Fraser Centre

State College, Pennsylvania

Revised Thesis Proposal

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Structural Option

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Executive Summary

Fraser Centre is a mixed-use, high-rise development located in State College, Pa. The 11 story structure has been designed using a two-way concrete slab with concrete shear walls.

In Technical Report 3, lateral loads were found to be resisted by two shear walls on the east end of the building. In an effort to reduce the torsion created by this configuration, shear walls on the theater level will be extended throughout the building. The new shear walls will then be redesigned for the new load distribution. With the new layout of shear walls an alternate floor system, composite deck, will also be studied.

Two non-structural breadth analyses will also be undertaken. An analysis and possible redesign of the architectural layout of the residential floors and garage floors will be conducted. This analysis will determine to what extent the architectural floor plan needs to be altered to accommodate the new shear wall locations and make sure the garage stays within parking standards. In addition to the architectural redesign a cost and schedule analysis will be completed for the existing design and the new design. This analysis will help determine if the proposed changes are economical.

Introduction

The Fraser Centre is a mixed-use, high-rise development located in downtown State College, Pennsylvania (See Fig. 1). The site will encompass an entire block on the corner of Beaver Avenue and Fraser Street, at an approximate elevation of 1100 feet above sea level. The development was designed by Wallace, Roberts, and Todd LLC, to be the only building in State College to have an all glass and aluminum façade. The structure was engineered by David Chou and Associates, Inc.; the MEP was engineered by AKF Engineers; and the theater was engineered by JKR Partners, LLC.

Figure 1: Site view of Fraser Centre (blue) bounded by Fraser St., Calder Way, Miller Alley, and Beaver Ave. Photo courtesy of Bing Maps.

Fraser Centre is an eleven story multi-use building. The first floor is exclusively parking; with 94 parking spaces. Residential parking takes up the majority of the second floor along with the theater lobby and 3 retail spaces. The entire third floor is occupied by the ten-auditorium movie theatre. The mechanical equipment is located on the fourth floor, or mechanical floor. At the fourth floor the building foot print reduces from roughly 270ft x 165ft to 190ft x 76ft. Floors five through eleven are all residential levels; floor five consists of nine units, levels six through ten all have eight units, and three penthouse suites makes up the penthouse or eleventh floor.

The structural system of Fraser Centre is reinforced concrete. The gravity load resisting system consists of concrete columns, shear walls, and two-way slabs. The lateral system is composed of reinforced concrete shear walls located throughout the entire building.

Structural Systems

Gravity System

Columns are designed with 5000 psi concrete for the columns below the sixth level and 4000 psi concrete will be used for columns above the sixth level. Figure 2 in the Appendix shows the column locations and the column size and reinforcement can be found in Figure 3a through 3g. Column sizes vary from 18"x24" and 16"x32" to 24"x72" and 36"x60" and there are also 24" diameter columns.

Beams on level 2 garage vary in width from 10" to 36" with 18" being the most common and a depth between 24" and 111", 30" is the most common depth. The theater level beams vary from 12" to 72" and 20" to 48" in width and depth respectively. Beams vary in depth from 24" to 40" and 16" to 48" on the mechanical floor. 12"x 78" and 48"x30" is the range of beams on the roof. All beams are made with 4000 psi concrete.

The parking garage has 9" slabs on grade reinforced with 13#5 bars on top and a bottom grid of #4 bars at 12" each way. 4000psi concrete will be used for the slab on grade. 18#5 top bars and a grid of #5 bottom bars at 12" reinforce the 14" concrete slab of the theatre level. In addition to #7 bottom bars at 9" East-West and #5 bottom bars North-South in the 16" slab, the mechanical floor also has a 12'-6"x7' transfer girder with 40 #11 bottom bars and 20 #11 top bars. The residential levels and penthouse (5 through 11) as well as the roof have 12" slabs reinforced with a grid of #5 bars at 14" east-west and 12" north-south. All of the structural slabs will have 5000 psi concrete and a typical span of 40 feet. Steel beams are used for the projection of the mezzanine floor, and they vary from W8x10 to W12x22.

