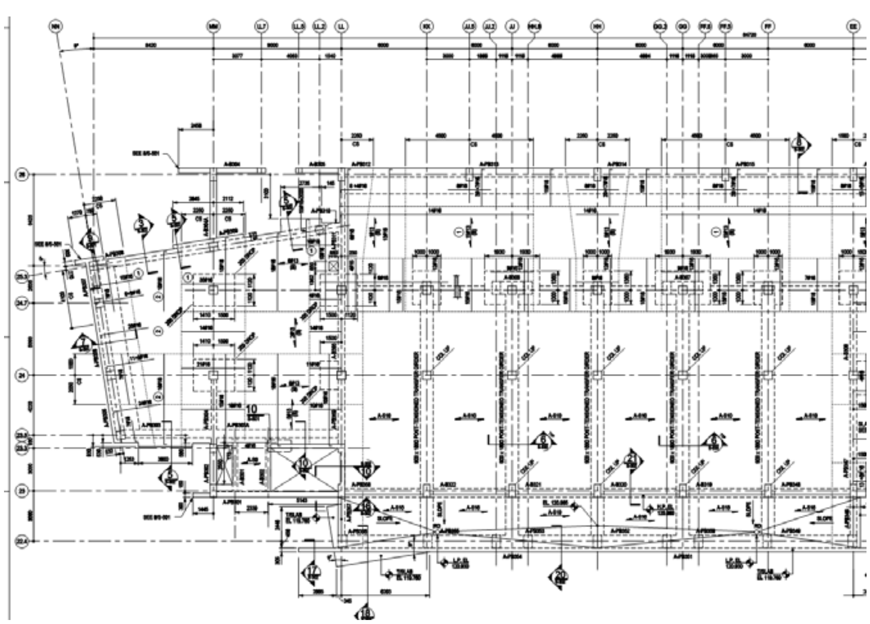


Figure 4: Framing Flan for Post Tension Transfer Girders

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).

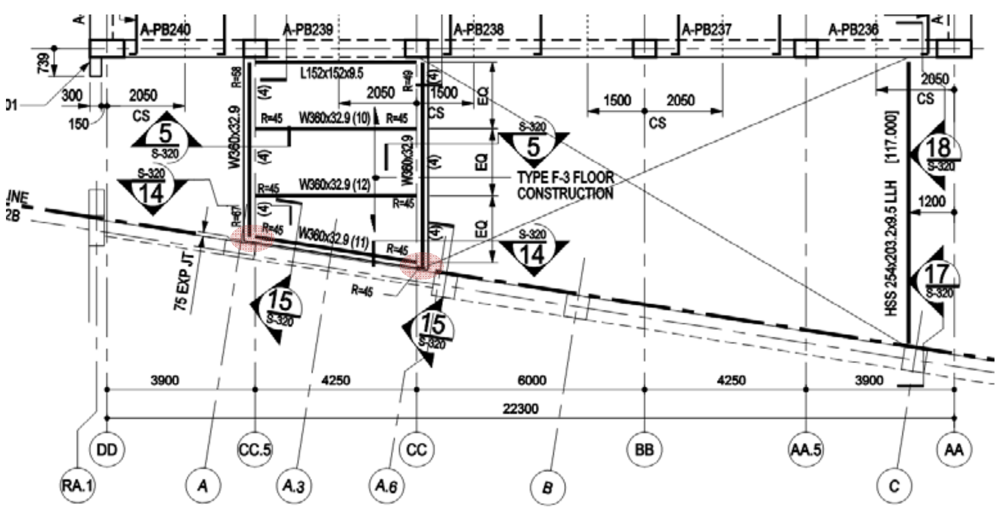


Figure 5: Wing A Atrium

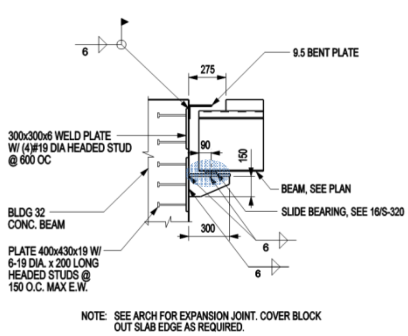


Figure 6: Expansion Joint Detail (Red)

