303 Third Street

Cambridge, Massachusetts

Brian Tufts

AE 482 – Thesis

Advisor: Dr. Ali Memari

Thesis Final Report

April 9, 2008

THESIS ABSTRACT

303 Third Street
Cambridge, MA
Mixed-Use Development

BRIAN TUFTS - STRUCTURAL OPTION

Project Team
Owner: Extell Development Corporation & Equity Residential
Architect: Cetra/Ruddy Inc
GC/CM: Bovis Lend Lease
Structural Engineer: McNamara/Salvia Inc
MEP Engineer: MGJ Associates
Civil Engineer: Tetra Tech Rizzo
Geotechnical Consultant: McPhail Associates, Inc

General Building Data
Location: 303 Third St Cambridge, MA
Number of Floors: Between 5 and 8 above grade
2 below grade parking levels
Occupancy: Primarily residential with some retail
Size: 485,227 SF residential and 7,500 SF retail
Construction Date: July 2006 - October 2008
Total Project Development Cost: $246 million
Delivery Method: Design-bid-build with a GMP

Structural System
* 5" slab on grade reinforced concrete
* 20' deep caissons bear on 3 TSF bearing material
* WF beams and girders typically cambered 1/2" - 1 1/2"
* Floors typical composite construction 4 1/2" slabs
* 25' typical beam span

Electrical System
* 2 primary power distribution boards
* 2 300 kVA transformers provide 120/208V to panels
* Backup power via 750 kW generator

Mechanical System
* 2 cooling towers each for north and south building totaling ~150,000 CFM per building
* 5 water cooled AC units serice lobby and fitness areas
* 14 rooftop air conditioning units service corridors
* 4 boilers totaling 23,300 MBH

Lighting System
* Residential units typically lit with 208V pole mounted lights with 175W Metal Halide lamps
* Service areas lit with 120V flush mounted fixtures with two T5 lamps

http://www.engr.psu.edu/ae/thesis/portfolios/2008/bmt132/

Architecture
330 Third Street is a large mixed-use development situated in urban Cambridge, MA. The site is located a short distance from the Massachusetts Institute of Technology and other prominent Cambridge landmarks. As such, 303 Third Street aims to create a green outdoor space within the site and a modern, elegant façade to attract busy city professionals. It consists of two large building (North and South) segments forming a U, with a green space filling the center. The design seeks to maximize rentable space while maintaining a comfortable living environment for its occupants.

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EXECUTIVE SUMMARY

303 Third Street is a cutting edge residential apartment building currently in the final framing stages in upscale Cambridge, MA. The building utilizes composite steel framing with lightweight concrete slabs, braced frames in each direction, some moment frames, and a large concrete below grade parking structure. Before the building is completed, the following thesis has been prepared to document some alternative building systems that could have been utilized.

Building weight is a major contributor to seismic base shear. In areas where seismic activity is a concern and typically governs lateral design, whenever a building can be made lighter, the lateral system can be decreased. The decrease in lateral bracing members, moment connections, as well as frame beam and column sizes can help decrease the overall cost of a project. It is in the best interest of the building owner to have as lightweight of a structure as possible.

Open-web steel joists are a great way to minimize the structural weight of a building. The joists themselves are lightweight and much more efficient in terms of quantity of material versus strength. By optimizing the material performance, a joist is able to span great distances and carry considerable load. It is also easier to frame with steel joists because they are much lighter than steel members and the connections are generally simpler to make.

Steel joists have drawbacks though, which is why they have not taken over as a predominant framing system. In office occupancies, steel joist systems may cause serviceability issues such as vibration. Vibration is a major reason why steel joists have been avoided in recent years. With lower weight framing systems, the dynamics of buildings is harder to predict and occupant comfort is a very important part of engineering, after all it is a customer based industry. There are also fireproofing issues with steel joists as it is very difficult to spray them with cementitious fireproofing without wasting a lot of material and still maintaining the proper cement coating for fire rating.

The purpose of my breadth study was to evaluate the implementation of an open-web steel joist system at 303 Third Street in terms of building structure, performance, and serviceability. My breadth studies seek to determine the potential LEED accreditation of 303 Third Street, as Cambridge is a very intellectual area where people value and desire the implementation of green design. By fine tuning the structural system, evaluating the building envelope performance, and researching additional green materials, this report aims to provide alternative strategies for building design.

After a careful analysis of the building system, it was determined that steel joists are a viable alternative framing system for 303 Third Street. The typical bay analyzed passed the qualifications of Design Guide 11 for walking excitation and an appropriate alternative fire proofing strategy was found. Furthermore, the mechanical breadth study determined that the existing building façade does not meet the Massachusetts Energy Code and remediation strategies were recommended. LEED accreditation of 303 Third Street would not add a great deal of cost to the building and would pay long term dividends to the developer.

CREDITS/ACKNOWLEDGEMENTS

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INTRODUCTION

303 Third Street is a $246 million project that 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 site urban site a short distance from the Massachusetts subway system as well as the Massachusetts Institute of Technology.

303 Third Street is a steel frame building with composite floor slabs. Lateral load resistance is provided by both moment frames and concentrically braced frames. The braced frames add stiffness in the plane of the lateral load and transfer the load to the columns. The moment frames rely on the strength of the connection between the floor slab and the columns for translation of loads vertically.

The Massachusetts State Building Code – 6th Edition was used in the design of 303 Third Street. My analyses primarily rely on the use of the Building Officials and Code Administrators (BOCA) code of 1993 which the technical provisions of the Massachusetts State Building Code are based on. Also, I used the Thirteenth Edition of the AISC Steel Construction Manual in performing my calculations. Small discrepancies between my own calculations and those of the engineers are expected due to load assumptions and design methodology. In no way does this report make the claim that any of the designer's approaches, assumptions, calculations or resulting designs are incorrect or unsuitable.

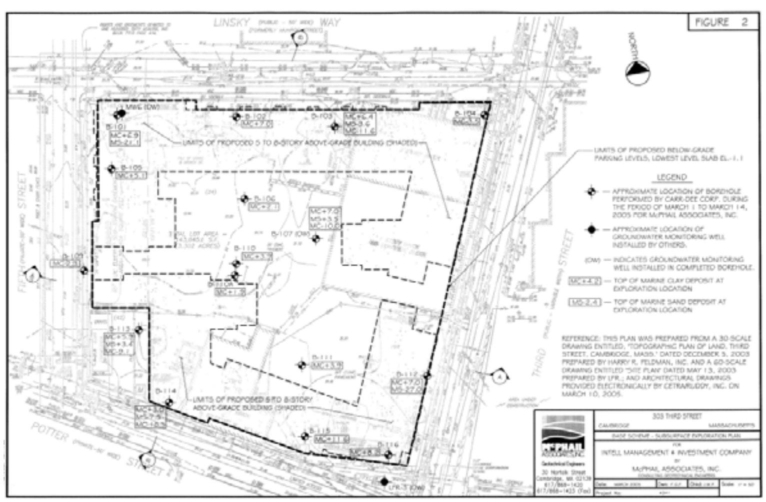


Figure 1: Site Plan

SITE AND ARCHITECTURE

Architecture:

330 Third Street is a large mixed-use development situated in urban Cambridge, MA. The site is located a short distance from the Massachusetts Institute of Technology and other prominent Cambridge landmarks. Cambridge is known for its technology companies, diverse population, and progressive attitude. As such, 303 Third Street aims to create a green outdoor space within the site and a modern, elegant façade to attract busy city professionals.

303 Third occupies a 3.3 acre site and consists of two large building (North and South) segments forming a U, with a green space filling the center. Parking is available via two below grade parking levels. The design seeks to maximize rentable space while maintaining a comfortable living environment for its occupants.

Site:

Zoning: 303 Third Street is located in Cambridge Zone PUD-KS which is designed for mixed use – office, residential, and retail spaces of at least 40,000 SF.

An existing 1-2 story brick building was located at the northeast corner of the site and an existing 1-story brick building fronts onto Potter Street to the south. The southwest and southeast corners of the site are occupied by electrical and steam easements, respectively. The portions of the site not occupied by the existing buildings were typically blanketed by bituminous concrete pavement. The existing ground surface across the subject site was relatively flat, prior to construction

Building envelope:

Floor-to-ceiling heights are typically 10'-0" and the exterior is sheathed primarily in a curtain wall with a terra cotta veneer. This gives the building a regal appearance which is quite breath-taking in contrast to the metal sheathing on other curtain walls. The intent of the design is to encourage busy city professionals to settle down near Kendall Square and MIT, just a short walk from the subway.

By varying the heights of the various buildings, 303 Third Street creates an active roofline giving different angles for the occupants and spectators. Buildings vary in number of floors from 5 to 8 above grade floors. The roof system consists of roof girders supporting 3 in x 16 gage composite deck with 3 ¼ lightweight concrete and waterproofing membrane.

STRUCTURAL DEPTH STUDY

Problem:

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 and more bracing, since an increased structure weight 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, 303 Third Street was redesigned utilizing open web steel joists as the primary floor system. Using BOCA 1993, Massachusetts State Building Code-6th Edition, and joist catalogues as well as finite element software (RAM Structural System), it will be determined whether or not this alternative floor system is a viable alternative to the as-designed system.

Code:

Massachusetts State Building Code – 6th Edition

Design Criteria:

Gravity Loads:

- Uniformly Distributed Loads:

Live Load	
Residential	40 psf
Dead Load	
Floor Finish	1 psf
Extra Concrete	5 psf
Slab	57 psf
Deck	2 psf
Structure	6 psf
HVAC	5 psf
Ceiling	3 psf
Partitions	20 psf

Live Load Reduction: Where live load reductions are permitted by code,

$L = NL_o$

Where N = the largest of the following:

$N = 1 – 0.0008 (A_T - A_B)$

$N = 0.75 – 0.20 (D_O / L_O)$

N = 0.50 for member supporting load from more than one floor, or 0.60 for members supporting loads from only one floor.

and,

L = Reduced design live load for the member,

L_o = Basic design live load.

D_O = Dead load on member

A_T = Loaded area tributary to the member, square feet

A_B = Basic tributary area defined as follows:

A_B = 100 SF for members supporting load from more than one floor.

A_B = 250 SF for members supporting load from one floor only.

Snow Loads: Snow Zone = 2, 30 psf

Wind Loads: Wind Zone = 3 Exposure - B

Basic Wind Speed (mph) = 90

Base Velocity Pressure: Pv = 26 psf

Seismic Loads: Aa = 0.12 S = 3.0 R = 5.0 Cd = 4.5, N/S
Av = 0.12 R = 5.0 Cd = 4.5, E/W

Combination of Loads:

D = Dead Load
W = Wind Load
L = Live Load
E = Seismic Load
S = Snow Load

Basic Load Combinations Strength Design

1. 1.4 Dead
2. 1.3 Dead + 1.6 floor live + 0.5 roof live (or 0.5 snow)
3. 1.3 Dead + 0.5 floor live + 1.6 roof live (or 1.6 snow)
4. 1.3 Dead + 0.5 floor live + 0.5 roof live (or 0.5 snow) + 1.3 wind
5. 1.3 Dead + 1.6 roof live (or 1.6 snow) + 0.8 wind
6. 0.9 Dead – 1.3 wind
7. 1.3 Dead + 1.0 floor live + 0.7 snow + 1.0 seismic
8. (0.90 – 0.5 A_v) Dead – 1.0 seismic

Alternate Seismic Load Combinations Strength Design (when required by Seismic Provisions)

9. 1.3 Dead + 1.0 floor + 0.7 snow +/- (2R/5) seismic
10. (0.9-0.5Av) Dead +/- (2R/5) seismic

Deflection of Flexural Members:

- Steel Members: Limit live load deflection to span/360 or 1" max.