Lateral System

Concrete shear walls will be used in Fraser Centre to resist lateral loads. Shear walls are composed of 5000 psi concrete and reinforced with #5 horizontal bars and #6 vertical bars. Shear walls are located along column lines 3, 4, 5, 6, and 7 as shown in Figures 2 and 3. The theatre level has 14" shear walls and 16" walls are typical of the parking levels and the residential levels.

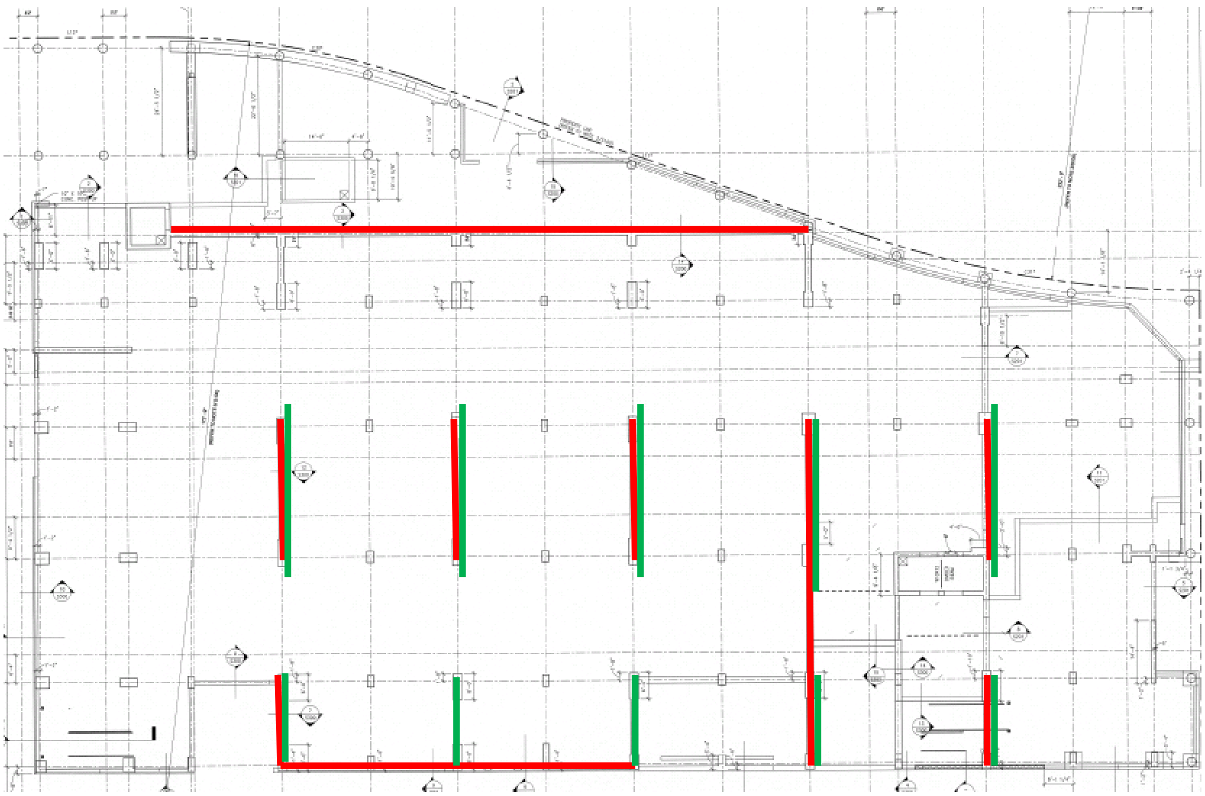


Figure 2: First Floor Shear Wall Plan

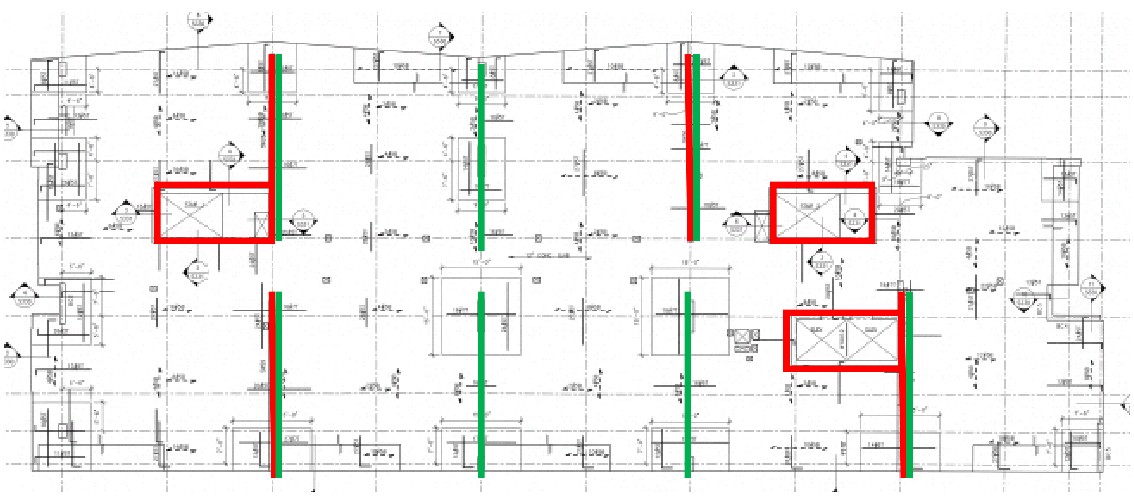


Figure 3: Typical Residential Floor Shear Wall Plan

Current shear walls

Proposed shear walls

Design Criteria

The following data is provided to illustrate the general design criteria for Fraser Centre.

Codes & Design Standards

Applied to Original Design
International Building Code **IBC 2006**
American Concrete Institute Building Code **ACI 318-05**
American Institute of Steel Connection **AISC, 9th Edition**
Steel Deck Institute **SDI Specification**
Building Code Requirements for Masonry Structures **ACI 530-05**
American Society for Civil Engineers **ASCE 7-05**

Substituted for Analysis
International Building Code **IBC 2006**
American Concrete Institute Building Code **ACI 318-08**
American Institute of Steel Connection **AISC, 13th Edition**
American Society for Civil Engineers **ASCE 7-10**