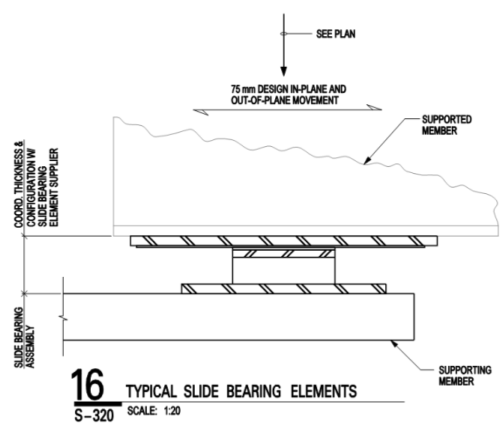


Figure 7: Expansion Joint Detail (Red)

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.

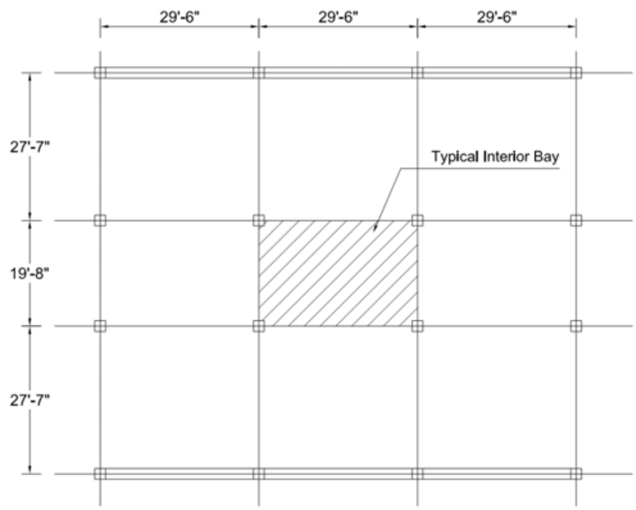


Figure 8: Building 32 Wing B Typical Bay Layout

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.

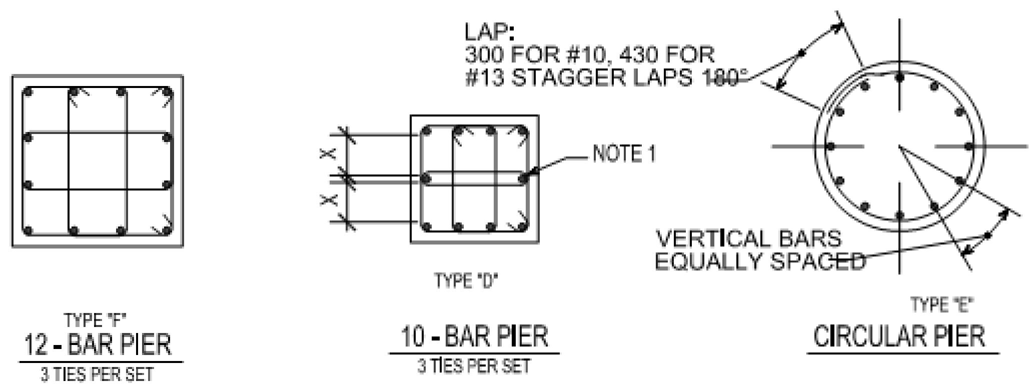


Figure 9: Typical Column Details

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).

