Aric Heffelfinger
Fordham Place
Bronx, NY
Structural Option
Advisor - Dr. Hanagan

Executive Summary – Thesis Proposal

Fordham Place is a 15 story office / retail building that is located at 400 East Fordham Road, Bronx, NY. The 174060 sq. ft tower is going to tie into an existing 6 story SEARS building. In the new tower, structural engineers used modern design, taking advantage of composite action using steel beams with a 6 ¼ " concrete slab. The slab will be supported by 3" composite floor deck with 3" headed shear studs within the slab. Steel columns are used to transfer load to foundation, where it will be supported by a number of 150 ton piles. The main lateral resisting system is made up of steel concentrically loaded chevron braced frames.

Proposed Thesis Redesign

For the proposed redesign, there was no other structural system that clearly seemed to be a more efficient design. Therefore, the two major structural systems used in buildings of this size and occupancy type will be compared. These two systems being; the current design concrete slab on composite metal deck supported by steel beams and a two way flat slab with drop panels. This is the best concrete option considering the size and geometry of the bays at Fordham Place. The change to a two way slab requires a redesign of the current lateral system of concentric steel chevron frames. Concrete moment frames and shear walls will be researched and studied to determine the more efficient design. If shear walls are used, architectural features will have to be considered.

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Executive Summary – Breadth Work

When changing from a steel building to a concrete building, the mechanical, architectural, plumbing, and many other system designs could be changed for better efficiency. Construction management issues such as construction schedule, construction cost, and duration of the project will also change. This being said, the two areas of breadth work will be the greatest impacted areas; mechanical systems and construction management issues.

Construction Management

With a switch from a steel building to a concrete building, impacts will be made on the construction schedule and methods used. Therefore, an analysis of each change in the depth work will be a crucial part in determining which solution is most economical and feasible. One analysis will compare the cost of a concrete slab on composite metal deck supported by steel beams to that of a two way flat slab with drop panels. This analysis will include the price difference due to a change in the lateral system from concentric chevron braced frames to either shear walls or concrete moment frames. Both shear walls and concrete moment frames will be researched to determine which a better option is. Another analysis will be of the construction schedule. This will clearly show critical paths and task durations for optimum construction processes for both the steel and concrete buildings. With all the changes made to the structure, there will be additional construction issues such as material availability, cost, constructability, and labor forces.

Mechanical

As a result of redesigning the structural system, mechanical system issues will arise. Changing the floor system to a two way flat slab will affect a number of things related to the current mechanical system design; such as routes of duct work, optimal mechanical systems used. Running duct work along walls may yield a smaller concrete slab rather than the current design of running it through interior sections of the floor. Also, it may be more efficient to use a totally different HVAC system such as individual units. This could possibly eliminate the need for punching large holes in the slab for duct work. Calculations will be performed to determine whether the current mechanical system is adequate to service the new structural systems. Adjustments to the mechanical system will be made as necessary.

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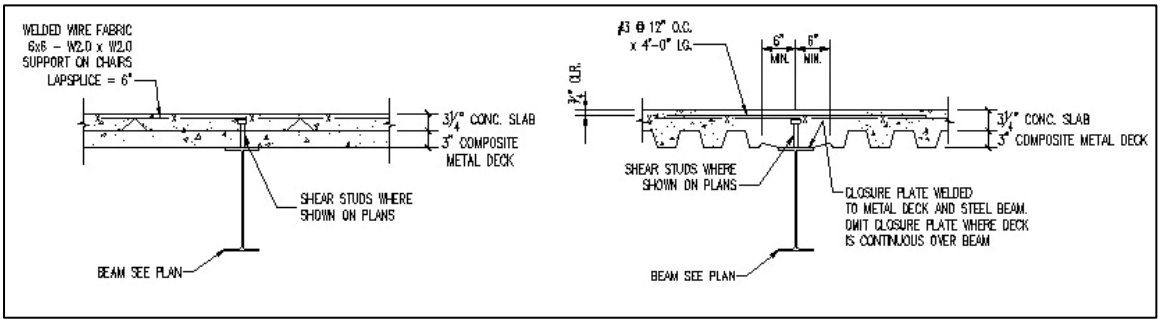
Building Description

