THE NEW YORK TIMES BUILDING

IPD / BIM SENIOR THESIS - FINAL REPORT

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EXECUTIVE SUMMARY

The following document is a report of the work that was completed during the spring 2010 semester by the IPD / BIM thesis team 3, which includes Matthew Hedrick, Kyle Horst, Casey Leman and Andres Perez. The purpose of this report is to introduce alternative concepts in the design and construction of the New York Times Building by utilizing both an integrated project delivery method and building information modeling. The alternative concepts have focused on achieving an overall team goal of increasing the profitability and marketability of the building while maintaining its iconic and sustainable image.

In order to achieve this primary goal, the following three strategies were identified:

1. Decrease the floor to floor height with the intension of adding additional rentable floors.
2. Redesigning the core configuration structurally and architecturally in order to add additional rentable space to each floor while maintaining the efficiency of the lateral system.
3. Improve the sustainability profile of the spaces to add marketability and possibly charge a higher rent.

To achieve a decreased floor to floor height several the design team has modified the structural floor configuration to a castellated composite steel beam system. In addition the underfloor air distribution system was replaced with an active chilled beam system which has been coordinated with the castellated beam system. A feasibility study has been done in order to determine the viability of adding additional rentable floors.

The redesign of the core configuration involved an investigation of alternative architectural layouts in order to increase rentable floor area. When changing the architectural configuration of the core the layout of the lateral system was an important consideration. Therefore, the opportunity of redesigning the lateral force resisting system with an alternative solution was presented. The alternative solution involving a concrete core with outriggers on the mechanical floors was explored and analyzed. The investigation of the core also involved an analysis of necessary infrastructure such as elevators and MEP risers.

Improving the sustainability profile has shaped two main redesign tasks. The first involved the façade which currently contributes to a large portion of the overall building cooling and heating loads. The team worked toward developing an alternative design which will optimize energy usage and maintain acceptable daylighting of the space. The second task involved a redesign of the cogeneration system in order to decrease energy costs and associated emissions for the building. The goal for this redesign was to supply The New York Times Company floors with 100% of its power needs, but ultimately cost, energy use and emissions were the driving factors.

It was the responsibility of all of the team members to update a central BIM file that the group used. This model was used to coordinate the different redesigns and efficiently organize the interior spaces of the New York Times Building. It was important to analyze the ways that BIM and an integrated project delivery design approach contributed to the project. Integrating the efforts of each of the team members was of high importance during all phases of this project, and it was essential to keep open the lines of communication between all of the team members. The utilization of BIM to aid methods of analysis has supported an overall integrated project delivery approach to design.

In the eyes of the design team a successful redesign of the New York Times Building has been achieved. The success of the redesign can be measured by how well the original goal of increasing the marketability and profitability of the building was met. In terms of energy cost savings, a reduction of roughly $2.23 million per year was achieved by the collective redesign. In regards to environmental sustainability, an overall reduction in energy use associated emissions of 50.1 million lbs CO^2e has been reached. Furthermore, with the addition of one rentable floor area the potential to earn $1.26 million per year for the building owner has been achieved. Ultimately, the redesign has increased rentable space, decreased operating costs and given the building a more environmentally sustainable profile.

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EXISTING STRUCTURE BACKGROUND

FOUNDATION

The foundation of the NYTB combines typical spread footings with caissons to achieve its maximum axial capacity. Below the building's 16-foot cellar, the tower and podium mostly bear on Medium/Hard rock with a bearing capacity of 80 ksf., Class 2-65 per the New York City Building Code. However, a core sample taken just before finalizing the site investigation report indicated that rock at the southeast corner of the tower only had a 16 ksf bearing capacity, Class 4-65. At the seven columns that fall within this area, indicated in red on Figure 2, 24-inch diameter concrete-filled steel caissons were used to replace the original foundation designs. Each caisson was designed to support a load of 2,400 kips with 6,000 psi concrete.

Under the other 22 columns, spread footings with a concrete compressive strength of 6,000 psi are used to support the loads. The areas depicted in purple represent the two cantilevered sections of the tower. The columns which fall in these areas do not directly transfer load to the ground which removes the need for footings at these locations.

The New York City Subway does pass the north and eastern sides of the New York Times Building. However, this is not a major site restriction since the transit system passes below Eighth Avenue and 41st Street and not directly beneath the structure. But, vibration effects on the foundation and building structure may have had an impact on the design.

COLUMNS

The 30” by 30” box columns (Figure 1) at the exterior notches of the tower consist of two 30 inch long flange plates and two web plates inset 3 inches from the exterior of the column on either side. Each web plate decreases in thickness from 7 inches as the column extends up the structure to account for the reduction in axial loads. Each flange plate decreases from 4 inches in thickness to relate to the architectural vision of the tower. Interior columns are a combination of built-up sections and rolled shapes. Column locations stay consistent throughout the height of the building, and every column is engaged in the lateral system. Refer to Figure 2 to view the column locations. Note that the unfilled boxes denote columns in the cantilevered areas which do not extend to the ground.

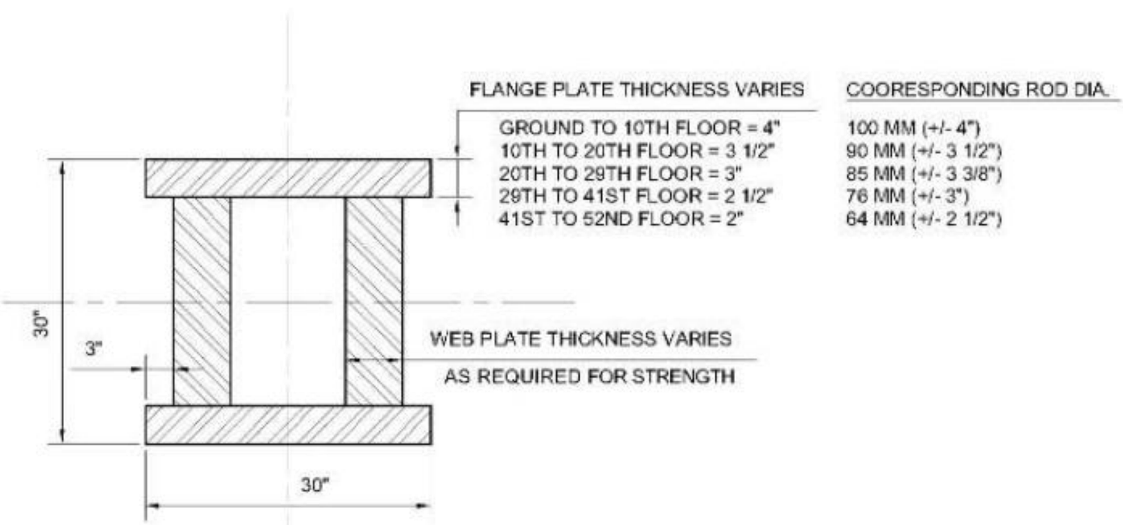


Figure 1

VIERENDEEL FRAME

A Vierendeel frame was used by Thornton Tomasetti as a combined solution at the 20 foot cantilever sections of the tower. Renzo Piano did not want columns obstructing the glass storefronts at the ground level, so these sections were cantilevered from the main structure. As a unique way to control deflections in the middle beams of the cantilevered section, the ladder-like moment frame engages all floors throughout the entire height of the tower. It connects to 28th and 52nd floor outriggers through the use of diagonal braces which effectively transfer loads from the frame to the core of the tower.

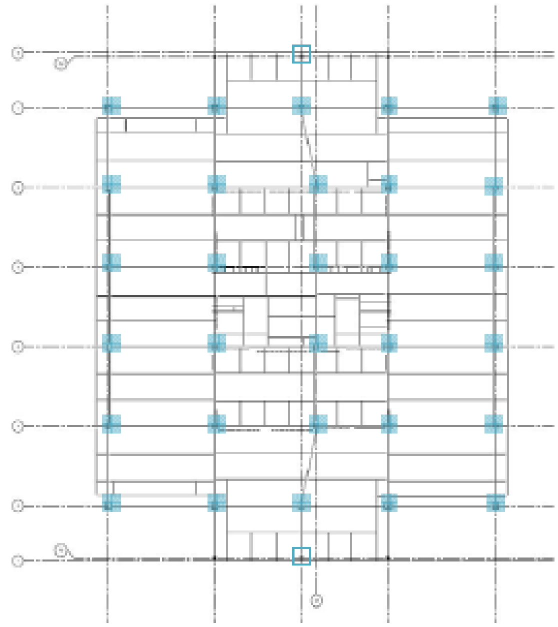


Figure 2

EXISTING FLOOR SYSTEM

The existing floor structure of the NYTB is comprised of a composite steel beam system. The typical bay size is 30'-0"x 40'-0" with 2 ½" normal weight concrete and 3" metal deck, typically spanning 10'-0" from W12x19 to W18x35 infill beams. These infill beams frame into W18x40 girders which in turn, transfer the floor loads to the various built-up columns throughout the structure. The rectangular bays are configured into a cruciform shape around the perimeter of the core. This composite system was selected to reduce the self weight of the structural system which greatly affects member sizes in high rise buildings. By reducing member sizes, the structural system was able to conform to "transparency" desired by the architectural design.

EXISTING LATERAL SYSTEM

The main lateral load resisting system for the tower of the NYTB consists of a centralized steel braced frame core with outriggers on the two mechanical floors (Levels 28 and 51). The structural core consists of a combination of concentric and eccentric bracing which surrounds elevator shafts, MEP shafts, and stair wells. At this time, the member sizes of these braces have yet to be disclosed. The core configuration remains consistent from the ground level to the 27th floor as shown in Figure 5. But above the 28th floor, the low rise elevators were no longer required. In order to optimize the rentable space on the upper levels of the tower, the number of bracing lines in the North/South direction were reduced from two to one Figure 6. Refer to Figures 7 and 8 to view the typical core bracing configurations.

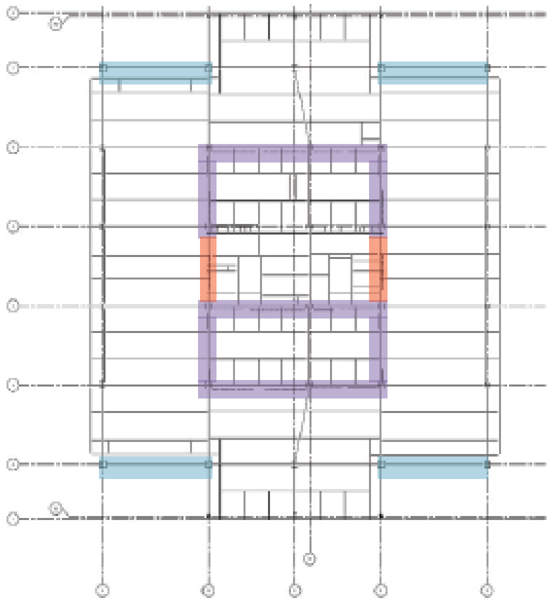


Figure 4: Typical Lateral System (Floors 29-50)

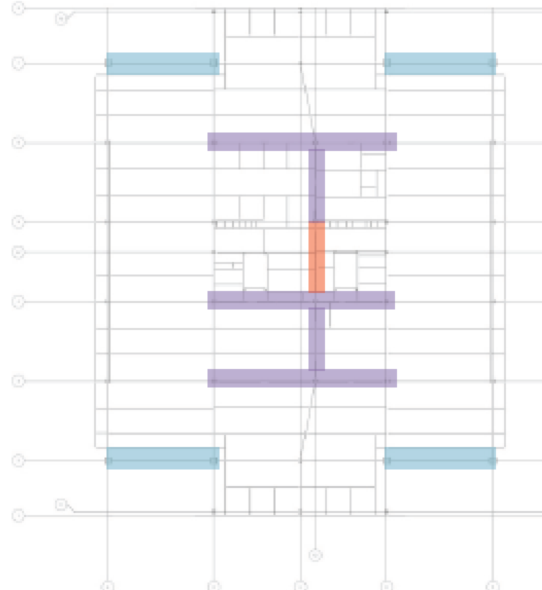


Figure 5: Typical Lateral System (Floors 1-27)

Key:
- Single Diagonal Bracing
- Pre-Tensioned Steel Rod X-Bracing
- Chevron & Eccentric Bracing

The outriggers on the mechanical floors consist of chevron braces Figure 10 and single diagonal braces. The outrigger system was designed to increase the stiffness of the tower by engaging the perimeter columns into the lateral system.

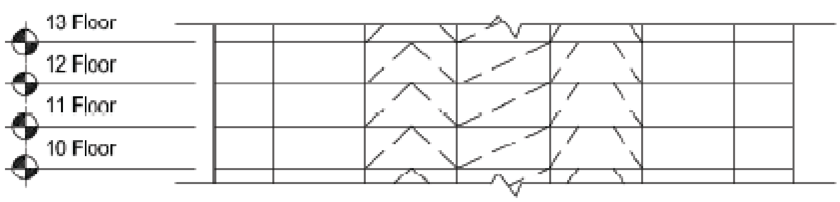


Figure 6: Typical Core N/S Core Bracing Elevation

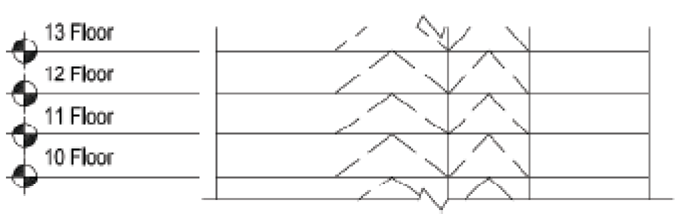


Figure 7: Typical Core E/W Core Bracing Elevation

In order to increase stiffness and meet wind deflection criterion, the structural engineers utilized the double story steel rod X-braces (original to Renzo Piano's exterior design) instead of increasing the member sizes of the main lateral force resisting system. These X-braces can be located on Figures 4 and 5 above. The steel rods transition from 2.5" to 4" in diameter and were prestressed to 210 kips. This induced tensile load prevents the need for large compression members which would not conform to the architectural vision of the exterior.

Although the X-braces did reduce the need for an overall member size increase, the lateral system still did not completely conform to the deflection criterion. Therefore, some of the 30” by 30” base columns were designed as built-up solid sections which reduced the building drift caused by the building overturning moment. After combining these solid base columns and the X-braces with the main lateral force resisting system, the calculated deflection of the tower due to wind was L/450 with a 10 year return period and a building acceleration of less than 0.025g for non-hurricane winds.

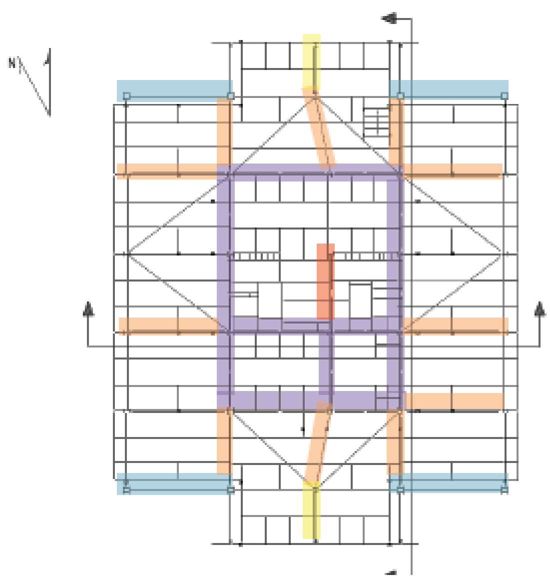


Figure 9: Mechanical Floor Framing Plan (Floors 28 & 51)

Key:
- Single Diagonal Bracing
- Pre-Tensioned Steel Rod X-Bracing
- Chevron & Open Knee Bracing
- Outrigger Bracing
- Single Diagonal Brace at Cantilever

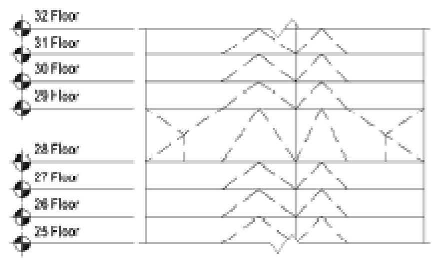


Figure 10: Typical E/W Outrigger Section (28th Floor)

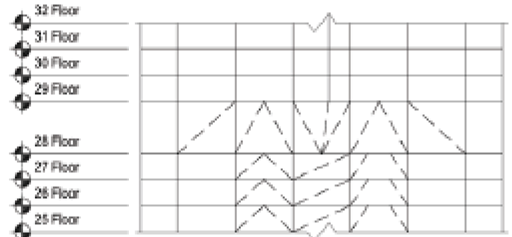


Figure 11: Typical N/S Outrigger Section (28th Floor)

THERMAL DIFFERENTIALS

Due to the fact that structural steel members at the notches of the tower were exposed to the exterior, affects due to thermal differentials had to be considered when designing the exposed steel members. The eight exterior box columns undergo thermal changes throughout the year while the interior members remain at a constant room temperature. This thermal cycling causes the exterior columns to undergo temperature deformation while the interior columns remain constant. This causes signification deflections at the upper floors exceeding L/100. To account for these thermal deflections, the design team at Thornton Tomasetti added two thermal trusses to the 51st mechanical floor, one on each of the eastern and western faces of the tower. These thermal trusses improved the deflections due to thermal deformation to an acceptable L/300.

CM BACKGROUND

PROJECT COST EVALUATION

Information about project cost for the New York Times Building has been difficult to obtain. Much of the information pertaining to overall and division costs for the project has been compiled and calculated using some conservative assumptions. The Architectural Record Project Portfolio of the New York Times Building states that the cost of the building "exceeds $1 billion." For the purposes of remaining consistent in this report, the construction cost of the project will be assumed to be $1 billion. Cost of the different building systems has been compiled in the parametric cost estimate section below. This will provide a reference for approximately how much the systems of the building cost.

Construction Cost	Construction Cost per Square Foot
$1 Billion	$667 per SF

Parametric Estimate with D4Cost

A detailed parametric cost estimate from D4Cost can be found in Appendix B.1)

There are very few buildings in the world that are similar to the New York Times Building in size and distinction. Because of its uniqueness, it was difficult to find similar buildings within the D4Cost estimation software that compare. The following four projects were selected in order to get a representative parametric estimate for the project.

Project Name	Project Location	Building Use	Size	Floors	Cost	Reason for Choosing
Ha-Lo Headquarters	Niles, IL	Office	267,334 SF	7	$40.1 M	Building Type, Tower Form
NYS DOT Region One Headquarters	Schenectady, NY	Office	125,000 SF	4	$18,914,056	Building Type, LEED Silver
Preston Point Office/Retail/Condo	Louisville, KY	Office	105,768 SF	8	$8,505,277	Building Type, Tower Form
SRO Residence	New York, NY	Residential	23,853 SF	5	$2,830,057	Location

The first three projects were mainly chosen for their building type and relative size. There were not many tower structures in D4Cost and there were no "skyscrapers" in the project database. The NYS DOT project was especially useful in the estimate because it was a LEED Silver certified building. Increases in the systems cost due to the sustainable features of the New York Times Building can be found in the NYS DOT project.

D4Cost produced a cost breakdown that would be similar to the New York Times Building. The estimate includes costs of each division of the project. The following is a breakdown of the costs of the major systems in the building:

System	% of Project Cost	Cost / SF	System Cost Projected for $1 Billion Project Cost
Site Work	2.03%	$ 13.53	$ 20,300,000
Steel and Concrete	17.93%	$ 119.53	$ 179,300,000
Interior Finishes	13.60%	$ 90.67	$ 136,000,000
Furnishings	1.29%	$ 8.60	$ 12,900,000
Mechanical	17.12%	$ 114.13	$ 171,200,000
Electrical	19.99%	$ 133.27	$ 199,900,000

Due to the change in CSI MasterFormat, multiple divisions had to be combined in order to come up with the systems costs. These systems costs are broken up in order to gain an accurate picture of the estimated costs of each of the systems and the projected cost of the systems actually installed in the New York Times Building. The costs used for the baseline New York Times building were from the division cost breakdown that was calculated by the D4Cost estimating software. This was done due to the lack of information that the group had about the building.