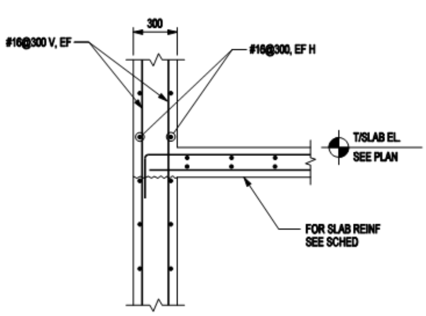


Figure 10: Shear Wall Detail

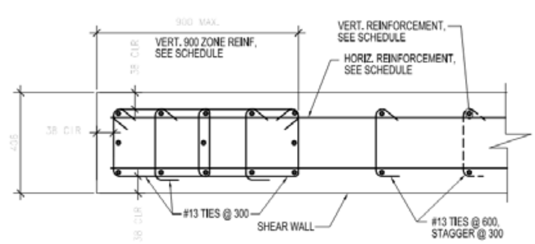


Figure 11: Shear Wall End Zone

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.

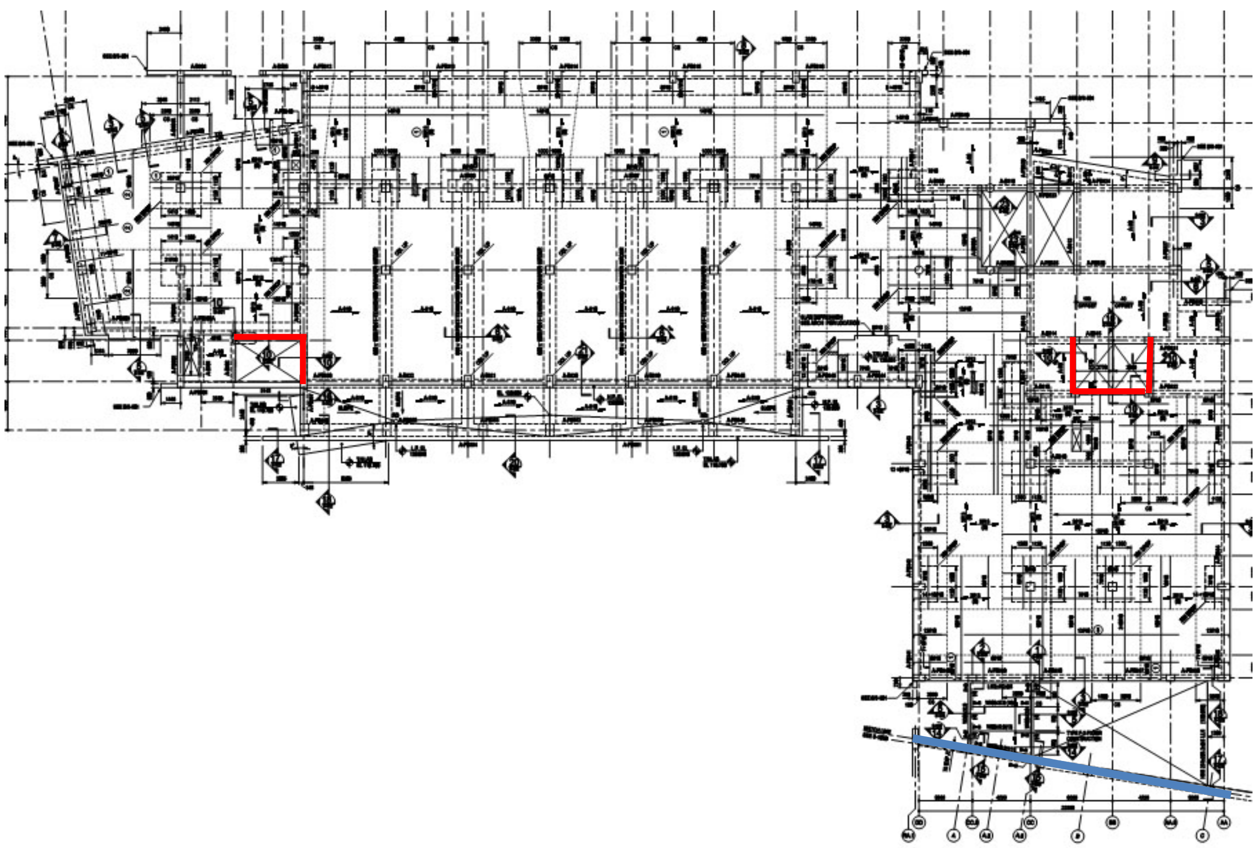


Figure 12: Shears Walls of Wing A

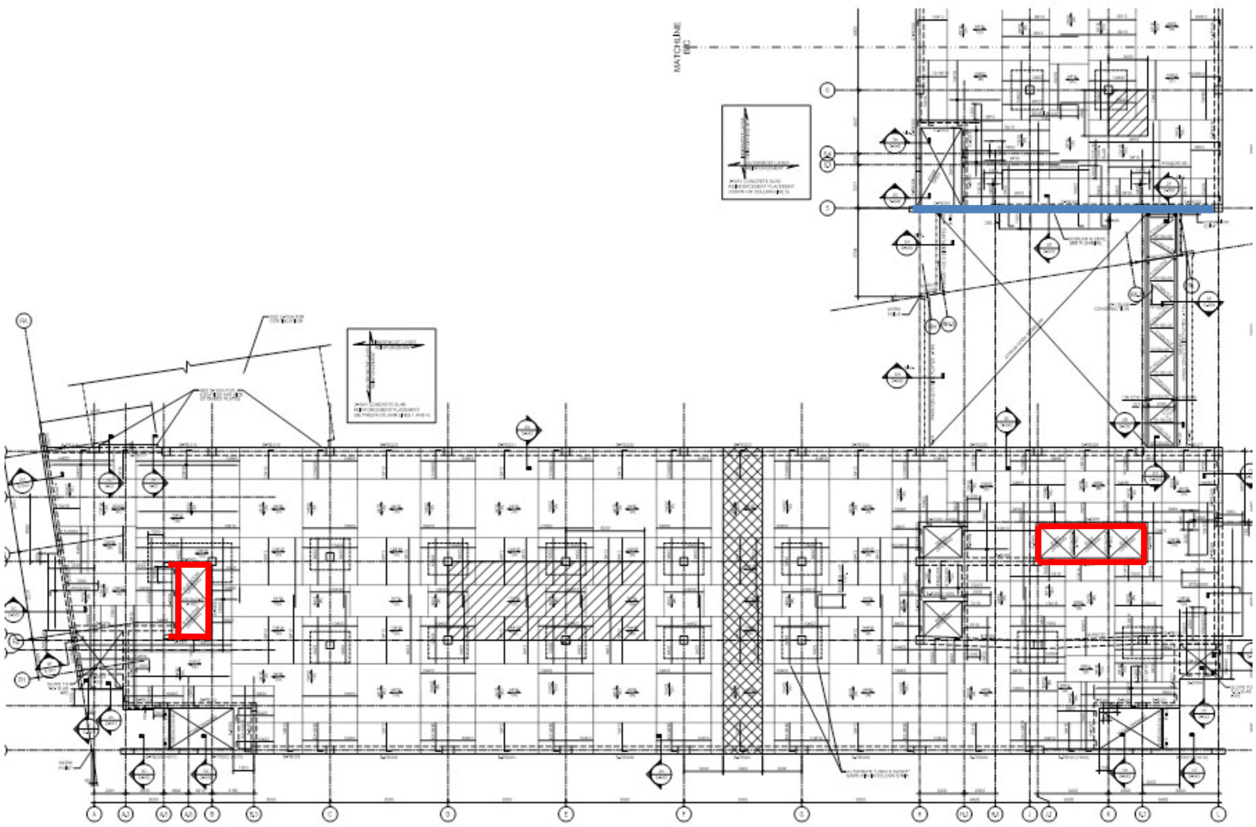


