303 Third Street

Cambridge, Massachusetts

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AE 481W – Thesis

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Thesis Proposal

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EXECUTIVE SUMMARY

The purpose of this proposal is to describe the proposed scope of analysis to be performed on 303 Third Street during the spring semester of thesis research. The end result of the analysis will provide an alternative structural system as well as investigations into the feasibility of meeting at a minimum a LEED Bronze rating.

BUILDING DESCRIPTION:

303 Third Street consists of a north and south building, ranging in story number from five to eight, which are joined below grade by two parking levels spanning nearly the entire area of the site. The building is a mixed use facility planned to offer 485,227 SF of rentable residential space and 7,500 SF of retail space. 303 Third Street is situated on a 3.3 acre urban site a short distance from the Massachusetts subway system as well as the Massachusetts Institute of Technology.

PROPOSAL:

Since the purpose of 303 Third Street is to provide rentable residential space, a great way to draw potential renters/owners to the building would be to achieve a LEED rating of at least Bronze. “Going Green” is an extremely popular phrase right now and by achieving a LEED rating, 303 Third Street will attract environmentally conscious and more educated clients. Additionally, the floor system will be redesigned using open web steel joists since an analysis performed in Technical Report 2 showed potential cost savings.

SOLUTION:

By switching the floor system from a steel composite system to a system supported by open web steel joists, the reduction of weight of the system should translate into lower cost and decreased member sizes throughout the framing. Using finite element programs such as ETABS and RAM, a model will be created of the new system to determine whether or not the alternative floor system will be best choice. To achieve a LEED rating of at least Bronze, breadth study investigations into the mechanical system as designed to evaluate the energy efficiency of the proposed design and a second breadth investigation into the utilization of renewable materials for both energy efficiency and conservation.

EXISTING STRUCTURAL SYSTEM

FOUNDATION:

The slab on grade concrete is normal weight (145 pcf dry unit weight) and has a minimum 28-day strength of 3500 psi. The 5" slab on grade is reinforced with 6x6 W2.9xW2.9 welded wire fabric. Column loads are supported by square spread footings (f'c = 4000 psi) ranging from 5'-6" to 14'-0". The spread footing bear directly on the undisturbed, natural outwash sand, marine clay, or marine sand deposits proportioned utilizing a maximum bearing pressure of 2.5 tons per square-foot. The foundation also contains a few internal and external piers (f'c = 4000 psi) for supporting larger loads. The foundation bears on belled caissons with a typical depth of 20'. The caissons bear on 3 TSF bearing material. A groundwater cut-off at the perimeter is maintained as well as underdraining of the lowest level slab to avoid hydrostatic uplift forces acting on the lowest level slab. The continuous perimeter wall footings are founded at least 12 inches below the surface of the relatively impervious marine clay deposit to provide a groundwater cut-off. The surface of the bedrock deposit was observed to vary from 66.3 to 90 feet below the existing ground surface.

FLOOR SYSTEM:

The sublevel floor system P1 consists of a 4 ½" normal weight concrete (f'c = 5000 psi) slab on a 3" deep 18 gage composite metal floor deck reinforced with #5 rebar at 12"parallel to the deck and #4 rebar at 12" temp for a total slab thickness of 7 ½". The slab is supported by steel beams with typical sizes ranging from W12 to W18. Wide flange beams typically span 25' with 8' spacing. Composite action is created by ¾" diameter shear studs with 5½" length. Girders are also wide flanges sized up to W24 with cambers over 1". The typical floor system throughout the rest of the building is 3 ¼" light weight concrete slab on a 3" deep 16 gage composite metal floor deck reinforced with 6x6 W2.1xW2.1 welded wire fabric. This slab is supported by steel beams with typical sizes ranging from W12 to W14. Wide flange beams typically span 18-26' with 12'-6" spacing.

COLUMNS:

The columns are ASTM A992 Grade 50 wide flange steel shapes laid out in a mostly rectangular grid. The columns act as the primary gravity resistance members. The columns that are attached as braced and moment frames are also the main lateral resistant force members. The braces between columns are ASTM A 500 Grade B HSS shapes ranging in size from 7x5x1/2" to 9x7x5/8". The largest column is a W14x159 and the smallest is a W12x53 on the ground floor. The maximum unbraced length is 15' which is the floor to floor height of the ground floor. Column splices occur every 20' – 25' at 4'-0" above the floor.