PROJECT DELIVERY METHOD

The New York Times Building utilizes a hybrid system of a Design-Bid-Build with a Construction Manager at-risk delivery. The core and shell delivery was by AMEC construction while Turner Construction Company delivered the interiors for the New York Times spaces. Floors 29 and above are owned by the developer Forest City Ratner Companies, and are to be constructed to the needs of the tenants. In a CM-at-risk delivery method, the owners hold contracts with the design team, architects and engineers, while the CM-at-risk holds contracts with the subcontractors. The construction management firm holds all risk by guaranteeing the cost and schedule to the owners. The hybrid system comes from the involvement of the design and construction teams having collaborative meetings to review and change the building design before construction while the owners were holding contracts with the parties. Architects Renzo Piano Building Workshop, along with architects FXFOWLE held design review meetings with interiors architect Gensler, as well as structural engineer Thornton Tomasetti and MEP engineers WSP Flack & Kurtz to discuss the design. These meetings were held before construction as well as throughout the construction of the building. There is also early involvement from specialty contractors, most notably with the curtain wall system. The early involvement from the interiors architect as well as specialty contractors is crucial to the success of the project.

CONTRACT TYPE

While the owners did not release the exact contract types, three main contract types were most likely utilized. These three types are cost plus fee, guaranteed maximum price and lump sum.

The New York Times Company and Forest City Ratner Company most likely held a GMP contract with AMEC Construction and The New York Times Company may have held a cost plus fee contract with Turner due to the repetitive nature of the interiors construction. While this is not exactly known, these are reasonable assumptions toward the delivery of the project.

With a typical Design-Bid-Build / CM-at-risk delivery method, the construction manager is contractually bound to the subcontractors. While not confirmed, it can be assumed that AMEC Construction holds contracts with the subcontractors, most likely being a lump sum contract.

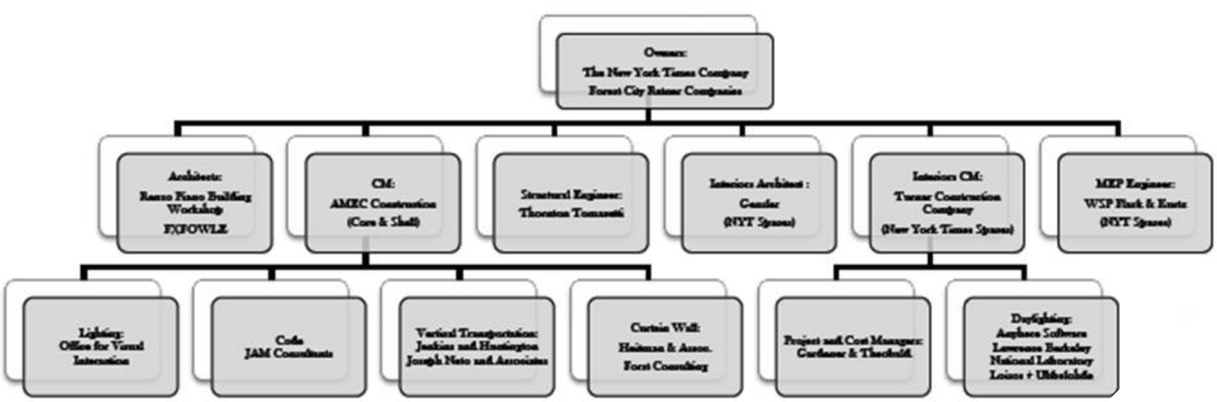


Figure 12: Assumed Project Team

PROJECT SCHEDULE

Overview

The detailed schedule represents the important activities that occurred during the construction of the New York Times Building. The full detailed schedule can be found in Appendix B.2. This schedule is a modification of the summary schedule that was provided in the Technical Report 1. Below are some key durations and milestones that were used in the General Conditions Estimate:

Activity	Years	Months	Weeks	Work Days
Construction Duration	3.5	42	182	910
Tower Crane	1.25	15	65	325
Material Hoists	2	24	104	520
Demolition	0.5	6	26	130
Foundations	1.5	18	78	390
Steel	1.5	18	78	390
Concrete	0.75	9	39	195
Curtainwall	1.25	15	65	325
Mech./Plum.	3	36	156	780
Electrical	2	24	104	520
Interiors	1.75	21	91	455

Durations	Date	Durations	Date
Start of Construction	12/1/2003	Concrete Fill / Tower Topout	8/23/2006
Start Demolition	12/1/2003	Curtainwall - Poduim Finish	3/13/2006
Finish Demolition	6/30/2004	Curtainwall - Tower	1/3/2007
Start of Excavation Foundations	4/19/2004	MP - Start	5/3/2004
Finish Foundations	9/12/2005	MP - Finish	4/23/2007
Start of Steel Erection (Tower)	5/2/2005	Electrical - Start	8/19/2005
Start of Steel Erection (Podium)	7/26/2005	Electrical - Finish	4/12/2007
Steel Top Out	5/24/2006	Interior Finishes - Start	10/3/2005
Mobilize Podium Concrete	10/24/2005	Interior Finishes - Finish	6/20/2007
Podium Concrete Finished	12/6/2005	Remove Tower Cranes	7/25/2006
Mobilize Tower Concrete	7/18/2005	Remove Hoists	5/31/2007
Pour Concrete 51,52	7/24/2006	Project Closeout	6/20/2007

SITE LAYOUT PLANNING

As outlined in Technical Assignment I, The New York Times Building is located in the Times Square District of Manhattan, directly across 8th Ave. from the Port Authority Bus Terminal and approximately eight blocks Northwest from the Empire State Building. There were four phases for the construction process - demolition, foundations (two parts), superstructure, and interior turnover.

Please refer to Appendix B.3 for more detailed information regarding the site layout planning for The New York Times Building site. General descriptions of major site logistics issues with a particular phase are outlined below. Please note that site layout plans were only obtained for the AMEC portion of the construction process as Turner plans were not obtained. It was assumed that the site layout plan remained largely the same following turnover for interior fit out.

Demolition

This phase consisted of the abatement of the existing structures on the block that the New York Times Building would ultimately occupy. Safety scaffolding was placed above the entirety of the 8th Avenue portion of the site, and partially along both the West 41st Street and West 40th Street site boundaries.

Foundations – Part I

The eastern portion of the site was demolished first- excavation then followed with the placement of the ramp in the northeast corner. The entire excavated area was surrounded with site fencing, and scaffolding was placed around the western cluster of existing structures that were still undergoing abatement. During this process, the foundation was placed (including deep foundations were placed in the southeast corner of the site).

Foundations – Part II

The remaining western portion of the site was demolished in the second portion of the foundation placement phase. The western portion of the site was then excavated (Ramp in NW corner) and foundations were placed.

Superstructure

The entirety of the steel erection took place during this phase. One tower crane was placed in the center of each of the northwestern and southwestern quadrants of the site. Personnel site access was allowed through the northern portion of the site, with staging areas on the northern and southern site boundaries. The subway exit could be closed on a provisional bases based on a permit obtained by the construction team.

Interior Turnover

For this phase, AMEC turned over the project to Turner Construction to complete the interior fit out of the project. It was assumed by the project team that the site layout plan would remain largely the same, for this portion of the project.

GENERAL CONDITIONS ESTIMATE

Overview

The general conditions estimate for the New York Times Building includes costs from field staff and facilities, temporary utilities, temporary site protection, clean up, and rigging and hoisting equipment for the project. The general conditions estimate will be used to assess any cost savings that could be seen if there is an acceleration in the project schedule.

There are a few assumptions that had to be made in order to put the general conditions estimate together:

- The total construction cost of the New York Times Building is $1 Billion.
- The square footage of the building is $1.5 million square feet.
- Only on site personnel is included in the general conditions.
- Site offices and crane equipment is rented for the project.
- Site protection has been purchased for the project.
- All lifts and equipment besides the hoists and cranes listed in the general conditions will be provided by the subcontractors.

Construction Durations

Below are listed the construction durations that factored into the general conditions estimate. There are 12 months in a year, 52 weeks in a year, and 5 work days in a work week.

Activity	Years	Months	Weeks	Work Days
Construction Duration	3.5	42	182	910
Tower Crane	1.25	15	65	325
Material Hoists	2	24	104	520
Demolition	0.5	6	26	130
Foundations	1.5	18	78	390
Steel	1.5	18	78	390
Concrete	0.75	9	39	195
Curtainwall	1.25	15	65	325
Mech./Plum.	3	36	156	780
Electrical	2	24	104	520
Interiors	1.75	21	91	455

Cost Breakdown

The general conditions on the New York Times Building project totaled $ 96,971,123. This accounted for approximately 9.71% of the overall project cost. The field personnel cost contributes $ 22,865,985 to the general conditions. That adds up to 2.3% of the overall project cost.

General Conditions Breakdown

Division	Description	Unit	Total	Quantity	Total Cost
01 31 13.20	**Field Personnel**				
0020	Clerk, 6	Week	$ 380.00	1,092	$ 414,960
0140	Field Engineer, 45	Week	$ 1,350.00	8,190	$ 11,056,500
0220	Project Manager, 20	Week	$ 2,175.00	1,781	$ 3,873,675
0280	Superintendant, 35	Week	$ 2,025.00	3,714	$ 7,520,850
					$ 22,865,985
01 51 13.80	**Temporary Utilities**				
0100	Heat, including fuel and operation, per week, 12 hrs	CSF Flr	$ 30.27	13,846	$ 419,123
0350	Lighting, including service lamps, wiring, and outlets, maximum	CSF Flr	$ 27.70	15,000	$ 415,500
0600	Power for job duration including elevator, etc., min	CSF Flr	$ 47.00	15,000	$ 705,000
0650	Power for job duration including elevator, etc., max	CSF Flr	$ 110.00	15,000	$ 1,650,000
					$ 3,189,623
10 52 13.20	**Office and Storage Space**				
0020	Trailer, furnished, no hookups, 20' x 8', rent per month, 8 Trailers	Each	$ 163.00	576	$ 93,888
0700	AC, rent per month, add	Each	$ 41.00	576	$ 23,616
0800	For delivery, add per mile	Mile	$ 4.50	600	$ 2,700
					$ 120,204
01 52 13.40	**Field Office Expense**				
0100	Office Equipment rental average	Month	$ 155.00	384	$ 59,520
0120	Office supplies, average	Month	$ 85.00	384	$ 32,640
0140	Telephone bill; avg. bill per month	Month	$ 80.00	384	$ 30,720
0160	Lights & HVAC	Month	$ 150.00	384	$ 57,600
					$ 180,480
01 54 19.50	**Truck Crane**				
0600	Truck Mounted, hydrolic, 100 ton capacity	Month	$ 14,100.00	16	$ 225,600
	Crew	Day	$ 104.90	320	$ 33,568
					$ 225,600
01 54 19.60	**Monthly Tower Crane Crew**				
0100	Crane, climbing, 106' jib, 6000 lb. capacity, 410 FPM	Month	$ 13,200.00	60	$ 792,000
	Tower Crane Crew	Day	$ 37.40	2,400	$ 89,760
4550	Hoist and tower, mast type, 6000 lb., 100' high, month	Each	$ 4,136.60	86	$ 357,402
4570	for each added 10' section, add, month	Each	$ 196.20	5,616	$ 1,101,859
					$ 2,341,021
01 56 26.50	**Temporary Fencing**				
0020	Chain Link, 11 ga, 6' high	L.F.	$ 8.51	980	$ 8,340
	Plywood, painted, 4" x 4" frame, 8' high	L.F.	$ 18.20	980	$ 17,836
					$ 26,176
01 56 29.50	**Temporary Protective Walkways**				
2200	Sidewalk, 2" x 12" planks, 2 uses	S.F.	$ 1.60	16,000	$ 25,600
2500	Exterior Plywood, 2 uses, 3/4" thick	S.F.	$ 0.95	16,000	$ 15,200
					$ 40,800
01 58 13.50	**Signs**				
0020	High intensity reflectorized, no posts, buy	S.F.	$ 21.00	1,000	**$ 21,000**
01 74 13.20	**Cleaning Up**				
0040	Maximum	Job	0.8%	$1 Billion	$ 8,000,000
0050	Cleanup of floor area, continuous, per day, during construction	M.S.F.	$ 27.23	1,670	$ 45,485
0100	Final by GC at end of job	M.S.F.	$ 56.44	1,670	$ 94,277
					$ 8,139,762
	Subtotal				**$ 74,313,871**
	Adjusted for Location (New York City, 130.7)				**$ 97,128,230**

MECHANICAL BACKGROUND

The building cooling load is served by a 6250 ton chilled water system, which consists of five 1,200 ton centrifugal chillers and one 250 ton single stage absorption chiller. The chilled water is pre-cooled by the absorption chiller before it enters the centrifugal chillers. A 1.4 MW natural gas-fired cogeneration plant with two parallel reciprocating engines provides the waste heat to run the absorption chiller. Both the chilled and condenser water system utilizes a variable flow primary pumping scheme, and a water-side economizer which provides "free cooling" and increased energy savings. Heating for the building is provided via high-pressure steam purchased from Consolidated Edison. Low-pressure steam is then distributed to each floor-by-floor air handler's heating coil. As an added cost, the New York Times Company also uses steam to humidify outdoor air.

Air distribution is achieved via variable air volume boxes for interior zones and fan powered boxes with heating coils for exterior zones. The floors occupied by the New York Times utilize an UFAD system. Swirl diffusers were installed to provide occupant control, while in high occupancy spaces perforated floor tiles provide a more visually pleasing layout. A traditional overhead ducted system was implemented on the Forest City Ratner floors. Demand controlled ventilation is achieved via carbon dioxide and VOC sensors located in the return ducts for each floor. Outdoor air is brought in through outdoor air units in the two mechanical penthouses on the 28th and 51nd floors, and then is distributed throughout the building.

An energy analysis and existing conditions evaluation of the NYTB was performed and reported in mechanical technical assignments one and two (See Figure 13 below). The third mechanical technical report presented three research studies that were performed to investigate the areas in which the building could be improved from a mechanical system point of view. These three studies focused on three topics including façade redesign, energy sources and alternative air distribution systems. The goal of these studies was to identify areas in which the design could be altered in order to optimize overall performance in areas such as energy use, sustainability, operating costs and maintainability. The report also investigated the mechanical engineer's role in a project which utilizes Building Information Modeling (BIM) and the Integrated Project Delivery (IPD) method.

Heating	814986	47%
Cooling	455743	26%
Auxiliary Fans/Pumps	126680	7%
Lighting	256644	15%
Receptacle	98009	6%
Total	1,752,062	(kBtu/yr)

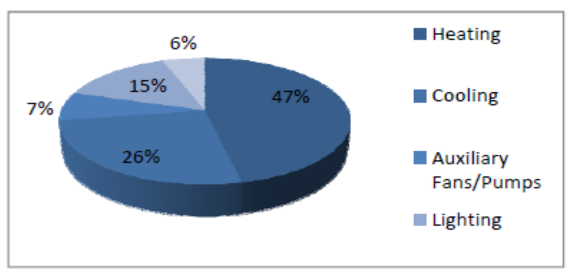


Figure 13 – UFAD Energy Use per Floor

LIGHTING BACKGROUND

The architect, Renzo Piano, was focused on establishing an archetypal beacon in the New York skyline. The ideas that are apparent throughout the design are lightness and transparency. To keep consistency with those concepts, the lighting design needed to highlight the exterior façade and also give spectators a view of the interior spaces. For individuals inside the building, the architecture was aimed at providing unimpeded views to the exterior from any location on any floor. Daylighting was an important factor that guided much of the architecture. The existing building design is able to reduce most of the lighting load during the day due to proper daylighting.

Upon entering the building, one is immediately pulled from the crowded urban streets and plunged into the colorful and spacious lobby. The space is filled with rich colors and instantly instills a sense of comfort and relaxation. The current lighting design is very subtle but provides a bright and warm atmosphere. Daylight also fills the space from the curtain walls surrounding the exterior, as well as the courtyard in the center of the podium.

Continuing through the building to the office spaces, the ideas of lightness and transparency are kept intact. The office floors are lit to promote activity but still have a comfortable feeling similar to the main lobby. Each floor continues to please individuals with warm, vibrant colors. Every floor offers daylight and views to the exterior from any location.

The existing lighting system is comprised of around 18,000 luminaires. This large quantity is simplified by the use of only 20 different luminaire styles. This manner of product selection helps reduce the complexity of the design and also provides a sense of consistency through each space. The entire building utilizes a digitally addressable lighting interface (DALI) system with dimmable ballasts to harvest the benefits of daylight. The system provides energy savings above 50 percent. There are 15 zones per floor, each with their own photosensor. Every luminaire within a zone takes input from the respective photosensor and dims accordingly. The system also allows for the programming of individual luminaires to accommodate to varying lighting needs.

The existing design is impeccable. The lighting strategy utilizes the most advanced lighting solutions to provide complete control over each space. A redesign of this building will require that the new solutions meet the expectations set by the current system.

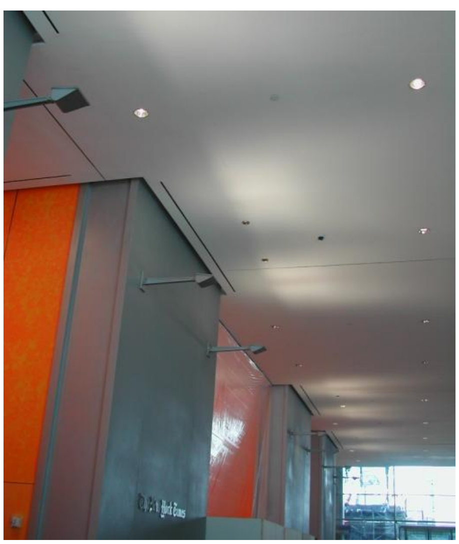


Figure 14 - Existing Entrance Lobby Lighting

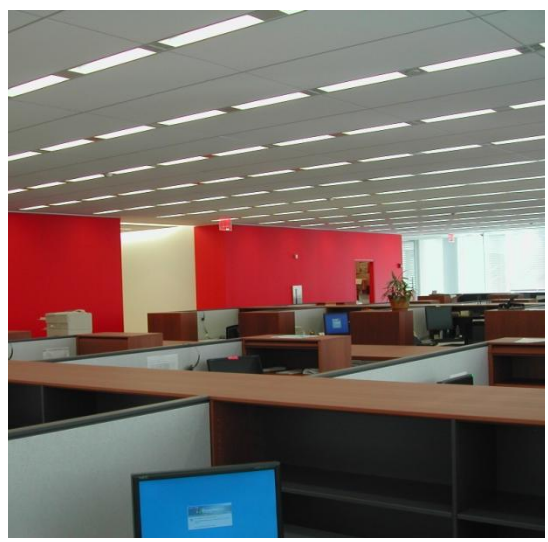


Figure 15 - Existing Typical Office Lighting

Photos Provided by Dr. Richard Mistrick

ELECTRICAL BACKGROUND

The New York Times building is comprised of two main tenants; The New York Times and the Forest City Ratner Companies (FCRC). These two tenants have two different distribution methods throughout the building. The New York Times tenants use conduit for all feeders throughout their part of the building, whereas the FCRC tenants run bus-duct throughout their part of the building.