Figure 13: Shear Walls of Wing B

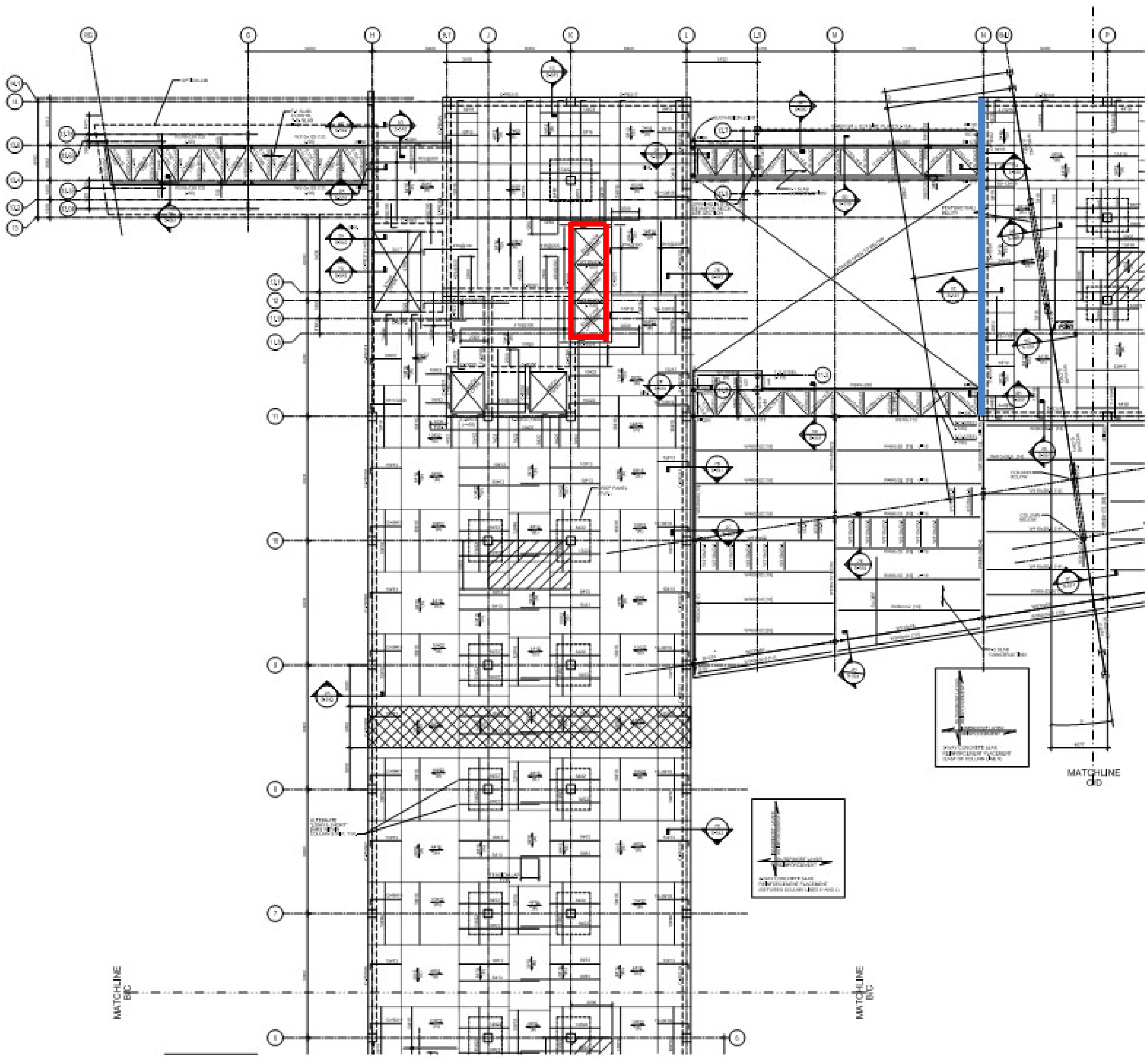


Figure 14: Shear Walls of Wing C

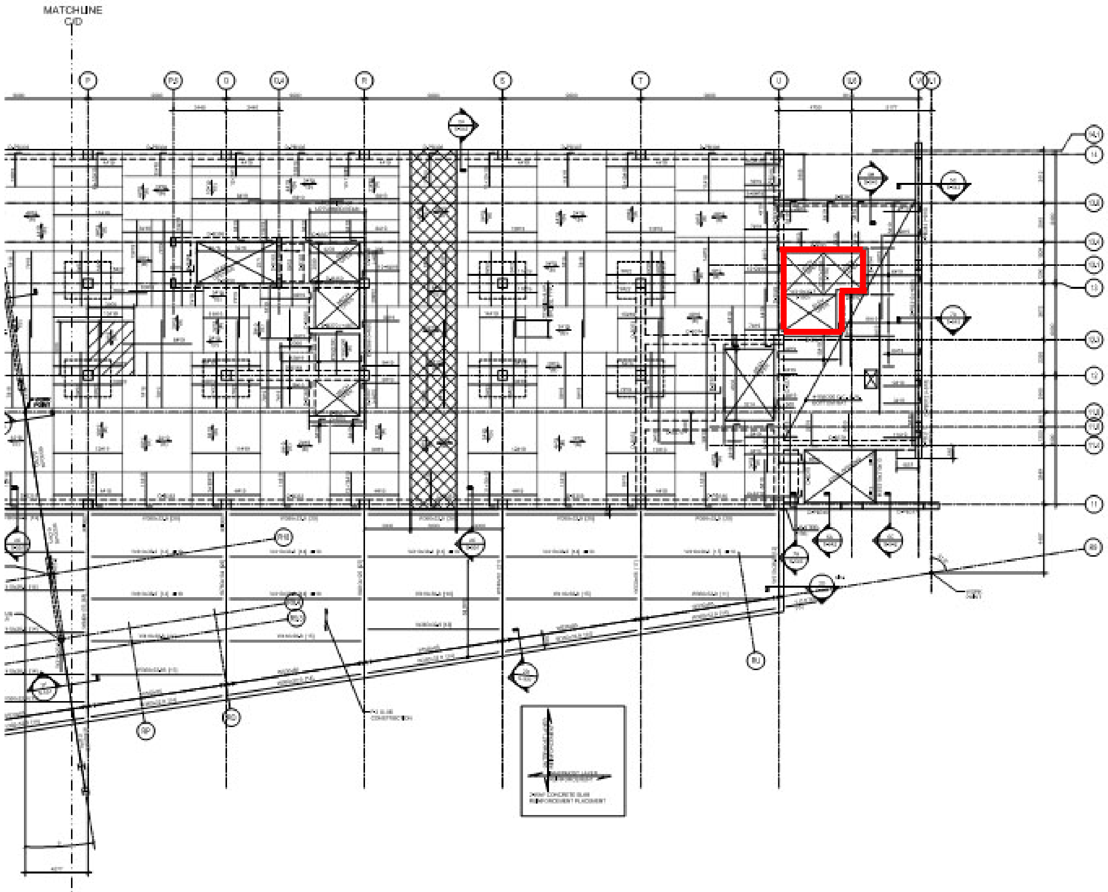


Figure 15: Shear Walls of Wing D

Proposal

Proposed Thesis

The FDA OC/ORA Office Building was designed as a cast in place concrete system with two way flat slab with exterior beams for the gravity system, and concrete shear walls as the lateral system. In the documentation and analysis of the existing conditions of Wing B, of the FDA OC/ ORA Office Building, it was determined that the requirements for the design were met. All government buildings that are designed are required to meet Progressive Collapse Requirements and Blast Design Requirements. For the purpose of this thesis the Wing B of the office building will be re-evaluated using a steel framing system meeting requirements for the resistance to progressive collapse.