Table 1: Codes and Standards used for Original Design and Analysis.

Material Strength Requirements

Material	Strength Requirement
Cast –In-Place Concrete:	
Footings	4 ksi NWC
Basement and Bearing Walls	4 ksi NWC
Shear Walls and Columns	5 ksi NWC
Grade Beams and Slab on Grade	4 ksi NWC
Structural Slab	5 ksi NWC
Reinforcement	ASTM A615, Grade 60
Structural Steel:	
Steel Shapes	ASTM A992
Structural Tubes	ASTM A500
Plates	ASTM A36

Table 2: Material Strength Requirements per drawing S001

Dead and Live Loads

Area	Design Live Load (psf)
Roof/Ground Snow (from drawing S001)	Min 40
Mechanical	125
Rooms	40
Stairs/Public Rooms/Corridors/ Balconies	100
Theater	60
Retail Sales	100
Light Storage	125

	Design Super-Imposed Dead Load (psf)
Roofing	10
Partitions	20
4” Hollow Non-Bearing Block	30 (/sf of wall)
8” Hollow Non-Bearing Block	55 (/sf of wall)
Brick Veneer	40 (/sf of wall)

Table 3: Design Live and Super-Imposed Dead Loads per drawing S001

Problem Statement

In Technical Report 3, wind loads were found to be the controlling load condition for the structure of the Fraser Centre. There are two components of every lateral load, direct and torsional. One way to reduce the lateral loads experienced by the lateral force resisting system is to reduce the eccentricity between the center of rigidity and the resultant force.

