Thesis Proposal

Administration Building

Justin Purcell

Structural

AE Faculty Consultant: Dr Hanagan

Pennsylvania

December 18, 2007

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Administration Building is an office building in Pennsylvania which is 87' tall, but only 67' are above grade. It has five floors with the first floor being 20' floor to floor height and the rest being 13.33' floor to floor height. It is a rather long building with 560' in the long direction and 203' in the short direction.

The building's primary structural system is comprised of a composite steel frame with composite floor slabs. The building resists lateral loads using braced frames between the floor slabs, which act as rigid diaphragms. The frames use stiffness in the plane of the lateral load and act similar to a truss to transfer the loads to the columns, which then transfer the loads to the foundation.

However, a composite steel building is not the most economical floor framing system. In technical assignment #2, four other systems were chosen as alternative floor framing methods and they all cost less than a composite steel building. A composite steel building is the industry standard for a steel structure and the design professional has more than sufficient experience in this type of design. With that in mind, the reason is clear why the design professional choose to use a composite steel building.

The proposed solution will involve changing the existing composite steel framing to a 1-way concrete slab. With the use of the existing column grid, the girders will frame in the 20' direction. The beams run perpendicular to the girders, spanning in the 40' direction. The lateral system will change from a braced frame system to moment frame system. The moment frames are achieved simply from the columns and beams. Since my building is only 4 stories above grade, moment frames should be sufficient. If moment frames are not sufficient, then the use of shear walls will be used.

By switching to 1-way slab system, multiple advantages are possible. The proposed solution requires no lead time which is a huge benefit when working on a tight schedule. With using concrete instead of steel, vibrations will not be an issue. Finally, the 1-way slab has a deflection of 1.77" which is deflection savings as compared to the composite system.

This system will be designed using ETABS or RAM Structural System, PCA Slab, PCA Column, ACI 318-05 as the model code, and the CRSI handbook. Trial sizes, as outlined above will be inputted into ETABS where multiple load combinations will be analyzed to determine what load combination controls. Also the sizes mentioned above are only trial sizes and most likely will change.

Changing from a composite system to 1-way slab system will impact the cost and schedule. An in-depth cost and schedule impacts of the 1-way slab will be analyzed for my construction management breadth. This includes a further analysis of just R.S. Means, but an assemblies estimate. Sub contractor input and vendor quotes will be analyzed.

For the electrical breadth study, a redesign of the transformers for the buildings electrical power distribution system. Currently there are an excessive amount of transformers used in the electrical power distribution. To reduce the number of transformers, the feeders must also be resized.

BUILDING BACKGROUND:

BUIDING INFORMATION:

This is an administration building for a confidential client in Pennsylvania that was constructed in July 2003. It offers offices and specialty amenity spaces as the architectural layout of 311,905 S.F. of usable floor area. There are five floors, four of which are above grade with a cost ranging between $70-75 million.

FOUNDATION:

The foundation system will consist of reinforced concrete spread footings that are sized utilizing bearing capacities ranging from 4,000 psf at soil bearing footings and 15,000 psf at rock-bearing footings. Total building settlements will be less than 1" with differential settlements not exceeding ½" or 1/300, based on a 20' bay. Typical perimeter frost walls are supported on continuous reinforced concrete strip footings. Foundation walls at basement or below grade levels are reinforced concrete basement walls designed for soil lateral loads and appropriate surcharge loads and supported by continuous reinforced concrete strip footings. These walls are drained on the soil side to minimize lateral surcharge loads on the walls and buildings. The slab on grade varies between a 5", 6" and 8" thickness, typically with 6x6-W4.0xW4.0 W.W.F.

FLOOR SYSTEM:

The structural floor system is 3¼" lightweight concrete slab on a 3", 20 gauge composite metal deck, totaling 6¼". The metal deck utilizes ¾" steel studs, supported by wide-flange beams and wide-flange columns. The typical sizes of the beams range from W18x40 to W30x116. The girders range from W21x50 to W27x146. The columns range from W10x43 to W14x211. The concrete is lightweight weight (115 pcf), cast-in-place concrete and will have a 28 day strength of 4,000 psi. The concrete slab is reinforced with 6x6-W2.9xW2.9 W.W.F. to minimize plastic shrinkage cracking. The thickness of the concrete is established based on the required 2 hour fire rating for the floor construction without spray fireproofing applied to the underside of the metal deck. Structural steel shall comply with ASTM A572, Grade 50. Steel stud shear connectors shall conform to ASTM A108.

