THESIS PROPOSAL

1000 CONTINENTAL SQUARE

KING OF PRUSSIA, PENNSYLVANIA

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Structural Option
April 15, 2008

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EXECUTIVE SUMMARY

GENERAL DESCRIPTION

1000 Continental Square is a high-end office building, featuring large, open floor plans with uninterrupted forty-foot bays along each side of the building. It is located along the prominent intersection of Pennsylvania Routes 202, 76 and 422; and is in close proximity to a Pennsylvania Turnpike interchange and the King of Prussia Mall. The building has a partially sub-grade ground floor mainly for mechanical systems and storage with five floors of leasable space above that. Total square footage is approximately 192,000 square feet. The structural frame is steel with composite concrete slabs, and lateral loads are resisted by two moment frames along the long axis of the building and two eccentrically braced frames along the short axis.

PROPOSAL

In order to cater to the intended occupants the building was designed with relatively large 30’ x 40’ typical bays and a 100 psf live load on all floors so the space was a versatile as possible. The problem with this was many of the beams had to be over designed to control defections which resulted in some inefficiency in the design. My proposal is that if the building is converted to a concrete structural system some if this inefficiency can be removed. Additionally, the floor will be designed as a pan-joist slab and beam system which should reduce the total floor system depth significantly, as well as potentially act as the lateral system in the long axis of the building.

SOLUTION

This proposal requires the building’s structural system to be completely redesigned as concrete. The first step will be the design of the Filigree floor system which I will approximate with a standard one-way slab with beams. Then the columns will need to be redesigned in concrete and the foundations modified for the added weight of the new system. The final step will be the design of the lateral systems which will be shear walls to replace the existing steel braced frames.

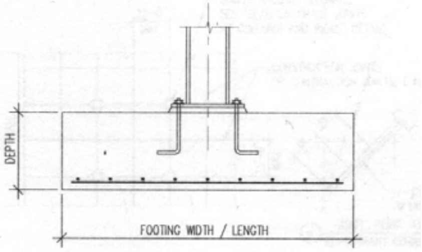
BREADTH TOPICS

In addition to the structural redesign, investigations into the lighting system and architectural design will be performed. The goal of the lighting system modification will be to include daylight calculations into the overall design in hopes of decreasing the energy used to light the office space. The architectural breadth will be an attempt to layout a suitable floor plan for an AE firm on one of the floors.

I. STRUCTURAL SYSTEMS

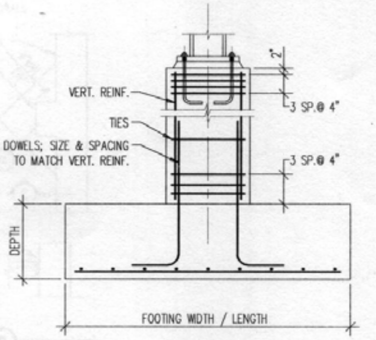
FOUNDATIONS

The foundations for 1000 Continental Square are a series of spread footings with continuous wall footings under the retaining walls located on the ground floor. The soils under the footings were found to withstand 4000 psf in most locations according to the geotechnical report furnished by Pennoni Associates Inc. on 24 of February 2004. Suitable bearing pressures were attained by deep dynamic compaction or partial soil exchange. Footing dimensions range from 4’ x 4’ x 1.5’ to 20’ x 20’ x 4’; however, typical footings are approximately 14’ x 14’ x 3’. Special 55’ x 18’ x 3.5’ spread footings are used under the braced frames. The tops of most footings are located 1.5’ below grade, and minimum bearing depth is 3’. Columns either bear directly on footings or in some atypical situations concrete piers are placed on top of the footings and columns bear on those. Footings have bottom reinforcement ranging from (7) #4’s to (16) #11’s with typical reinforcement being approximately (12) #9’s. The continuous wall footings are integrated into the spread footings they intersect, and their reinforcement is continuous throughout. Concrete in all footings has a minimum compressive strength, f’c = 3000 psi with a unit weight of 145 pcf. There is a 4” thick slab on grade which acts as the floor system for the ground floor and utilizes 4000 psi compressive strength concrete.



