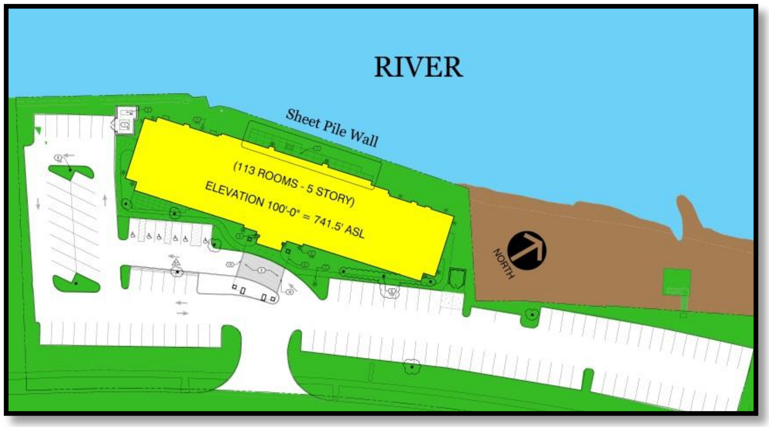
Contents

Introduction

Located along a river in the Northeast United States (henceforth referred to as Hotel N.E.U.S.), this five story, 113 room hotel is constructed with masonry bearing walls and a precast concrete floor system. It stands in place of an old steel mill and was constructed as part of the area's development in the 1990's.



At its tallest, the building is 60'-8" tall with a long slender shape that allows for windows in every room. Its façade consists of arching exterior insulation finishing system (EIFS) and a brick veneer. The warm colors of beige and brown provide a sense of comfort and soothing that communicate the architecture's purpose, a place to rest.

All of the amenities of a hotel are included, such as a pool, fitness area, meeting room, ADA accessible rooms, and sunlight for all rooms. There is an overhang at the entrance allowing for drop off and pick up with protection from the elements. The Hotel N.E.U.S. provides 75,209 ft^2 of floor area to a location lacking such facilities. Construction started in October of 2011 and is slated to finish in November of 2012 and cost $9.2 million dollars.

Note: The overhang at the entrance is not considered in the analysis or evaluation of this building at any point.

All photos/plans/documents provided by Atlantic Engineering Services/Meyer Associates

Executive Summary

The Hotel N.E.U.S. is a 5 story, 61' tall hotel located in the Northeast United States. With an approximately 16,000 square foot floor plan there are 113 rooms of varying sizes. The building is constructed of steel framing on the first floor with masonry bearing and shear walls with a floor that consists of hollowcore precast plank.

The purpose of this proposal is to establish the plans and procedures for the Spring 2013 spring semester. The structural depth will be comprised of redesigning the gravity and lateral systems. Since there is already steel used in the Hotel N.E.U.S. it is reasonable to design the entire structure using steel. A composite deck will be used with composite beams to create the floor. Braced frames will be utilized where the former shear walls were located, while moment frames will be placed on the exterior to allow for window openings. Shear connections for a bay will be developed while a typical moment and braced connection will be designed for the lateral resistance. The new system will be compared to the old based on cost and construction schedule.

To accompany the depth study, two breadths will be investigated that are interrelated. The exterior of the building is constructed of brick veneer and EIFS. Although EIFS has become a more popular material to use, there have been issues with its performance, especially in wet regions such as the Northeast United States. Therefore, an enclosure/façade study will be conducted. Advantages and disadvantages will be examined for the current enclosure while alternates are prepared. Factors such as thermal properties, water protection, and cost will be used to compare the systems. A typical detail will be drawn for the best alternative to the current enclosure/façade.

The second breadth topic will be how the changes in the structure and enclosure impact the architecture. A study will be conducted on Hotel aesthetics, the accenting of structure through architecture, and facades. There are many ways these can cause the architecture to change. In today's world, hotels are "branded" and have a look that gives off a look that people can associate with a name. Due to the Hotel N.E.U.S. standing as its own piece, these typical ideas can be explored and new architecture can be established.

Structural Overview

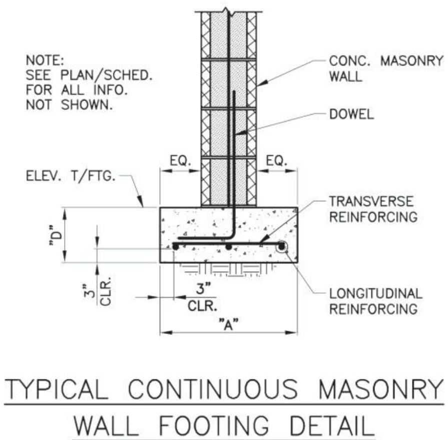
Foundations

Michael Baker Jr., Inc. provided the Geotechnical report in July of 2011. Their report included a history of the site that impacts the features below grade for this project. Prior to 1986 the site of the Hotel N.E.U.S. was occupied by a steel mill. Cooling towers were located at the footprint of the current building while a gantry crane and tracks were to the Southwest. The sheet pile retaining wall was constructed in 1979. In 1990's a development of the area began and the mill was removed. Foundations and other below grade structures were usually removed to about to about one foot below grade. In 2001 a Damon's Restaurant and parking lot were constructed in the area that the hotel is to be located. Fill was added to the site during this time.

Geotechnical Consultants, Inc. drilled seven test boring in April of 2001 to support Damon's Restaurant and those reports were included and mostly consisted of Slag and Concrete with little Silt. Terra Testing excavated four test pits and drilled thirteen test borings in April of 2011. They totaled 10 linear feet of rock and 282 linear feet of soil (see Figure 3 for location of all borings). The major finding in these tests was that there were buried concrete obstructions. They were determined to be the concrete pad that supported the cooling towers in the past.