LATERAL FRAMING:

There is a dual lateral system implemented consisting of concentrically braced steel frames in both the N-S and E-W directions and moment frames in the E-W direction. These frames consist of wide flange columns, wide flange beams at each story and two HSS (hollow structural section) diagonal braces between each story and may include moment connections depending on the frame type.

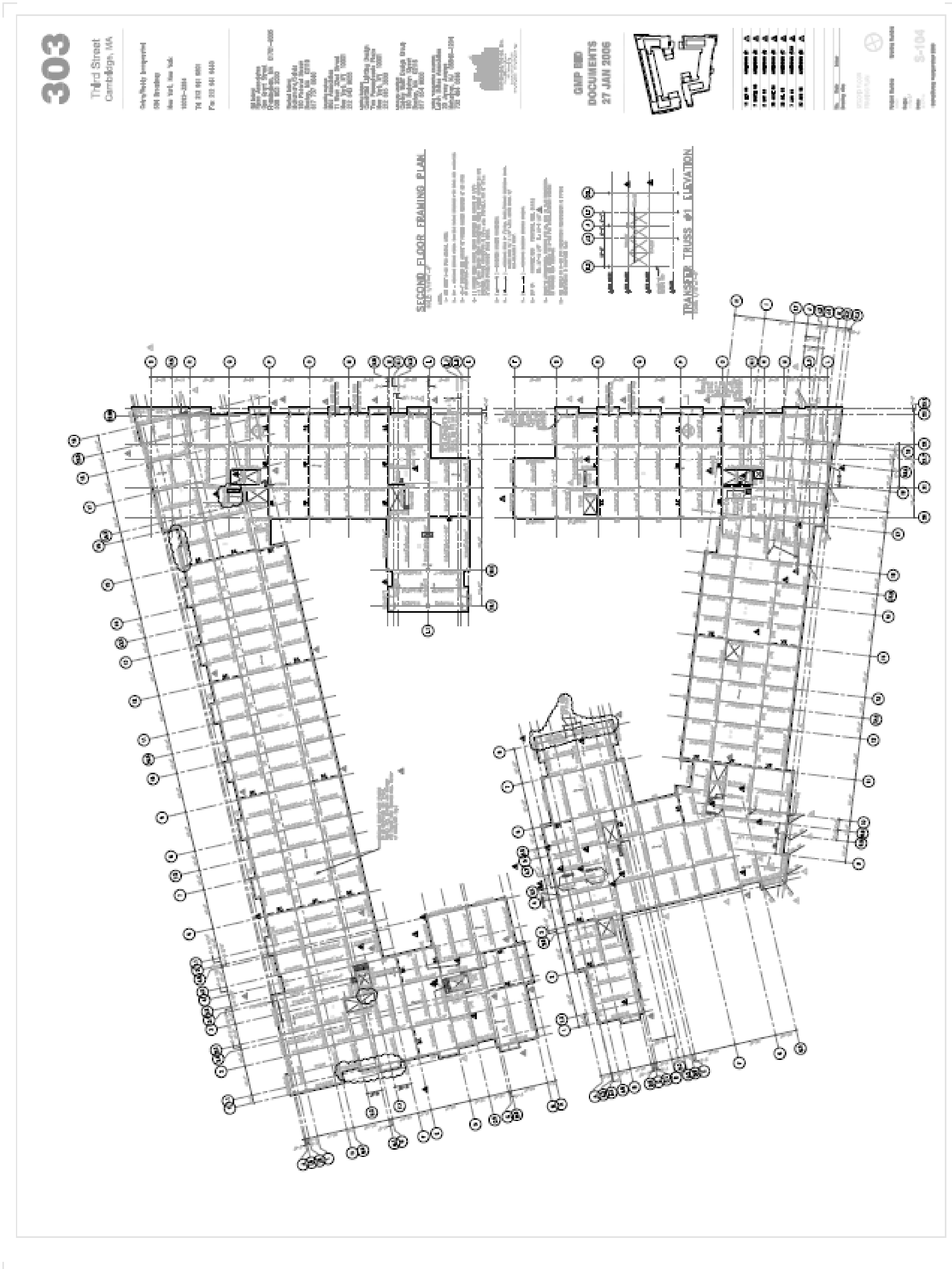

Figure 1: Existing Typical Framing Plan

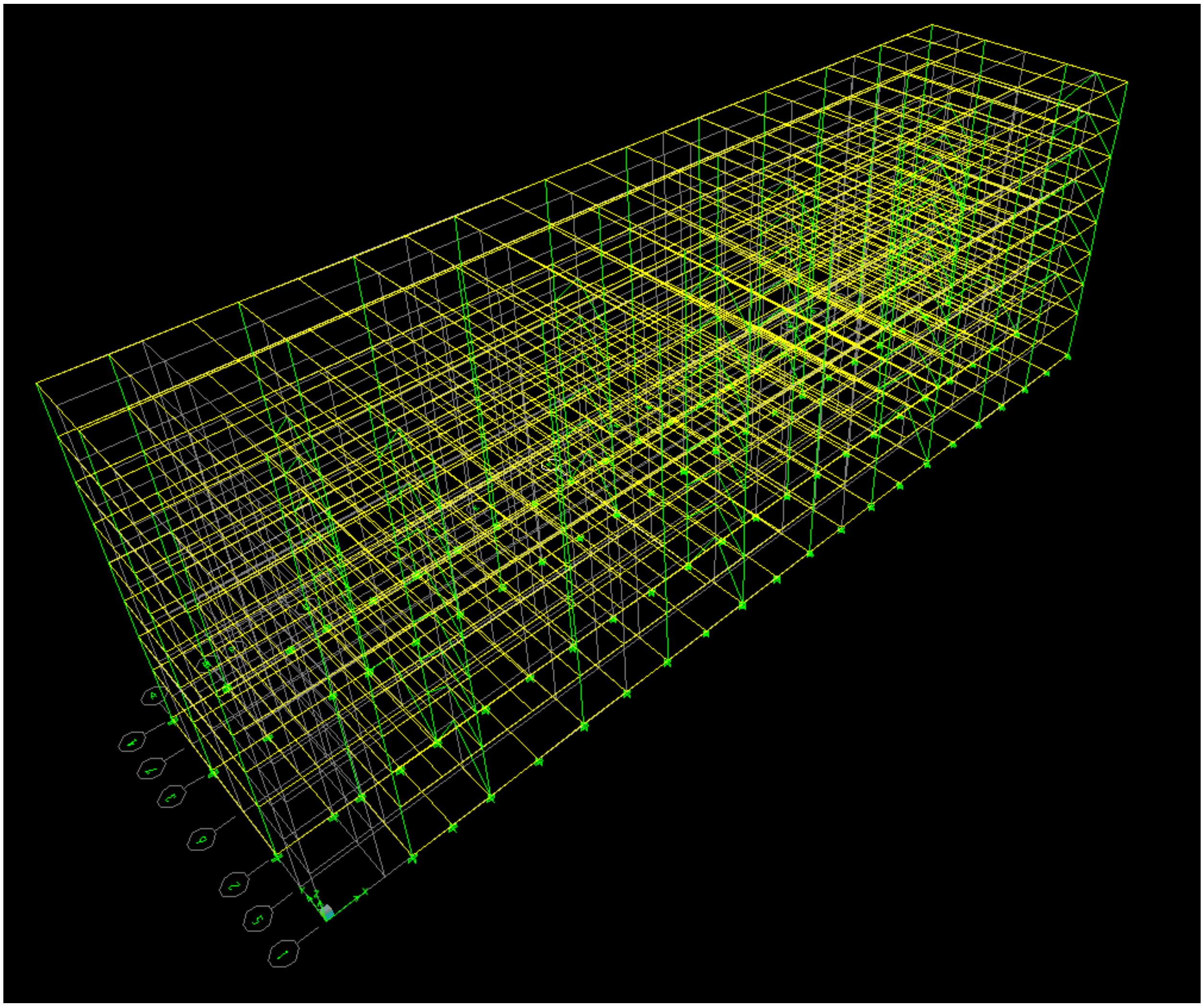

Figure 2: Existing Braced Frame and Moment Frame Lateral System for

U Section of the North Building

Problem Statement

303 Third Street is designed utilizing composite action between concrete slab and steel beams. The weight of this system is significantly more than if the floor system were designed using K-Series open web steel joists supporting the floor slab.

Increased structure weight results in larger member sizes of columns, as well as more bracing, since an increased structure weight also increases the seismic base shear. Since 303 Third Street is situated in Cambridge, MA with poor soil conditions, reducing the seismic load of the building would save money by possibly reducing the number of moment connections necessary in the building and reducing the number and/or size of braced frame members.