Proposed Solution

Since the controlling lateral load was determined to be wind, a center of rigidity closer to the center of the exterior walls would reduce the torsional component of the wind load. By continuing the shear walls of the theater down to the foundations and up to the roof the lateral force resisting system will be more evenly distributed than the current layout. The current layout only has two shear walls that continue from foundation to roof located on the east side of the building.

With the change to the shear wall layout, a composite slab and beam floor system will be used instead of the current two-way concrete floor. The composite nature of the proposed slab also allows for a thinner slab which reduces the weight and there for the seismic loads felt by the building. This will maintain wind as the controlling load condition.

Breadth Topics

Architectural

Due to the extension of the theater shear walls the layout of the other floors will need to be examined. The largest impact on the residential floors will most likely occur in the smaller room like bathrooms, laundry rooms, and closets. These areas will be redesigned if necessary or proven to be large enough if redesigning is not required. The apartments will also be redesigned if necessary. The two parking levels will be examined to ensure that the parking standards are still met with the extension of the shear walls.

Construction Management

A cost comparison of the proposed and original systems should be undertaken to determine the economic effects of the changes. This comparison will also include the impact the changes will have on the schedule. The material and construction costs of the composite system will be compared to the costs of the current system. Since a delay in opening would cost the owner in lost income, it will be important to not impact the schedule in a negative manner.

MAE Course Related Study

As required for this project, important concepts and skill sets pertaining to MAE coursework are integrated into the proposed solution. To redesign the lateral system computer modeling software and techniques learned in AE 597A will be used. Rigid diaphragm modeling, rigid end offsets, shear wall meshing, and property modifiers will be used in ETABS models. Steel connections will also be designed for the composite floor using knowledge from AE 534.

Methods

The investigation will begin by determining impact the proposed shear wall locations will have on the architectural layout of the building. After it is determined to be feasible the new center of rigidity will be determined and its effect on the wind and seismic loads evaluated by hand as well as with an ETABs model. Shear walls will be redesigned as necessary.

After the proposed walls are designed and verified, the proposed composite system will be evaluated for the new layout. The design of the composite slab and beam system will be based on Specifications and Codes of The Steel Construction Manual. Additional walls or columns will be added as required for span and deflection limits.

Tasks and Organization

Main Topic

1. Design of continuous shear walls
    a. Determine shear wall locations
    b. Find live loads and dead loads
    c. Establish lateral loads from code
    d. Determine loads per floor
    e. Check deflections
2. Design of floor system from loads and layout
    a. Check spans and deflections
3. Establish computer model
4. Perform analysis of new foundation requirements
    a. Determine building weight
    b. Check overturning moment and uplift forces
5. Prepare Presentation