The fill was considered to be suitable for a shallow spread foundation system. The bearing pressure was controlled by a limiting settlement of one inch and the capacity of the soil. The allowable bearing capacity of the soil increases with the size of the footing. Larger footings cause much higher stresses however, so the bearing pressure decreases with larger sizes (see Figure 1 for tables providing various sizes). A minimum of a 3' x 3' reinforced footing was suggested and no less than 16.7' center-to-center distance between wall footings. Footings bearing on the concrete pad were allowed a reduction of 1.5'.

Continuous wall footings range from 2'-0" wide to 9'-0" wide with typically #5 or #7 for longitudinal and transverse reinforcement. Column footings ranged from 6'x6'x1'-6" to 8'x8'x1'-8" (see Figure 1 for footing schedule). Typical piers are 24"x24" with 4-#6 vertical with #3 at 12" ties.



CONTINUOUS WALL FOOTING SCHEDULE

MARK	WIDTH "A"	DEPTH "D"	LONGITUDINAL REINFORCING	TRANSVERSE REINFORCING	MARK
WF1	2'–0"	1'–0"	2–#5 CONT.	#5x1'–6" @ 24" O.C.	WF1
WF2	3'–0"	1'–0"	3–#5 CONT.	#5x2'–6" @ 24" O.C.	WF2
WF3	9'–0"	1'–6"	6–#7 CONT.	#7x8'–6" @ 12" O.C.	WF3
WF4	5'–0"	1'–0"	3–#7 CONT.	#7x4'–6" @ 18" O.C.	WF4
WF5	6'–0"	1'–3"	6–#5 CONT.	#5x5'–6" @ 18" O.C.	WF5