General

As you look around Bronx, NY you will notice a distinct similarity between most buildings; this being they are shorter older buildings, most less than 6 stories. Once Fordham Place is erected, it will tower over the city of Bronx, rising 15 stories above ground level. As you go up the building, its size decreases as the building steps in at the 6th floor and then again at the 15th floor. The 15 story office tower will connect into an existing 5 story brick and limestone building which will have retail space up to the second floor and a sports club on the third. The office tower base will be clad in GFRC or cast stone to match the limestone base of the existing building. The tower itself will be a panelized brick veneer system to compliment the existing building. The Tower design includes modern references to the classical detailing of the existing building (such as the cornices, cast iron mullions etc.) The floor elevations of the new building will match the existing and there will be an expansion joint separating the new and old.

Floor System

The floor system of Fordham Place consists of structural steel W sections that support metal deck and concrete slab. The W shape beams and girders are A992 grade 50 and support a light weight concrete (115pcf) slab of 6.25 in. The concrete's compressive strength is f'_c = 3000psi for all floors. Reinforcing of concrete is done with high strength billet deformed steel bars with fy = 60,000psi as a minimum. All floor deck is 20 gage 3" deep galvanized composite deck and is continuous over 2 spans at the joints of the deck. All shear studs are headed studs of grade 1015 or 1020 cold finish carbon steel. Studs, at a maximum are spaced every 12".



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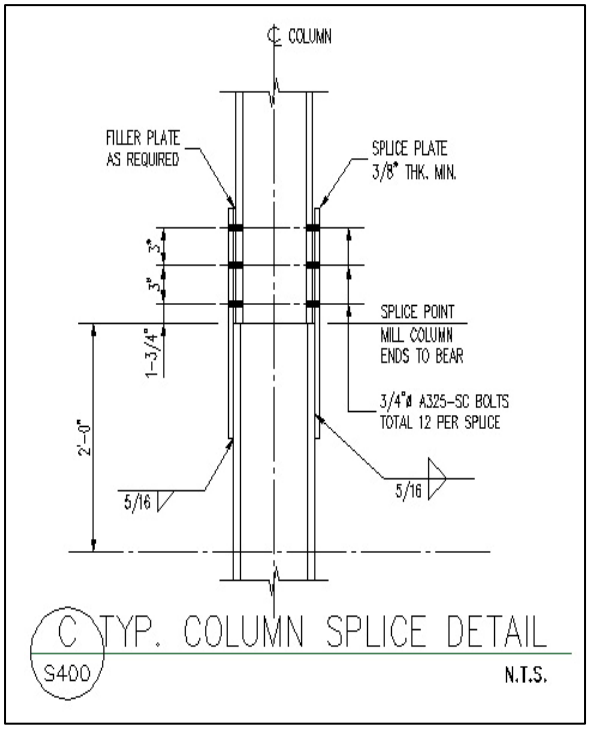
Columns

Columns consist of rolled structural W14 shapes grade 50. However there are a few W10x39's that extend from the 14th floor to the roof at selected areas. Columns extend from the concourse floor to just above the second floor, extending 3 floors or 36'. From the second floor up to the roof, columns are spliced at every two floors or 27'. Column Splices consist of 2 – 3/8" plates applied to the flanges of the columns being spliced. The plates are then connected to the bottom column with a 5/16" fillet weld all around the plate. The top column is then connected to the splice plate with 12 - 3/4" Ø A325 S.C. bolts.



Roof

The roof consists of rolled structural steel W shapes supporting roof deck and a lightweight concrete slab. Structural steel members are grade 50 W16 shapes and typically span approximately 27' with spacing of 9'. Roof deck is 20 gage, 3" deep galvanized wide rib type NI and is continuous over 2 spans at the joints of the deck. The roof deck will span from beam to beam, 9ft., and the short direction of a typical roof bay. The roof deck will be connected to the structural steel with 5/8" puddle weld in a 12-6-12 in pattern. Compressive strength of concrete on the roof is f'c = 3500psi at a minimum. The top of the concrete slab is 3 ¼"above top of slab, totaling to a 6 ¼"concrete slab.