  Beams Supporting Masonry: Limit deflection to span/ 600 or ¾" max. under weight of masonry plus live load.

  Composite Steel Beams: Camber for 85% of computed deflection under weight of wet concrete within the standard practice described in AISC Manual, 8th Edition, Page 1-123.

Building Drift:

Wind: Limit each story drift to story height/500.

Seismic: Limit each story drift to story height/50.

Secondary Drift Effects: Account for "p-delta" forces created by building drift. Approximate method is to increase lateral loads by an amplification factor.

Reference Design Standards:

- Structural Steel:

  "Specification for Design, Fabrication and Erection of Structural Steel for Buildings", AISC – 5326-78.

  "Specification for Structural Joints Using ASTM A325 or A490 Bolts", AISC – 5314-78.

  "Structural Welding Code", AWS D1.1-79.

- Lightgage Steel Deck and Joists:

  "Specification for Design of Cold-Formed Steel Structural Members", AISI – 86.

  "Specification for Welding Sheet Steel in Structures", AWS D1.3-78.

  "Steel Deck Diaphragm Design Manual", SDI – 87.

- Reinforced Concrete:

  "Building Code Requirements for Reinforced Concrete", ACI 318-95.

  "Reinforced Steel Welding Code", AWS D12.1-75.

- Masonry:

  "Specifications for Design and Construction of Load Bearing Concrete Masonry", NCMA –70.

  "Building Code Requirements for Masonry", ANSI A41.1-70.

COMPUTER MODELING

Composite Steel System:

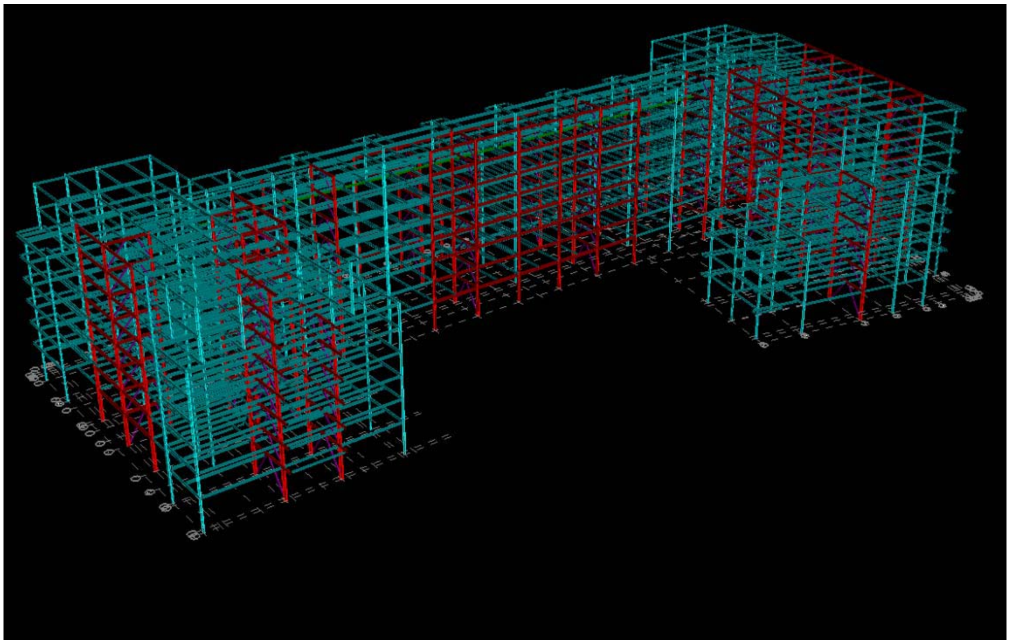


Figure 2: Composite Steel Joist System – RAM Model

In order to compare the two floor systems, an accurate computer model of the existing design structural system was created using the same design criteria. Extra care was taken to assign the appropriate member sizes where the model deviated from the structural construction documents. It is also important to note that both models were created from the ground up. If a heavier alternative system was to be analyzed by this method, the model would need to start from the foundation, because the foundations would need to be augmented. However, since steel joist systems are significantly lighter than composite steel construction, it was assumed early in the modeling process that the existing foundations would be more than adequate for the redesign.

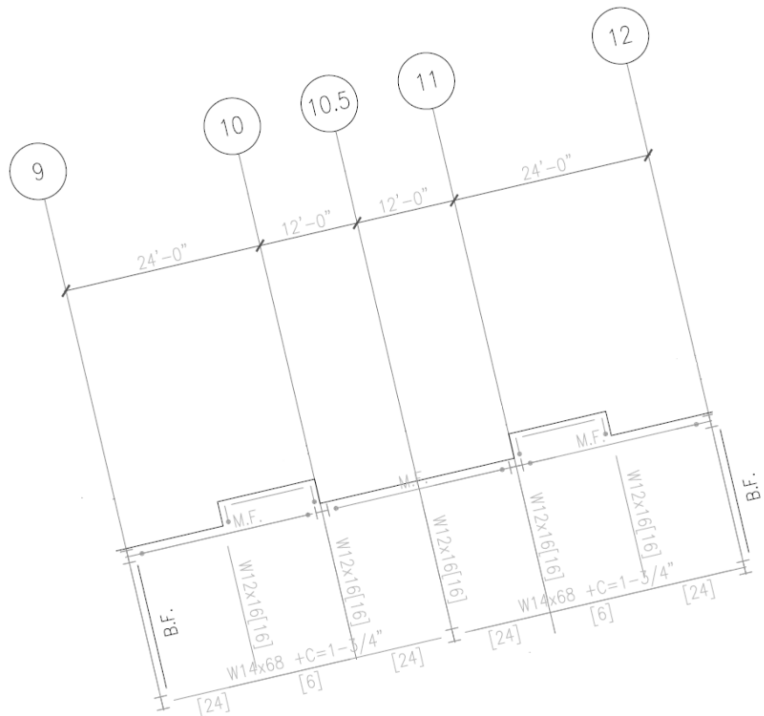


Figure 3: Typical Bay – Composite Steel Joists

Open-Web Steel Joist System:

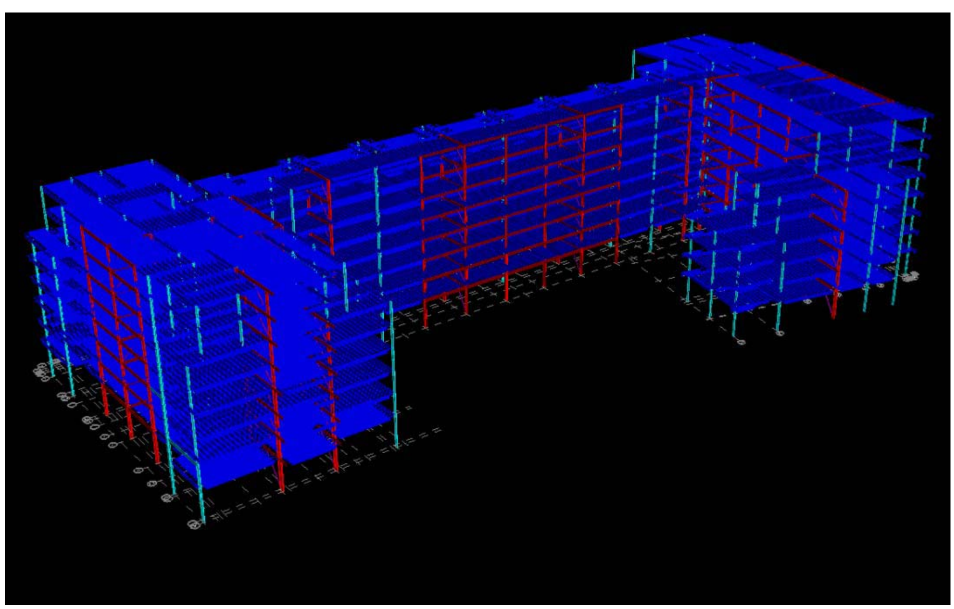


Figure 4: Typical Bay – Composite Steel Joists – RAM Model

RAM Structural System is slightly limited when it comes to designing an open-web steel joist system. RAM will not factor in member self weight or design joist-girders. Using the Vulcraft joist catalog and analyzing the typical bay (see Figure 5), an average floor dead load of 24.8 psf was added to the entire building structure. This accounted for the joists, slab system, deck, MEP allowance, and ceiling construction (see Figure 6) as well as the 1.3/1.2 multiplier which must be used to scale up dead loads for the Massachusetts State Building Code to comply with the load combinations listed in the Design Criteria.

After designing the gravity system, tuning of the lateral system was performed. Since the joist system significantly reduced the building weight, seismic story shears were decreased substantially. To save additional steel tonnage, the lateral system could then be lightened up, but must still comply with AISC Standard Provisions as well as the Seismic Provisions, which limit bracing members based on width/thickness ratio (b/t), strength, and braced length (KL/r) under amplified loading.