To maintain the 5'-0" building module within the typical bay sizes of 20'-0" and 40'-0", the typical beams supporting the composite slab are spaced at 10'-0" on center. These beams supporting the composite slab for the typical bays span to girders oriented across the width of the building. The wide flange steel girders in the long direction or the building support the wide flange steel beams that span the 3 bay width of the building consisting of (1) 20'-0" and (2) 40'-0" bays. Spanning the beams across the width of the building works best in combination with a braced frame lateral load resisting system.

ROOF SYSTEM:

The structural roof system consists of a 1½", 20 gauge, Type B, galvanized metal roof deck with spray fireproofing. Below mechanical equipment a concrete slab on composite metal deck is used instead of the standard roof deck and the concrete slab is reinforced with 6x6-W2.9xW2.9 W.W.F. to minimize shrinkage cracking. The framing members supporting the metal deck are either open-web joists or wide flange steel beams at 4'-0" and 5'-0" centers. The beams supporting the composite slab are wide flange steel beams at 10'-0" centers that span the width of the building.

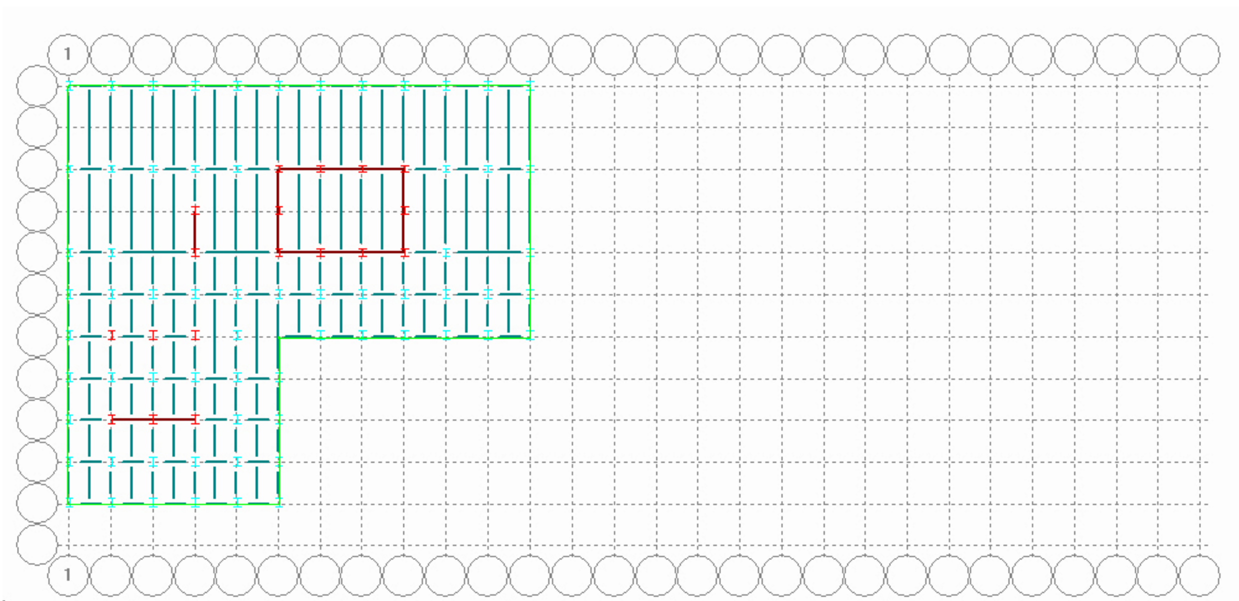
LATERAL SYSTEM:

The typical composite steel-framed building utilizes a braced frame lateral load resisting system. The braced frames have been coordinated, located and configured to integrate with the architectural layout and mechanical distribution. These frames consist of wide flange columns, wide flange beams at each story and one HSS (hollow structural section) diagonal braces between each story. Typically the HSS braces will be HSS8x6x1/2.