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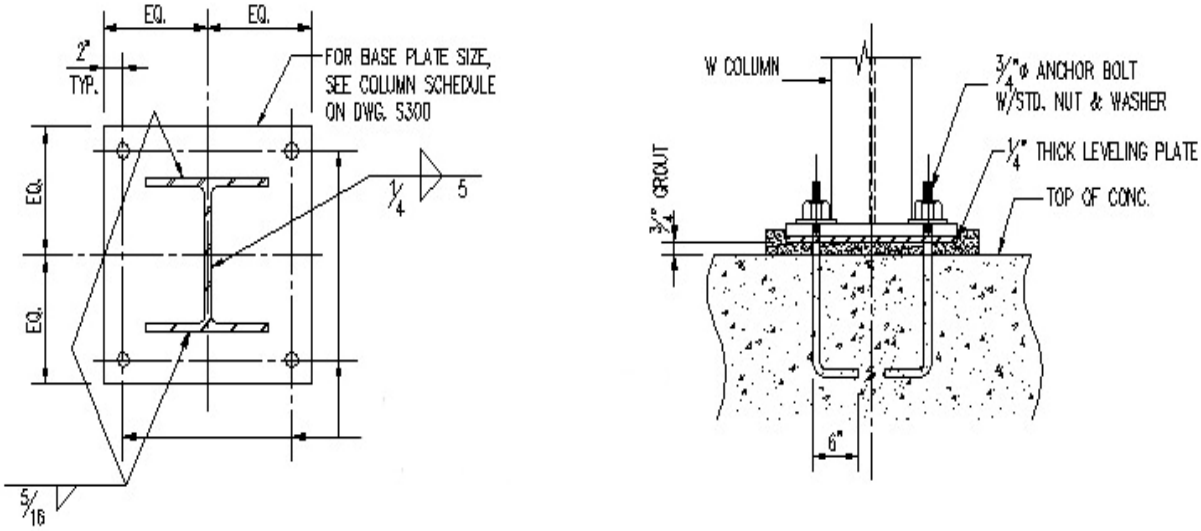
Foundations

The foundation system of Fordham Place is composed of 150 ton steel piles that extend approximately 45 – 50ft deep into bedrock. The piles are A992 grade 50 rolled W shapes and are capped with concrete caps that have a compressive strength of f'c = 3000psi. The pile caps will range in size depending on the number of piles it needs to contain, which is dependent on the load a given column transfers. The number of piles per pile cap ranges from 4 (PC-4) to 13 (PC-13). Load is transferred from the columns to the pile caps via A36 1/4" steel base plates. The base plate is welded to the column using a 5/16" fillet weld on the exterior of the flanges and a ¼" fillet weld on the web and interior of the flanges. The base plate is connected to the pile cap with 4 - 3/4" Ø anchor bolts extending 12 inches into the pile cap before turning 180 degrees and extending 6 more inches. Flush with the pile cap will be a slab on grade with a compressive strength f'c = 4000psi.



Base Plate Details

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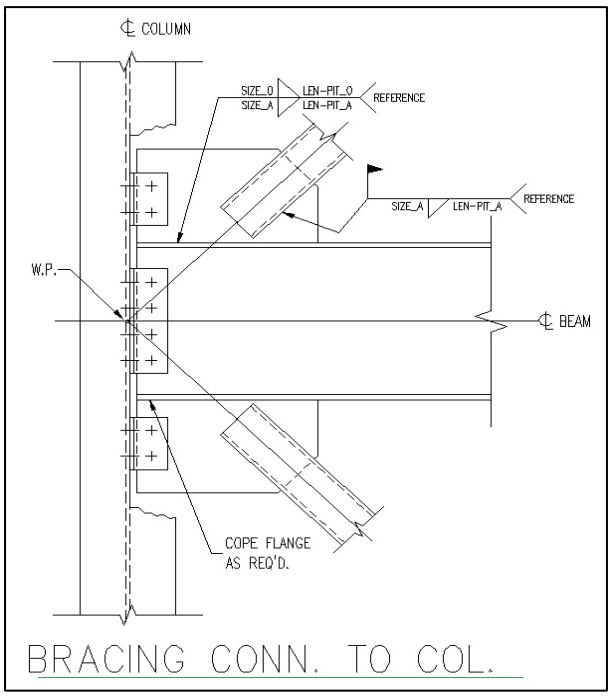
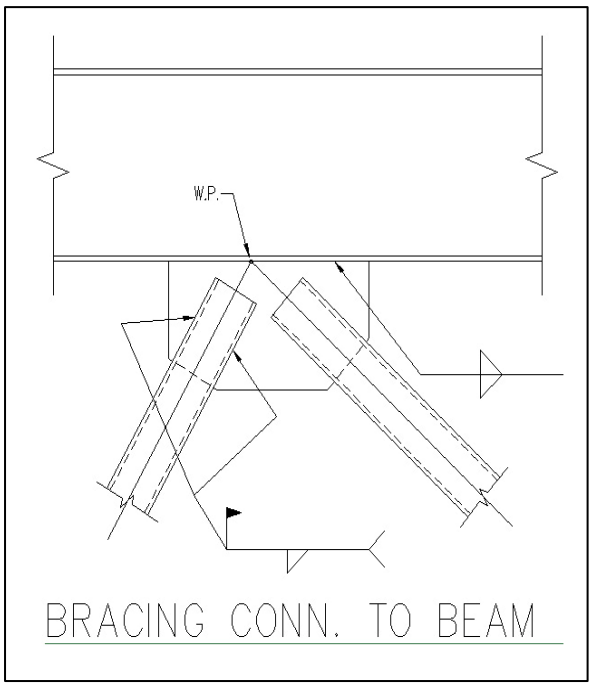
Connections