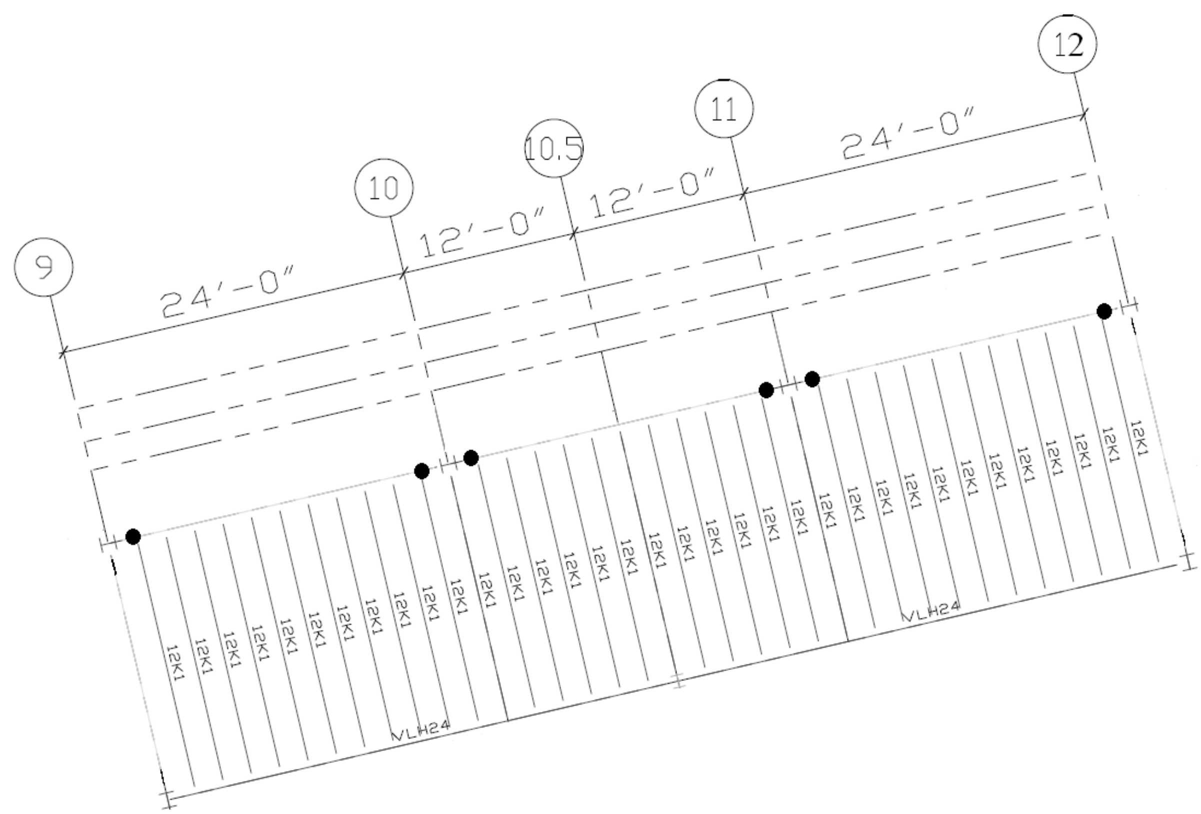


Figure 5: Typical Bay – Open-Web Steel Joists

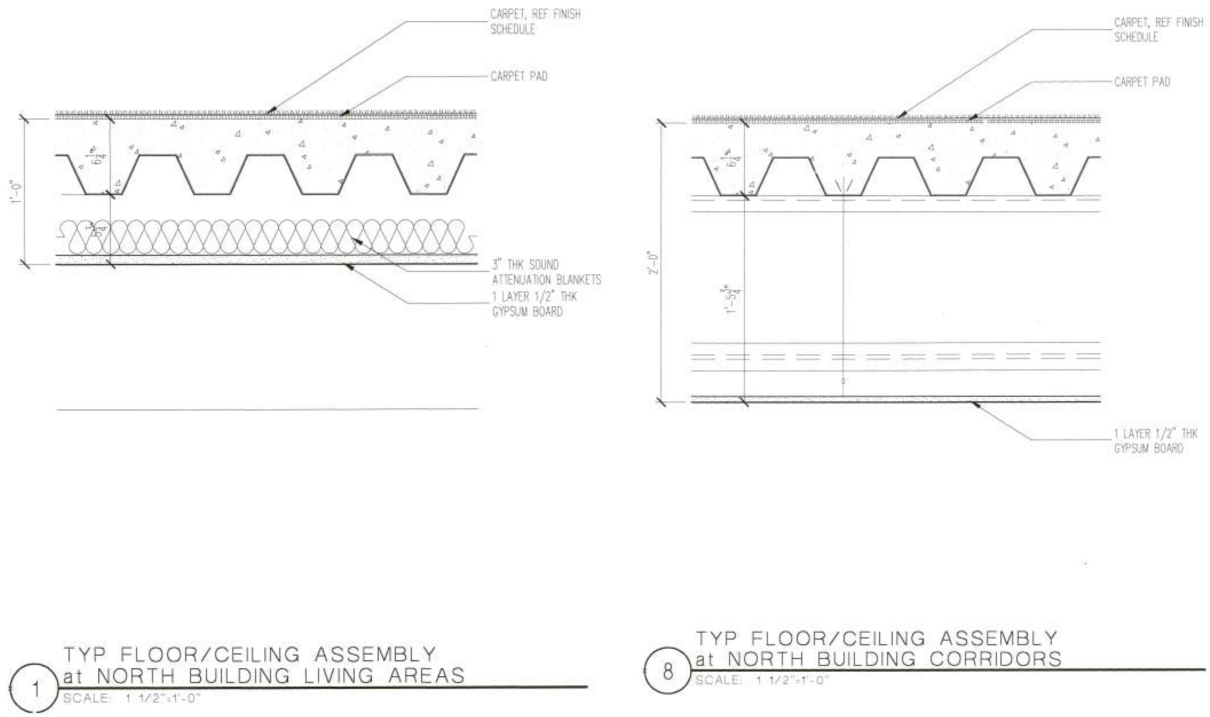


Figure 6: North Building Ceiling Sections

Vibration Criteria/Serviceability:

Whenever an open-web steel joist system is proposed for an office, residential, or industrial building, a couple major questions must be answered. How will it be fireproofed? Will vibration cause the occupants to be dissatisfied with the building's performance?

After discussions with engineers in the field, the best way to fireproof steel joists is by using spray-on cementitious fireproofing. The process is not simple as typically the joists may be wrapped in chicken wire first and then sprayed, or just sprayed outright. Since the joist system application at 303 Third Street would allow the majority of the 12K series joists to be within the ceiling cavity, the best alternative would be to specify a fire rated ceiling assembly. Figure 7 shows a 2 hour Underwriter's Laboratory specified ceiling assembly for a joist that is within the ceiling.

Gypsum Wallboard Floor/Ceilings – Steel Framing (steel joists with concrete floor) (CAD FILE NAME GOLDP.DWG OR GOLDP.DXF OR GOLDR.DWG OR GOLDR.DXF)

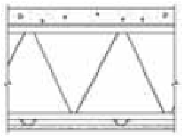
No.	Fire Rating		Ref.	Design No.	Description	STC	Test No.	IIC No Carpet	IIC Carpet & Pad
1	1 hr.		OSU	T-1936	5/8" (15.9 mm) Fire-Shield Gypsum Wallboard screw attached to furring channels spaced 24" o.c. (610 mm) attached to steel bar joists spaced 24" o.c. (610 mm). Concrete floor 2" (51 mm) thick.	53	Based on NGC 4075	21 Based on NGC 5121	67 Based on NGC 5122
	2 hr.		UL	G503	5/8" (15.9 mm) Fire-Shield Gypsum Wallboard or 5/8" (15.9 mm) Fire-Shield Kal-Kore plaster base screw attached to furring channels spaced 12" o.c. (305 mm) attached to or suspended from steel bar joists spaced 24" o.c. (610 mm). Concrete floor 2 1/2" (63.5 mm) thick.	53	(Direct) Based on NGC 4075	21 Based on NGC 5121	67 Based on NGC 5122
						57	(Susp.) Based on NGC 4078	28 Based on NGC 5126	75 Based on NGC 5127

Figure 7 – Steel Joist Fireproofing Assembly *courtesy of National Gypsum Company*

To evaluate the floor system for vibration considerations, AISC Design Guide 11- *Floor Vibrations Due to Human Activity* was used. Analyzing the typical bay for walking excitation would give the design engineer a good idea whether or not the steel joist system would be acceptable for residential as well as a future retrofit for office space occupancies. Since a lot of vibration issues occur due to a lack of slab dead load or joists that are not deep enough, it was decided early in the redesign process not to alter the slab dimensions from the original design.

Since the majority of vibration complaints occur in office spaces, the typical bay (Figure 5) was analyzed for a future office space retrofit. Analyzing the 12K1 joists with VLH24 joist-girders with a 3" deck and 3 ¼" LWC topping, it was found that the deflections induced in the joists and girders were quite close ($\Delta j = 0.186$ in and $\Delta g = 0.266$ in). The frequency of the system was determined to be 5.263 Hz and consequently $a_0/g = 0.003$, which is below the acceptable upper bound of 0.005 for an office and residential occupancy. It can be safely assumed that for the current residential occupancy for the typical bay, vibration will not be an issue if the proposed open-web steel joist system is implemented.

COMPARISON

	Composite Steel	Steel Joists
W (Kips)	33744.66	32111.80
V (Kips)	1551.23	1476.17
Max Drift (in)	1.554	1.758
Gravity Col (Tons)	117.6	115.2
Lateral Col (Tons)	196.6	178.9
Lateral Beams/Braces (Tons)	234.1	196.6
Total Tonnage (Cols + Lateral)	548.3	490.7
Cost	$1,919,050.00	$1,717,450.00
Savings		$201,600.00

Figure 8 – Comparison Chart – Columns and Lateral System

Using current pricing figures obtained from McNamara/Salvia Inc, an approximate cost savings due to decreasing column sizes, slimmer bracing members, and smaller lateral beams was calculated based on the tonnage. The approximate cost for steel including union erection in Boston, MA is about $3500 per ton of steel. Since RAM does not size joist girders, a gravity beam takeoff could not be performed to quickly determine how many tons of open-web steel joists would be required. However, in a previous tech report the RSMeans catalog had been used to calculate a rough cost/SF for the typical bay beam framing (Figure 9).

Criteria	Composite	Steel Joist
Cost/SF	27.25	22.54
Fireproofing	Spray On	Special Detail
Constructability	Medium	Easy
Deflection Issues	None	None
Vibration Resistance	Average	Below Average
Slab Width	6.25"	6.25"
Total Depth	20.25"	20.25"
Weight relative to Orig Design	As Designed	Slightly Lighter
Durability Issues	Steel Fatigue	Steel Fatigue
Column Grid Changes	No	No
Lateral System Effects	No	Minor
Viable Solution?	Yes	Yes