Figure 1: Continuous Masonry Wall Footing detail and schedule

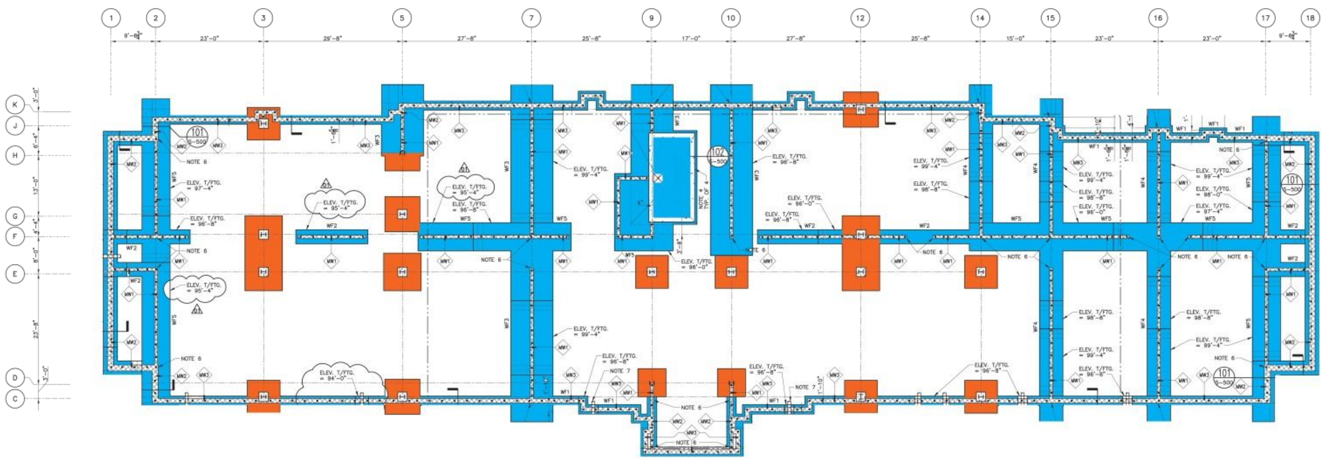


Figure 2: Foundation Plan.
Blue- wall footings
Orange- Column Footings

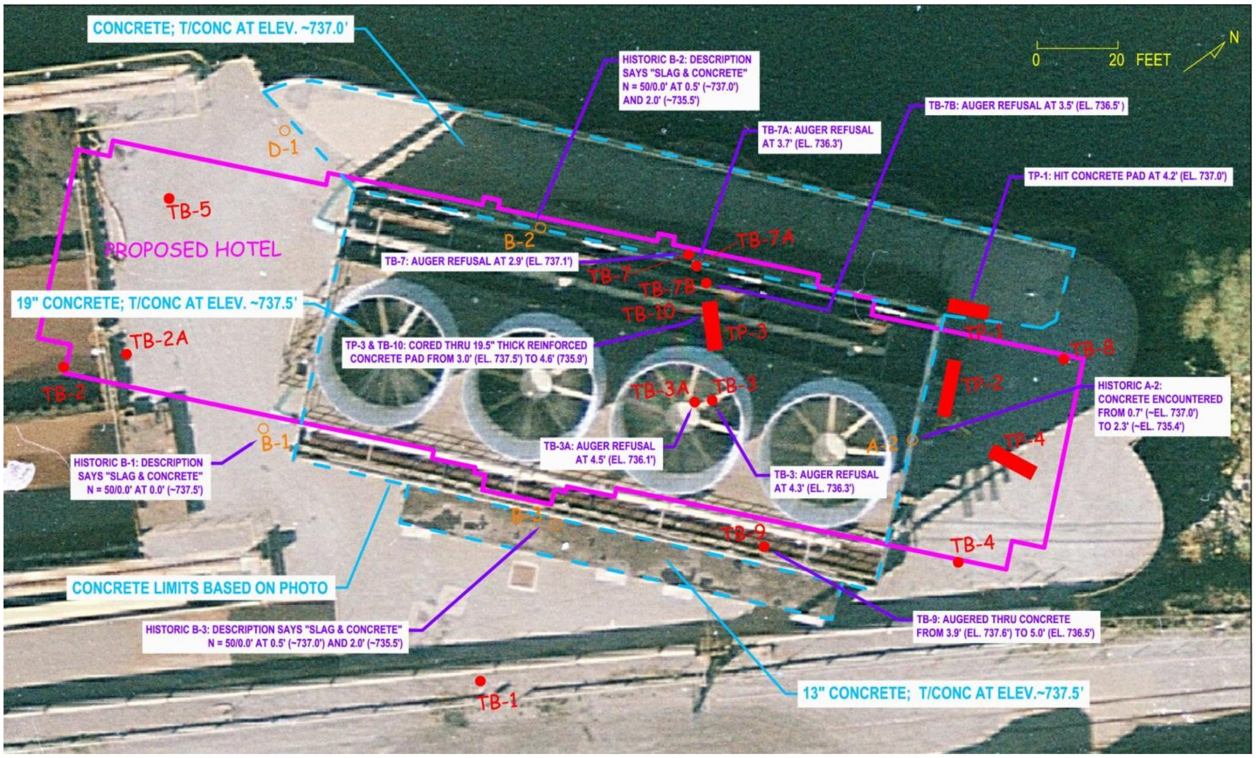


Figure 3: Site map showing test borings, existing mat foundation, hotel footprint, and location of former cooling towers.

Floor System

The floor system is composed of 8" Hollowcore precast concrete plank. There is a 3/4" topping to level off the floor since the planks have camber when they come out of production. The plank allows for long spans between the bearing walls. The smallest span is 15'-0" while the largest is 29'-8". Due to the large open spaces on the first floor, large transfer beams are used to carry the walls on the second floor up to the roof. These wide flange beams are approximately 30" in depth and weigh anywhere from 90 to 191 pounds per foot. Smaller beams span the corridor between walls and are much smaller, ranging from W6x25 to W24x68.

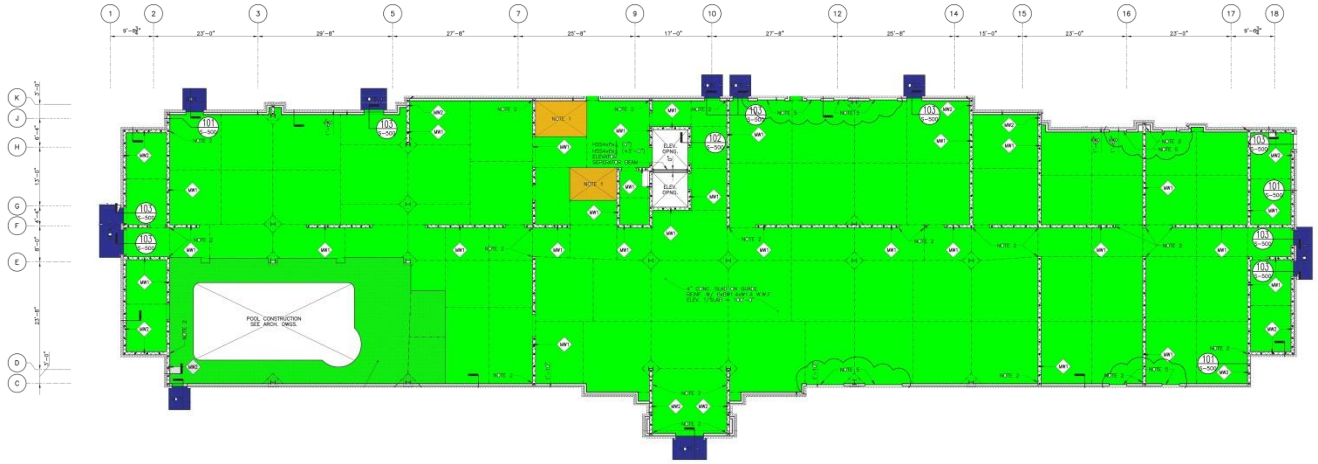


Figure 4: Slab on grade. Light green- 4" Conc. Slab on grade w/ 6x6W1.4xW1.4 W.W.F.

Orange- 3'-0" thick Conc. Slab w/ #5@12" O.C. Top and B.E.W. Isolated from adjacent slab.

Blue- Exterior 4" Conc. Slab on grade w/ 6x6W1.4xW1.4 W.W.F sloped away from building.

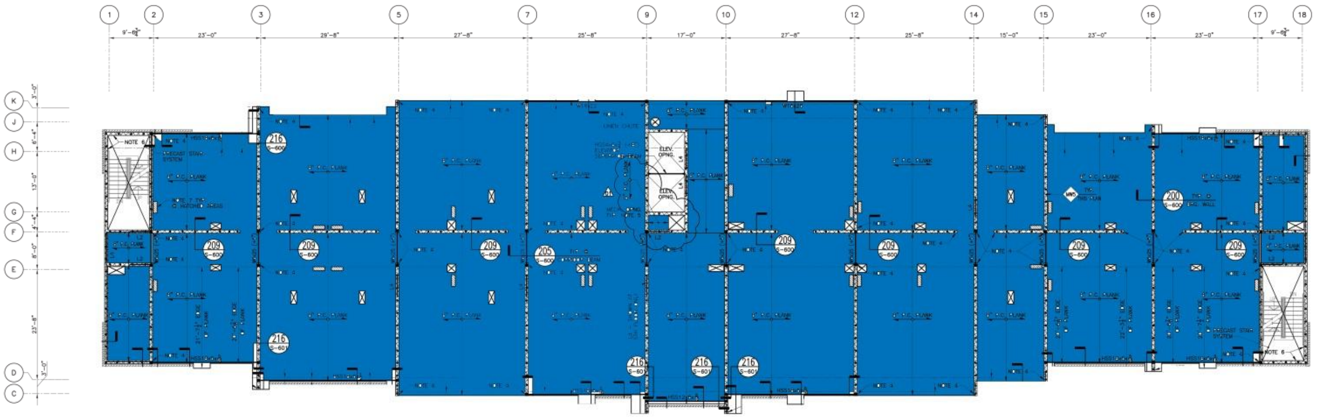


Figure 5: Typical Floor plank layout

Framing System

The framing system for the Hotel N.E.U.S consists of steel columns on the first floor mixed with masonry bearing walls. Due to the gathering areas and general openness of the first floor, steel columns are used. These columns only exist on this floor, save for column C12 and E12 that span the first two floors (see Figure 7) Everywhere else in the building, masonry walls are used to support the floor system. The exterior is supported by cold-formed steel (see Figure 7 for sections) Bays are typical except for on the second floor where an opening exists for an open ceiling breakfast region. The longest bearing wall is about 28' long, located on column line 9 near the center of the building where it is widest.