A commonality between them is the shared incoming service. Though the system is metered for every tenant, including the per floor fit-out of the FCRC floors, Consolidated Edison provides a main utility entrance to the entire building. The service entrance is located in the cellar and distributed from there to each of the floors above. The New York Times tenants also have a co-generation plant, 1.4 Megawatts, to supplement the utility need. Due to the importance of servers in the New York Times spaces, a UPS system is also located in the cellar and distributed accordingly. The entire building has a main diesel generator for emergency use. The building has the ability to have remote generators connected at street level, should the generator need to be serviced.

While the lighting, appliance, and mechanical panels are on a floor-by-floor design, the emergency panels are located every third floor. In addition, the UPS system has panels spaced out in a similar design. Each floor contains an east and west electrical room. The loads are ran to the nearest electrical room. Each floor also houses a mechanical room and a server room. The mechanical is believed to contain certain mechanical panels, though no information is available.

The service entrance is located at the south side of the building on the cellar floor. There are six compartments housing 5 transformers with a future compartment. These 6 compartments are connected to the main electrical room. There is no information on the drawings as to the equipment located in these areas. In addition to the utility service entrance, there is a 1.4 Megawatt co-generation plant owned and operated by the New York Times (NYT) tenant. Each tenant is metered separately for utility usage, and the NYT is paid by each tenant for their usage from the co-generation plant.

There are three ways the emergency loads could be powered. The primary emergency power is a redundant feed from the utility company. The building also has the capability to connect street generators, should this become necessary. The NYT tenants 1.4 Megawatt co-generation plant can provide power to the entire emergency system. This combination of power sources allows for complete redundancy within the emergency system. There is an automatic transfer switch, within the cellar floor, responsible for switching between sources. In addition to these emergency systems, the NYT tenants have a complex Uninterrupted Power Source (UPS) system. This system is strictly for server backups. There is a "Tech Room" on each floor which has dedicated receptacles fed from the UPS system.

REDESIGN GOALS

The challenge for the redesign project will be to increase the marketability and profitability of the building while maintaining the iconic image that the New York Times Building reflects. The redesign must also focus on both primary energy use and the sustainability of the overall building.

When brainstorming goals for the development of this IPD / BIM Thesis project, the group found that there were a few areas which provided the opportunity to enhance the New York Times Building. Some of the areas of focus included increasing the amount of rentable space, and improving overall sustainability profile of the building. Further discussion of these topics revealed that all of the options would have some hand in developing these possible areas of focus.

ADDING ADDITIONAL RENTABLE SPACE

Floor To Floor Heights

One of the goals put forward by the group was to investigate whether it would be possible to lower the floor to floor height in order to add additional floors. These additional floors could offer a payback to the owner by providing additional rentable office space in the building. There are a few ways that the group came up with to possibly eliminate height from each floor.

Andres explored the possibility of using a castellated beam system that would allow for penetrations through the structural members. This would allow the possible coordination of HVAC, electrical, and fire protection distribution through these castellations. In order to possibly lower the floor to floor height, the group would perhaps eliminate the raised floor system and explore the use of chilled beams to take care of heating and cooling the space. The chilled beams would decrease the size of ductwork that would be needed to condition the space and allow for it to possibly be run through the castellations in the structural members. In addition to using chilled beams for heating and cooling concerns, the idea of integrating lighting fixtures into the beams was also considered. This would provide an opportunity to reduce the required plenum space even more by combining both an HVAC unit and a luminaire into one component.

The typical floor sandwich in the New York Times Building is 4' – 9" from the bottom of the ceiling to the top of the raised floor system. The goal of the group is to reduce the overall height of the floor sandwich to be able to reduce the floor to floor height and add additional rentable floors to the building.

REDESIGN OF THE CORE

In addition to lowering floor to floor heights, the group determined that redesigning the core in order to increase rentable space within the tower would be a viable investigation. Increasing the rentable space on each floor will cause the owner's profits to increase. The group plans on shrinking the core footprint by investigating alternative architectural layouts. By altering the architectural core configuration of the New York Times Building, the lateral system of the structure must be reconfigured as well.

FAÇADE

The façade was immediately looked at as a primary focus for all of the group members. There is a lot of room for improvement in the current New York Times envelope efficiency and shading abilities. The façade is comprised of an ultra-clear glazing system accompanied by an array of ceramic tubes that provide shading to the interior of the building. The intent of the façade is to give a transparent feel to the building.

The ceramic rods on the façade account for 30% shading of the interiors but only provide 1% energy savings in the mechanical systems. This provides a great opportunity to investigate how to best improve the façade system in order to create a more efficient envelope. If the changes made can lower the amount of heating and cooling that is needed, it can save on the energy use of the HVAC system in the building. A better performing façade can be produced by changing to a higher reflective glazing and a more efficient shading system. Some of the systems that are being looked into will drastically affect how the structural system would perform.

COGENERATION OPTIMIZATION

The current cogeneration plant provides The New York Times Company's floors with roughly 40% of their overall power needs. Compared to a national average of 12 cents per kWh, New York City has extremely high electricity rates at roughly 25 cents per kWh. (See appendix A) Also, this energy is produced from primarily non-renewable fossil fuels which have varying associated emissions. (See appendix B)Therefore, the plant must be optimized to help reduce lifecycle cost and associated emissions from electricity use. However, equipment is costly and initial cost will also play a large role in the sizing of the cogeneration plant. Ultimately the plant needs to be sized in order to best balance the electrical needs and the heating and cooling needs of the building while being cost and energy conscious.

REDESIGN METHODS

The overall goal of the group is to increase the marketability and profitability of the building while maintaining the iconic image that the New York Times Building reflects. Profitability will be defined as the buildings ability to both generate revenue for the Forrest City Ratner Company and decrease payback period for The New York Times Company. The redesign must also focus on both primary energy use and the sustainability of the overall building. There are three main strategies that the group has come up with to achieve these goals:

1. Decrease the floor to floor height with the intension of adding additional rentable floors.
2. Redesigning the core configuration structurally and architecturally in order to add additional rentable space to each floor while maintaining the efficiency of the lateral system.
3. Improve the sustainability profile of the spaces to add marketability and possibly charge a higher rent.

DECREASE THE FLOOR TO FLOOR HEIGHT

The design team identified a great opportunity to provide benefit to the owner by reducing the height of the typical floor sandwich in both the New York Times and the Forrest City Ratner sections of the building. A reduction in floor/ceiling assembly height can provide the opportunity of adding additional floors to the building. Assuming that the New York Times has no need for additional floor space, additional floors can be used by Forrest City Ratner to lease to possible tenants and accrue additional income. For the purposes of this engineering study, the team has assumed that current economic issues are not present and that a market does exist for additional office space in New York City.

CORE REDESIGN

This is an architecturally and structurally intensive analysis of modifying the core of the New York Times Building. The overall goal is to shrink the footprint of the core in order to add rentable space to each of the floors of the building. Various strategies will be looked into to help reconfigure the core to an optimal layout and size. The benefits of this redesign are also to be considered.

IMPROVE THE SUSTAINABILITY PROFILE

It is the desire of The New York Times Company to maintain an iconic image within their industry and around the world. Sustainability and energy consciousness were indeed factors when the building began design nearly a decade ago. However they are no doubt much more of a focus in today's society and within the current building industry. For this reason improving the sustainability profile of the building while maintaining a certain transparent feel within the space will be very important in the redesign.

FAÇADE REDESIGN

REDESIGN GOALS

Initially, the façade was identified as an area of interest for the redesign. The design team noticed an opportunity for improvement in the current New York Times façade's envelope efficiency and shading abilities. The façade is comprised of an ultra-clear glazing system accompanied by an array of ceramic tubes that provide shading to the interior of the building. The intent of the façade is to give a transparent feel to the building, but the ceramic rods only provide a minimal reduction in thermal envelope loads on the building. This presented a great opportunity for improvement of the façade system in order to create a more thermally efficient envelope. The design team knew that changes could be made to lower the amount of necessary heating and cooling and save on the energy use of the HVAC system in the building. In order to increase façade performance the design team began by looking at higher reflective glazing and a more efficient shading system.

Many systems were considered, such as horizontal louvers and shape changes to the rods. The group found that a double-skin façade system with integrated horizontal louvers would help increase the thermal efficiency of the façade, while still keeping the architects vision of maintaining a transparent façade.

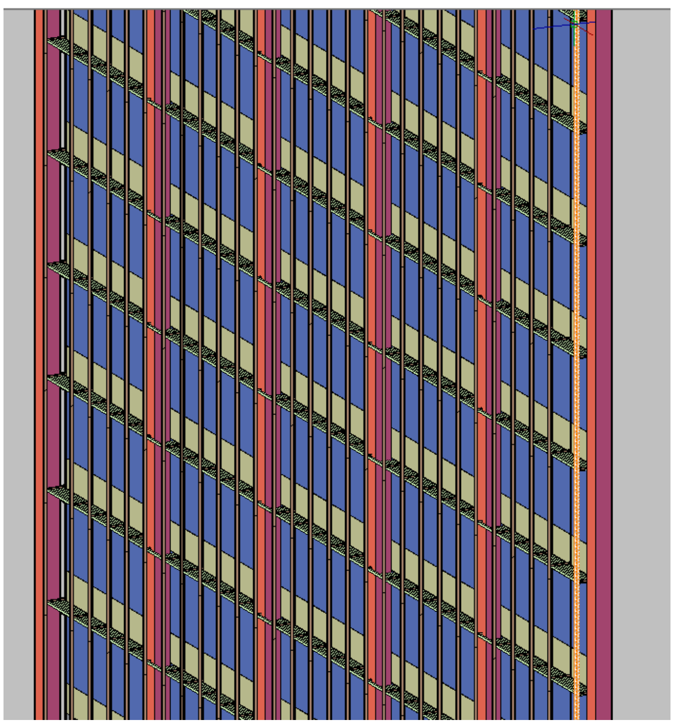


Figure 16: Schematic Design for Double-Skin Facade

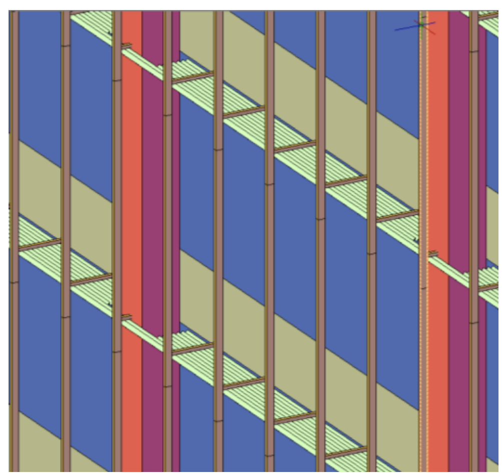


Figure 17: Enlarged Schematic Facade

SYSTEM DESCRIPTION

The façade system that is being proposed by the group is a double-skin façade, consisting of the existing interior glazing system, with a 3' airspace and an outer single glazed system. The existing interior glazing system is made up of a 1" Insulating Glass Unit that is clear with a Low E coating. The structural frame is an aluminum mullion system. The spandrel panels are made of 3/16" aluminum outer panel with a 2 ½" rigid insulation backup. The airspace contains a horizontal louvered shading system at each floor to provide shading to the interior spaces. The shading configuration has been designed to provide the equivalent shading to the existing system. The outer façade layer is made up of an aluminum mullion system with a single lite of 5/8" laminated glass. The double façade system is enclosed on both sides and open on both the top and bottom to allow for natural airflow.

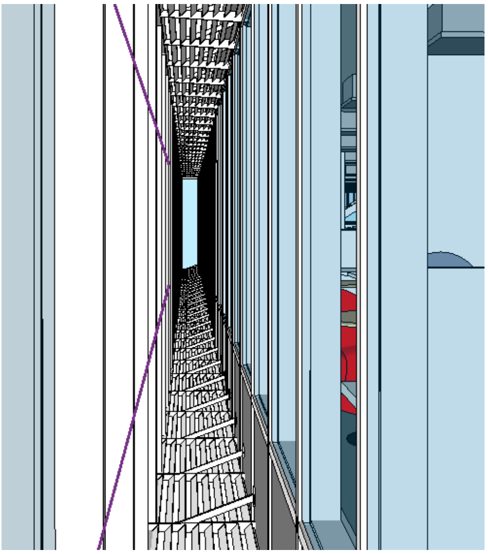


Figure 18: Interior View of Facade

Figure 19: Double Skinned Facade Cavity

Serviceability and maintenance has to be considered with a system like this. The existing façade with the rod shading system could be cleaned and serviced from the exterior of the building. There are some challenges in doing so, such as, cleaning behind the rods. The rods create an obstacle for cleaning and maintenance. The proposed system creates a challenge in cleaning the interior of the double façade. The louvered shading system was selected partially because it is specified to be able to support a person walking on it. Cleaning and maintenance can be performed within the double façade cavity. This creates a need for access to the cavity. Access to the cavity will be from one end of the façade where there will be access doors for each floor.

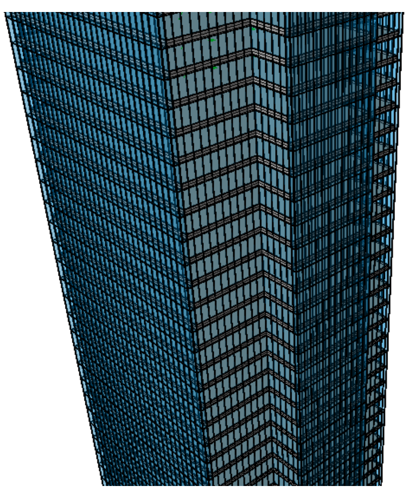


Figure 20: Exterior Facade Perspective

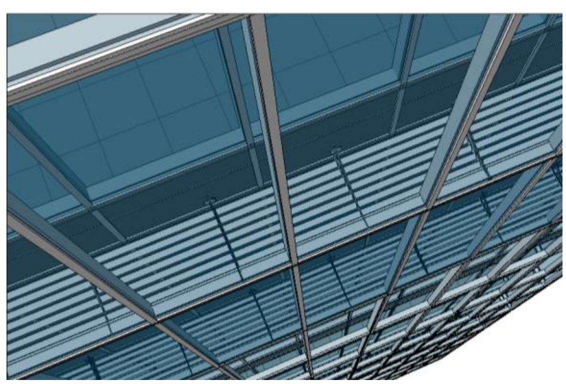


Figure 21: Enlarged Facade Rendering

HVAC LOADS

According to the building energy model and analysis, the thermal loads on the existing building are largely controlled by the envelope efficiency. In fact, during peak cooling conditions the envelope load makes up 58% of the total demand for cooling in the building which was calculated to be approximately 63 tons per typical floor. Similarly, for peak heating conditions the envelope load comprises of 75% of the total heating demand which was estimated at 560 MBh. These relatively high load percentages are largely the result of the low thermal efficiency of the façade comprised of primarily ultra-clear glazing material.

Façade thermal efficiency is driven by both the U-value and solar shading coefficient of the glazing system. The existing system was estimated to have a U-value of 0.625 and a solar shading coefficient of 0.75. In order to address the high envelope load issue, the design team researched potential alternative façade designs which could offer a higher performance in terms of thermal load while still delivering the desired day lighting and transparent feel. The double skin façade that was ultimately chosen as a façade alternative will offer an improved U-value of 0.5 and a solar shading coefficient of 0.38. The double skin design is also coupled with an external shading system which will allow for reduced solar gain through fenestration and lower thermal loads during summer months. Using 2.5' bladed shades, this system provides daylight penetration into building spaces similar to that of the existing rod system. In addition, the air space in between the two sets of glazing systems will act as a thermal barrier which will further increase the performance of the façade system.

PRIMARY ENERGY USE AND COST ANALYSIS

As seen in Figure 22 below, the total estimated annual energy savings associated with this new façade system is 21% or roughly 365,000 kBtu per floor. When translated to operating costs, this reduction in energy use would save the building approximately $16,300 per year per floor as seen in Figure 23. The energy consumption and operating costs associated with the current designs are shown in dark blue, while the same numbers for the redesigned systems are shown in light blue. When extrapolated to the entire building the energy consumption and operational cost savings would equal approximately 14,770,000 kBtu per year and $800,000 per year respectively.

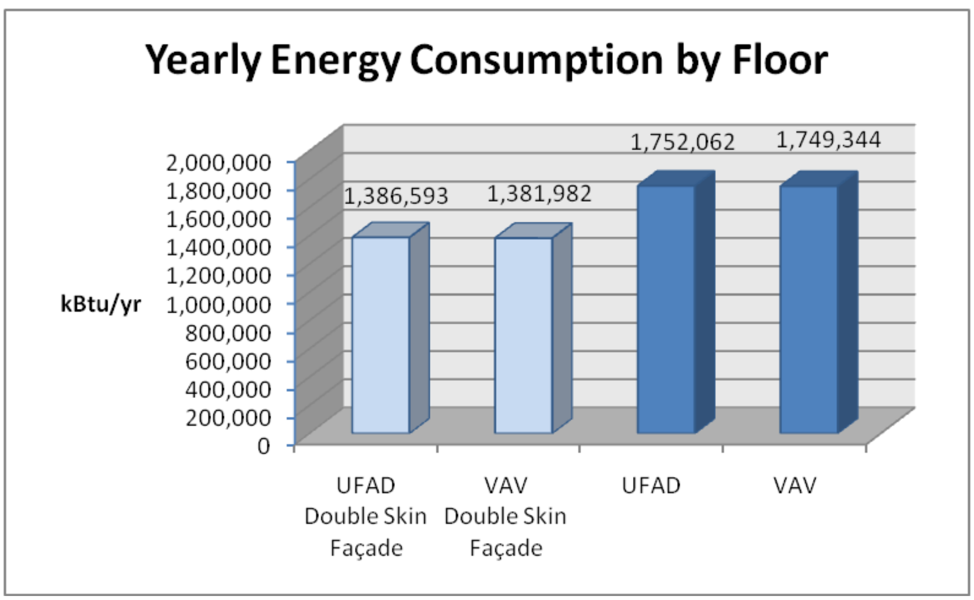


Figure 22: Yearly Energy Consumption by Floor

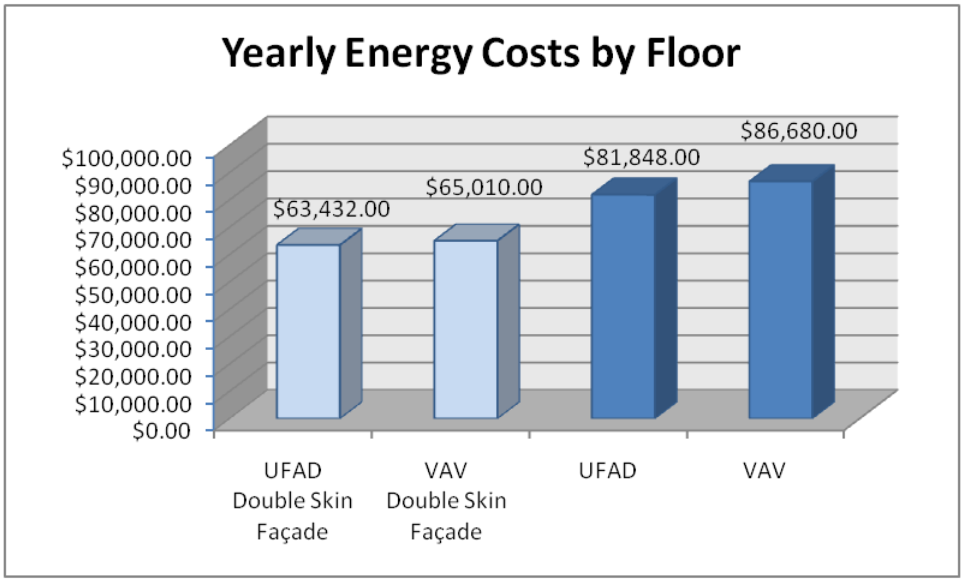


Figure 23: Yearly Energy Costs by Floor

COST ANALYSIS

An estimate was done in order to compare the existing façade with the proposed double façade. A detailed estimate of the faced is included in Appendix B.4. The original façade was found to cost approximately $83.5 million. Replacing the existing façade with a double façade system will increase the upfront cost to about $102.3 million. This accounts for an $18.7 million dollar increase in price. This cost can be offset by the increase in energy performance of the new façade. When doing an energy analysis of improving the U-Value from 0.625 BTU / ft^2–^{0}F–hr to 0.5 BTU / ft^2–^{0}F–hr, it was found to save $800,000 per year in energy. Therefore, a simple payback period was found to be around 23.4 years. Any improvement over the assumed 0.5 BTU / ft^2–^{0}F–hr U-Value would increase the energy savings and decrease the length of the payback period.