Figure 9 – Comparison Chart – Typical Bay Framing

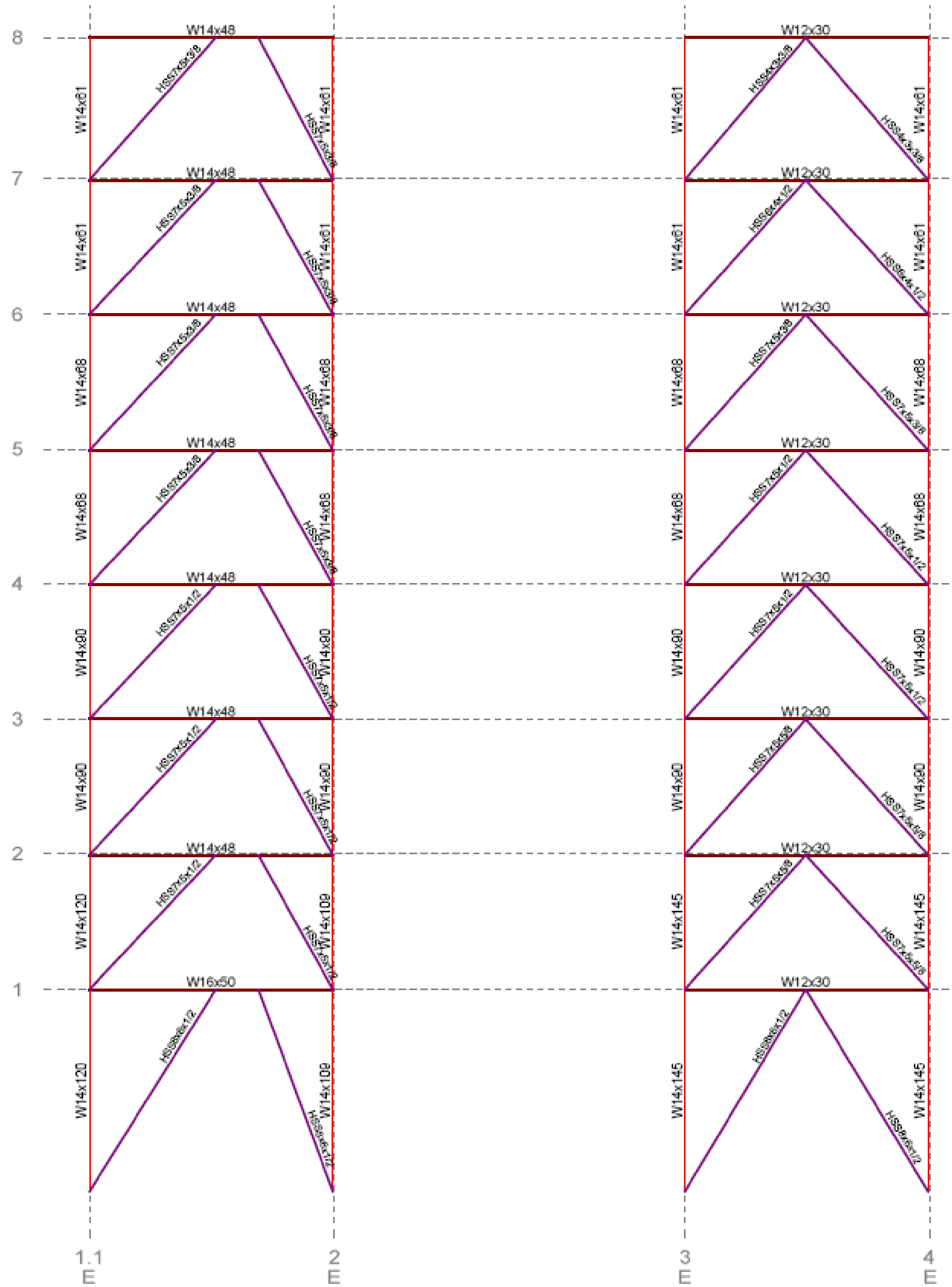


Figure 10 – Braced Frames Along Line E- Composite Steel Framing

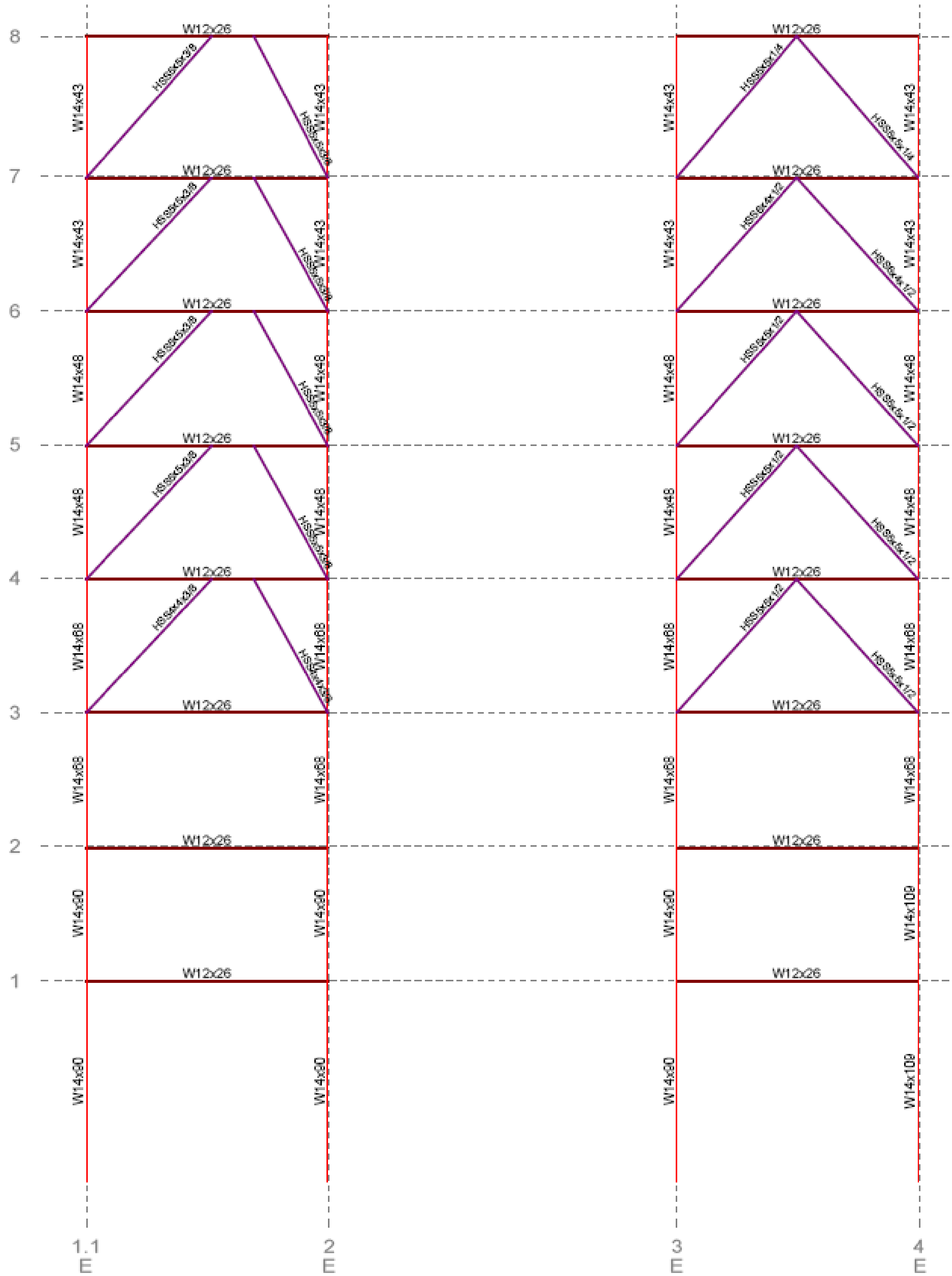


Figure 11 – Braced Frames Along Line E- Steel Joist Framing

Conclusions:

Open-web steel joists are a viable alternative solution for 303 Third Street. All concerns regarding the implementation of the system were alleviated once a careful side-by-side analysis of the two systems was performed. Boston is regarded in the profession as a “steel city.” Union erectors prefer the typical composite steel joists system that was originally designed. If more developers became aware of the potential savings due to a lighter framing system, open-web steel joist systems may become more commonplace. The major drawback is the vibration considerations and the lack of an easy back of the envelope vibration check. The dynamic properties of vibration analyses are a hindrance to the easy implementation of a steel joist system devoid of vibration issues. More study in the field of floor vibrations will eventually lead to the easier implementation of open-web steel joist floor systems.

MECHANICAL BREADTH STUDY

After consulting with a local mechanical engineer, it was determined that the most effective way for improving a building's energy efficiency is through the building envelope. Focusing on the Massachusetts Energy Code, the baseline energy efficiency can be determined by using a compliance check program (COMCheck 3.5.3). The program allows the user to input specific parameters such as the building location, building area, wall U-values, window U-values and the corresponding wall and window areas. Using the regional azimuth angles with the appropriate wall orientations, the program uses the ASHRAE Handbook of Fundamentals procedure for calculating the approximate code compliance.

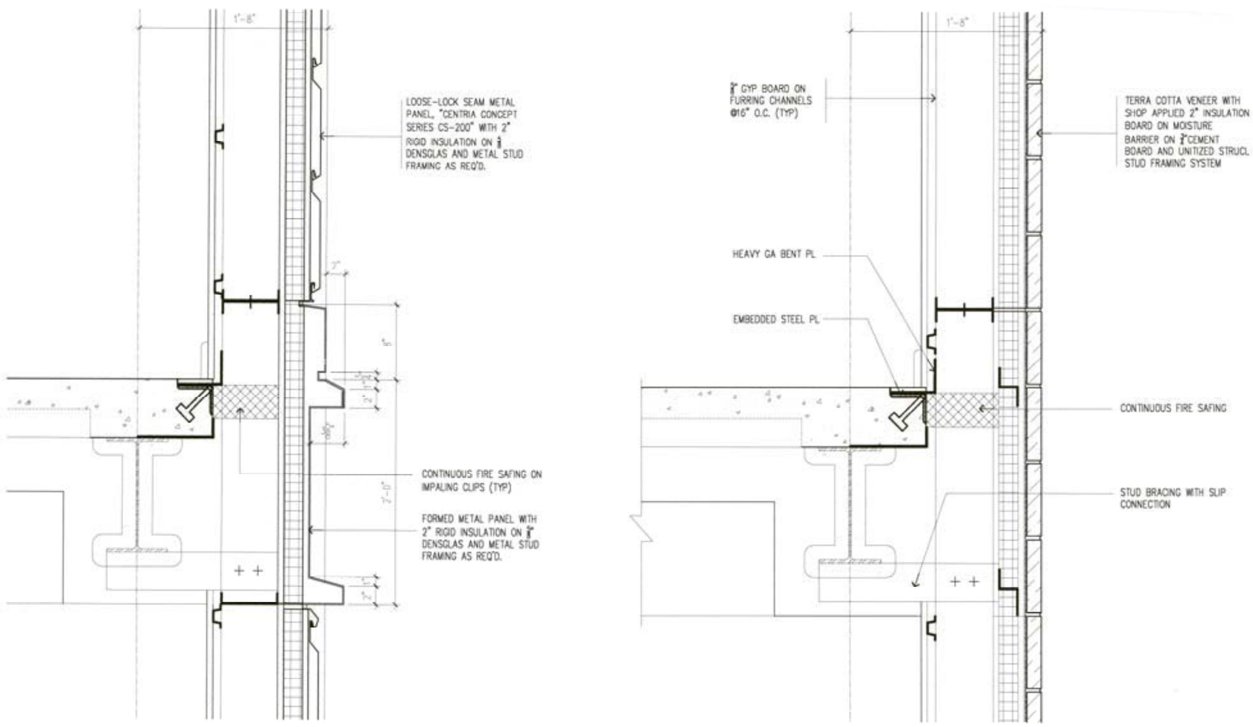


Figure 12 – Typical Wall Sections – North Building

Using the two wall sections above, appropriate U values were calculated using the ASHRA Handbook of Fundamentals Chapter 20 – Design Heat Transmission Coefficients along with the printed resistance values obtained from manufacturer data (when available). See Figures 13 and 14.

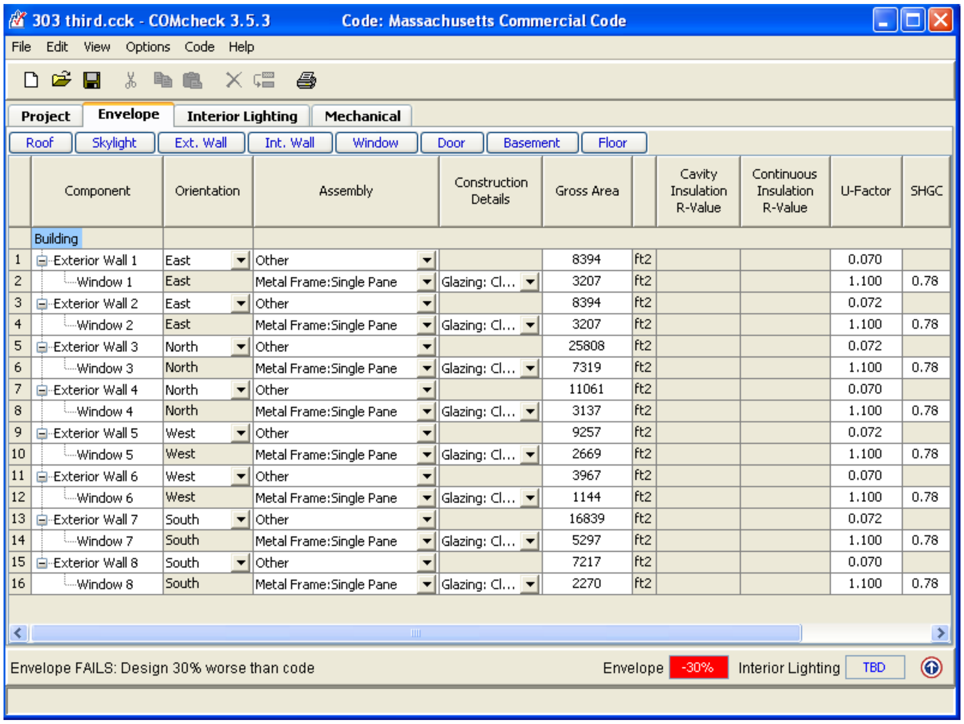
Metal Panel Wall	
Material	Resistance (R)
Outside Air Film	0.17
Loose-Lock Seam Metal Panel	0.61
2" Extruded Polystyrene Board Insulation	5.4/in
5/8" Densglass	0.47
Interior Air Space	0.97
5/8" Gypsum Wall Board	0.56
Interior Air Film	0.68
∑R	14.26
U	0.07013

Figure 13 – U-Value Calculation for Metal Panel Wall

Terra Cotta Wall	
Material	Resistance (R)
Outside Air Film	0.17
Terra Cotta Veneer	0.22
2" Extruded Polystyrene Board Insulation	5.4/in
3/4" Cement Board	0.52
Interior Air Space	0.97
5/8" Gypsum Wall Board	0.56
Interior Air Film	0.68
∑R	13.92
U	0.07184

Figure 14 – U-Value Calculation for Terra Cotta Wall

Using the architectural elevations, appropriate wall areas and window areas were calculated for each elevation. The internet was used to obtain appropriate U-values and SHGC values for the specified ¼" clear single-pane flat glass specified in the bid package Project Specifications dated January 27, 2006. After running COMCheck for the Massachusetts Energy Code, the building envelope fails the current code by about 30% (see Figure 15).