NOTES:
1. WHERE CONCRETE OR REINFORCED CMU WALLS BEAR ON THE FOOTING INSTALL WALL DOWELS INTO THE FOOTING.
2. INSTALL WALL FOOTING REINFORCING CONTINUOUS THROUGH INTERSECTING SPREAD FOOTINGS.

① SPREAD FOOTING
SUPPORTING STEEL COLUMN

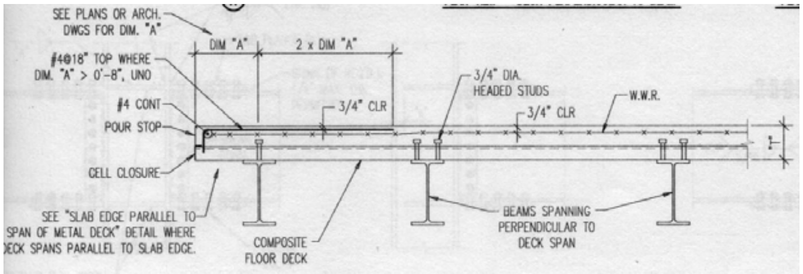


NOTES:
1. WHERE CONC WALLS OCCUR, INSTALL WALL DOWELS IN THE FTG.
2. INSTALL INTERSECTING WALL FOOTING REINF CONTINUOUS THROUGH SPREAD FOOTING.

⑤ SPREAD FOOTING
SUPPORTING CONCRETE PIER

FLOOR FRAMING

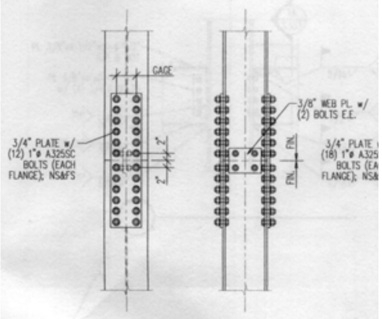
All the floor framing above grade in the 1000 Continental Square project is 6¼” composite slabs. They consist of 3¼” lightweight concrete over 3” deep 20 gage galvanized composite floor deck. The slab is reinforced by one layer of 6 x 6 – W1.4 x W1.4 WWR, and has a weight of 115 pcf and a compressive strength of 3500 psi. This is supported by W 18 x 35’s spanning 40’ bays which tie into an assortment of girders spanning 30’; W 24 x 55’s being the most typical. Composite action



is achieved through 6” long ¾” diameter headed studs, approximately 34 evenly spaced per beam. The W 18’s feature a typical camber of 1.5”. Variations in design occur at architectural features, the elevator shafts, and intersections with the moment frames, elsewhere the system is nearly identical on all floors.