Original Façade System	$ 83,527,260
Proposed Double Façade	$ 102,273,745
Upfront Cost Increase	$ 18,746,485
Annual Energy Savings	$ (800,000)
Simple Payback Period	**23.43 Years**

SOURCE ENERGY ASSOCIATED EMISSIONS ANALYSIS

The energy savings shown above will also lead to significant HVAC associated emissions for the building. Figures 24 and 25 show the estimated annual reduction in HVAC energy associated emissions by floor pounds of carbon dioxide equivalent and nitrous oxide. A reduction of 350,000 lb to 380,000 lb of CO_2e and 600 lb to 650 lb of NO^X is estimated for each floor. Therefore, the new double skin façade system is projected to reduce HVAC associated emissions by approximately 23% which is equivalent to 17,087,574 lbs of CO_2e and 29,449 lbs of NO^X per year.

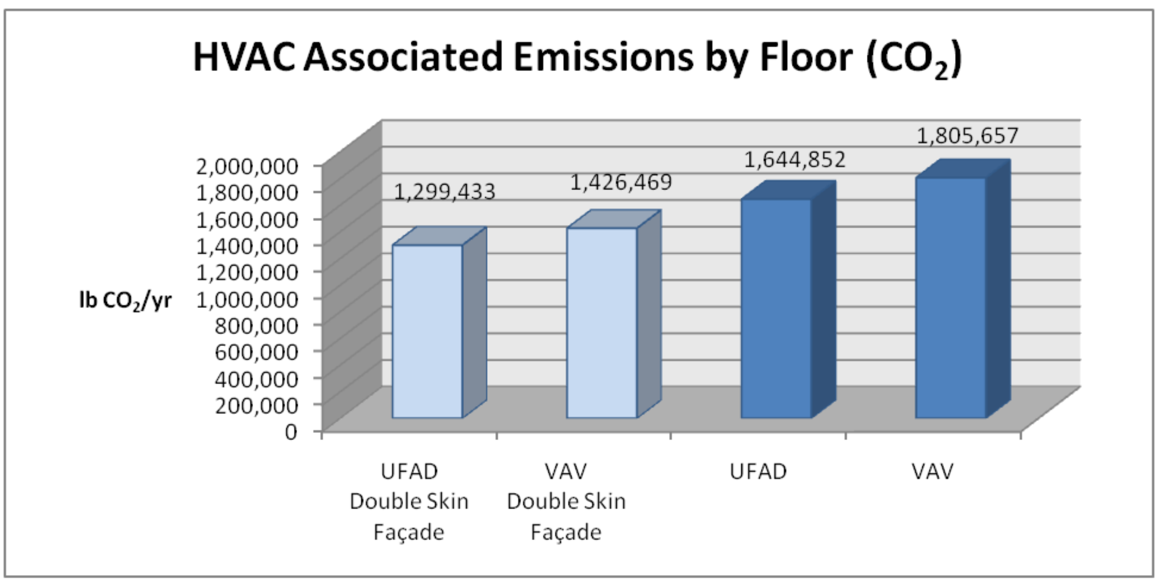


Figure 24: HVAC Associated Emissions by Floor

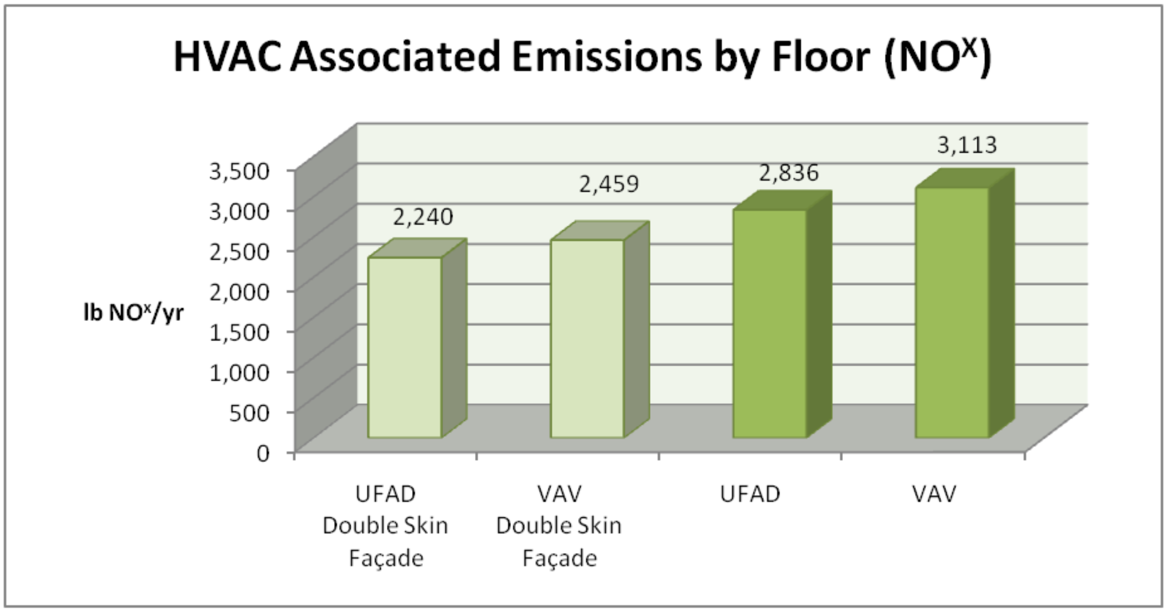


Figure 25: HVAC Associated Emissions by Floor

FAÇADE LIGHTING DESIGN

Spatial Summary

The double-skin façade offers opportunities for both daylighting design and exterior lighting. To mimic the daylighting characteristics of the original design, a horizontal louver system was applied to each floor. An additional single ply curtain wall is attached to the louvers to create a cavity between the building and the outer surface. This double-skin system is placed across the same surfaces where the rods were located on the north, south, east, and west faces.

Surfaces/Material Reflectance

**All values assumed due to lack of information*

- Aluminum Louvers: 70%
- Aluminum Framing System: 70%
- Glass Walls: 25%
- Spandrel Glass: N/A
- Steel: N/A

Activities/Tasks

The main purpose of this façade design is to provide shading while also decreasing heating and cooling loads. The unique concept also creates an interesting architectural feature that compliments the themes of the building and should therefore be a key consideration in the lighting design.

Design Concept

The original design highlighted the ceramic rods used as the external façade. The idea was to illuminate the unique architecture while also creating the sense of a light floating structure. In the redesign, the architecture was again a key concern. Highlighting the louver system would not only create an interesting view but also reveal a structure that would portray the concepts of transparency and lightness. With the louvers potentially blocking the light from below, the tower would seem to vanish in the night sky as illuminance levels gradually decreased upwards across the face of the building. The main consideration was to provide a lighting design that could enhance the building's presence and keep its iconic image at night.

Design Criteria

- IESNA Recommendations: Façade (Bright Surrounding – Medium Light Surface)
  - Vertical Illuminance – 50 lux (5fc)

- ASHRAE Recommendations: Facade
  - Lighting Power Density – .2 W/ ft^2

Design Considerations

Psychological Impression

Impression of Visual Clarity

- Bright, uniform lighting mode

Appearance of Space and Luminaires (Very Important)

The architect's concept for the New York Times Building was to create a beacon in the New York skyline. The lighting design should highlight the architecture of the building and promote the unique design. The interior spaces of the building should also be visible from the outside to reinforce the transparent theme.

Color Appearance (Important)

Another design concept implemented by the architect was the idea of a constantly changing building appearance. The building should reflect the concept of lightness as the façade reacts to the changing daylight and night conditions. The lighting design should create a glowing structure that seems to disappear into the night sky. The horizontal louvers should be brought out at night to create a different look for the building.

Direct Glare (Important)

All luminaires shall have no direct glare to create a safe environment in the streets surrounding the perimeter. Fixture accessories should be used to completely remove glaring effects.

Light Distribution on Surfaces (Very Important)

The lighting design should highlight the entire building to promote the architect's concepts. The facade should be washed horizontally with uniform light gradually fading vertically as the building progresses into the sky. The focus of the uniform wash should be on the horizontal louvers. This will create depth and detail across the buildings face. The interior spaces should be visible from the street.

Light Pollution/Trespass (Very Important)

Avoid light pollution into the night sky by utilizing cutoff fixtures. This will reduce interference with air traffic and keep the light directly on the building. Spill light should not hit the surfaces surrounding buildings. Fixtures should be kept close to building with medium to narrow distribution.

Point(s) of Interest (Important)

The text across the front of the facade should be emphasized. The double-skin facade design should also be displayed as a highlight of the structure. To emphasize the height of the structure, the entire facade should be illuminated. To promote direction, the main lobby should be clearly visible from the street with luminaires accenting the entry.

Shadows (Important)

Shadows should be present across the building facade to create a visually interesting structure. The building should have dark and light areas to create depth and detail and promote the unique design.

Source/Task/Eye Geometry (Important)

The expansive curtain wall requires that luminaires are not placed too close or aimed directly at the glass. This can prevent irritation to individuals inside the building. Persons walking along the sidewalk or in vehicles should also be taken into consideration. Luminaires should not provide any disturbances to these individuals.

Sparkle/Desirable Reflected Highlights (Somewhat Important)

The interior spaces can provide sparkle and highlight. The different colors of the interior should be visible from the street. The floodlighting across the facade can also cause reflections from parts of the building structure and create a changing visual display.

Surface Characteristics (Important)
The horizontal louvers will reflect the light very well. The steel structure of the building will reflect less light and create an interesting contrast. The interior spaces should also provide additional detail to the exterior view.

Maintenance
Luminaires should not be easily accessed by individuals in the street or along the sidewalk. The chosen fixtures and lamps should have a long life to reduce required upkeep. The fixtures should also be rated to withstand the varying weather conditions in New York, NY. Fixtures should also have easy relamping capabilities.

Luminaire Schedule (*Full, enlarged schedule located in Appendix C.1)*

Type	Image	Product Title	Manufacturer	Catalog Number	Description	Lamp	Ballast	Input Watts	Voltage
F1		Parscoop IV Washlight	Erco	33281.33982.000	Metal Halide Floodlight, corrosion-resistant aluminium, anodised silver aluminium reflector, no spill light, graphite mounting plate	HTI 250W/D5/80 BSHARXS Osram Sylvania: 54297 BABY SharXS Double Ended Metal Halide	Philips Advance 72C5783 250W Metal Halide Lamp Ballast	290	277
F2		Beamer In Projector	Erco	34067.33982.000	Metal halide Floorlight, corrision-resistant aluminium, anodised silver aluminium reflector, 50dg cut-off w/no spill light, graphite mounting plate,	HTI 400W/D3/75 SHARXS Osram Sylvania: 54241 SharXS Double Ended Metal Halide	Philips Advance 72C6182 400W Metal Halide Lamp Ballast	465	277

Refer to Appendix C.2 for Luminaire Cut Sheets

Light Loss Factors
24 Month Cycle and Medium Environment

Type	Lamp	Mean Lumens	BF	LDD		RSDD	Total LLF
F1	Metal Halide	18000	1.0	Category V	.75	N/A	.75
F2	Metal Halide	26000	1.0	Category V	.75	N/A	.75