In an effort to save construction and material costs, it is proposed that 303 Third Street be redesigned utilizing open web steel joists as the primary floor system. Using the IBC, ASCE 7-05, and joist catalogues as well as finite element software such as RAM, ETABS, and STAAD, it will be determined whether or not this alternative floor system is a viable alternative to the as-designed system.

Problem Solution

From calculations performed in Technical Report 2, the proposed solution consists primarily of 14K4 K-Series open web steel joists spaced at 2' on center. The joists will support the as designed 3.25" light weight concrete slab on 3" deep 16 gage deck with 6x6 W2.1xW2.1 welded wire fabric. Calculations will be performed as to the weight of the new system in order to determine the decrease in column size to accommodate the change. Additionally, the lateral system will be downsized to accommodate the decreased seismic load and a cost savings will be calculated.

Solution Method

A model of the building will be created in RAM to back up the hand calculations and determine new member sizes. Additionally, a cost/SF estimate will be performed using the RS Means catalogs to compare the economic advantage of the alternative floor system. Also, hand calculations will be performed to check that the joist system performs adequately under vibration criterion outlined in AISC Steel Design Guide Series 11. Also, the existing model in ETABS will be modified for K-Series joists and new seismic loading to recalculate deflection with the existing lateral system. From this new deflection information, the lateral system will be altered to maximize efficiency and still meet appropriate drift guidelines.

Breadths

Along with the main study of the alternative floor system, two individual breadth studies will also be conducted. The goal of the two individual breadth studies is to achieve a LEED Bronze rating. A detailed look at the energy efficiency of the mechanical system will be performed to determine whether an alternative system is necessary to reach the goal. Also, a second breadth study will be performed to incorporate the use of renewable energy and resources.

The first breadth study will focus on the energy efficiency of the current mechanical system. Often, costs are saved during construction by installing standard mechanical system without consideration of future operating costs of the building. Equipment efficiencies will be analyzed and compared to alternative equipment as well as alternative system types. Projected energy savings calculations will be performed to conform to USGBC The New Construction and Major Renovation Reference Guide v2.2 – Second Edition September 2006.

The second breadth study will involve research into methods for using renewable energy and materials. Time will be spent researching readily available renewable materials in the New England area. Additionally, research into renewable energy sources will be performed to cut down on grid energy consumption and increase the point total towards a LEED rating.

Task and Tools

I. Design Floor Structure to use Open Web Steel Joists

- Task 1: Determination of Superimposed Loads
  - a.) Determine superimposed loads from construction documents
  - b.) Determine superimposed live loads per ASCE7-05
- Task 2: Establish Trial Member Sizes
  - a.) Establish trial member sizes using the joist catalog
  - b.) Determine joist spacing
- Task 3: Analyze Effect of Floor System on Building
  - a.) Create RAM model
    - a. Compare column sizes to existing
    - b. Compare beam sizes to existing
  - b.) Alter existing ETABS model
    - a. Calculate new seismic base shear based on new structure weight
    - b. Compare story drift to original analysis performed in Tech 3
    - c. Reduce bracing element sizes to match previous drift criteria
  - c.) Check vibration performance per AISC Design Guide Series 11
  - d.) Calculate cost savings

II. Breadth Studies

- Task 1: Mechanical System Efficiency Analysis
  - a.) Acquire and analyze information regarding current mechanical systems
  - b.) Explore alternative equipment/systems to improve efficiency
  - c.) Determine how many LEED points can be earned

Task 2: Renewable Energy and Materials Incorporation

a.) Research renewable materials available near Boston, MA
b.) Acquire information regarding renewable energy sources
c.) Determine how renewable energy sources can be used at 303 Third St
d.) Determine how many LEED points can be earned

Timetable

Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Determination of SDLs	■													Final Presentation Week
Establish Trial Member Sizes		■												
Creat RAM Model			■	■										
Compare RAM output sizes to existing			■	■										
Alter ETABS model					■	■								
Recalculate seismic based on new weight					■	■								
Compare drift to Tech 3 analysis							■							
Check vibration performance								■						
Calculate cost								■						
Acquire and analyze mechanical system info									■					
Research alternative mechanical systems									■					
Research renewable materials in area										■				
Acquire information regarding renewable energy										■				
Implement renewable energy sources											■			
Determine LEED points earned by changes											■			
Prepare final presentation												■	■	