Breadth

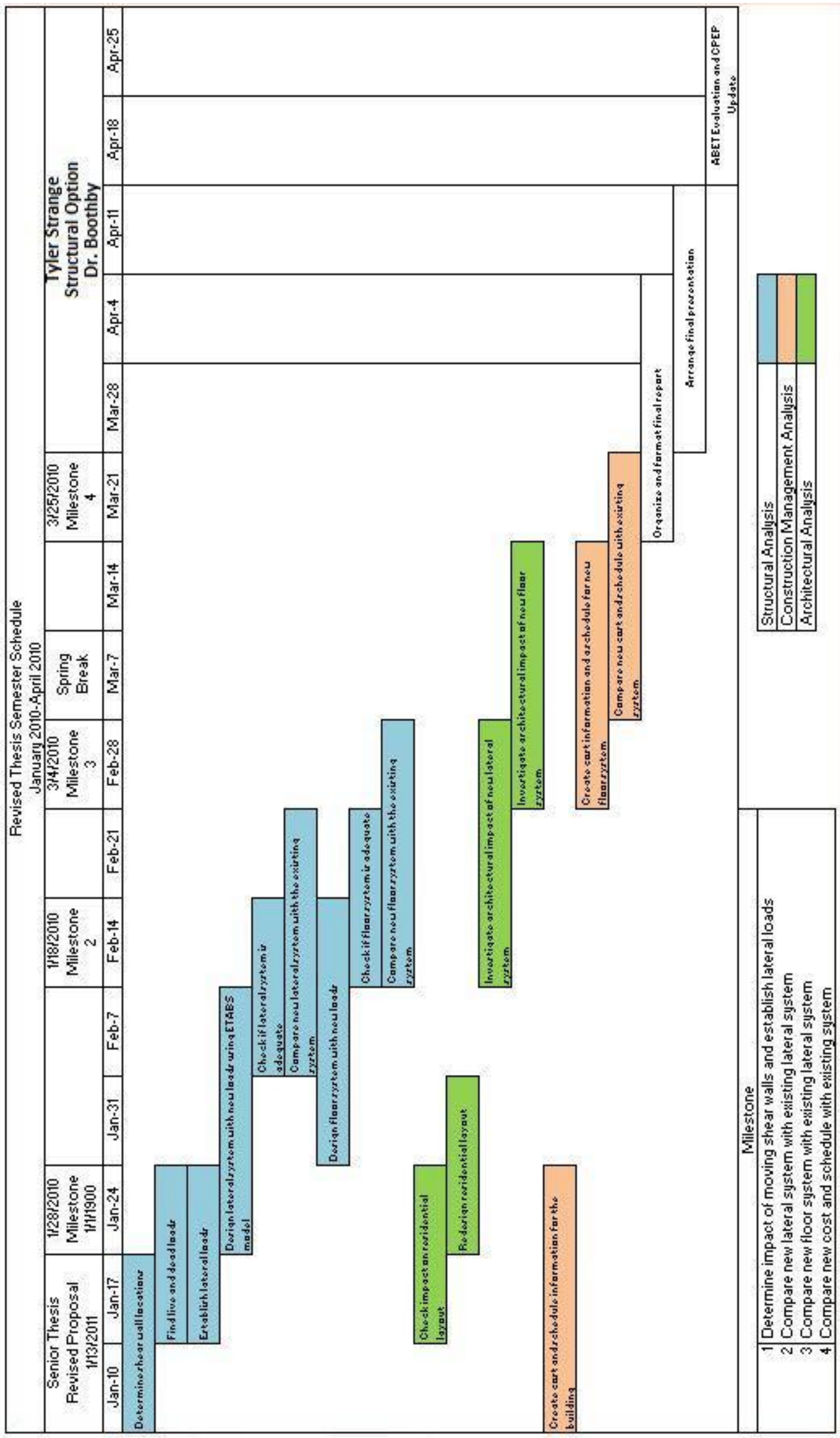
Architecture

1. Check impact on residential layout
2. Redesign apartment layout if necessary

Construction Management

1. Develop schedule for existing and proposed systems
2. Develop cost estimates for existing and proposed systems
3. Compare existing and proposed systems

Timetable


Revised Thesis Semester Schedule
January 2010-April 2010
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Structural Option
Dr. Boothby
Senior Thesis Revised Proposal 1/13/2011
1/28/2010 Milestone 1/1/1900
1/18/2010 Milestone 2
3/4/2010 Milestone 3
Spring Break
3/25/2010 Milestone 4
Jan-10
Jan-17
Jan-24
Jan-31
Feb-7
Feb-14
Feb-21
Feb-28
Mar-7
Mar-14
Mar-21
Mar-28
Apr-4
Apr-11
Apr-18
Apr-25
Structural Analysis
Construction Management Analysis
Architectural Analysis
Milestone
1 Determine impact of moving shear walls and establish lateral loads
2 Compare new lateral system with existing lateral system
3 Compare new floor system with existing lateral system
4 Compare new cost and schedule with existing system

Conclusion

The proposed systems will designed and compared to the existing design. The goal of this investigation will be to reduce the lateral loads on Fraser Centre. New shear wall locations will be used to achieve this by reducing torsion as described previously. Building weight will also be reduced to lower the seismic load on the lateral system. An alternative floor system will be used to reduce the building weight. Hand calculations and computer models will be performed as necessary. The proposed and existing systems will have a cost/schedule impact comparison to determine feasibility.