Lighting Plans
All lighting plans located in Appendix C.3

Façade Lighting Design Results

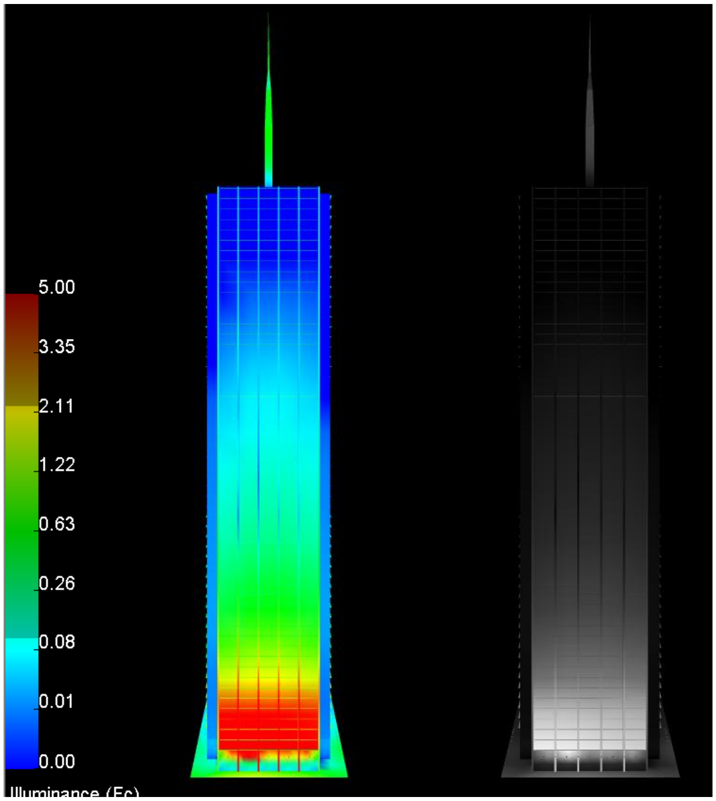


Figure 27: West Facade Pseudo Color

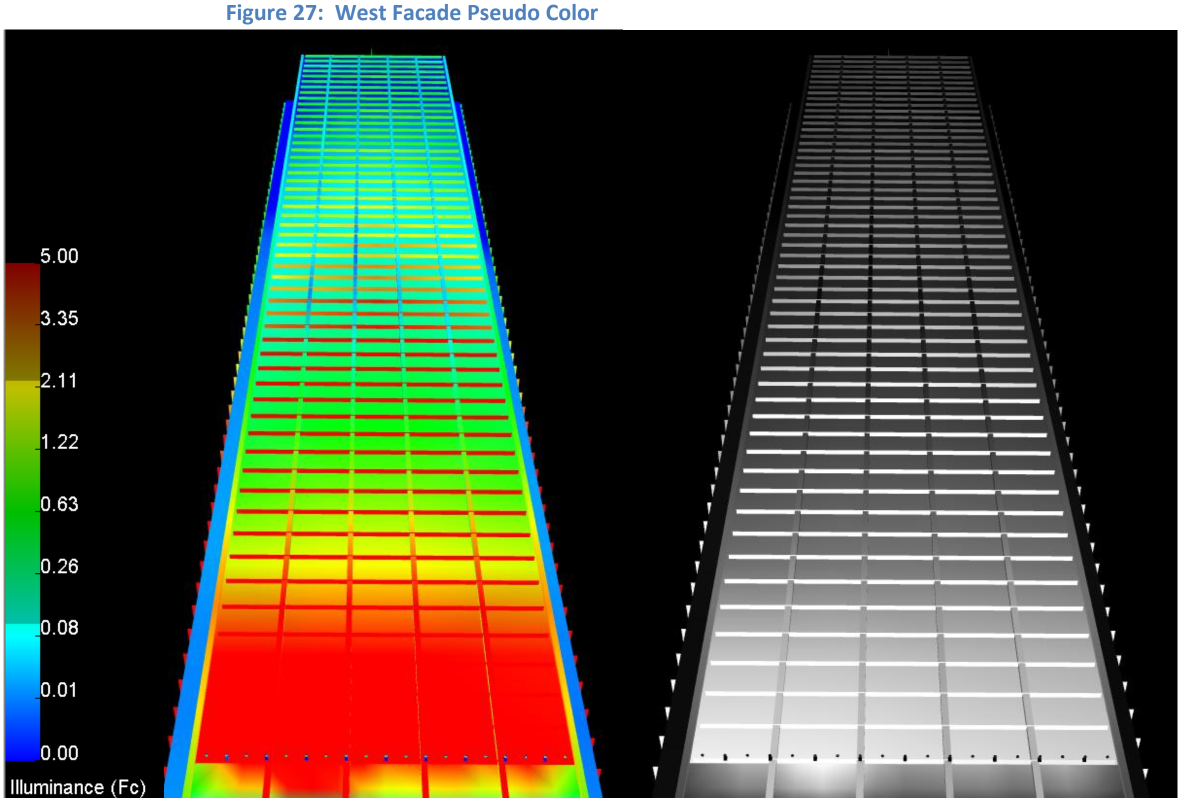


Figure 26: West Facade Pseudo Color (*view from below)*

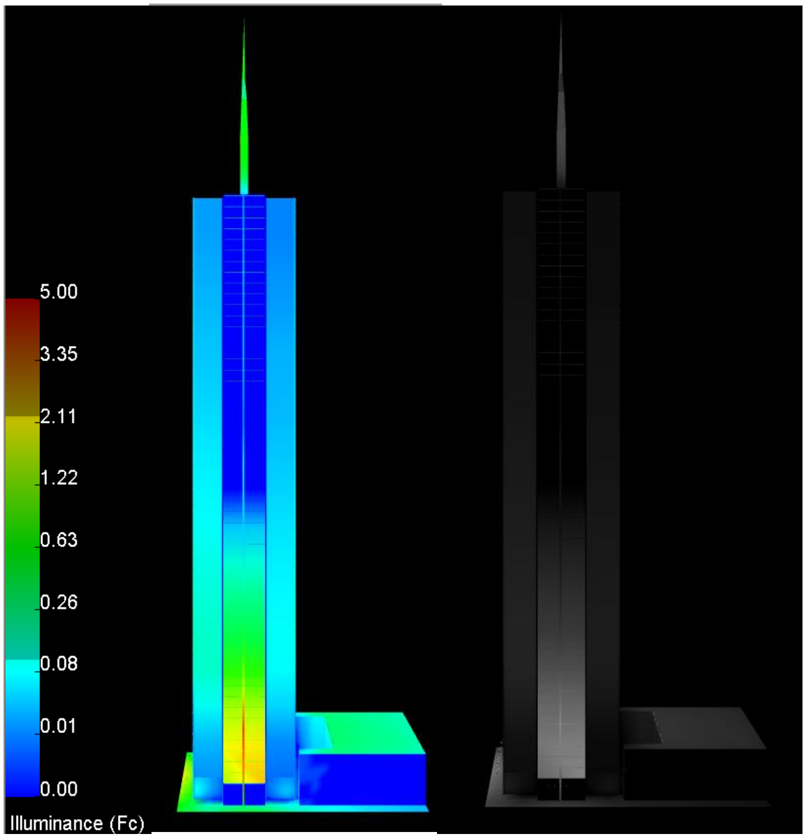


Figure 29: North/South Façade Pseudo Color

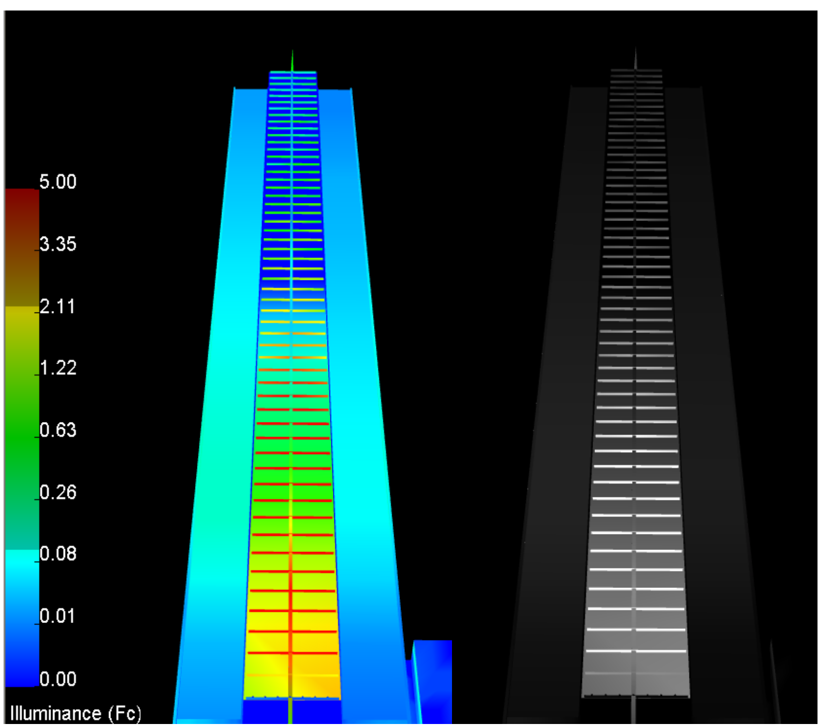


Figure 28: North/South Façade Pseudo Color (*view from below)*

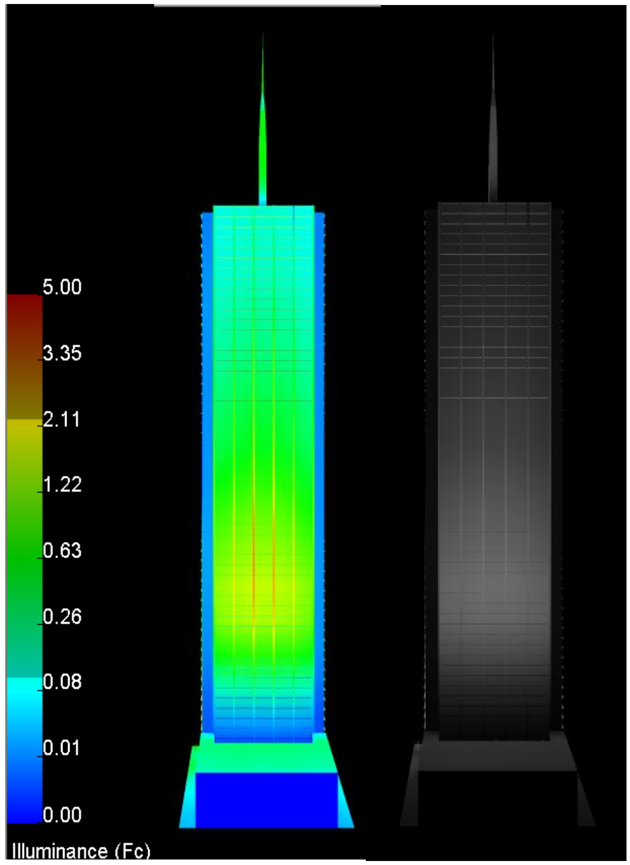


Figure 30: East Facade Pseudo Color

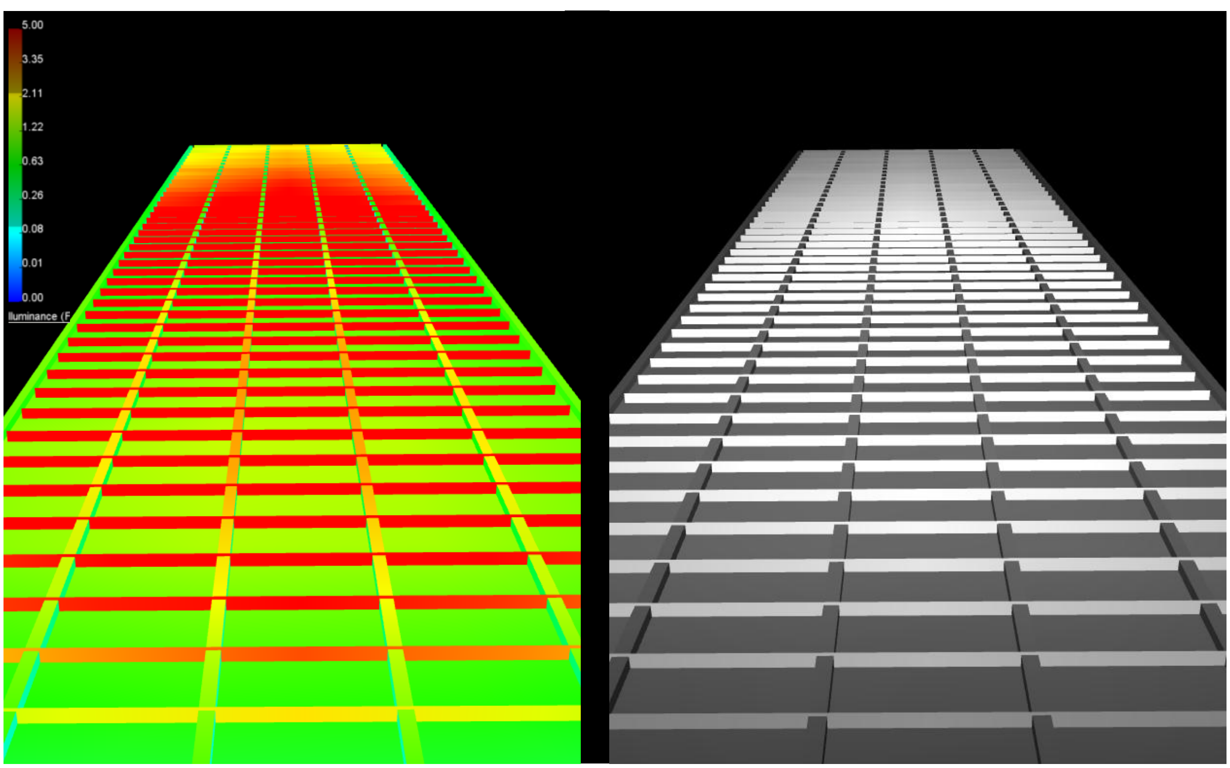


Figure 31: East Facade Pseudo Color (*view from below)*

ASHRAE Compliance **(*Required LPD < = .2 W/Ft^2 per vertical surface*)**

Lighting Power Density

Area (*Ft^2)* = 319500
Total Watts = 14894
LPD (*W/Ft^2*) = 0.05

Lighting Performance Summary

The lighting design creates a constantly changing look for the façade. When below the tower, the undersides of the louvers are illuminated by the flood lights. Most of the tower is highlighted with a gradient that fades off at higher elevations. This would portray the NYT Building as a glowing beacon towering over the streets of New York City. Upon moving away from the building or looking at it from above, the bright tower seems to disappear. Most of the light is focused around the base with a slight gradient reaching the center of the tower. This creates a very dramatic fading effect that allows the building to disappear into the night sky. The illuminated louvers create the look of a light, floating structure. The louver design also increases the viewing capabilities from inside, which enhances the theme of transparency.

The design provides enough illuminance around the base to make the large New York Times signage visible. The design also met ASHRAE standards; however, the recommendation of 50lux or 5fc across the surface was not met. This could pose as a problem if the surroundings are illuminated to greater levels. The result could be that the NYT Building gets lost in the New York Skyline.

FACADE ELECTRICAL REDESIGN

The new lighting design replaced all existing luminaires in the space. Information regarding the existing panelbaord was not available. To complete this portion of document, the assumed lighting panel was noted and the redesigned loads were added. All fixtures added to the panel operate at 277V.

Controls

The exterior lighting will be controlled by an astronomical time clock, which will automatically turn the lights on and off. All circuits will run through this control before reaching the panelboard. Refer to Appendix C.5 for equipment cut sheets

Circuiting Layout

Refer to Appendix C.3 for full size drawings of the electric layout and circuiting

New Panelboard/ Modified Circuits

The following figures depict the redesigned panelboard with the modified lighting circuits highlighted. Due to the lack of information provided for the IPD/BIM thesis, no other loads were able to be added to the panelboard. Refer to Appendix C.4 for a listing of all redesigned panelboards and feeders.

Panelboard Tag	Voltage	Normal/Emergency
HV-SLC	480Y/277	No

New Panelboards/ Modified Circuits

PANELBOARD SCHEDULE

VOLTAGE:	480/277,3PH,4W	PANEL TAG:	HV-SLC	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	100A	PANEL LOCATION:	WEST CELLAR ELEC ROOM	OPTIONS:	
SIZE/TYPE MAIN:	100A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
EXTERIOR LTG	W FAÇADE	3600	20A/1P	1	*			2	20A/1P	4050	W FAÇADE	EXTERIOR LTG
EXTERIOR LTG	W FAÇADE	2610	20A/1P	3		*		4	20A/1P	3150	N FAÇADE	EXTERIOR LTG
EXTERIOR LTG	S FAÇADE	3150	20A/1P	5			*	6	20A/1P	2700	E FAÇADE	EXTERIOR LTG
EXTERIOR LTG	E FAÇADE	2700	20A/1P	7	*			8	20A/1P	2250	E FAÇADE	EXTERIOR LTG
0	0	0	20A/1P	9		*		10	20A/1P	0	0	0
0	0	0	20A/1P	11			*	12	20A/1P	0	0	0
0	0	0	20A/1P	13	*			14	20A/1P	0	0	0
0	0	0	20A/1P	15		*		16	20A/1P	0	0	0
0	0	0	20A/1P	17			*	18	20A/1P	0	0	0
0	0	0	20A/1P	19	*			20	20A/1P	0	0	0
0	0	0	20A/1P	21		*		22	20A/1P	0	0	0
0	0	0	20A/1P	23			*	24	20A/1P	0	0	0
0	0	0	20A/1P	25	*			26	20A/1P	0	0	0
0	0	0	20A/1P	27		*		28	20A/1P	0	0	0
0	0	0	20A/1P	29			*	30	20A/1P	0	0	0
0	0	0	20A/1P	31	*			32	20A/1P	0	0	0
0	0	0	20A/1P	33		*		34	20A/1P	0	0	0
0	0	0	20A/1P	35			*	36	20A/1P	0	0	0
0	0	0	20A/1P	37	*			38	20A/1P	0	0	0
0	0	0	20A/1P	39		*		40	20A/1P	0	0	0
0	0	0	20A/1P	41			*	42	20A/1P	0	0	0

CONNECTED LOAD (KW) - A Ph.	12.60	TOTAL DESIGN LOAD (KW)	29.05
CONNECTED LOAD (KW) - B Ph.	5.76	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	5.85	TOTAL DESIGN LOAD (AMPS)	44

PANELBOARD SIZING WORKSHEET

Panel Tag------------------------->	HV-SLC	Panel Location:	WEST CELLAR ELEC ROOM
Nominal Phase to Neutral Voltage------->	277	Phase:	3
Nominal Phase to Phase Voltage-------->	480	Wires:	4

Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	EXTERIOR LTG	4	W FAÇADE	3600	w		3600	4500		
2	A	EXTERIOR LTG	4	W FAÇADE	4050	w		4050	5063		
3	B	EXTERIOR LTG	4	W FAÇADE	2610	w		2610	3263		
4	B	EXTERIOR LTG	4	N FAÇADE	3150	w		3150	3938		
5	C	EXTERIOR LTG	4	S FAÇADE	3150	w		3150	3938		
6	C	EXTERIOR LTG	4	E FAÇADE	2700	w		2700	3375		
7	A	EXTERIOR LTG	4	E FAÇADE	2700	w		2700	3375		
8	A	EXTERIOR LTG	4	E FAÇADE	2250	w		2250	2813		
9	B					w		0	0		
10	B					w		0	0		
11	C					w		0	0		
12	C					W		0	0		
13	A					W		0	0		
14	A					W		0	0		
15	B					w		0	0		
16	B					w		0	0		
17	C					w		0	0		
18	C					w		0	0		
19	A					w		0	0		
20	A					w		0	0		
21	B					w		0	0		
22	B					w		0	0		
23	C					w		0	0		
24	C					w		0	0		
25	A					w		0	0		
26	A					w		0	0		
27	B					w		0	0		
28	B					w		0	0		
29	C					w		0	0		
30	C					w		0	0		
31	A					w		0	0		
32	A					w		0	0		
33	B					w		0	0		
34	B					w		0	0		
35	C					w		0	0		
36	C					w		0	0		
37	A					w		0	0		
38	A					w		0	0		
39	B					w		0	0		
40	B					w		0	0		
41	C					w		0	0		
42	C					w		0	0		
PANEL TOTAL								24.2	30.3	Amps=	36.4
PHASE LOADING								kW	kVA	%	Amps
		PHASE TOTAL	A					12.6	15.8	52%	56.9
		PHASE TOTAL	B					5.8	7.2	24%	26.0
		PHASE TOTAL	C					5.9	7.3	24%	26.4

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		0.0	0.0		0.0	0.0			
4	HID lighting		24.2	30.3		24.2	30.3	0.80		
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
Total Demand Loads						24.2	30.3			
Spare Capacity			20%			4.8	6.1			
Total Design Loads						29.1	36.3	0.80	Amps=	43.7

DAYLIGHT ANALYSIS

Design Intent

In redesigning the façade, it was pertinent to address the benefits that the rod design provided in regards to solar shading. The existing system reduced the amount of direct sunlight entering into the space while also providing an opportunity for daylight harvesting. The office floors of the NYT Building were split into 15 different zones that were each operated by their own photosensors. In recreating the façade, it was important to attempt to provide a solution that offered daylight penetration that was at least equivalent to the rod design. Upon the decision to incorporate a double-skin façade, it was decided to apply a horizontal louver design that would serve as both a solar shading device and as the structural support for the second curtain wall. This new design provided an opportunity to enhance the theme of transparency that architect, Renzo Piano, wanted to instill. The double-skin façade also allowed for the NYT Building to keep that unique aesthetic and continue being an architectural icon. Refer to Appendix C.6 for information regarding the louver system used

Scope of Work

In this study, both the existing rod design and the new louvered design were analyzed to determine if the systems offered similar daylight benefits. Both illuminance contributions and daylight autonomy capabilities were compared between each system. Daylight autonomy was also analyzed to determine what kind of costs savings both designs could provide. The focus of this study was on the eighth floor of the NYT Building and it was assumed that the results of this floor represented the savings experienced on each of the other office floors.

Daylight Contribution

Four days were analyzed over the course of a year. The days recorded were the March 20th equinox, June 21st solstice, September 23rd equinox, and December 21st solstice. Each day was analyzed at 12:00 P.M. All data was found using DAYSIM. The following charts depict the contribution daylight offers to the overall illuminance in the space.

Illuminance(lux) Values for Original Rod Design

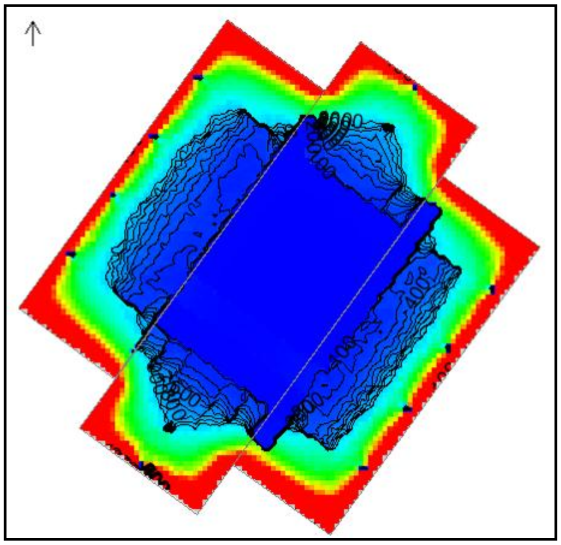


Figure 32 March 20, 2010, 12:00PM

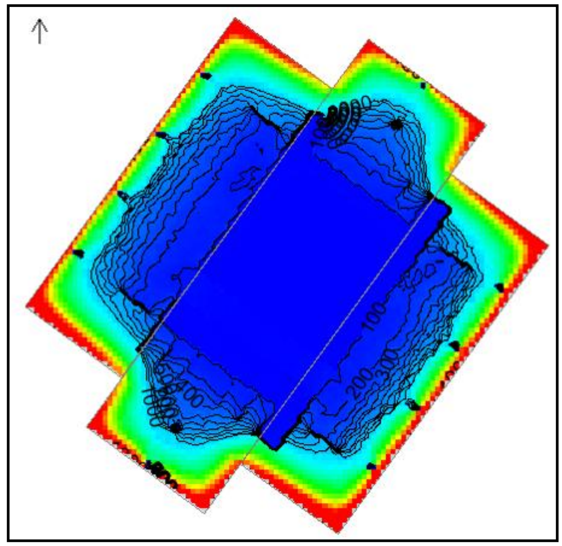
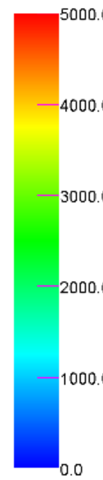


Figure 33 June 21, 2010, 12:00PM



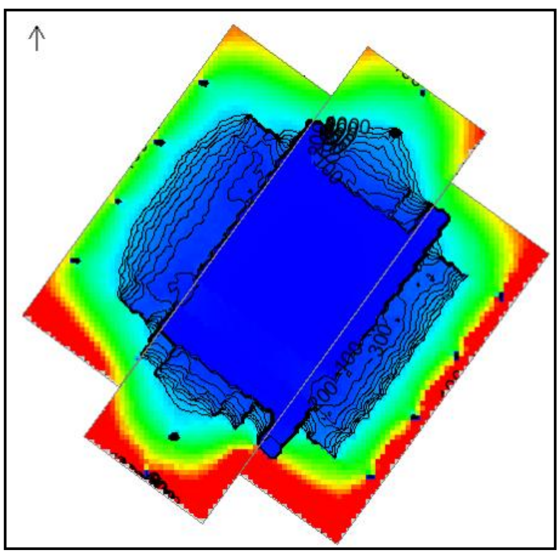


Figure 34 September 23, 2010, 12:00PM

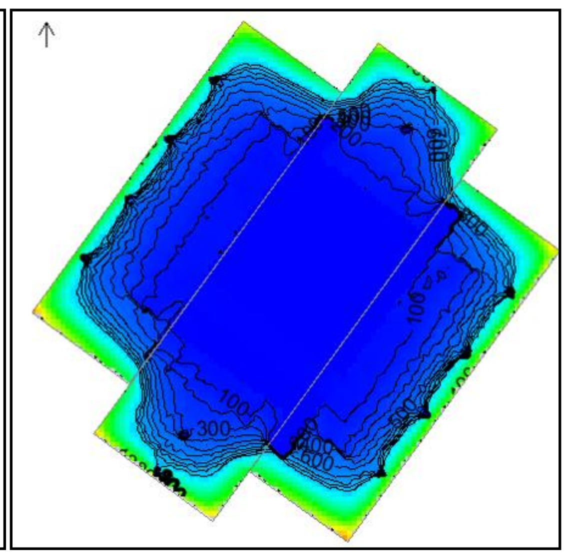


Figure 35 September 23, 2010, 12:00PM

Illuminance(lux) Values for New Double-Skin Façade with Louveres

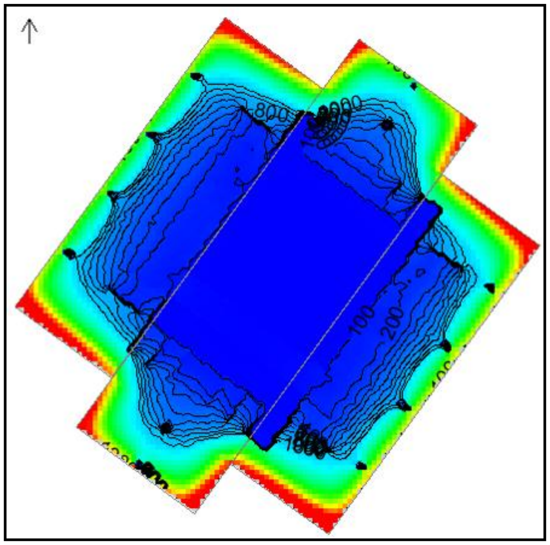


Figure 36 March 20, 2010, 12:00PM

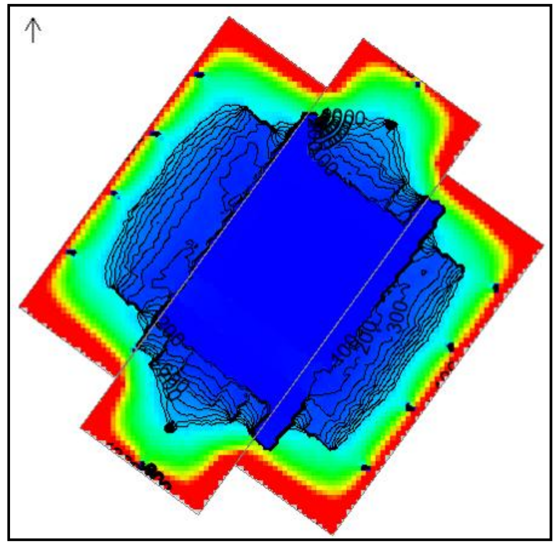
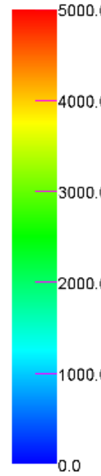