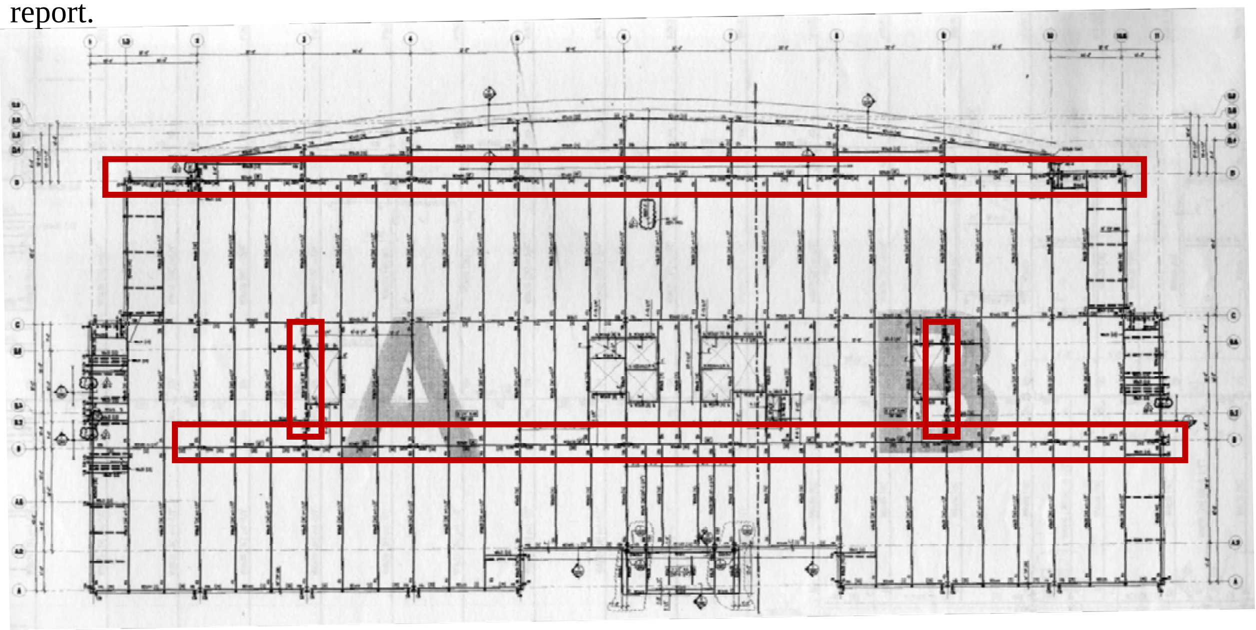
COLUMNS

The column grid for the building is laid out rectilinearly using three spans: 40’, 35’, 40’, in the N-S direction and (10) 30’ spans in the E-W, thereby creating large, uninterrupted, regular bays to simplify leasing. Column sizes vary between W 12 X 230’s on the first floor of the moment frames to W 12 X 40’s for gravity columns on the top floors. Splice levels are located a maximum of 4ft above the second and fourth floors. Typical columns are W 12 x 152’s on the bottom floors, W 12 x 96’s on the middle floors, and W 12 x 40’ on the top levels. Typical columns are fixed to foundations with four ¾” diameter anchor rods with 1’ embed depths and 4” hooks.



LATERAL LOAD RESISTING SYSTEMS

1000 Continental Square is reinforced against lateral loads by different systems along its long axis (E-W) and short axis (N-S). In the E-W direction two moment frames fit into the existing grid along column lines B and D, and act over the full height of the building and effectively its full length. In the N-S direction two full height eccentrically braced frames fit off grid between lines B and C along column lines 3 and 9 to provide support for the short axis. These systems act to counter both wind and seismic forces, however wind loads were found to control the design in this situation. There are two additional types of one story braced frames used in the building to mainly support architectural elements which are not analyzed in this report.

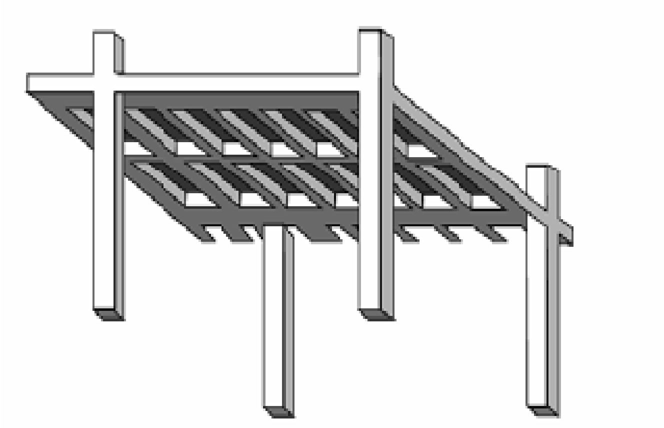


II. PROBLEM STATEMENT

1000 Continental Square uses a composite steel structural system. This system was found to be the lightest weight and relatively easy to construct making it one of the best options. However, it was found to have some rather serious drawbacks as well. Problems like long lead times and the need for spray on fireproofing drag out the construction process and add cost. Additionally, through the first three technical reports it appeared that many of the members were oversized when checked for strength in order to deal with serviceability issues. These issues arise from the large bay sizes and relatively light structural system. This inefficiency could be minimized with an alternate framing system. The current steel system also uses two moment frames to resist lateral loads along the long axis of the building. This moment frame adds a great deal weight and cost to the building. An alternate system could more efficiently handle these lateral loads.