	Component	Orientation	Assembly	Construction Details	Gross Area		Cavity Insulation R-Value	Continuous Insulation R-Value	U-Factor	SHGC
	Building									
1	Exterior Wall 1	East	Other		8394	ft2			0.070	
2	Window 1	East	Metal Frame:Single Pane	Glazing: Cl...	3207	ft2			1.100	0.78
3	Exterior Wall 2	East	Other		8394	ft2			0.072	
4	Window 2	East	Metal Frame:Single Pane	Glazing: Cl...	3207	ft2			1.100	0.78
5	Exterior Wall 3	North	Other		25808	ft2			0.072	
6	Window 3	North	Metal Frame:Single Pane	Glazing: Cl...	7319	ft2			1.100	0.78
7	Exterior Wall 4	North	Other		11061	ft2			0.070	
8	Window 4	North	Metal Frame:Single Pane	Glazing: Cl...	3137	ft2			1.100	0.78
9	Exterior Wall 5	West	Other		9257	ft2			0.072	
10	Window 5	West	Metal Frame:Single Pane	Glazing: Cl...	2669	ft2			1.100	0.78
11	Exterior Wall 6	West	Other		3967	ft2			0.070	
12	Window 6	West	Metal Frame:Single Pane	Glazing: Cl...	1144	ft2			1.100	0.78
13	Exterior Wall 7	South	Other		16839	ft2			0.072	
14	Window 7	South	Metal Frame:Single Pane	Glazing: Cl...	5297	ft2			1.100	0.78
15	Exterior Wall 8	South	Other		7217	ft2			0.070	
16	Window 8	South	Metal Frame:Single Pane	Glazing: Cl...	2270	ft2			1.100	0.78

Figure 15 – COMCheck Input Parameters and Envelope Energy Compliance

Upgrading from single pane glass to double pane glass improves energy code compliance from -30% to -17%. A 13% increase in energy performance could qualify the building for 2 LEED points under the Optimize Energy Performance section. A 14% increase in energy cost savings versus the ASHRAE/IESNA Standard 90.1-2004 baseline building performance rating corresponds to 2 LEED points.

This quick analysis using the COMCheck utility allows the mechanical engineer to alert the architect that the building envelope as designed may not meet the appropriate energy code. The low wall section R values are a major contributor to the building's failure of the current Massachusetts energy code.

With increased window efficiency comes increased initial cost. After calling a few architects for a rough cost/SF for single versus double-paned clear glass, an increase from $35/SF to $45-50 can be expected. This cost includes window framing and installation. To obtain the LEED credit and the corresponding decreased energy costs over the course of the building life, the increased initial cost is well worth it. Depending on the rental agreement, by increasing energy efficiency of the building envelope and including heat in the rent, the owner may be able to make more money off of the units and the building may actually meet the building energy code.

ARCHITECTURAL MATERIALS BREADTH STUDY

To achieve a LEED Bronze rating, a minimum of 26 points must be earned. A fair amount of these points can be earned by employing a conscientious contractor who will take special care to minimize construction waste. However, a lot can be done by the architect to ensure that appropriate recycled, reused, local, low-emitting, and renewable materials are employed. By researching manufacturers in the Massachusetts area, some alternative materials were found to improve the LEED qualification of 303 Third Street.

Since the residential space of 303 Third Street is intended to be rented out as apartments, the use of a carpet floor may not be in the owner's best interest. In rental spaces, carpets are usually worn out exceptionally fast due to lack of maintenance and care on the part of the renter. A great way to avoid the hassle of replacing the carpet every time a new renter moves in is to install durable, rapidly renewable bamboo or cork flooring.

Grade A bamboo flooring can be purchased at about $2/SF depending on the supplier. Bamboo flooring comes in multiple shades and hardness. Since bamboo is technically a grass, it can grow in China up to a foot in a week. This rapid growth qualifies bamboo as a rapidly renewable resource. The downside to bamboo is that it is almost exclusively produced grown in China and it is very hard to verify that the bamboo is naturally grown or if forests were destroyed to provide the space necessary to grow it. As this is the case, it does not qualify as a regional material, but it does qualify for Materials and Resources Credit 6 – Rapidly Renewable Materials. The low cost and durability may make this a very appealing alternative to the building owner.

An alternative floor system that may qualify for two LEED credits is cork flooring. Though less durable than bamboo, cork flooring produced in the United States is often comprised of at least 10% recycled cork from wine stoppers (Materials and Resources Credit 4.1 – Recycled Content: 10%). Since the majority of cork comes from Spain, the floors do not qualify as a regional material, but if a certain percentage can be proven recycled locally, the developer can count that toward LEED certification. Cork is inherently softer than bamboo and thus more likely to be damaged by renters. Cork flooring is also more expensive than bamboo flooring at over $3/SF.

After performing the building envelope mechanical breadth, it became apparent that the exterior walls need better insulation. A great insulator that has a total recycled content of 82% is blown in cellulose insulation. Cellulose insulation also required only 750 btu/lb to manufacture as compared to 12,000 btu/lb for standard fiberglass insulation. The initial cost for cellulose insulation is a bit higher than fiberglass, but it is more than made up for by the increased performance as well as the environmental impact. Figure 16 shows the U-value calculation for each wall type if 3" of cellulose insulation was blown in to the metal stud cavity.

Metal Panel Wall	
Material	Resistance (R)
Outside Air Film	0.17
Loose-Lock Seam Metal Panel	0.61
2" Extruded Polystyrene Board Insulation	5.4/in
5/8" Densglass	0.47
3" Blown-in Cellulose Insulation	3.7/in
Interior Air Space	0.97
5/8" Gypsum Wall Board	0.56
Interior Air Film	0.68
∑R	25.36
U	0.03943

Terra Cotta Wall	
Material	Resistance (R)
Outside Air Film	0.17
Terra Cotta Veneer	0.22
2" Extruded Polystyrene Board Insulation	5.4/in
3/4" Cement Board	0.52
2" Blown-in Cellulose Insulation	3.7/in
Interior Air Space	0.97
5/8" Gypsum Wall Board	0.56
Interior Air Film	0.68
∑R	25.02
U	0.03997

Figure 16 – U Values for Cellulose Insulated Walls

Cellulose insulation would contribute toward LEED Materials and Resources Credit 4.1: Recycled Content, Credit 5.1: Regional Materials, and Energy and Atmosphere Credit 1: Optimize Energy Performance. There is a cellulose insulation manufacturer (National Fiber) located in Belchertown, MA, which is about 80 miles from Cambridge. Cellulose insulation would be an easy way to improve the energy efficiency of 303 Third Street without having a negative impact on the environment.