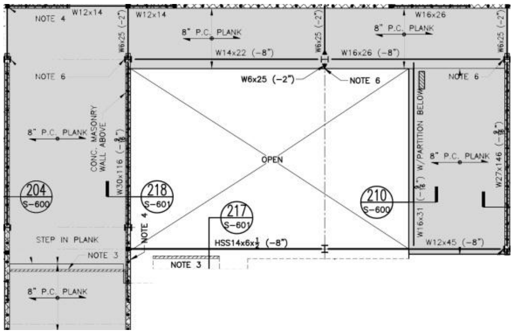
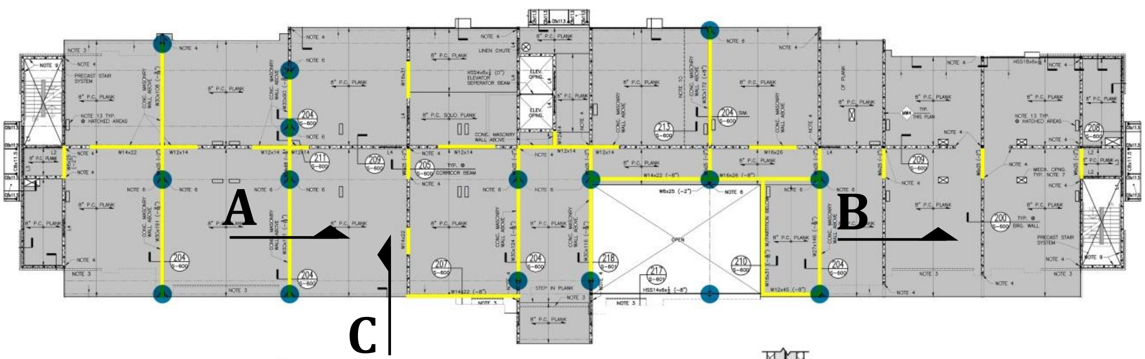
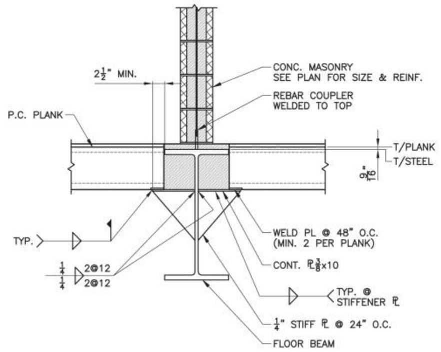
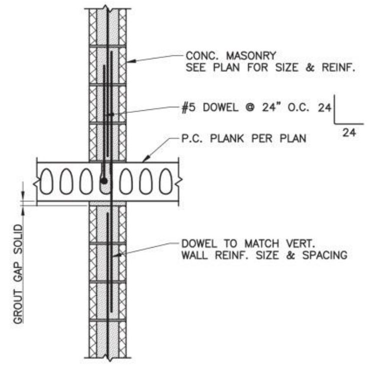


Figure 6: Open section on second floor

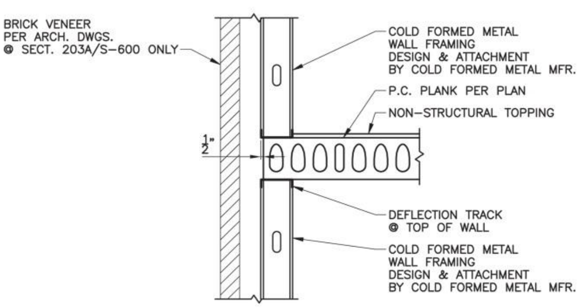




SECTION A- Beam carrying masonry wall



SECTION B- Plank on masonry wall



SECTION C- Plank resting on cold-formed steel at exterior

Figure 7: Second Story framing
Yellow indicates beams
Blue indicates columns

Lateral System

In the Hotel N.E.U.S, the lateral system consists is the same as the gravity system. Reinforced masonry shear walls provide the resistance to lateral loads applied to the building. The masonry is 8" wide with #5 bars at 24" on center. Cells with reinforcement are grouted solid. As with the gravity system, these walls are controlled by the fact that the first floor requires a space without obstructions. Therefore the shear walls are located in an irregular pattern shown in Figure 8. Due to the slenderness of the building, much more resistance is required perpendicular to the long side of the building.