Figure 37 June 21, 2010, 12:00PM



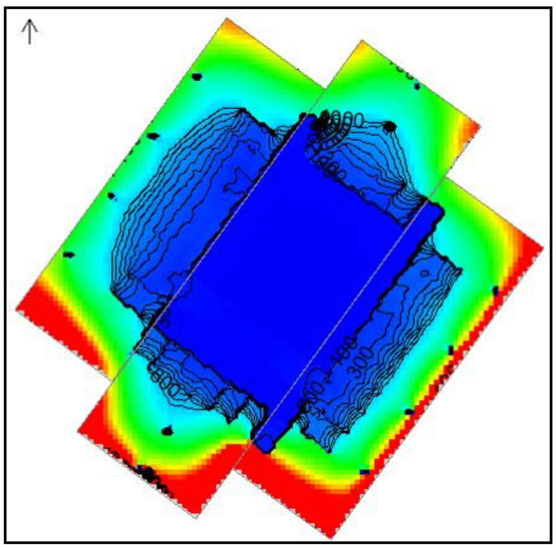


Figure 38 September 23, 2010, 12:00PM

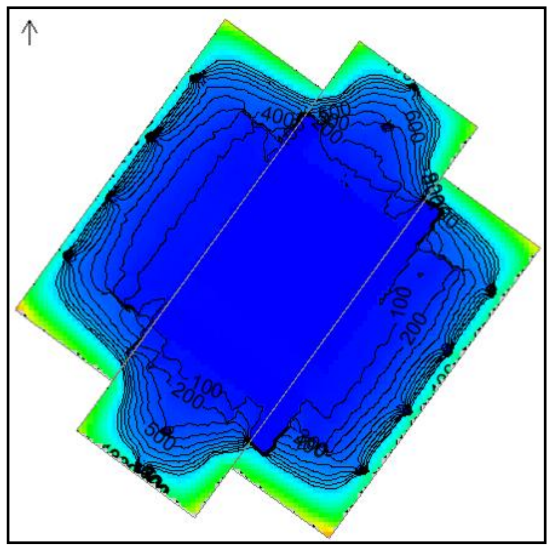
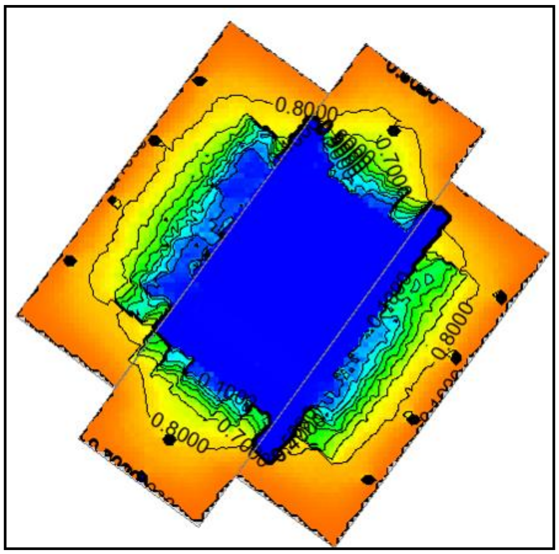


Figure 39 December 21, 2010, 12:00PM

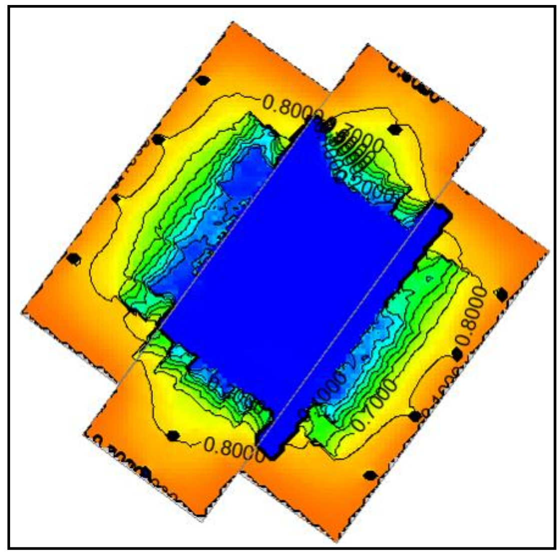
Review of Illuminance(lux) Levels from Daylight Penetration

Both systems allow daylight to penetrate deep into the space throughout most of the year. At least 1000lux is received across the open office area. Illuminance levels increase significantly closer to the glazing. Both systems are also effective at reducing direct daylight into the space. If 5000lux is assumed to be areas where direct daylight is entering the space, each scenario provides minimal direct penetration. To further analyze the daylgihting benefits of both systems, daylight autonomy was recorded. Each scenario was analyzed with a 300lux target illuminance. The results of this analysis showed that both systems provided similar daylight autonomy conditions. This information was recorded at varying illuminance levels and applied to an Excel spreadsheet designed to determine the savings from dimming to accommodate daylighting contributions. These charts can be found in Appendix C.7.

Rod Design DA



Louvered Design DA



Energy Comparison

To determine the energy savings of each system, the space was split into four sections. Daylight Autonomy was recorded at varying illuminance levels at a specific point in each zone. The sections were split into the north, south, east, and west portions of the building. The original electric lighting system was used for the comparison. It was assumed that all luminaires would be dimmed to accommodate to the varying amount of penetrating daylight. The potential maximum usage of electric light was also accounted for to determine energy savings.

The results revealed that the electric lighting system would be in use for a total of 27.5kWhrs in the original rod design. The louver design resulted in 28.2kWhrs of electric light usage. The max potential of the lighting system was found to be 71.2kWhrs. The rod shading system offered an energy savings of 61% while the louver design offered an energy savings of 60%. Assuming that the cost of electricity in New York is $0.25/kWhr, the rod system would provide a cost savings of $10,900/year on the eighth floor. The louvered system would offer a cost savings of $10,700/year.

Daylighting Performance Summary

The final results revealed that the new louvered double-skin façade would offer a similar solution for daylight harvesting. The illuminance levels recorded similar results for both the rod design and the louvered system. The daylight autonomy graphs were also very similar. With the final cost savings only varying by $200.00, it can be concluded that the redesign meets the performance characteristics of the rod system. The added benefit of the louvered double-skin façade is that the windows will not be blocked. This increases the viewing characteristics of the building while also enhancing the idea of transparency through the tower. The overall result of the new daylight design is that the system performs to expectations and also compliments the architectural concepts.

METRICS OF SUCCESS: FACADE

As stated previously, the goal of the façade redesign was increase the thermal performance of the envelope while maintaining daylighting characteristics and the aesthetic appeal.

The double skin façade will offer a unique design that will help meet the goal of increasing envelope thermal performance while maintaining a very transparent feeling throughout the building. Using an alternative façade design with a decreased overall U-value and shading coefficient has allowed for a substantial decrease in HVAC loads throughout the year. This decrease in loads has consequently brought yearly energy use and HVAC energy associated emissions down with it, which makes a overall building design more economically and environmentally sustainable.

The goal of the lighting redesign was to promote the unique architecture used In the façade redesign. The lighting system used provided an interesting view of the building at night time. The tower creates the illusion of a changing façade. Depending on a person's viewing location the NYT Building could either be fully illuminated or seem to disappear into the night sky. The design emphasized the idea of a light floating structure. The theme of transparency was also enhanced.

The daylight analysis assured our design team that the new façade design would provide similar daylight harvesting opportunities. The louver system allows for daylight to penetrate deep into the space and allow for ample dimming opportunities. The new façade design also increases the idea of transparency while keeping the icon image.

The total façade system cost comes to $102.3 million at an increase of $18.7 million over the existing system. The annual energy savings is $800,000 which will amount to a simple payback period of 23.43 years.

FLOOR SYSTEM

REDESIGN GOALS

The design team saw a great opportunity to provide benefit to the owner by reducing the height of the typical floor sandwich in both the New York Times and the Forrest City Ratner sections of the building. The typical floor sandwich in the New York Times typical floors is 4' – 9" from the bottom of the ceiling to the top of the raised floor system. A reduction in floor/ceiling assembly height could provide the opportunity of adding additional floors to the building which would produce additional rentable floor space and increased profitability for the building.

Assuming that the New York Times has no need for additional floor space, additional floors will be assumed to be used by The Forrest City Ratner Company to lease to possible tenants and accrue additional income. For the purposes of this engineering study, the team has assumed that current economic issues are not present and that a market does exist for additional office space. The goal to reduce overall floor sandwich height in order to reduce the floor to floor height and add additional rentable floor space to the building was accomplished with the following design changes.

ALTERNATE STRUCTURAL FLOOR

In order to ultimately add additional rentable space to the New York Times Building, the structural floor system was designed to maximize the flexibility of coordination between the other disciplines and minimized the depth of the floor sandwich. The existing composite beam structural floor system only allows service distribution to be coordinated below the level of the steel beams or through a system similar to the existing raised floor. Therefore, in order to optimize floor to floor height, it was proposed to investigate alternatives to the existing structural floor system.

Two configurations, shown in Figures 40 and 41, were investigated and selected based upon their feasibility. The first configuration looked at decreasing the number of members by maintaining one intermediate beam per bay, while the second investigated utilizing two intermediate beams. Overall however, the investigation involved the examination of six different options which utilized composite castellated steel beams. The six options are as follows:

1. Beam Configuration 1 w/ Long-span Metal Deck, Light Weight Concrete
2. Beam Configuration 1 w/ Long-span Metal Deck, Normal Weight Concrete
3. Beam Configuration 1 w/ Dove-tail Composite Metal Deck, Normal Weight Concrete*
4. Beam Configuration 1 w/ Dove-tail Composite Metal Deck, Light Weight Concrete*
5. Beam Configuration 2 w/ Dove-tail Composite Metal Deck, Normal Weight Concrete
6. Beam Configuration 2 w/ Dove-tail Composite Metal Deck, Light Weight Concrete

* Shoring required during construction

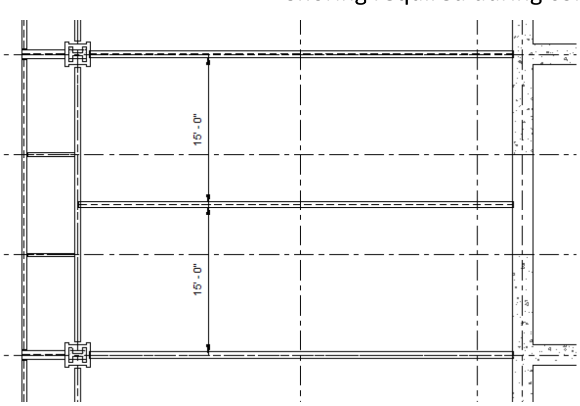


Figure 40: Floor Configuration 1

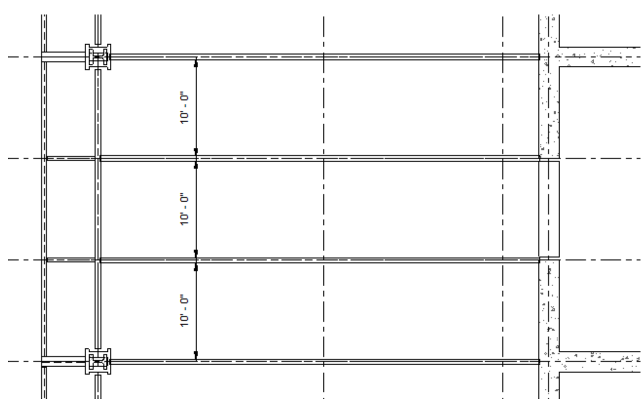


Figure 41: Floor Configuration 2

PRELIMINARY INVESTIGATION

Before a full investigation was conducted, a typical 30’ x 40’ perimeter bay was analyzed to determine if utilizing coordination between castellated beams and services would decrease the existing floor sandwich. I was the hope of the team that this decrease floor sandwich would essentially decrease the required floor to floor height enough to add an additional floor to the Forest City Ratner portion of the tower while maintaining an overall building height of 745.5 feet. The analysis was performed using the existing system’s 93 psf dead and 50 psf (+20 psf for partitions) live load on a layout similar to that of Configuration 1. Other parameters which were taken into consideration were the removal of the 1’-4” UFAD system in the New York Times portion of the tower while maintaining a 6” raised floor for the telecom. Also, the existing floor to finish floor to ceiling height of 9’-8” was required to be maintained or the preliminary analysis. The preliminary analysis determined that the required castellated member depth in this configuration and under this loading condition was about 28”. Once a required member depth was determined, a new typical floor sandwich of 13’-7”was determined for the typical office floors in the New York Times portion and 13’-3” for the typical floors of the Forest City Ratner portion of the tower. After this preliminary analysis, it was determined that global reduction in floor sandwich was enough to add a 53rd level to the New York Building while maintaining the overall building height of 745.5 feet.

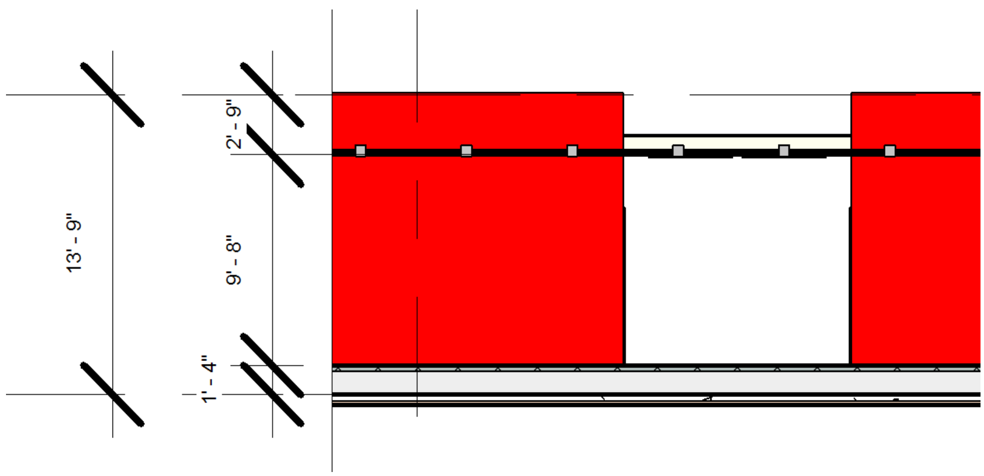


Figure 42: Section of Existing Conditions – 8th Floor

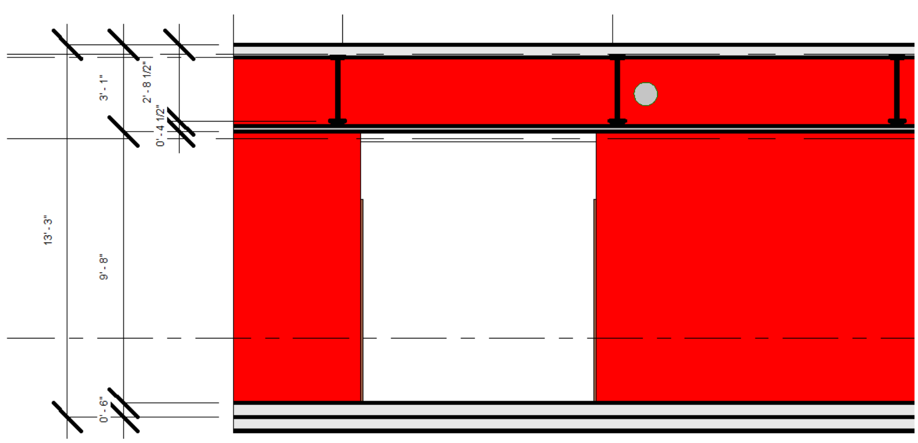


Figure 43: Section of Proposed Floor System – 8th Floor

DESIGN PARAMETERS

Gravity Loads

When designing the different alternatives to the existing perimeter floor system a superimposed dead load of 20 psf was applied for MEP systems, architectural finishes, and miscellaneous loads. Also, a live load of 50 + 20 psf for partitions was applied to the typical office area as well. The specific self weight of each option was applied respectively.

Deflection Criteria

Construction Dead Load deflection limitation for beams and girders – L/240

Live Load deflection limitation for beams and girders – L/360

Full Service Load deflection limitation for beams and girders – L/240

Floor Vibrations (AISC-Design Guide 11)

Floor vibrations resulting from human activity were also a consideration when looking at the alternatives to the existing floor system. This parameter was especially important when looking at the options which utilized configuration 1 where larger beam spacings occur. The AISC Design Guide 11, Floor Vibrations Due to human activity, was employed to determine if the dynamic response of each system fell within the recommended criterion for human comfort. According to the Design Guide 11, the maximum recommended peak acceleration, a_p, for office occupancy is 0.5% of the acceleration due to gravity, g. The peak acceleration of each floor option was determined using the equation:

$$\frac{a_p}{g} = \frac{P_o e^{-0.35 f_n}}{\beta W}$$

where,

P_o = a constant force representing the excitation,

f_n = the fundamental natural frequency of a beam or joist panel, a girder panel or combined panel,

β = model damping ratio,

W = the effective weight supported by the beam or joist panel, a girder panel or combined panel

Also when calculating the peak acceleration, the recommended values, as shown from Table 4.1 of Design Guide 11, of 65 lbs for Po and 0.03 for damping were utilized for each configuration. In addition, the recommended live load of 11 psf for office areas per 3.3 of AISC Design Guide 11 was used in the analysis.