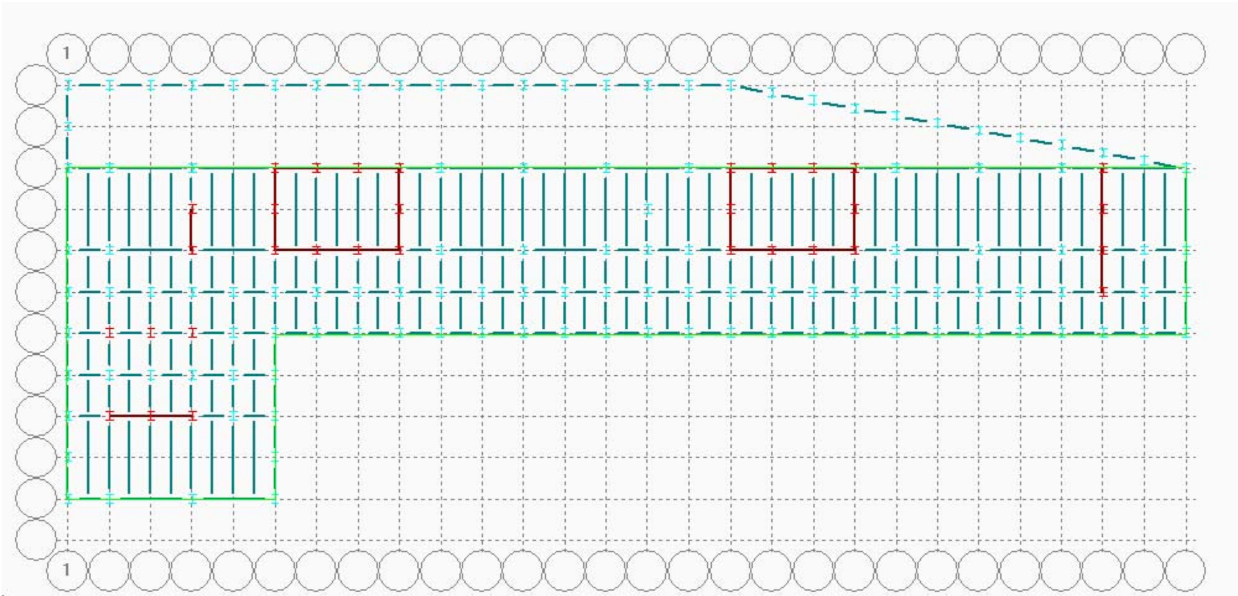
EXTERIOR WALL SYSTEM:

Pre-fabricated brick truss panel assemblies comprised of structural tube and stud infill, steel relieving lintels, and shop-applied exterior brick face. There was a nine-month lead-time for brick materials. This system is independent of the floor and roof framing thus enabling smaller spandrel beam sizes.

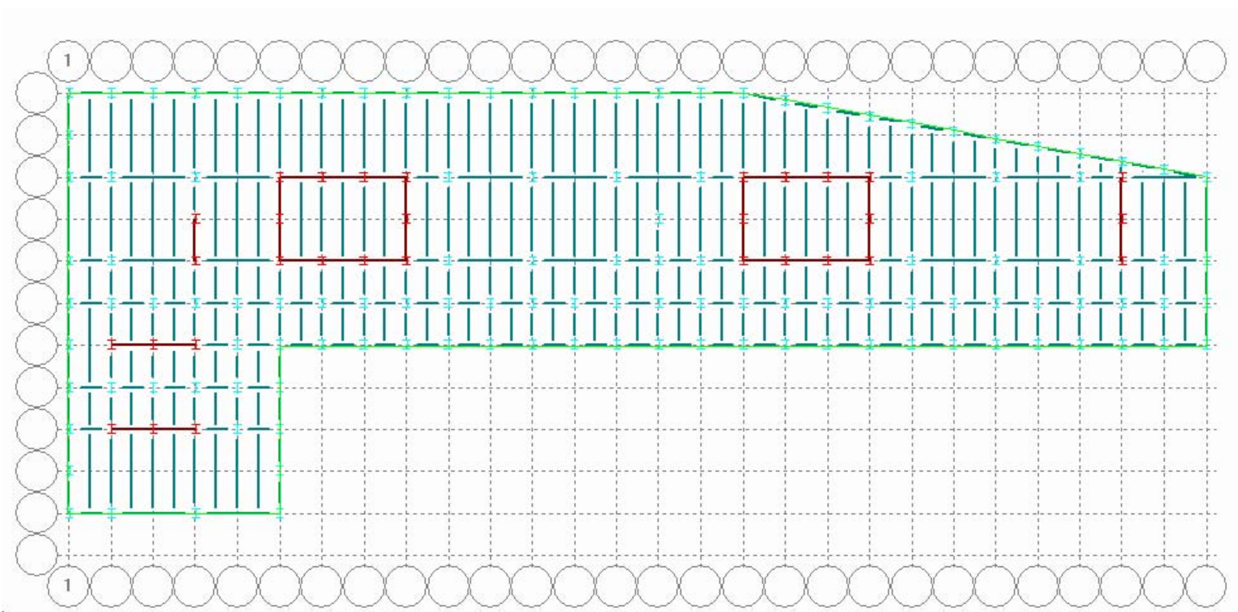
FIRST FLOOR FRAMING PLAN:



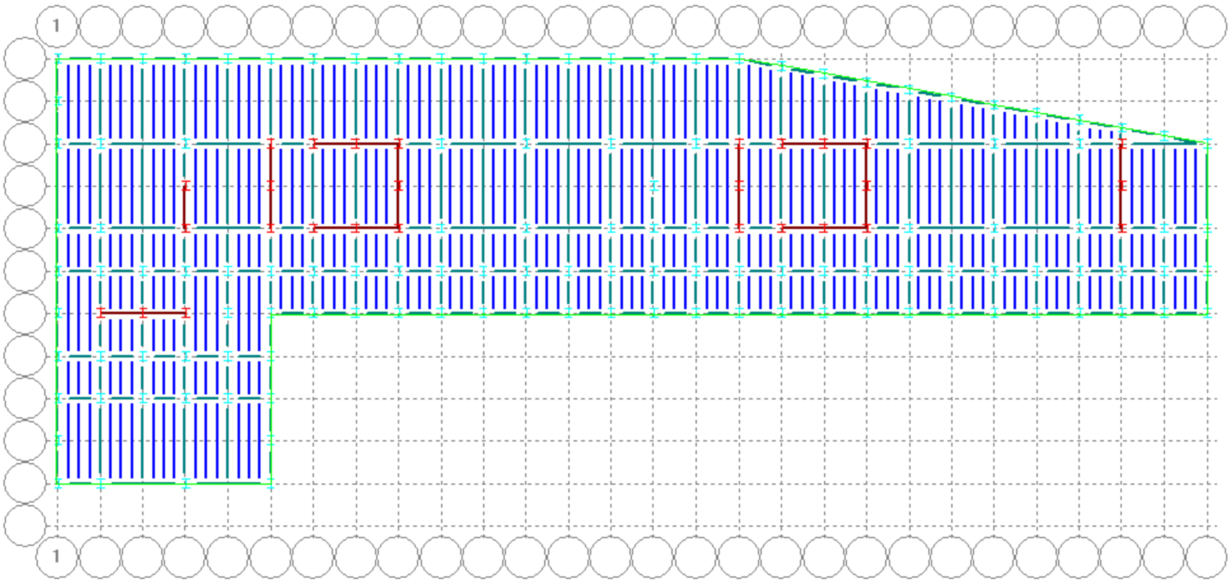
SECOND FLOOR FRAMING PLAN:



THIRD-FIFTH FLOOR FRAMING PLAN:



ROOF FRAMING PLAN:



Red indicates braced frame
Blue indicates open-web joists
Dark green indicates composite beams
Light green indicates columns

PROBLEM STATEMENT

The administration building is a composite steel building with braced frames to resist lateral loads. As portrayed in Technical assignment #3, the gravity and lateral components were sufficient to carry the loads. However, a composite steel building is not the most economical floor framing system. In technical assignment #2, four other systems were chosen as alternative floor framing methods and they all cost less than a composite steel building. A composite steel building is the industry standard for a steel structure and the design professional has more than sufficient experience in this type of design. With that in mind, the reason is clear why the design professional choose to use a composite steel building.