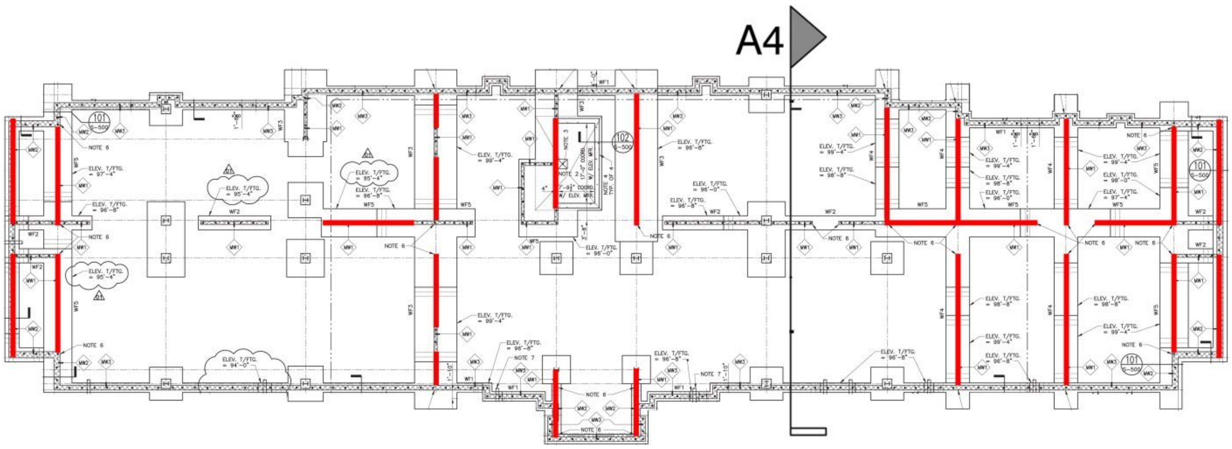


Figure 8: Location of shear walls on foundation plan

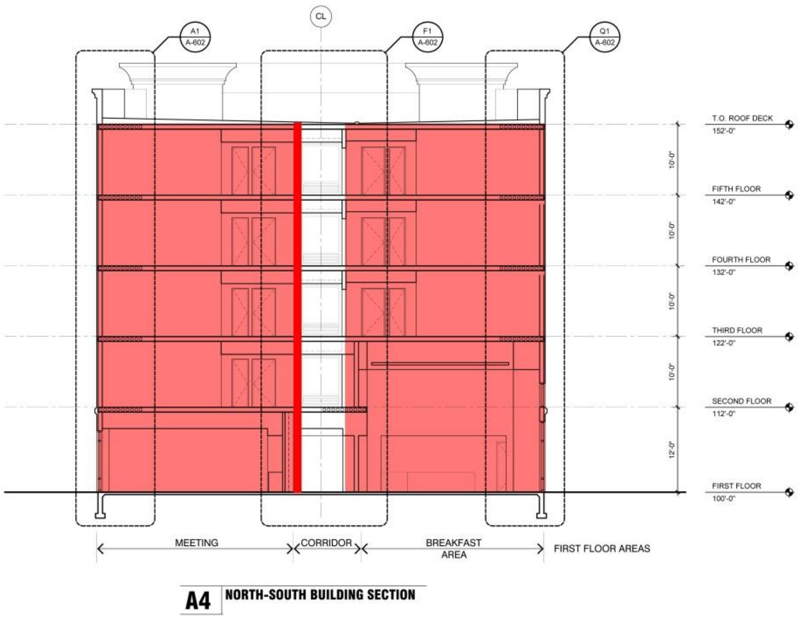
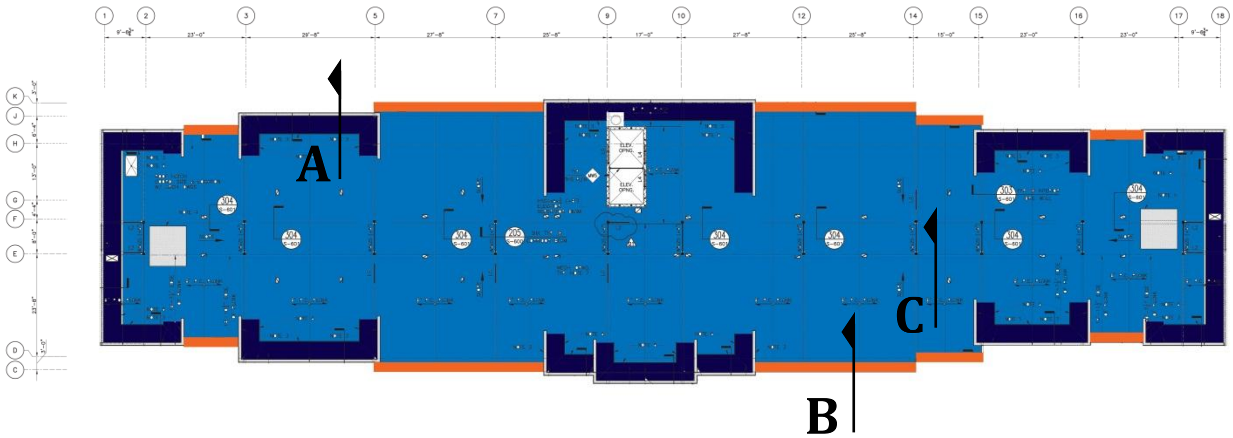
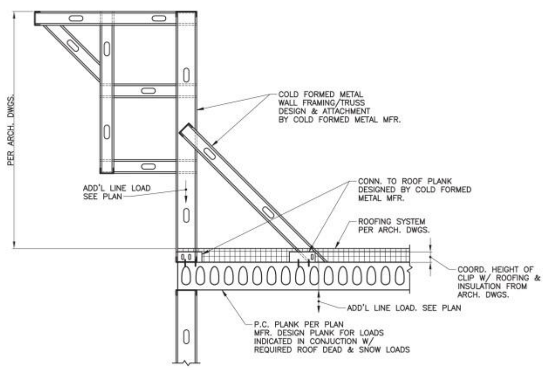


Figure 9: Section showing orientation of shear walls.

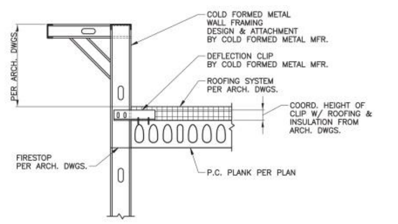
Roof System

As with the floor system, the roof is constructed of 8" Hollowcore Precast plank with insulation on top. A parapet constructed of cold-formed steel engrosses the entire perimeter and is to 8'-8" high. Mechanical units weighing 4,000 lbs each are located at either end of the roof.