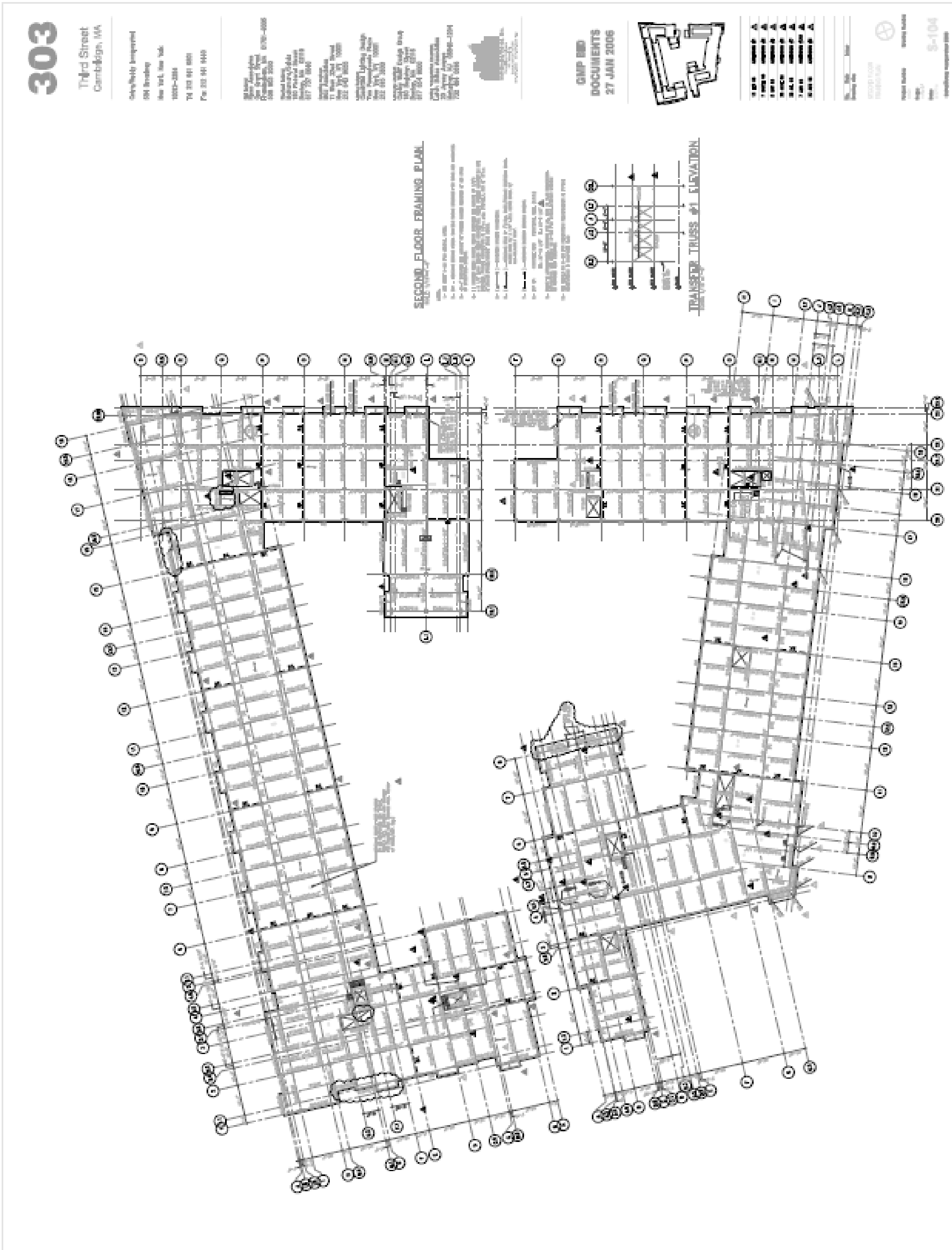
SUMMARY/CONCLUSIONS

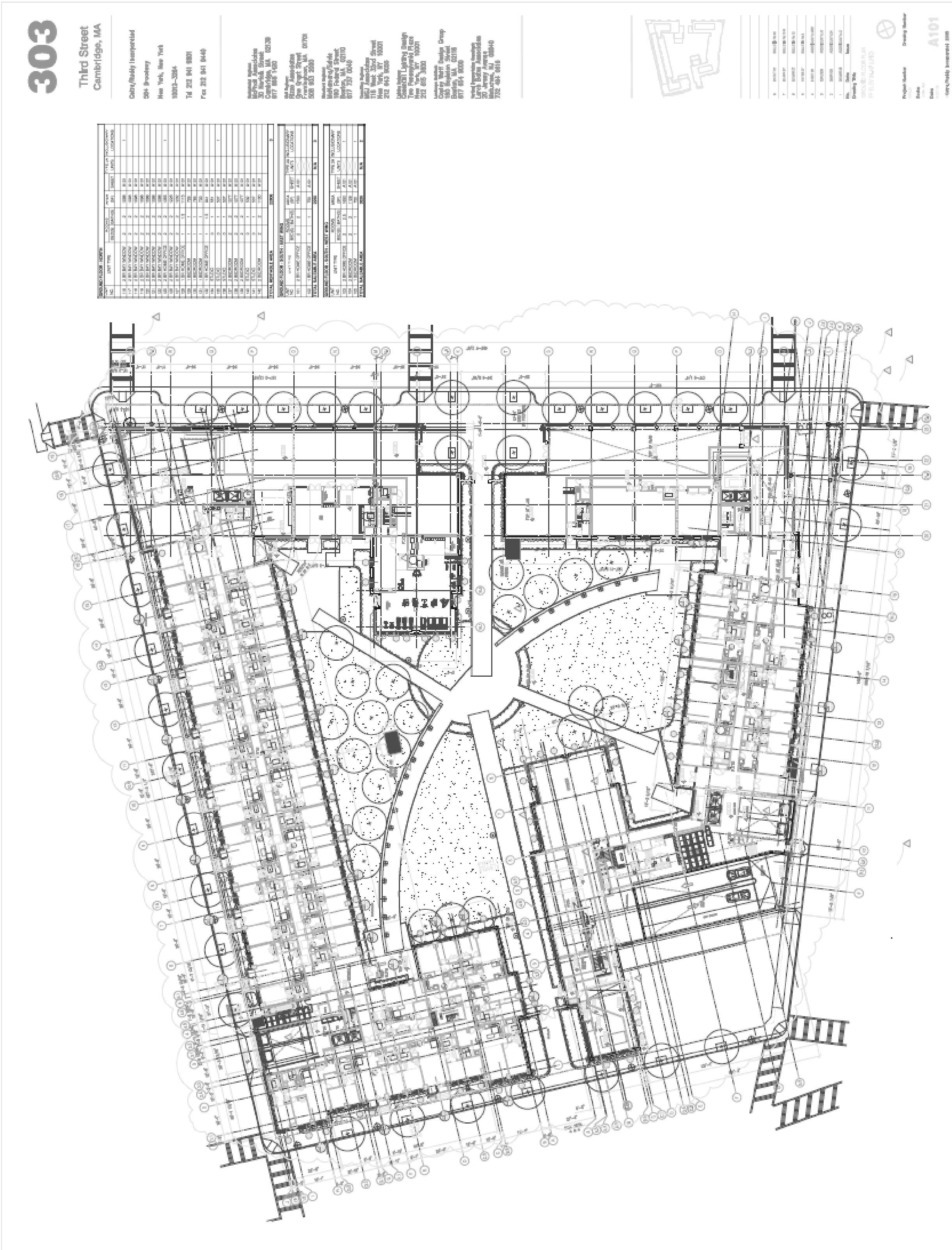
Every small step involved in designing a building has immense consequences toward building efficiency in terms of energy costs and building performance. Coordinating an efficient design that optimizes the use of materials structurally, architecturally, and mechanically is a challenge that every team of engineers and architects accept. Through the introduction of new building methods and materials, buildings will continue to be more efficient as materials become more scarce and expensive. What may cost more initially often is the cheaper alternative when taking in to account the life span of the building. Developers must be more cognizant of the payback period of certain upgrades so that new technologies are adopted more readily.

By reducing the weight of the structural system, the controlling lateral load (seismic) was reduced and thus initial costs were saved in terms of tons of steel needed to erect 303 Third Street. Steel joists are a viable alternative floor system when fire rated ceiling assemblies are utilized and vibrations are controlled. Pressure must be exerted on contractors and unions to adopt new construction methods that promote the efficiency of building systems because it costs the developers more money in initial cost and drains the environment of resources. The alternative floor system proposed for 303 Third Street is a viable alternative to composite steel framing for this residential occupancy.

To achieve a LEED Bronze certification, 26 points need to be earned. By increasing the efficiency of the building envelope, using rapidly renewable materials, regional materials, and hiring a responsible general contractor who will manage site waste, 26 LEED points would add minimal initial cost to 303 Third Street. The location of the building is ideal for LEED because there are many credits that could be easily earned due to it's urban location under Sustainable Sites (Credits 1, 2, 3, 4.1, 4.2, etc). To appeal to the intelligent Cambridge society, LEED accreditation would be a feather in the cap to 303 Third Street, making it more rentable.

APPENDIX


303
Third Street
Cambridge, MA
SECOND FLOOR FRAMING PLAN
TRANSFER TRUSS #1 ELEVATION
GMP BID
DOCUMENTS
27 JAN 2006
S-104


303
Third Street
Cambridge, MA
A101

Wide Flange:

Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W14X109	7	105.0	11433	
W14X120	18	270.0	32431	
W14X132	21	315.0	41588	
W14X145	2	30.0	4359	
W14X159	6	90.0	14302	
	54		104113	2.35

Beams:

Wide Flange:

Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W12X30	15	271.2	8113	
W14X22	2	52.0	1148	
W14X43	2	54.8	2351	
W14X30	2	50.0	1506	
W14X34	1	26.0	885	
W14X38	1	26.0	991	
W16X50	1	18.1	905	
W18X65	19	456.0	29636	
W18X71	2	41.9	2967	
W21X73	1	18.1	1323	
	46		49824	1.12

Braces:

Tube:

Steel Grade: Other

Size	#	Length ft	Weight lbs	UnitWt psf
HSS7X7X1/2	1	19.9	786	
HSS8X6X1/2	10	178.6	7051	
HSS9X7X1/2	2	39.7	1824	
HSS9X7X5/8	2	39.7	2215	
HSS9X5X5/8	6	108.5	5168	
HSS9X9X1/2	6	116.5	6065	
HSS9X5X1/2	10	175.1	6913	
	37		30022	0.68

TOTAL STRUCTURE FRAME TAKEOFF

Floor Area (ft**2): 317872.6

Columns:

Wide Flange:

Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W14X61	78	799.0	48666	
W14X68	78	780.0	53082	
W14X90	104	1040.0	93779	
W14X74	28	280.0	20770	
W14X82	4	40.0	3267	
W14X109	14	175.0	19055	
W14X120	36	450.0	54052	
W14X132	42	525.0	69313	
W14X145	4	50.0	7265	
W14X159	12	150.0	23836	
	400		393086	1.24

Beams:

Wide Flange:

Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W12X14	1	18.1	256	
W12X26	3	54.2	1412	
W12X30	113	2043.4	61118	
W14X22	2	52.0	1148	
W14X43	46	1139.7	48863	
W14X30	4	98.0	2951	
W14X48	31	684.7	32849	
W14X26	1	24.0	628	
W14X53	21	497.9	26431	
W14X61	21	497.9	30328	
W14X34	1	26.0	885	
W14X68	28	665.9	45319	
W14X38	2	50.0	1906	
W14X74	14	329.9	24473	
W16X50	1	18.1	905	
W18X65	19	456.0	29636	
W18X71	2	41.9	2967	
W21X73	1	18.1	1323	
	311		313396	0.99

Braces:

Tube:

Steel Grade: Other

Size	#	Length ft	Weight lbs	UnitWt psf
HSS4X3X3/8	2	27.7	386	
HSS4X4X3/8	2	27.7	451	
HSS5X5X1/2	2	30.7	824	
HSS6X4X5/16	4	55.4	992	
HSS6X4X3/8	15	207.5	4363	
HSS6X4X1/2	21	283.1	7591	
HSS7X7X1/2	1	19.9	786	
HSS7X7X5/8	8	107.9	5138	
HSS7X5X3/8	25	332.1	8566	
HSS7X5X1/2	45	605.8	20079	
HSS7X5X5/8	50	686.5	27331	
HSS8X6X1/2	10	178.6	7051	
HSS9X7X1/2	2	39.7	1824	
HSS9X7X5/8	2	39.7	2215	
HSS9X9X1/2	6	116.5	6065	
HSS9X5X1/2	49	710.2	28031	
HSS9X5X5/8	47	694.9	33105	
	291		154798	0.49

Note: Length and Weight based on Centerline dimensions.

Gravity Column Design TakeOff

RAM Steel v11.2
DataBase: 303 Third Street - Steel
Building Code: MASS

Steel Grade: 50

I section

Size	#	Length (ft)	Weight (lbs)
W12X40	146	2966.5	118104
W12X45	11	225.0	10030
W12X50	14	295.0	14656
W12X53	29	625.0	33177
W12X58	5	110.0	6363
W12X65	19	430.0	27947
W12X72	3	75.0	5385
W12X87	6	150.0	13067
W12X96	2	50.0	4798
W12X106	1	15.0	1593
	236		235119

LOAD CASE: SEISMIC 2

Seismic BOCA 96/99 Equivalent Lateral Force
Av: 0.120 Aa: 0.120 Soil Type: S3
Provisions for: Force
Ground Level: Base

Dir	Eccent	R	Ta Equation	Building Period-T
X	+ And -	5.0	Std,Ct=0.020	Calculated
Y	+ And -	5.0	Std,Ct=0.020	Calculated

Dir	Ta	Ca	T	T-used	Cs	k
X	0.562	1.620	1.645	0.911	0.0460	1.206
Y	0.562	1.620	1.341	0.911	0.0460	1.206

Total Building Weight (kips) = 33744.66

APPLIED DIAPHRAGM FORCES

Type: EQ_BOCA96/99_X_+E_F

Level	Diaph.#	Ht ft	Fx kips	Fy kips	
Roof	1	85.50	409.00	0.00	-19
Eighth	1	75.00	199.92	0.00	-19
Seventh	1	65.00	326.92	0.00	-19
Sixth	1	55.00	198.39	0.00	-19
Fifth	1	45.00	170.99	0.00	-19
Fourth	1	35.00	120.39	0.00	-19
Third	1	25.00	80.83	0.00	-19
2nd	1	15.00	44.79	0.00	-19

APPLIED STORY FORCES

Type: EQ_BOCA96/99_X_+E_F

Level	Ht ft	Fx kips	Fy kips
Roof	85.50	409.00	0.00
Eighth	75.00	199.92	0.00
Seventh	65.00	326.92	0.00
Sixth	55.00	198.39	0.00
Fifth	45.00	170.99	0.00
Fourth	35.00	120.39	0.00
Third	25.00	80.83	0.00
2nd	15.00	44.79	0.00
		1551.23	0.00