Initially steel framing will be designed to support the gravity loads determined in the early technical reports. Typical steel on metal deck system will be design for the gravity system, and later the impact on MEP will be considered as a breadth topic. The existing grid will be used as a template to start the design process; variations may be needed to supplement the design. After the initial design is accomplished, the lateral loads will be determined and the lateral resisting systems will be designed.

It was observed in Tech 3, that the location of the shear walls and their sizes posed a torsional problem with eccentric loading. It is planned to design braced frames around the two cores of Wing B, and design exterior moment resisting frames to also take the lateral forces on the building. It is planned that adding the exterior moment frames to help decrease the eccentric loading scene on the lateral system.

Time permitting, the procedures to evaluate the progressive collapse requirements will be incorporated in the thesis. The design to resist progressive collapse assumes the lost of a primary structural element, for example an exterior corner column and exterior column. With the loss of these primary structural elements and analysis and redesign will be performed. The analysis will be compared to ultimate strength of the structure and the structure will be redesigned. A 3D model will be used to model the gravity system to aid in the design of the progressive collapse members, and verify the accuracy of the design.

Graduate Course Integration

The connections for steel buildings have to be design to not only meet the structural requirements, but also meet constructability requirements. For the master's integration, the typical connections for the steel building will be designed. The typical beam connection will include shear connections for the floor systems, and moment connections for the moment resisting frames. Also the braced frames will incorporate the design of a bracing connection.

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: MEP Coordination Breadth

After the gravity system is design and the depth of the structural beams a MEP Coordination Study will be performed. Using the current ceiling height and re-adjusting the mechanical, electrical and plumbing that passes through a section of the building, the change in the allowable space without having interferences. The proposal is to re-design the MEP coordination to allow for the increased depth of the structural floor without impacting the architectural of the space. Redesigning of mechanical ducting to allow the increased floor depth but not impact the ceiling height is to be considered in order for this breadth to be applicable.

Breadth Study 2 Alternate: Lighting Study of Conference Room

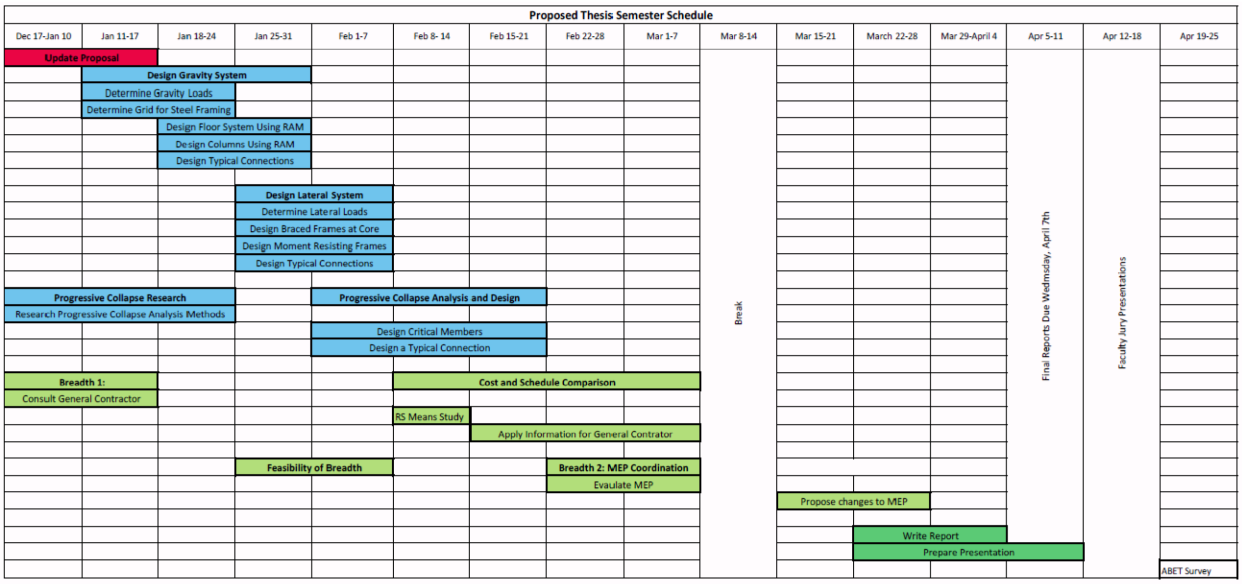
If the MEP Coordination Breadth fails to meet the requirements as a Breadth, the lighting of a typical conference room will be redesigned. To design a space that is both aesthetical pleasing but also functional in allowing various different lighting requirements to be met. The conference room will be design to incorporate typical office lighting, for presentation and typical conference meetings. Also the use of wall mounted visuals will also be considered.