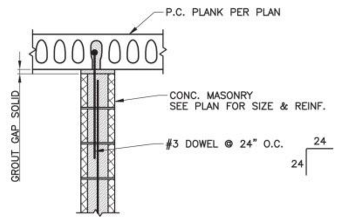




SECTION A- 8'-8" Cold-formed steel parapet wall



SECTION B- 5'-0" Cold-formed steel parapet wall



SECTION C- Roof plank on top of masonry wall

Figure 10: Roof layout.
Blue- 8" Hollowcore Precast Plank
Orange- 5'-0" Cold-formed steel parapet wall
Dark Blue- 8'-8" Cold-formed steel parapet wall

Materials

Listed in Figure 11 are the materials used in the construction of the Hotel N.E.U.S. They were gathered from the structural engineer's general notes and specifications.

Shallow Foundations Wall Footing Capacity	
Width	Allowable Bearing Pressure
2'-0"	4,100 PSF
3'-0"	4,600 PSF
4'-0"	4,500 PSF
5'-0"	3,800 PSF
6'-0"	3,250 PSF
7'-0"	2,800 PSF
8'-0"	2,500 PSF

Column Footing Capacity	
Width	Allowable Bearing Pressure
3'-0"	4,600 PSF
4'-0"	4,500 PSF
5'-0"	3,800 PSF
6'-0"	3,250 PSF
7'-0"	2,800 PSF
8'-0"	2,500 PSF
9'-0"	6,650 PSF
10'-0"	6,250 PSF
11'-0"	5,500 PSF

Reinforced Concrete	
Type	Design Compression Strength (f'c)
Foundations and Concrete Fill	3,000 PSI
Walls	4,000 PSI
Slabs and Grade	4,000 PSI
Reinforcement	
Deformed Bars	ASTM A625 GRADE 60
Deformed Bars (weldable)	ASTM A706, GRADE 60
Welded Wire Fabric	ASTM A185

Figure 11: Material Standards used in Hotel N.E.U.S.

Masonry	
Mortar	ASTM C270
	Type M for all F'm = 2,500 PSI, Type S for all structural masonry
Grout	F'c = F'm but no less than 2,000 PSI

Face Brick
ASTM C216, Grade SW, Type FBS absorption not more than 9% by dry weight per ASTM C67.

Structural Steel	
W shapes	ASTM 992
M, S, C, MC, and L shapes	ASTM A36
HP shapes	ASTM A572, GRADE 50
Steel Tubes (HSS shapes)	ASTM A500, GRADE B
Steel Pipe (Round HSS)	ASTM A500, GRADE B
Plates and Bars	ASTM A36
Bolts	ASTM A325, TYPE 1, 3/4" U.N.O.

Galvanized Structural Steel	
Structural Shapes and Rods	ASTM A123

Precast Concrete	
Type	Design Compression Strength (f'c)
Reinforcement (deformed)	ASTM A 615/A 615M, Grade 60
Welded Wire Reinforcement:	ASTM A 185
Pretensioning Strand	ASTM A 416/A 416M, Grade 250 or Grade 270, uncoated, 7-wire, low-relaxation strand wire or ASTM A 886/A 886M, Grade 270, indented, 7-wire, low-relaxation strand
Portland Cement	ASTM C 150

Figure 12: Material Standards used in Hotel N.E.U.S.

Design Codes

Because of the wide variety of materials used on this project there are also many different codes to abide by. These are listed in Figure 13. The codes used for analysis in this thesis are listed in Figure 14. For a list of other codes used see Appendix A.

Design Codes	
Reinforced Concrete	Building Code Requirements for Structural Concrete (ACI 318, latest)
	Specifications for Structural Concrete (ACI 301, latest)
Masonry	Building Code Requirements for Masonry Structures (ACI 530)
	Specifications for Masonry Structures (ACI 530.1)
Precast Concrete	Building Code Requirements for Structural Concrete (ACI 318, latest)
	Commentary (ACI 318R, latest)
	PCI Design Handbook - Precast and Prestressed Concrete (PCI MNL 120)
Structural Steel	Specification for Structural Steel Buildings (ANSI/AISC 360-05)
Metal Decking	Steel Roof Deck Specifications and Load Tables (Steel Deck Institute, latest edition)
Cold Formed Steel	Most current edition of the "North American Specification for the Design of Cold-Formed Steel Framing"
Wind and Seismic	ASCE 7-05
Loads	International Building Code 2009

Figure 13: Codes used by the engineer of record to design this structure

Thesis Analysis Codes	
Reinforced Concrete	Building Code Requirements for Structural Concrete (ACI 318-11)
Precast Concrete	PCI Design Handbook - Precast and Prestressed Concrete (PCI MNL 120)
Structural Steel	AISC Steel Manual 14th Edition, A
	AISC 360 2010 Specification for Structural Steel Buildings
Wind and Seismic	ASCE 7-05
Loads	International Building Code 2009
Masonry	Building Code Requirements forMasonry (ACI 530-05)

Figure 14: Codes used for thesis

Gravity Loads

The dead loads for this structure were either provided by the engineer of record or assumed by referencing structural handbooks. The plank weight was obtained using PCI Manual 120 and Masonry walls were determined using NCMA TEK 14-13B. The density was assumed as 105 lb/ft^3 as it was described as "medium" in the specifications. The topping is to level the surface since the camber of the plank will cause it to be uneven. These loads prove to be very similar to the overall load used by the engineer of record as the spot checks performed give good results.

Dead Loads	
Location	Load (psf)
8" Precast Plank	56
3/4" Topping	6
MEP/Misc.	5
Ceiling	3
Roof Insulation	12
C.F. Studs	5
Roof	20
Masonry Walls	43-53

Figure 15: Dead Loads for Hotel N.E.U.S.

Live loads were listed in the general notes on sheet S001. All of them were in accordance with the International Building Code 2009. Due to the typical layout of floors in a hotel, 40 psf was used on the entire floor except for stairwells on floors two through five. The engineer of record used live load reduction when determining loads for the beams, columns, and column footings. However, there was no reduction for the wall footing.