APPLIED DIAPHRAGM FORCES

Type: EQ_BOCA96/99_X_-E_F

Level	Diaph.#	Ht ft	Fx kips	Fy kips	
Roof	1	85.50	409.00	0.00	-19

Eighth	1	75.00	0.00	199.92	-1
Seventh	1	65.00	0.00	326.92	-1
Sixth	1	55.00	0.00	198.39	-1
Fifth	1	45.00	0.00	170.99	-1
Fourth	1	35.00	0.00	120.39	-1
Third	1	25.00	0.00	80.83	-1
2nd	1	15.00	0.00	44.79	-1

APPLIED STORY FORCES

Type: EQ_BOCA96/99_Y_+E_F

Level	Ht ft	Fx kips	Fy kips
Roof	85.50	0.00	409.00
Eighth	75.00	0.00	199.92
Seventh	65.00	0.00	326.92
Sixth	55.00	0.00	198.39
Fifth	45.00	0.00	170.99
Fourth	35.00	0.00	120.39
Third	25.00	0.00	80.83
2nd	15.00	0.00	44.79
		0.00	1551.23

APPLIED DIAPHRAGM FORCES

Type: EQ_BOCA96/99_Y_-E_F

Level	Diaph.#	Ht ft	Fx kips	Fy kips	
Roof	1	85.50	0.00	409.00	-2
Eighth	1	75.00	0.00	199.92	-2
Seventh	1	65.00	0.00	326.92	-2
Sixth	1	55.00	0.00	198.39	-2
Fifth	1	45.00	0.00	170.99	-2
Fourth	1	35.00	0.00	120.39	-2
Third	1	25.00	0.00	80.83	-2
2nd	1	15.00	0.00	44.79	-2

APPLIED STORY FORCES

Type: EQ_BOCA96/99_Y_-E_F

Level	Ht ft	Fx kips	Fy kips
Roof	85.50	0.00	409.00
Eighth	75.00	0.00	199.92
Seventh	65.00	0.00	326.92
Sixth	55.00	0.00	198.39
Fifth	45.00	0.00	170.99
Fourth	35.00	0.00	120.39
Third	25.00	0.00	80.83
2nd	15.00	0.00	44.79

Loads and Applied Forces

RAM Frame v11.2
DataBase: 303 Third Street - Steel

LOAD CASE: WIND 2

Wind BOCA 96/99
Exposure: B
Basic Wind Speed (mph): 90.0 Importance Factor: 1.000
Internal Pressure Coeff GCpi: +0.25/-0.25 (Condition 1)
Mean Roof Height (ft): Top Story Height + Parapet = 85.50
Ground Level: Base

WIND PRESSURES:

Gh = 1.330 CpWindward = 0.80 Pv = 20.74 psf

Height	Kz	CpLeeWard		Pressure (psf)	
ft		X	Y	X	Y
85.50	0.798	-0.356	-0.500	25.411	28.58
75.00	0.752	-0.356	-0.500	24.416	27.59
65.00	0.706	-0.363	-0.500	23.550	26.56
55.00	0.656	-0.363	-0.500	22.436	25.45
45.00	0.600	-0.363	-0.500	21.202	24.22
35.00	0.536	-0.363	-0.500	19.804	22.82
25.00	0.462	-0.363	-0.500	18.161	21.17
15.00	0.368	-0.363	-0.500	16.093	19.11
0.00	0.368	-0.363	-0.500	16.093	19.11

APPLIED DIAPHRAGM FORCES

Type: Wind_BOCA96/99_X

Level	Diaph.#	Ht	Fx	Fy	
		ft	kips	kips	
Roof	1	85.50	31.01	0.00	-2
Eighth	1	75.00	59.02	0.00	-2
Seventh	1	65.00	56.59	0.00	-2
Sixth	1	55.00	55.16	0.00	-2
Fifth	1	45.00	52.11	0.00	-2
Fourth	1	35.00	48.64	0.00	-2
Third	1	25.00	44.52	0.00	-2
2nd	1	15.00	50.35	0.00	-2

APPLIED STORY FORCES

Type: Wind_BOCA96/99_X

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	85.50	31.01	0.00
Eighth	75.00	59.02	0.00
Seventh	65.00	56.59	0.00
Sixth	55.00	55.16	0.00
Fifth	45.00	52.11	0.00
Fourth	35.00	48.64	0.00
Third	25.00	44.52	0.00
2nd	15.00	50.35	0.00
		397.39	0.00

CRITERIA:

Rigid End Zones: Include Effects: 50.00% Reduction
Member Force Output: At Face of Joint
P-Delta: Yes Scale Factor: 1.33
Ground Level: Base
Wall Mesh Criteria :
Wall Element Type : Shell Element with No Out-of-Plane Stiffness
Max. Allowed Distance between Nodes (ft) : 8.00

LOAD CASE DEFINITIONS:

E5	SEISMIC 2	EQ_BOCA96/99_X_+E_Drft
E6	SEISMIC 2	EQ_BOCA96/99_X_-E_Drft
E7	SEISMIC 2	EQ_BOCA96/99_Y_+E_Drft
E8	SEISMIC 2	EQ_BOCA96/99_Y_-E_Drft
W3	WIND 2	Wind_BOCA96/99_X
W4	WIND 2	Wind_BOCA96/99_Y

Level: Roof, Diaph: 1

Center of Mass (ft): (-199.41, -125.43)

LdC	Disp X in	Disp Y in	Theta Z rad
E5	1.55420	0.16543	-0.00014
E6	1.54306	0.19687	0.00003
E7	0.19752	1.48095	0.00029
E8	0.21884	1.42107	-0.00003
W3	0.39762	0.04865	-0.00001
W4	0.09748	0.61121	0.00001

Level: Eighth, Diaph: 1

Center of Mass (ft): (-199.35, -124.87)

LdC	Disp X in	Disp Y in	Theta Z rad
E5	1.32599	0.14750	-0.00012
E6	1.31565	0.17235	0.00002
E7	0.17068	1.21636	0.00024
E8	0.19048	1.16884	-0.00004
W3	0.35304	0.04466	-0.00001
W4	0.08803	0.53319	0.00000

Level: Seventh, Diaph: 1

Center of Mass (ft): (-199.70, -116.49)

LdC	Disp X in	Disp Y in	Theta Z rad
E5	1.11054	0.12792	-0.00010
E6	1.09049	0.14554	0.00002
E7	0.12667	0.95588	0.00018
E8	0.16512	0.92203	-0.00004
W3	0.30457	0.03950	-0.00001
W4	0.07718	0.44249	0.00000

Level: Sixth, Diaph: 1

Center of Mass (ft): (-199.05, -120.19)

LdC	Disp X in	Disp Y in	Theta Z rad
E5	0.87757	0.10170	-0.00008
E6	0.86566	0.11692	0.00001
E7	0.10888	0.76778	0.00015
E8	0.13177	0.73848	-0.00003
W3	0.25276	0.03319	-0.00000
W4	0.06513	0.36880	0.00000

Level: Fifth, Diaph: 1

Center of Mass (ft): (-191.22, -125.18)

LdC	Disp X in	Disp Y in	Theta Z rad
E5	0.65968	0.07267	-0.00006
E6	0.65500	0.09060	0.00001
E7	0.09142	0.59187	0.00011
E8	0.10043	0.55726	-0.00002
W3	0.20080	0.02646	-0.00000
W4	0.05279	0.29219	-0.00000

Level: Fourth, Diaph: 1

Center of Mass (ft): (-195.62, -122.36)

LdC	Disp X	Disp Y	Theta Z
	in	in	rad
E5	0.46957	0.05422	-0.00004
E6	0.46460	0.06483	0.00001
E7	0.06353	0.41608	0.00008
E8	0.07314	0.39554	-0.00001
W3	0.15117	0.02026	-0.00000
W4	0.04030	0.21840	0.00000

Level: Third, Diaph: 1

Center of Mass (ft): (-195.65, -122.37)

LdC	Disp X	Disp Y	Theta Z
	in	in	rad
E5	0.30926	0.03678	-0.00003
E6	0.30604	0.04324	0.00000
E7	0.04318	0.26274	0.00005
E8	0.04942	0.25020	-0.00001
W3	0.10632	0.01442	-0.00000
W4	0.02887	0.14724	-0.00000

Level: 2nd, Diaph: 1

Center of Mass (ft): (-197.66, -121.99)

LdC	Disp X	Disp Y	Theta Z
	in	in	rad
E5	0.17235	0.02174	-0.00001
E6	0.17051	0.02426	0.00000
E7	0.02502	0.13141	0.00003
E8	0.02859	0.12652	-0.00001
W3	0.06368	0.00868	-0.00000
W4	0.01765	0.08046	-0.00000

Size	#	Length ft	Weight lbs	UnitWt psf
HSS5X3X1/2	2	27.0	552	
HSS5X4X3/8	4	60.1	1120	
HSS5X5X1/2	28	377.5	10122	
HSS7X7X5/8	2	31.2	1488	
	36		13283	0.30

Level: 2nd

Floor Area (ft**2): 44373.7

Columns:

Wide Flange:

Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W14X90	3	45.0	4058	
W14X99	2	30.0	2971	
W14X109	30	450.0	48999	
W14X120	13	195.0	23423	
W14X132	6	90.0	11882	
	54		91332	2.06

Beams:

Wide Flange:

Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W12X14	1	18.1	256	
W12X26	2	36.2	941	
W12X30	13	235.1	7031	
W14X22	2	52.0	1148	
W14X30	2	50.0	1506	
W14X26	2	54.8	1435	
W14X34	1	26.0	885	
W14X38	1	26.0	991	
W18X35	2	48.0	1682	
W18X65	17	408.0	26517	
W18X71	2	41.9	2967	
W21X73	1	18.1	1323	
	46		46682	1.05

Braces:

Tube:

Steel Grade: Other

Size	#	Length ft	Weight lbs	UnitWt psf
HSS5X3X1/2	2	35.0	718	
HSS5X4X3/8	4	74.9	1397	
HSS5X5X1/2	23	421.3	11297	
HSS7X7X5/8	4	78.1	3721	
	33		17132	0.39

TOTAL STRUCTURE FRAME TAKEOFF

Floor Area (ft**2): 317871.2

Columns:

Wide Flange:

Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W14X43	10	102.5	4395	
W14X48	22	223.0	10699	
W14X53	12	123.0	6529	
W14X61	48	490.5	29876	
W14X90	62	635.0	57259	

Size	#	Length	Weight	UnitWt
W14X68	100	1000.0	68054	
W14X74	6	60.0	4451	
W14X99	4	50.0	4951	
W14X82	38	380.0	31033	
W14X109	60	750.0	81665	
W14X120	26	325.0	39038	
W14X132	12	150.0	19804	
	400		357754	1.13

Beams:

Wide Flange:

Steel Grade: 50

Size	#	Length ft	Weight lbs	UnitWt psf
W12X14	1	18.1	256	
W12X26	24	434.0	11297	
W12X22	2	36.2	797	
W12X30	98	1772.2	53005	
W14X22	2	52.0	1148	
W14X43	32	743.7	31884	
W14X30	8	194.0	5842	
W14X48	39	923.8	44324	
W14X26	16	420.0	10990	
W14X61	36	857.9	52255	
W14X34	12	290.0	9868	
W14X68	7	168.0	11433	
W14X38	2	50.0	1906	
W14X74	10	240.0	17803	
W18X35	2	48.0	1682	
W18X65	17	408.0	26517	
W18X71	2	41.9	2967	
W21X73	1	18.1	1323	
	311		285298	0.90

Braces:

Tube:

Steel Grade: Other

Size	#	Length ft	Weight lbs	UnitWt psf
HSS4X4X3/8	2	25.1	409	
HSS5X5X1/4	2	27.7	405	
HSS5X3X1/2	4	62.0	1270	
HSS5X4X3/8	12	195.1	3637	
HSS5X5X3/8	20	275.6	5796	
HSS5X5X1/2	221	3117.3	83585	
HSS6X4X1/2	2	27.0	723	
HSS7X5X1/2	2	27.0	894	
HSS7X7X5/8	14	234.3	11163	
	279		107882	0.34

Note: Length and Weight based on Centerline dimensions.