Throughout Fordham Place, there are many different connections, of which I have already talked about two; base plates and column splices. Other connections to consider are shear, moment, bracing connections to both columns and beams. Typical shear connections consist of double angles with the required number of A325 3/4"Ø S.C. bolts. Moment connections will be the same as a typical shear connection but will also have the top and bottom flanges of the beam welded with a 5/16" full penetration field weld. Bracing connections from the braced frames will be to beams and columns at different elevations of the building (See pictures below). Bracing to a column connections will compose of a gusset plate being welded to the underside of a beam and bolted to the column. Bracing members will be bolted to the gusset plate. Bracing to beam connections will occur at the midspan of the beam and will consist of a gusset plate welded to the underside of the beam. Bracing members will then be bolted to the gusset plate.





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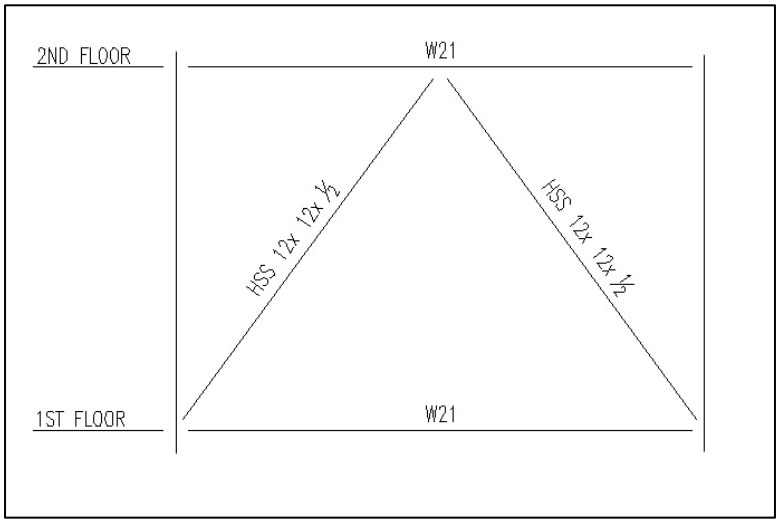
Enclosure

The building enclosure at Fordham Place consists of many different types. For the existing building, you will notice an older light brown brick wall with granite piers running the height of the building to interrupt the brick. At the base there currently is steel covering windows. But soon, when Fordham Place is finished with construction, it will return to display windows for retail stores. Playing off the older style building the existing structure brings, the new tower will match the light brown brick in the façade. The façade will also have sunlight gleaming off the many blue tinted glass panes. Finally, on the lower 2 floors facing Fordham Road, the building will have a glass façade enclosing a two story lobby area.