PROPOSED SOLUTION

As mentioned in the problem statement, there are four alternative floor framing systems that are all less expensive than a composite steel building. However, only two of the four systems are viable systems, which are open web steel joists and a 1-way slab. In a preliminary analysis the open web joists were found to be $6.65 million and the 1-way slab was $7.9 million.

The proposed solution will involve changing the existing composite steel framing to a 1-way concrete slab. With the use of the existing column grid, the girders will frame in the 20' direction. The beams run perpendicular to the girders, spanning in the 40' direction. The floor system is a 10" normal-weight concrete slab. The slab is typically supported by 16"x28" beams and 20"x26" girders. The concrete is normal weight, cast-in-place concrete and will have a 28 day strength of 3,000 psi for the slab and 4,000 psi for the beams/girders. The required 2 hour fire rating is sufficiently adequate with a 10" slab. The lateral system will change from a braced frame system to a moment frame system. The moment frames are achieved simply from the columns and beams. Since my building is only 4 stories above grade, moment frames should be sufficient. If moment frames are not sufficient, then the use of shear walls will be used.

By switching to 1-way slab system, multiple advantages are possible. The proposed solution requires no lead time which is a huge benefit when working on a tight schedule. With using concrete instead of steel, vibrations will not be an issue. Finally, the 1-way slab has a deflection of 1.77" which is savings as compared to the composite system.

This system will be designed using ETABS or RAM Structural System, PCA Slab, PCA Column, ACI 318-05 as the model code, and the CRSI handbook. Trial sizes, as outlined above will be inputted into ETABS where multiple load combinations will be analyzed to determine what load combination controls. Also the sizes mentioned above are only trial sizes and most likely will change.

Changing from a composite system to 1-way slab system will impact the cost and schedule. An in-depth cost and schedule impacts of the 1-way slab will be analyzed for my construction management breadth. This includes a further analysis of just R.S. Means, but an assemblies estimate. Sub contractor input and vendor quotes will be analyzed.

For the electrical breadth study, a redesign of the transformers for the buildings electrical power distribution system. Currently there are an excessive amount of transformers used in the electrical power distribution. To reduce the number of transformers, the feeders must also be resized.

TASK AND TOOLS

I. 1-Way Slab alternative

A. Calculate new dead loads
B. Determine slab thickness
C. Determine beam sizes
D. Determine girder sizes
E. Determine column sizes
F. Analyze system in ETABS or RAM Structural System
G. Check deflections
H. Adjust design if necessary

II. Lateral system analysis

A. Recalculate lateral loads according to ASCE 7-05, using new building weight and rigidity
B. Distribute wind and seismic lateral loads to moment frames
C. Analyze lateral system in ETABS or RAM Structural Steel
D. Determine story and total drift and compare to allowable
E. Add shear walls if moment frames are not sufficient
F. Consider lateral impact on foundation design
G. Adjust design if necessary

III. Construction Management breadth

A. Obtain actual cost information from GC, if possible
B. Perform takeoff of existing structural system
C. Perform takeoff of new structural system
D. Compare the two take-offs
E. Request feedback from GC on proposed system cost to ensure accuracy
F. Consider cost implications of schedule changes.

IV. Electrical breadth

A. Find actual panel board loads on panel board schedule
B. Reduce number of transformers
C. Resize feeders

TIME TABLE

Week	Dates	Activity
1	1/14/08-1/18/08	1A-1D,3A,4A
2	1/21/08-1/25/08	1E-1H
3	1/28/08-2/1/08	2A-2B
4	2/4/08-2/8/08	2C
5	2/11/08-2/15/08	2D-2G
6	2/18/08-2/22/08	3A
7	2/25/08-2/29/08	3B
8	3/3/08-3/7/08	3C
9	3/10/08-3/14/08	Spring Break
10	3/17/08-3/21/08	3D-3F
11	3/24/08-3/28/08	4A
12	3/31/08-4/4/08	4B
13	4/7/08-4/11/08	Finalize Report
14	4/14/08-4/18/08	**Present**