III. PROPOSED SOLUTION

I intend to solve these inherent problems of the steel system by converting the existing structural system to an all concrete system. There are two possibilities for the new floor system. Either a one-way post tensioned slab with beams or a pan-joist slab and beam system could be used. The pan-joist system would be preferred because it is far easier to construct than the PT slab since it reduces the amount of form work than needs to be constructed to that of a flat plate. If the pan-joist system proves to be unfeasible, the fall back will be the more expensive PT slab. The other problem with the PT slab is issues with shear but hopefully the beams with alleviate that concern. Both of these methods have many benefits over the existing steel system. Since they are concrete, there is no need for additional fire proofing which should save construction costs, and the more massive nature of the concrete should take care of any serviceability issues. Both systems should result in a thinner final floor depth when compared to the current system. If the beams in either system are run in the building's long direction they can also be used to resist lateral loads thereby preventing the need for an additional lateral load resisting system. The braced frames in the short direction can be replaced by two concrete shear walls and all other columns will remain in their current locations so there is no real effect on building architecture. The main drawbacks of the concrete systems



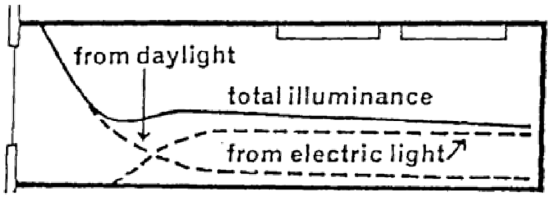
are the added weight, but if the foundations and lateral systems can be designed to support it, the resulting building will hopefully be more economical and serviceable design.

IV. SOLUTION METHODS

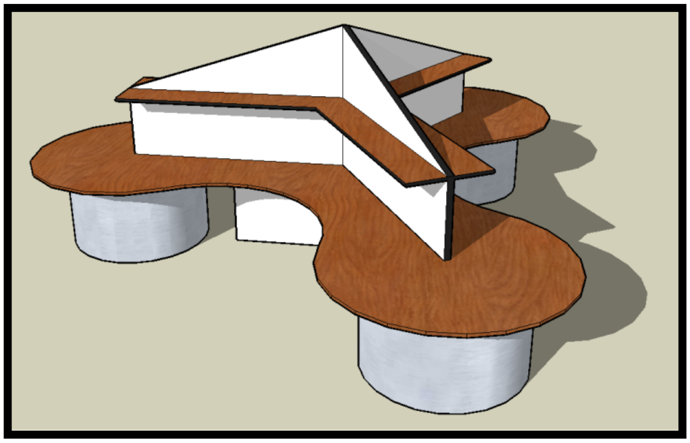
The redesign will start with the floor system. The pan-joist will be design with the CRSI Handbook, and then checked by hand. Then this design will be used to approximate the final weight of the system. Using this weight I will design the columns and recheck the wind and seismic calculations from the first technical report. Using the updated lateral loads I will check the capacity of the beams in the floor system and design the connections for their moments. Then I will design of the two shear walls and look into possibly including more in the elevator cores if needed to deal with those lateral loads. Finally the foundation capacities will be checked and redesigned to deal with the increased weight of the structure. An RAM model will be used to double check the final design as well as drift and torsion effects.

V. BREADTH ONE - EFFECTS OF DAYLIGHT

My first breadth study will look at how energy costs can be saved by using daylight. The north side of the building is a continuous glass curtain wall. This should allow a great deal of ambient daylight into the work space which should save on power costs. Additionally, there is also a large curtain wall at the front entrance on the south side of the build, this curtain wall could possibly be used to help light the elevator and lobby space since the harsher direct sunlight is not as good for lighting work spaces. Hand calculations will be conducted to figure out solar angles, solar gain, and daylight levels. All of this will then be used to decide if it would be feasible to introduce a lighting system with zones which are adaptable to various levels of daylight, and perhaps integrate photosensor light controls.



VI. BREADTH TWO – ARCHITECTURAL STUDY



The architectural breadth will concentrate on the layout of a mid-sized AE firm in half of one of the typical floors. The design will include features to make the space a more enjoyable and motivating pace to work. The design will incorporate features of the overall building design into the floor plan like curving lines and extensive glazing. Additionally the new design will feature an improve cubicle layout which inspires productivity through ergonomics. The Final design will meet area requirements determined from other AE offices, and will incorporate ideas from professionals currently in the field. The result should be an excite and adaptive work space.