Gravity Column Design TakeOff

RAM Steel v11.2
DataBase: 303 Third Street - Steel Joist
Building Code: IBC

Steel Grade: 50

I section

Size	#	Length (ft)	Weight (lbs)
W12X40	149	3031.5	120692
W12X45	14	285.0	12704
W12X50	15	300.0	14904
W12X53	23	520.0	27603
W12X58	13	280.0	16197
W12X65	11	260.0	16898
W12X72	2	50.0	3590
W12X79	5	125.0	9868
W12X87	3	75.0	6533
W12X96	1	15.0	1439
	236		230429

LOAD CASE: SEISMIC 2

Seismic BOCA 96/99 Equivalent Lateral Force
Av: 0.120 Aa: 0.120 Soil Type: S3
Provisions for: Force
Ground Level: Base

Dir	Eccent	R	Ta Equation	Building Period-T
X	+ And -	5.0	Std,Ct=0.020	Calculated
Y	+ And -	5.0	Std,Ct=0.020	Calculated

Dir	Ta	Ca	T	T-used	Cs	k
X	0.562	1.620	1.916	0.911	0.0460	1.206
Y	0.562	1.620	1.455	0.911	0.0460	1.206

Total Building Weight (kips) = 32111.80

APPLIED DIAPHRAGM FORCES

Type: EQ_BOCA96/99_X_+E_F

Level	Diaph.#	Ht	Fx	Fy	
		ft	kips	kips	
Roof	1	85.50	395.18	0.00	-19
Eighth	1	75.00	189.10	0.00	-19
Seventh	1	65.00	310.60	0.00	-19
Sixth	1	55.00	187.61	0.00	-19
Fifth	1	45.00	161.79	0.00	-19
Fourth	1	35.00	113.60	0.00	-19
Third	1	25.00	76.15	0.00	-19
2nd	1	15.00	42.12	0.00	-19

APPLIED STORY FORCES

Type: EQ_BOCA96/99_X_+E_F

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	85.50	395.18	0.00
Eighth	75.00	189.10	0.00
Seventh	65.00	310.60	0.00
Sixth	55.00	187.61	0.00
Fifth	45.00	161.79	0.00
Fourth	35.00	113.60	0.00
Third	25.00	76.15	0.00
2nd	15.00	42.12	0.00
		1476.17	0.00

APPLIED DIAPHRAGM FORCES

Type: EQ_BOCA96/99_X_-E_F

Level	Diaph.#	Ht	Fx	Fy	
		ft	kips	kips	
Roof	1	85.50	395.18	0.00	-19

Eighth	1	75.00	0.00	189.10	-1
Seventh	1	65.00	0.00	310.60	-1
Sixth	1	55.00	0.00	187.61	-1
Fifth	1	45.00	0.00	161.79	-1
Fourth	1	35.00	0.00	113.60	-1
Third	1	25.00	0.00	76.15	-1
2nd	1	15.00	0.00	42.12	-1

APPLIED STORY FORCES

Type: EQ_BOCA96/99_Y_+E_F

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	85.50	0.00	395.18
Eighth	75.00	0.00	189.10
Seventh	65.00	0.00	310.60
Sixth	55.00	0.00	187.61
Fifth	45.00	0.00	161.79
Fourth	35.00	0.00	113.60
Third	25.00	0.00	76.15
2nd	15.00	0.00	42.12
		0.00	1476.17

APPLIED DIAPHRAGM FORCES

Type: EQ_BOCA96/99_Y_-E_F

Level	Diaph.#	Ht	Fx	Fy	
		ft	kips	kips	
Roof	1	85.50	0.00	395.18	-2
Eighth	1	75.00	0.00	189.10	-2
Seventh	1	65.00	0.00	310.60	-2
Sixth	1	55.00	0.00	187.61	-2
Fifth	1	45.00	0.00	161.79	-2
Fourth	1	35.00	0.00	113.60	-2
Third	1	25.00	0.00	76.15	-2
2nd	1	15.00	0.00	42.12	-2

APPLIED STORY FORCES

Type: EQ_BOCA96/99_Y_-E_F

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	85.50	0.00	395.18
Eighth	75.00	0.00	189.10
Seventh	65.00	0.00	310.60
Sixth	55.00	0.00	187.61
Fifth	45.00	0.00	161.79
Fourth	35.00	0.00	113.60
Third	25.00	0.00	76.15
2nd	15.00	0.00	42.12

Loads and Applied Forces

RAM Frame v11.2
DataBase: 303 Third Street - Steel Joist

LOAD CASE: WIND 2

Wind BOCA 96/99
Exposure: B
Basic Wind Speed (mph): 90.0 Importance Factor: 1.000
Internal Pressure Coeff GCpi: +0.25/-0.25 (Condition 1)
Mean Roof Height (ft): Top Story Height + Parapet = 85.50
Ground Level: Base

WIND PRESSURES:

Gh = 1.330 CpWindward = 0.80 Pv = 20.74 psf

Height	Kz	CpLeeWard		Pressure (psf)	
ft		X	Y	X	Y
85.50	0.798	-0.356	-0.500	25.412	28.58
75.00	0.752	-0.356	-0.500	24.416	27.59
65.00	0.706	-0.363	-0.500	23.550	26.56
55.00	0.656	-0.363	-0.500	22.436	25.45
45.00	0.600	-0.363	-0.500	21.202	24.22
35.00	0.536	-0.363	-0.500	19.804	22.82
25.00	0.462	-0.363	-0.500	18.162	21.17
15.00	0.368	-0.363	-0.500	16.093	19.11
0.00	0.368	-0.363	-0.500	16.093	19.11

APPLIED DIAPHRAGM FORCES

Type: Wind_BOCA96/99_X

Level	Diaph.#	Ht	Fx	Fy	
		ft	kips	kips	
Roof	1	85.50	31.01	0.00	-2
Eighth	1	75.00	59.02	0.00	-2
Seventh	1	65.00	56.59	0.00	-2
Sixth	1	55.00	55.16	0.00	-2
Fifth	1	45.00	52.11	0.00	-2
Fourth	1	35.00	48.64	0.00	-2
Third	1	25.00	44.52	0.00	-2
2nd	1	15.00	50.35	0.00	-2

APPLIED STORY FORCES

Type: Wind_BOCA96/99_X

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	85.50	31.01	0.00
Eighth	75.00	59.02	0.00
Seventh	65.00	56.59	0.00
Sixth	55.00	55.16	0.00
Fifth	45.00	52.11	0.00
Fourth	35.00	48.64	0.00
Third	25.00	44.52	0.00
2nd	15.00	50.35	0.00
		397.40	0.00

Story Displacements

RAM Frame v11.2
DataBase: 303 Third Street - Steel Joist
Building Code: IBC

04/05/08 15:06:49

CRITERIA:

Rigid End Zones:		Include Effects: 50.00% Reduction	
Member Force Output:		At Face of Joint	
P-Delta:	Yes	Scale Factor:	1.33
Ground Level:	Base		

Wall Mesh Criteria :

Wall Element Type : Shell Element with No Out-of-Plane Stiffness
Max. Allowed Distance between Nodes (ft) : 8.00

LOAD CASE DEFINITIONS:

E5	SEISMIC 2	EQ_BOCA96/99_X_+E_Drft
E6	SEISMIC 2	EQ_BOCA96/99_X_-E_Drft
E7	SEISMIC 2	EQ_BOCA96/99_Y_+E_Drft
E8	SEISMIC 2	EQ_BOCA96/99_Y_-E_Drft
W3	WIND 2	Wind_BOCA96/99_X
W4	WIND 2	Wind_BOCA96/99_Y

Level: Roof, Diaph: 1

Center of Mass (ft): (-199.35, -125.46)

LdC	Disp X in	Disp Y in	Theta Z rad
E5	1.75780	0.22771	-0.00014
E6	1.74743	0.24134	0.00003
E7	0.26674	1.52038	0.00024
E8	0.28738	1.49388	-0.00011
W3	0.53768	0.07426	-0.00001
W4	0.14830	0.72279	-0.00003

Level: Eighth, Diaph: 1

Center of Mass (ft): (-199.03, -124.88)

LdC	Disp X in	Disp Y in	Theta Z rad
E5	1.53605	0.20454	-0.00012
E6	1.52601	0.21440	0.00003
E7	0.23540	1.28129	0.00019
E8	0.25541	1.26199	-0.00011
W3	0.48730	0.06895	-0.00001
W4	0.13651	0.64298	-0.00003

Level: Seventh, Diaph: 1

Center of Mass (ft): (-199.04, -116.35)

LdC	Disp X in	Disp Y in	Theta Z rad
E5	1.32346	0.18109	-0.00010
E6	1.30219	0.18609	0.00002
E7	0.19049	1.03325	0.00015
E8	0.23301	1.02337	-0.00010
W3	0.43267	0.06259	-0.00001
W4	0.12667	0.54784	-0.00004

Level: Sixth, Diaph: 1

Center of Mass (ft): (-198.72, -120.32)

LdC	Disp X in	Disp Y in	Theta Z rad
E5	1.09367	0.15409	-0.00008
E6	1.08109	0.15756	0.00002
E7	0.16916	0.84458	0.00012
E8	0.19438	0.83769	-0.00009
W3	0.37456	0.05533	-0.00000
W4	0.11072	0.46687	-0.00003

Level: Fifth, Diaph: 1

Center of Mass (ft): (-190.79, -125.41)

LdC	Disp X in	Disp Y in	Theta Z rad
E5	0.86778	0.12082	-0.00007
E6	0.86296	0.13014	0.00001
E7	0.14598	0.66657	0.00009
E8	0.15568	0.64785	-0.00007
W3	0.31319	0.04706	-0.00000
W4	0.09337	0.37874	-0.00003

Level: Fourth, Diaph: 1

Center of Mass (ft): (-195.35, -122.50)

LdC	Disp X	Disp Y	Theta Z
	in	in	rad
E5	0.66163	0.09929	-0.00005
E6	0.65615	0.10245	0.00001
E7	0.11484	0.48076	0.00006
E8	0.12592	0.47438	-0.00005
W3	0.25119	0.03924	-0.00000
W4	0.07846	0.29178	-0.00002

Level: Third, Diaph: 1

Center of Mass (ft): (-195.37, -122.51)

LdC	Disp X	Disp Y	Theta Z
	in	in	rad
E5	0.45355	0.06930	-0.00003
E6	0.44985	0.07112	0.00001
E7	0.08077	0.31169	0.00004
E8	0.08829	0.30800	-0.00004
W3	0.18289	0.02879	-0.00000
W4	0.05784	0.20150	-0.00002

Level: 2nd, Diaph: 1

Center of Mass (ft): (-197.16, -122.15)

LdC	Disp X	Disp Y	Theta Z
	in	in	rad
E5	0.26153	0.04030	-0.00002
E6	0.25921	0.04080	0.00000
E7	0.04728	0.16192	0.00002
E8	0.05201	0.16091	-0.00002
W3	0.11194	0.01739	-0.00000
W4	0.03559	0.11292	-0.00001