Lateral System

The lateral system is composed of moment connections and braced frames. Moment connections are mostly located along the plane in which the existing building and new tower are connected. This is done so that each building can act independent of each other. The braced frames are "K" type braces utilizing A500 grade B HSS12x12x1/2" structural steel members. They are located in six different bents, all of which are centrally located near the core of the building and extend from the concourse floor to the roof. The bracing is located near the core of the building in order to avoid inducing any internal torsion. As discussed in the connections part of this report, there is bracing connections to beams and columns. On each side of the bent, a bracing member will be framed from the bottom corner of the bent (column connection) to the midspan of the upper beam (beam connection). See picture to right.



Picture: Typical Chevron Bracing

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Problem Statement

After completing Technical Reports 1, 2, and 3, it was clear to me that the current design of Fordham Place is a complete efficient design. Technical report 1 was an exploration of the existing structural system and calculation of loads. For technical report 2, the existing floor system of concrete on composite metal deck supported by steel beams was compared to six other viable floor systems. It was obvious the existing system was the best and most efficient option, however two other options would be reasonable; two-way flat slab with drop panels and concrete on non-composite metal deck supported by steel beams. In technical report 3, a detailed analysis of the existing lateral system was done. It was determined the existing system, concentric steel chevron bracing, was also a great design for 2 reasons. One, chevron frames is a frame that is inexpensive compared to other lateral resisting systems such as moment frames. Two, the location of the frames throughout the building are located so that when lateral forces are applied to building, very little torsional moment will be induced into the building. With this said, there was not an obvious system to change in Fordham Place. Therefore, I would like to design Fordham Place using a two way slab with drop panels to gain experience with a concrete floor system.

Proposed solution

A viable solution will be to use an all concrete building as opposed to an all steel building. Due to architectural features, column locations will remain in the same locations; therefore leaving bay sizes the same. Considering the existing, 28' x 28' bay size, the only viable concrete system is a two way slab with drop panels. The new concrete floor system will require replacing the existing lateral force resisting system from concentric steel chevron braced frames to either concrete moment frames or shear walls. Both moment frames and shear walls will be further evaluated to determine which is better suited. Other design considerations will be floor to floor height, duct work / pipe / electrical paths, weight of building, and both story and total building drift.

Solution Method

The design of Fordham Place using a two-way flat slab with drop panels will done using the existing footprint and column locations of the building. A model of the building will be constructed using a finite element analysis computer program such as ADOSS or ETABS. Parameters such as slab thickness, gravity and lateral loads, concrete strength, etc. will be either hand calculated or assumed and inputted into the model. The modeling program will be used to design reinforcement; however spot checks will be done to assure a satisfactory design.

Once, gravity loads are transferred throughout the building and slabs and columns are designed, the lateral system will then be considered. Concrete shear walls and concrete moment frames will be considered as possible lateral resisting systems. With both systems, torsional effects can have a significant effect on the lateral design. However if they can be placed so that their center of rigidity is located near the geometric center of the building, the effects will be negligible. Floor deflection, story drift and total building drift will be checked. All designs of concrete elements will conform to ACI 02.

Proposed solutions design process

Two-way flat slab with drop panels

1. Determine Loads
2. Calculate Factored Loads
3. Determine slab thickness
4. Determine drop panel width and drop depth
5. Design reinforcement
6. Design columns
7. Check deflections
8. Check drift

Breadth Work

Construction Management

1. Gather duration information from CM's
2. Create schedule for proposed system
3. Obtain cost information from RS Means
4. Perform Cost Analysis for system

Mechanical

1. Determine if mechanical system is adequate for proposed solution
2. Determine if duct work paths need to be moved
3. Redesign mechanical systems and duct work paths as needed

Comparison of existing system vs. proposed system

1. Advantages and disadvantages of each system
2. Cost and duration of each system
3. Select which system is more appropriate
4. Prepare a final written report presenting results
5. Prepare a fantastic oral presentation based on results

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Proposed Schedule

January	GOALS
9	Explore which two-way slab will best suited
16	Place column locations and bulding footprint in ADOSS or ETABS model
23	Determine approximate gravity loads
30	Design two way slab
February	
6	Design Column sizes and reinforcement
13	Determine controlling lateral load
20	Design lateral System
27	Design lateral System
March	
6	SPRING BREAK
13	Develop Construction Schedule
20	Determine Cost Estimate using RS Means
27	Redesign mechanical systems and duct work paths as needed
Aprl	
3	Prepare Presentation
10	Presentation