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. Research
    - Research the requirements to be met for Progressive Collapse Design
2. Gravity System
    - Determine the gravity loads to be used in the design
    - Create RAM Model to aid in the design of the steel framing
    - Design the floor system under the gravity loads using RAM
3. Lateral System
    - Determine Lateral Loads to be used in the design
    - Design Braced Frames around the core using RAM
    - Design Moment Frames at the perimeter using RAM
4. MAE Integration
    - Design a typical shear connection for floor system
    - Design a typical moment connection for moment resisting frames
    - Design a typical braced connection for braced frames
5. Progressive Collapse Application
    - Time permitting after design evaluate possible application for progressive collapse
    - Implement analysis procedures to meet progressive collapse requirements
    - Design Critical Members to resist progressive collapse
    - Design typical connection for progressive collapse
6. 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
7. MEP Coordination Study
    - Consult with general contractor
    - Re-evaluating the existing MEP through a section of the building
    - Re-design the MEP through a space to fit with the new design parameters

Schedule


Proposed Thesis Semester Schedule
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
Update Proposal
Design Gravity System
Determine Gravity Loads
Determine Grid for Steel Framing
Design Floor System Using RAM
Design Columns Using RAM
Design Typical Connections
Design Lateral System
Determine Lateral Loads
Design Braced Frames at Core
Design Moment Resisting Frames
Design Typical Connections
Progressive Collapse Research
Research Progressive Collapse Analysis Methods
Progressive Collapse Analysis and Design
Design Critical Members
Design a Typical Connection
Breadth 1:
Consult General Contractor
Cost and Schedule Comparison
RS Means Study
Apply Information for General Contrator
Feasibility of Breadth
Breadth 2: MEP Coordination
Evaulate MEP
Propose changes to MEP
Write Report
Prepare Presentation
ABET Survey
Break
Final Reports Due Wedmsday, April 7th
Faculty Jury Presentations

Conclusion

The FDA OC/ORA Office Building is designed as a reinforced concrete structure with a two-way flat slab for the gravity system. This thesis proposes to pursue the development of Progressive Collapse Design and implement that design to the FDA OC/ORA Building. The office building will be redesigned using a steel superstructure.

The structure will be redesigned in still, even in a market that favors concrete construction. The floor system will be redesigned using steel on metal decking framing system. The new floor system will cause a change in the seismic loading, and the new lateral loads will be used to design a steel lateral system. The lateral system will be composed of braced frames around the two elevator cores, and exterior moment resisting frames.

The design of structures to resist progressive collapse is a very important concept after recent events in previous years. The design assumes the loss of a primary structural element, and allows the structure to redistribute the forces through alternate load paths. The gravity system will be designed as typical steel on metal deck flooring system, and then the requirements for progressive collapse design will be evaluated. The design of connections that meet the requirements for progressive collapse will be implemented as a part of the master's integration for this thesis.

The changes to a steel 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 structural system. The scheduling changes that would involve the additional construction time for the erecting the steel and lead time to order the steel.

Using the existing ceiling height, and re-evaluating the existing MEP through a section of the building. The intent is to redesign the MEP passing through a section to account for the added depth of the gravity system without impacting the architecture of the office building.