VII. TASKS & TOOLS

1. MAIN STUDY - ADAPTATION TO CONCRETE STRUCTURAL SYSTEM

Task 1: Verify assumptions and feasibility

1. Double check loadings from ASCE 7-05
2. Check feasibility of Filigree System with manufacturer

Task 2: Design substitute pan-joist slab and beam system

1. Modify one-way slab from tech 2 so beams run in the long direction
2. Check deflections in beams and serviceability
3. Specify reinforcement for negative moments at columns and over beams

Task 3: Update Loads

1. Recalculate building weight
2. Modify seismic calculations

Task 4: Design columns and footings

1. Use PCA Column to design all columns
2. Double check shear if column sizes change
3. Design footings for new weight and layout reinforcement

Task 5: Design lateral systems

1. Check if beams can support lateral load in the long direction

2. Add reinforcement for additional moment from lateral at columns
3. Design shear walls where braced frames were located

Task 6: RAM model

1. Construct model of new system in RAM
2. Check drifts and torsion with RAM

2. BREADTH ONE – EFFECTS OF DAYLIGHT

Task 1: Determine existing conditions

1. Get lighting plans and luminaire schedule from lighting designer
2. Calculate standard energy loads resulting from lighting daily
3. Calculate solar angles and potential solar gains

Task 2: Modify existing system

1. Reconfigure lighting circuits and switches based on required lumens including daylight
2. Calculate and balance circuit loads
3. Recalculate daily energy usage and contrast with original values

3. BREADTH TWO – ARCHITECTURAL STUDY

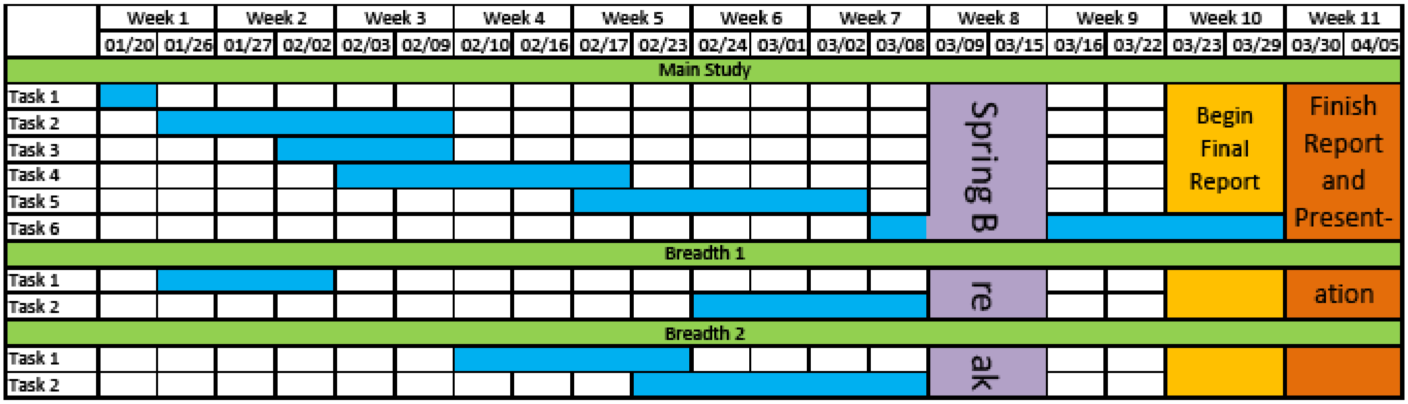
Task 1: Determine required spaces

1. Use Thornton Tomasetti's floor plan to get general square footages
2. Talk with engineers to find problems with their offices
3. Modify square foot areas to better meet engineer's needs

Task 2: Layout new system

1. Integrate design features form other parts of the building
2. Develop new cubicle system
3. Determine correlation of different components
4. Layout a system to meet listed needs

VII. TIMETABLE



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