Table 4.1
Recommended Values of Parameters in Equation (4.1) and a_o / g Limits

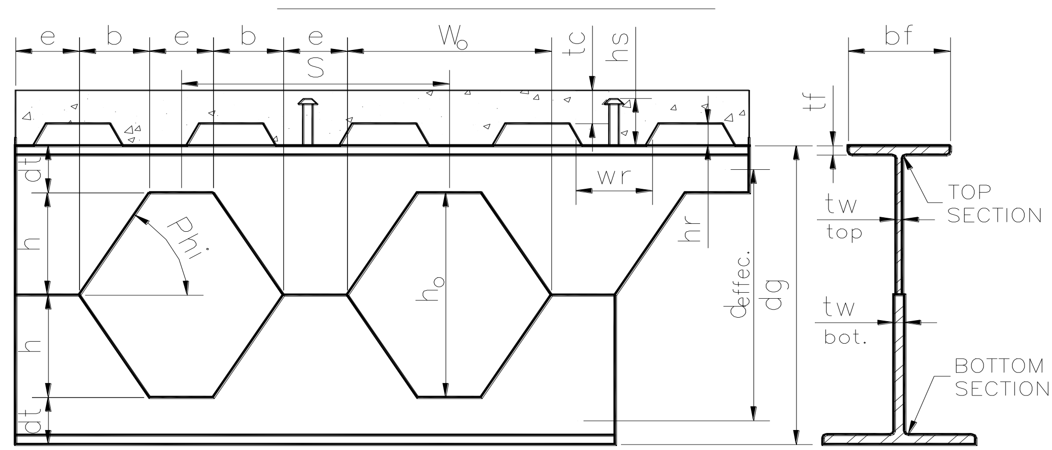
	Constant Force P_o	**Damping Ratio** β	**Acceleration Limit** $a_o / g \times 100\%$
Offices, Residences, Churches	0.29 kN (65 lb)	0.02–0.05*	0.5%
Shopping Malls	0.29 kN (65 lb)	0.02	1.5%
Footbridges—Indoor	0.41 kN (92 lb)	0.01	1.5%
Footbridges—Outdoor	0.41 kN (92 lb)	0.01	5.0%

* 0.02 for floors with few non-structural components (ceilings, ducts, partitions, etc.) as can occur in open work areas and churches,
0.03 for floors with non-structural components and furnishings, but with only small demountable partitions, typical of many modular office areas,
0.05 for full height partitions between floors.

Also for comparison, the peak acceleration of 0.42 % was calculated for a typical 30'x40' bay of the existing for system. In order to review this calculation, please refer to the Appendix D.3.

Castellated beam parameters

According to AISC¸ castellated beams and girders are proprietary and need to be designed according to criterion established by the manufacture (AISC, p.2-21). After preliminary research by the team, it was determined that SMART BEAM by CMC Steel Products was to be utilized in the design. Therefore, the design of the castellated beams was conducted with the aid of a design spread sheet provided by CMC steel products. In order to determine the correctness of the spread sheet, a hand calculation was performed in order to confirm its result. Refer to Appendix D.2 for this calculation. Please note that the analysis of the castellated beams in both the spread sheet and the hand calculation utilized ASD rather than LRFD as the design approach.



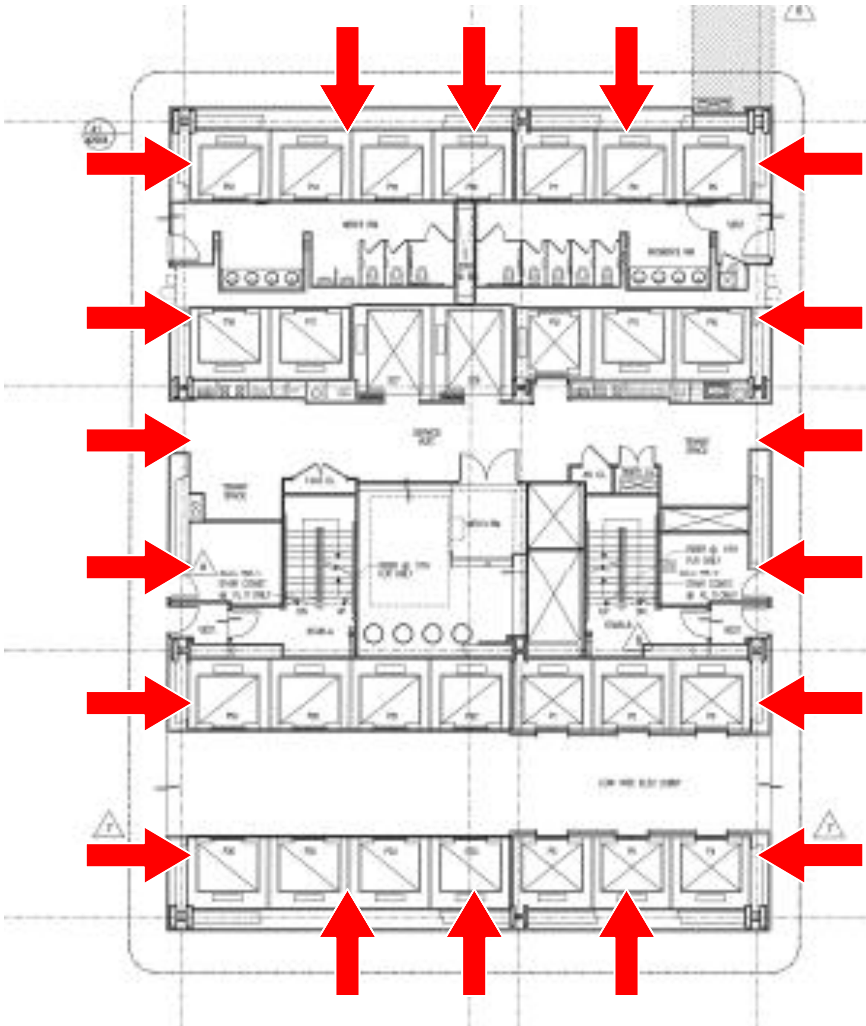
When designing with castellated beams, one must understand the structural limit states associated to them. *The Design of Welded Structures* by Omar W. Blodgett was consulted in order to understand the engineering principles castellated members. The following are the limit states are required considerations for design:

1. Total Bending Stress which is a combination for the main bending stress (σ_b) resulting from the main bending moment in the member and the secondary bending stress (σ_T) from vertical shear in the stems above the constellations.
2. Buckling due to the axial compression in the Tee sections (web posts).
3. Horizontal Shear Stress along the Neutral Axis of the member
4. Web Bucking resulting from horizontal shear forces.
5. Web Buckling due to the compression in the web

e = web post width & tee length
b = width of sloped portion
d_t = tee depth
d_g = castellated beam depth
t_c = conc. thick. above the flutes
h_r = height of deck, d_s = stud dia.
f_c' = 28 day concrete strength
w_c = unit weight of concrete
d = depth of root beam
b_f = flange width
t_f = flange thickness
tw = web thickness
h_o = height of hole
w_o = width of hole
S = hole spacing

Affect of Core Redesign

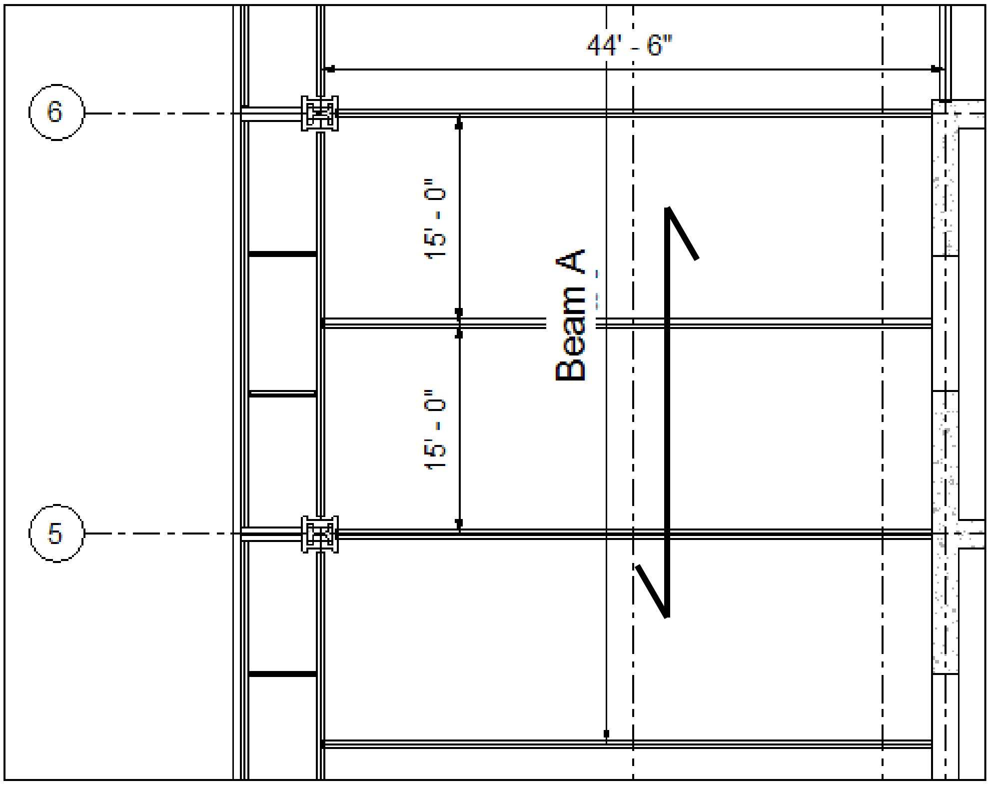
Due to the fact that one of the supports to the new floor system is the concrete core, the new core configuration greatly affected the design of the alternative systems. With this in mind, the member spans and spacing had to be reconfigured with every dimension change to core footprint. The final dimension of the core resulted in the members running in the East/West direction to be designed to span 44'-6" while the members running in the North/South directions retained the existing span of 30'-0".



Deck Considerations

Two types of composite metal deck were considered in for the investigation of the different castellated beam alternatives: long span metal deck and dove tail rib composite metal deck. It was determined early on in the redesign of the floor system that the team would utilize the decks manufactured by EPIC Metals Corporation for the alternatives. The long span metal deck was investigated due to the system's inherent span capabilities which would conform to Configuration 1 without requiring the use of shoring during the construction of the structure. The dovetail rib composite metal deck, in this case Epicore, was selected because due to the ease of contractibility. The dovetail ribs allow for the simple installation of mechanical, fire protection, and utility components. Refer to Appendix D.4for the deck sheets utilized in the investigation.

OPTION 1 – LONGSPAN METAL DECK w/ LWC



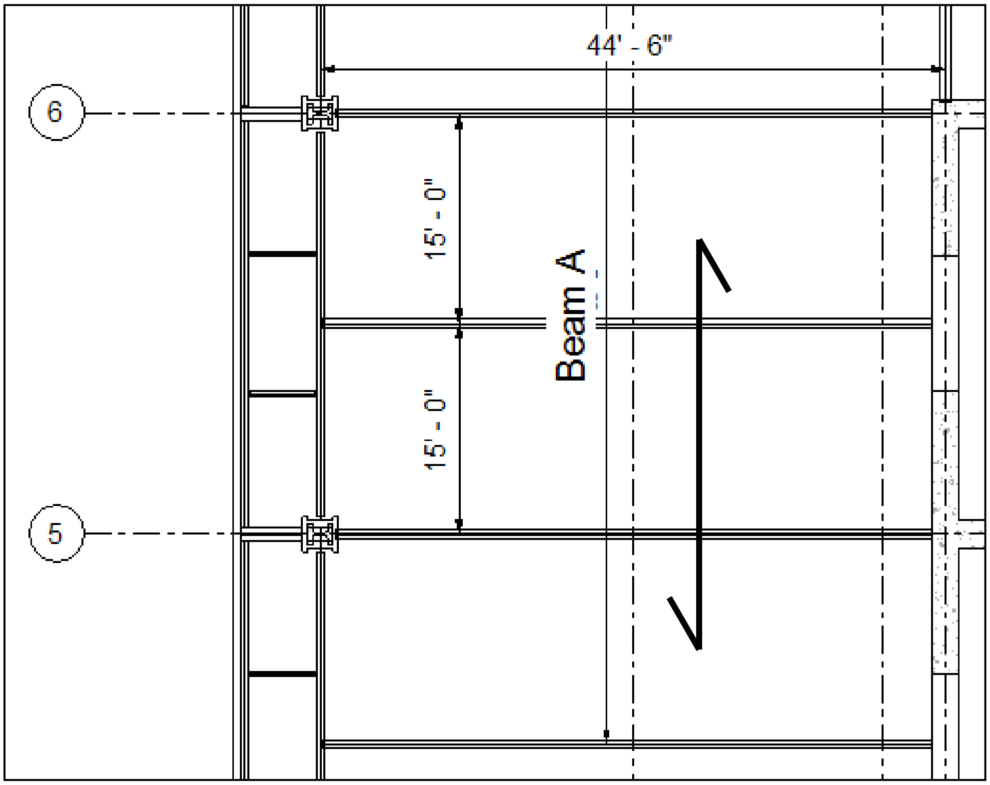
Beams:	Beam Type A – CB27X46/55

Slab Properties:

Concrete:	7” slab (2.5” toping)
	f’c = 4000 psi
Reinforcement:	fy = 60,000 psi
Metal Deck:	EC450 LWC – Gage 18 (EPIC Composite Floor Decks)
Self Weight:	39 psf

The resulting castellated beam for this for this design option was a CB27X46/55. However, the vibration analysis for this design resulted in a peak acceleration of 0.58% g which exceeded that of the existing floor system as well as that of the recommended 0.5% g per ACSE’s Design Guide 11. Therefore, this design was not investigated further. Refer to Appendix D.1 and Appendix D.3 respectively for the design summary and the vibration analysis of this system.

OPTION 2 – LONGSPAN METAL DECK w/ NWC



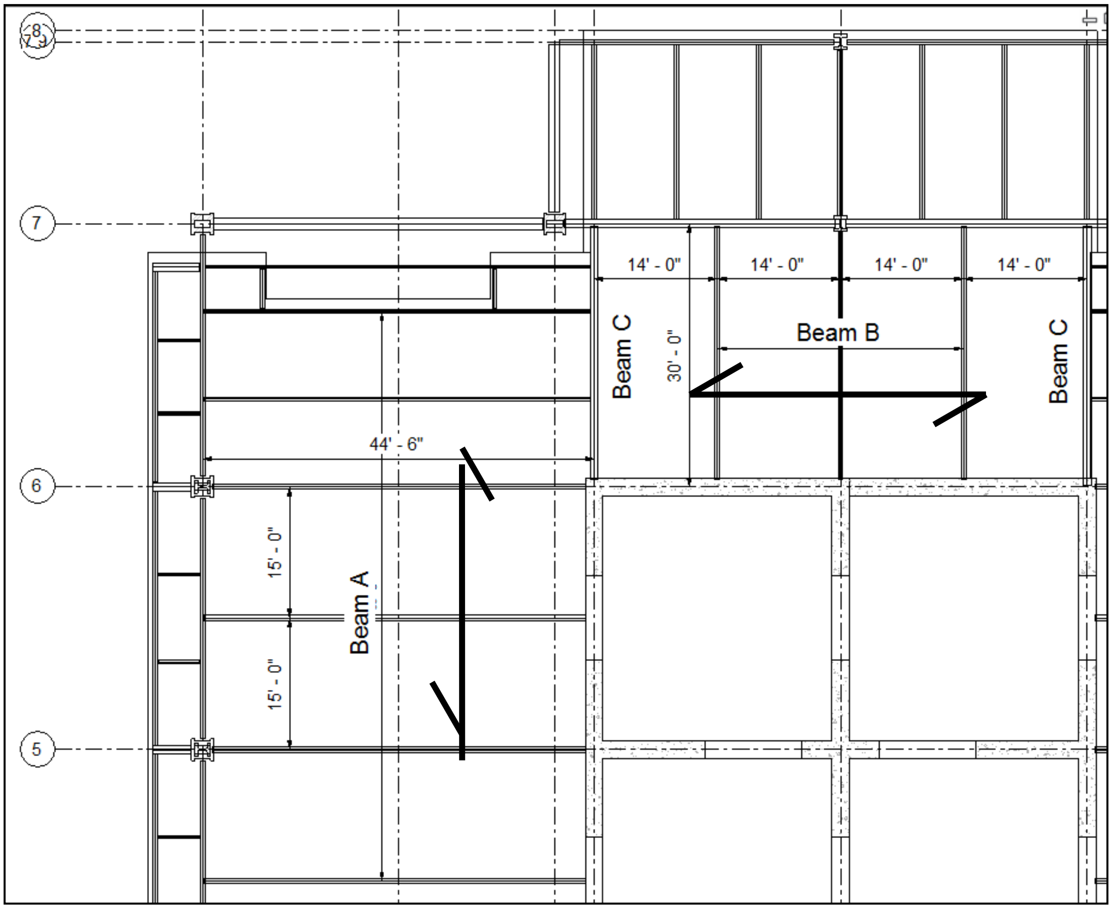
Beams: Beam Type A – CB27X55/65

Slab Properties:

Concrete: 7" slab (2.5" toping)
f'c = 4000 psi
Reinforcement: fy = 60,000 psi
Metal Deck: EC450 NWC – Gage 18 (EPIC Composite Floor Decks)
Self Weight: 49 psf

The resulting castellated beam for this for this design option was a CB27X55/65. However, the vibration analysis for this design resulted in a peak acceleration of 0.55% g which exceeded that of the existing floor system as well as that of the recommended 0.5% g per ACSE's Design Guide 11. Therefore, this design was not investigated further. Refer to Appendix D.3 for the vibration analysis of this system.

OPTION 3 – DOVE TAIL COMPOSITE METAL DECK w/ NWC (SHORING REQUIRED)



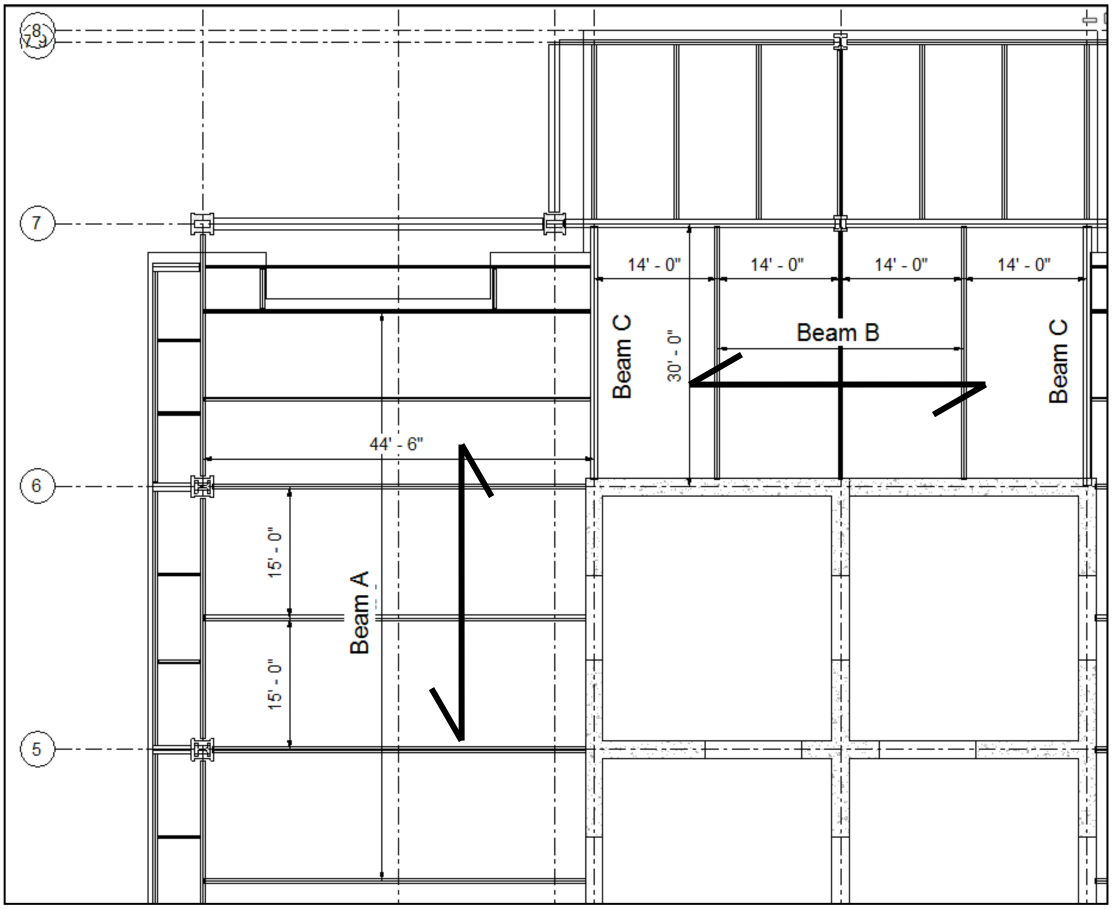
Beams: Beam Type A – CB27x65
Beam Type B – CB27x35
Beam Type C – CB27x71

Slab Properties:

Concrete:	5.25” slab (3.25“ toping)
	f’c = 3000 psi
Reinforcement:	fy = 60,000 psi
Metal Deck:	EPICORE GAGE 0.0358
Self Weight:	63 psf

The resulting peak acceleration for this configuration was that of 0.40% (less than both the existing and the recommended limit of 0.5% from AISC Design Guide 11) Therefore, the system was considered as a viable alternative. Refer to Appendix D.3 for the vibration analysis of this system.