Live Loads			
Location	Design Live Load (psf)	IBC 2009 Live Load (psf)	Reference Note
Public Areas	100	100	Residential - hotels and multifamily dwellings - public rooms and corridors serving them
Guest Rooms and Corridors	40	40	Residential - hotels and multifamily dwellings - private rooms and corridors serving them
Paritions	20	20	
Stairs	100	100	Stairs and exits - all other
Roof	20	20	Roofs - ordinary flat, pitched, and curved roofs

Figure 16: Live Load comparison and references

Proposed Depth Topic

Problem Statement:

The Hotel N.E.U.S. utilizes an unusual gravity system that is a hybrid of steel and masonry. The first floor has large open spaces that call for steel framing while the second through fifth floors are guest rooms where the masonry walls can be used as partitions. In Technical Report 2, the use of alternative gravity framing was explored to see whether there was a method that could use the same material from ground to roof and eliminating the need to provide special treatment to the ground floor. Therefore the first issue to address is to redesign the gravity floor system and framing to accommodate the spacious first floor while being able to successfully provide the same sized rooms in floors two through five.

The lateral system of the Hotel N.E.U.S. is composed of masonry shear walls. In Technical Report 3, an in depth investigation of the lateral loads and the ability of the shear walls to resist them was performed. It was found that in the long direction, the building was not suitable to resist torsion because there is only one shear wall. Typically there are two or more walls providing a line of action for the torsional load to be resisted. The shear wall was also over capacity for direct seismic forces. The second item to address is finding a lateral system that will work well with the gravity framing and provide the necessary resistance in the long direction.

Proposed Solution:

Since the Hotel N.E.U.S. is already partially constructed of steel it seems adequate to investigate how a full steel system could be utilized. For this project, the gravity system will be redesigned with composite steel framing and concrete on metal deck. An efficient column grid will be developed to accommodate the first floor spaces and partitioned guest room floors while maintaining the same room areas.

The lateral system will be redesigned using braced frames in place of the shear walls in the short direction. The diagonal members can be enclosed in the partitioned walls in the same locations as the shear walls. In the long direction, moment frames will be designed for the exterior. These will be used to allow for the large amount of windows to retain their locations.

ASCE 7-05 will be used to calculate all the loads for the Hotel. A typical bay will be selected and gravity connections will be designed. For the lateral system, a typical moment and braced connection will be designed as well. A RAM model will be created in order to verify the size of members and connections designed by hand.

Breadth Studies

Breadth 1: Enclosure

The exterior façade of the Hotel N.E.U.S. is mainly constructed of Exterior Insulation and Finishing System (EIFS) which is known to have poor performance especially in wet regions such as the Northeast U.S. The existing enclosure will be examined with pros and cons. A study of alternative façade materials and building enclosures will be performed. The criteria used will be based upon waterproofing, air barrier, thermal properties/insulation, and structural integrity. A new façade/enclosure will be developed to better protect the Hotel and a typical detail will be drawn.

Breadth 2: Architecture

By redesigning the framing and enclosure of the Hotel N.E.U.S., there will be an impact on the architecture. The aesthetics of hotels in today's world are made to represent their "brand" so you can recognize them from a distance and associate them with the qualities of that "brand". For this project, the Hotel N.E.U.S. is going to break away from this idea. An investigation of how the steel and structure can be accented will be performed. The redesign of the enclosure will be taken into consideration as well. A Sketch-Up and/or Revit model will be constructed to evaluate and visualize the architecture.

MAE Coursework

Knowledge gained from AE 530-Computer Modeling of Building Structures will be used to model the building in RAM Structural System. Other programs such as ETABS and STAAD Pro may be incorporated as well.

The information from AE 534-Steel Connections will be used to design the connections for this project's depth study and redesign.

AE 537- Building Performance Failures and Forensic Techniques has provided knowledge of enclosures and overall building science that will be incorporated in the enclosure/façade study.

In the Spring 2013 semester, the principles and data gained from AE 542-Building Enclosures will be used for the breadth study of the Hotel N.E.U.S.

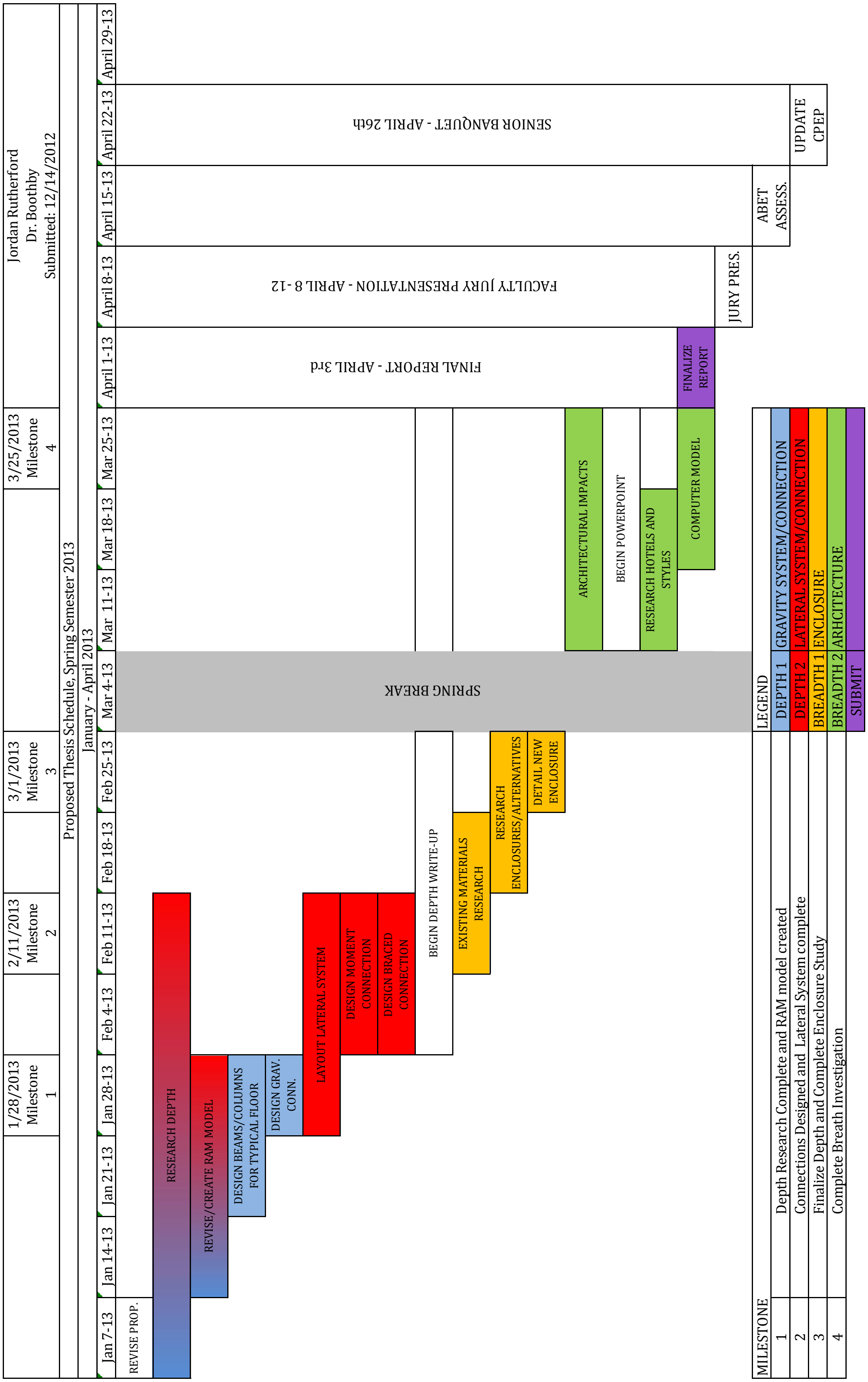
Tasks and Tools

- ASCE 7-05
    - Gravity Loads
    - Calculate Lateral Loads
        - Revised wind for assumed height
        - Seismic for short and long direction

- Framing System
    - Revise/develop new column grid
    - Create RAM model
    - Analyze RAM model to obtain member sizes for gravity
        - Design a typical bay for gravity loads and verify by hand
        - Design shear connections
    - Analyze RAM model for lateral loads
        - Design moment/braced connection
    - Compare results to original system

- Enclosure study
    - Research EIFS
        - Advantages
        - Disadvantages
        - Properties/Uses
    - Research alternative facades
        - Create a typical detail in AutoCAD for most effective new material

- Architectural Impacts
    - Determine how new enclosure impacts architecture
    - Determine how new framing impacts architecture
        - Research styles and structural influences
    - Create model (Sketch-Up/RAM) to visualize impacts
        - Render designs


Jordan Rutherford
Dr. Boothby
Submitted: 12/14/2012
1/28/2013 Milestone 1
2/11/2013 Milestone 2
3/1/2013 Milestone 3
3/25/2013 Milestone 4
Proposed Thesis Schedule, Spring Semester 2013
January - April 2013
Jan 7-13
Jan 14-13
Jan 21-13
Jan 28-13
Feb 4-13
Feb 11-13
Feb 18-13
Feb 25-13
Mar 4-13
Mar 11-13
Mar 18-13
Mar 25-13
April 1-13
April 8-13
April 15-13
April 22-13
April 29-13
REVISE PROP.
RESEARCH DEPTH
REVISE/CREATE RAM MODEL
DESIGN BEAMS/COLUMNS FOR TYPICAL FLOOR
DESIGN GRAV. CONN.
LAYOUT LATERAL SYSTEM
DESIGN MOMENT CONNECTION
DESIGN BRACED CONNECTION
BEGIN DEPTH WRITE-UP
EXISTING MATERIALS RESEARCH
RESEARCH ENCLOSURES/ALTERNATIVES
DETAIL NEW ENCLOSURE
SPRING BREAK
ARCHITECTURAL IMPACTS
BEGIN POWERPOINT
RESEARCH HOTELS AND STYLES
COMPUTER MODEL
FINALIZE REPORT
FINAL REPORT - APRIL 3rd
JURY PRES.
FACULTY JURY PRESENTATION - APRIL 8 - 12
ABET ASSESS.
UPDATE CPEP
SENIOR BANQUET - APRIL 26th
MILESTONE
1 Depth Research Complete and RAM model created
2 Connections Designed and Lateral System complete
3 Finalize Depth and Complete Enclosure Study
4 Complete Breath Investigation
LEGEND
DEPTH 1 GRAVITY SYSTEM/CONNECTION
DEPTH 2 LATERAL SYSTEM/CONNECTION
BREADTH 1 ENCLOSURE
BREADTH 2 ARHCITECTURE
SUBMIT

Conclusion

The current gravity system is a combination of steel on the first floor with masonry bearing and shear walls making up the rest of the structure. Due to the partial use of steel in the Hotel N.E.U.S. in the current layout, it is reasonable to explore a full steel redesign. The floor will changed to composite beams with concrete on metal deck. It will be supported by steel beams and columns. The lateral system will be changed to the most effective steel resistance system depending on the direction. For the short direction the masonry shear walls will be replaced by steel braced frames. In the long direction, moment frames will be placed on the exterior to allow for the large amount of windows.

Two breadth studies will be completed as well. The existing enclosure is constructed of EIFS which is prone to issues. Therefore an enclosure/façade study will be conducted and a new material will be selected for the Hotel. This change in enclosure along with the structural system altered will impact the architecture of the building. A study of architectural features will be completed and the aesthetics features will be reformed and rendered.

The depth and breadths will be completed throughout the Spring 2013 semester and a final report will be submitted by April 3, 2013.