OPTION 4 – DOVE TAIL COMPOSITE METAL DECK W/ LWC (SHORING REQUIRED)



Beams:

Beam Type A – CB27x55/65

Beam Type B – CB27x35

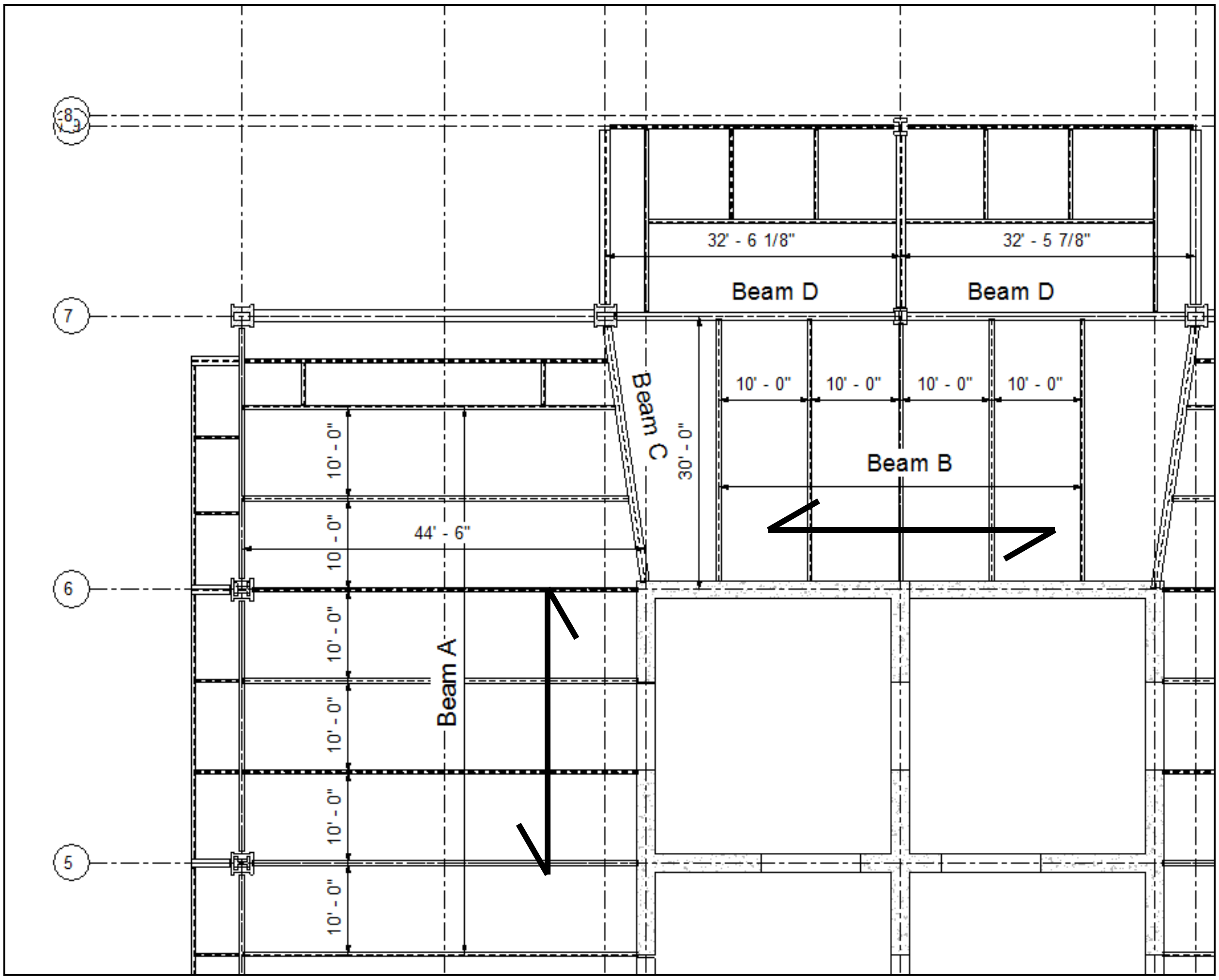
Beam Type C – CB27x65

Slab Properties:

Concrete:	5.25" slab (3.25" toping)
	f'c = 3000 psi
Reinforcement:	fy = 60,000 psi
Metal Deck:	EPICORE GAGE 0.0474
Self Weight:	49 psf

The resulting peak acceleration for this configuration was that of 0.48% g. This acceleration is greater than the 0.4% g of the existing. However, the system did fall under the 0.5% limit recommended by AISC Design Guide 11. Therefore, the system was still considered to be a viable alternative. Refer to Appendix D.3 for the vibration analysis of this system.

OPTION 5 – DOVE TAIL COMPOSITE METAL DECK W/ NWC (NO SHORING REQUIRED)



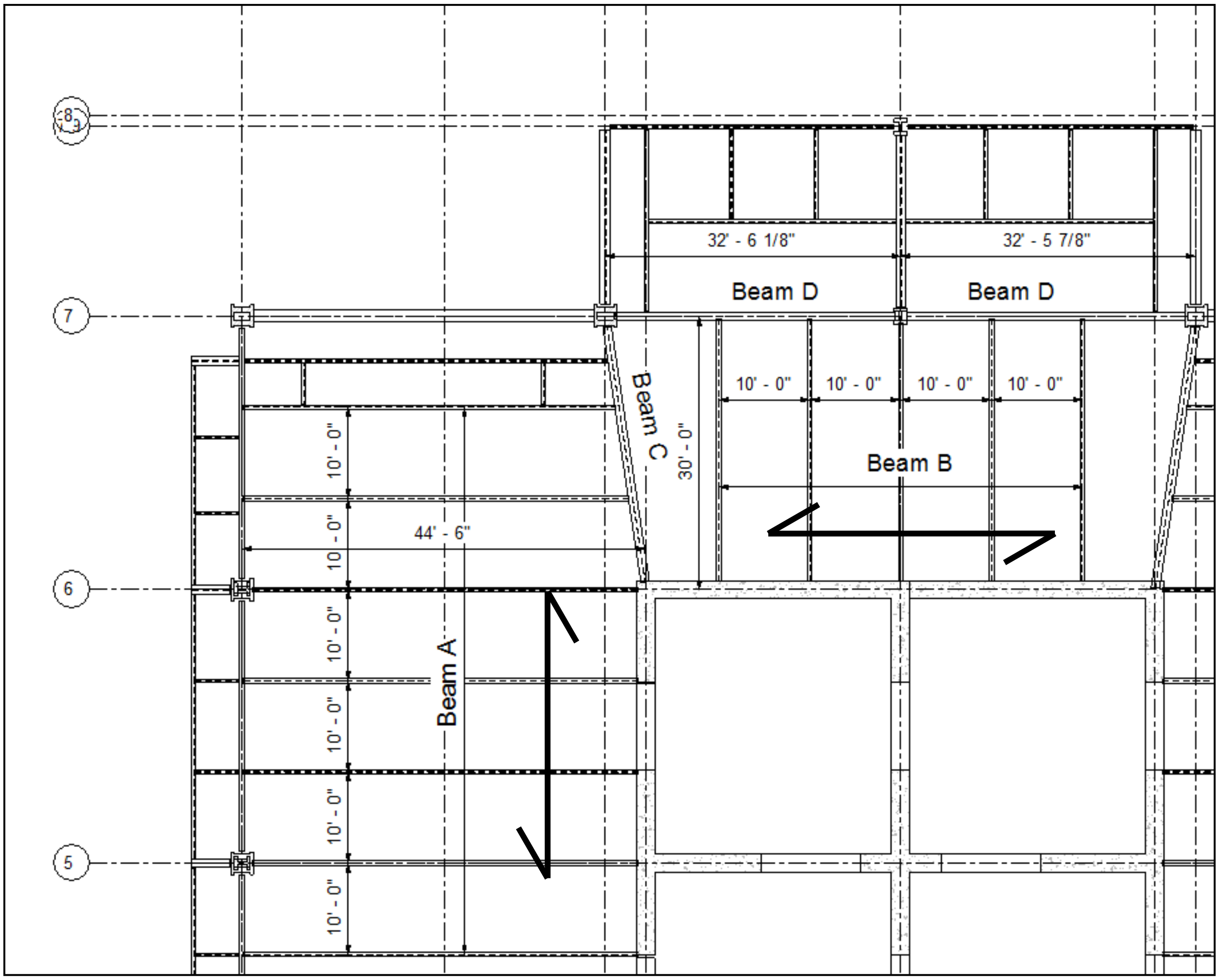
Beams: Beam Type A – CB27x35/46
Beam Type B – CB27x35
Beam Type C – CB27x106
Beam Type D – CB27x106

Slab Properties:

Concrete: 5.25” slab (3.25“ toping)
f’c = 3000 psi
Reinforcement: fy = 60,000 psi
Metal Deck: EPICORE 0.0600
Self Weight: 63psf

After seeing that Floor Option 3 fell within the limitations for vibration, the assumption could be made that this option met the criterion as well since the addition of a second intermediate beam would reduce the vibration affect of the beam panel mode. Therefore, this option was presented as a viable alternative floor configuration.

OPTION 6 – DOVE TAIL COMPOSITE METAL DECK W/ LWC (NO SHORING REQUIRED)



Beams: Beam Type A – CB27x40
Beam Type B – CB27x35
Beam Type C – CB27x106
Beam Type D –CB27x106

Slab Properties:

Concrete: 5.25" slab (3.25 " toping)
f'c = 3000 psi
Reinforcement: fy = 60,000 psi
Metal Deck: EPICORE GAGE 0.0600
Self Weight: 49 psf

After seeing that Floor Option 4 fell within the limitations for vibration, the assumption could be made that this option met the criterion as well since the addition of a send intermediate beam would reduce the vibration affect of the beam panel mode. Therefore, this option was presented as a viable alternative floor configuration.

STRUCTURAL COST ANALYSIS

It was important to weigh each of the structural floor system options by their cost. An analysis was done to determine the cost of material and labor for each of the options. The real area of interest was to see if the additional cost of reshoring would outweigh the cost for additional framing that would eliminate the need for reshoring. The estimate produced the following results:

System	Steel Framing	Concrete Floor	Reshoring	Total
Lightweight Concrete - Config. 1	$ 7,920,000	$ 82,160,000	$ 2,490,000	$ 92,580,000
Normalweight Concrete - Config. 1	$ 7,920,000	$ 61,950,000	$ 2,490,000	$ 72,370,000
Lightweight Concrete - Config. 2	$ 8,540,000	$ 82,160,000	$ -	$ 90,700,000
Normalweight Concrete - Config. 2	$ 8,540,000	$ 61,950,000	$ -	$ 70,490,000

The design team decided to go with the normalweight concrete with framing configuration 2. This framing configuration eliminates the need for reshoring, which makes it cheaper and easier to construct. More detailed breakdown of costs for each of these systems is included in Appendix B.5.

AFFECT OF THE SELECTED OPTION

Once the Option 5 was selected as the alternative slab design base, the affect on unchanged portions of the typical floor system, such as the North and South cantilevered floor areas and the and the cantilevered perimeter edges on the East and West sides of the tower, Figure 44. The sizes of these members were checked to incorporate the new slab weight of 63 psf. The load of the new façade design was also applied to the perimeter members. The new façade assembly had yet to be determined at the point of this calculation. Therefore, an assumed weight of 30 psf per foot of wall was applied. A summary of this check can be viewed in the chart below. To review the check calculations, refer to Appendix D.5.

Beam Check Summary										
Location	Existing Member	New Load		Existing Capacity		Deflection	Adequacy	New Member	New Capacity	
		M_u (k-ft)	V_u (k)	ϕM_n (k-ft)	ϕV_n (k)				ϕM_n (k-ft)	ϕV_n (k)
Cant.	W12x19	28.47	10.98	92.6	85.7	ok	OK	W12x19	92.6	85.7
Cant.	W14x22 (int)	259.3	36	277	85.7	ok	OK	W14x22	277	85.7
Cant.	W14x22 (ext)	372.56	36	125	94.8	----	NG	W14x61	1250	156
Cant.	W21x76	63.03	18.73	750	316	ok	OK	W21x76	750	316
Edge	W12x19	7.21	5.77	92.6	85.7	ok	OK	W12x19	92.6	85.7
Edge	W18x130	96.39	25.05	1090	387	ok	OK	W18x130	1090	387
Edge	W24x76	117.2	13.51	750	316	ok	OK	W24x76	750	316
Edge	W18x40	577	57.7	294	169	ng	NG	W30x99*	1170	463

*Selected to elminate the coping of castellated members

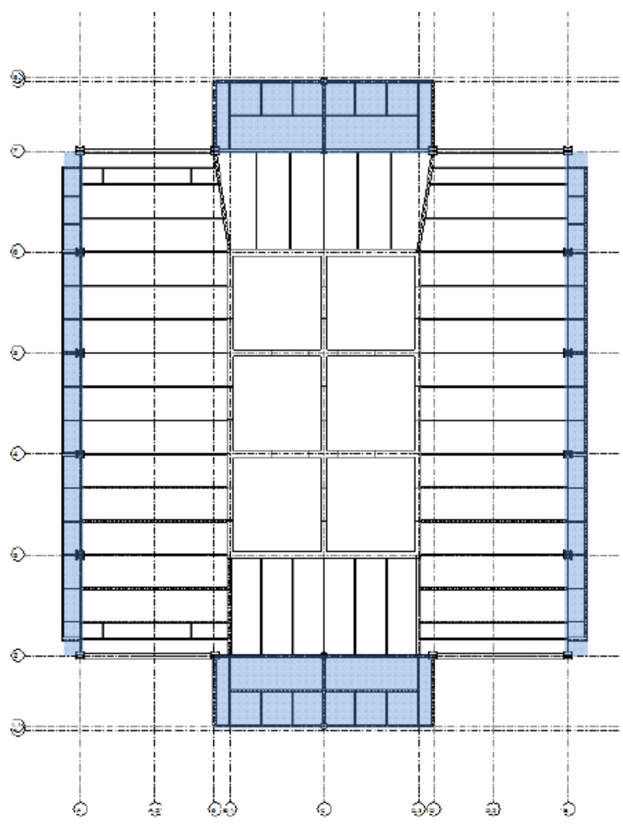


Figure 44: Cantilever Floor Area

HVAC REDESIGN:

Existing System

In the existing system air distribution is achieved via variable air volume boxes for interior zones and fan powered boxes with heating coils for exterior zones. The floors occupied by the New York Times utilize an UFAD system (See Figure 45 below). Swirl diffusers were installed to provide occupant control, while in high occupancy spaces perforated floor tiles provide a more visually pleasing layout. A traditional overhead ducted system was implemented on the Forest City Ratner floors. Demand controlled ventilation is achieved via carbon dioxide and VOC sensors located in the return ducts for each floor. Outdoor air is brought in through outdoor air units in the two mechanical penthouses on the 28th and 51nd floors, and then is distributed throughout the building.

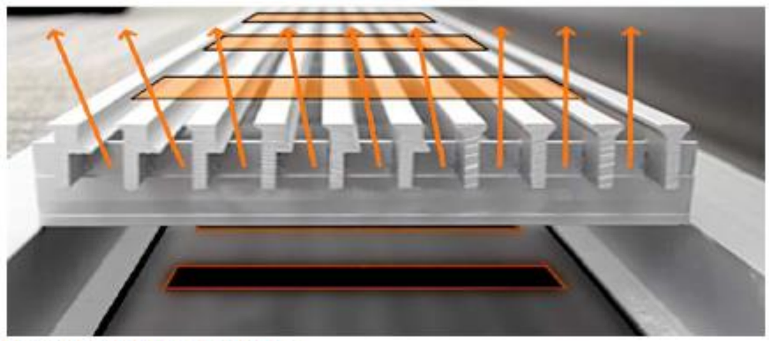


Figure 45 - UFAD

An energy analysis and existing conditions evaluation of the NYTB was performed and reported in mechanical technical assignments one and two. The third mechanical technical report presented three research studies that were performed to investigate the areas in which the building could be improved from a mechanical system point of view. These three studies focused on three topics including façade redesign, energy sources and alternative air distribution systems. The goal of these studies was to identify areas in which the design could be altered in order to optimize overall performance in areas such as energy use, sustainability, operating costs and maintainability. The report also investigated the mechanical engineer's role in a project which utilizes Building Information Modeling (BIM) and the Integrated Project Delivery (IPD) method.

Redesign Considerations

During the mechanical redesign the primary task involved an optimization of the HVAC system to save space between floors in the building while maintaining desirable energy efficiency and indoor air quality. As proposed, the underfloor air distribution system was removed from all New York Times Company floors as was the conventional overhead VAV system from all Forest City Ratner floors.

An active chilled beam system coupled with a dedicated outdoor air application has replaced these two systems on every floor. This alternative system will save space between floors by eliminating the underfloor plenum. The new system will also work in conjunction with the alternative floor system which employs a castellated beam system where smaller ducts and piping can be run through structural members.

According to David Callan, senior vice president, director of sustainable design and high-performance building technology, Syska Hennessy Group, Chicago, chilled beams are best used in situations where solar gain contributes largely to the overall thermal load on the building. Callan was also quoted in Interiors and Sources Magazine, "These systems are better for projects where your air-conditioning system is sized based on heating and cooling loads rather than ventilation." With this considered, The New York Times Building project presents an ideal case for a chilled beam system because of high thermal envelope loads and the ability to reduce system airflow to roughly 1/10 the size by using only ventilation air.

The design team reviewed active chilled beam systems from various manufactures in order to find a system that best suited the needs of the New York Times Building. Dadanco, an American based company, was initially selected as the chilled beam provider because of considerations involving cost and proximity to the project location. Dadanco provides a well built product at a very competitive price, but no specific product cost numbers could be obtained. However, the design team was looking for exceptional integration of the chilled beam system with both the lighting and fire protection systems, and the Dadanco beams could not offer this coordination.

Products from companies like Halton and TROX were also considered when selecting the best chilled beam system for the building.

When considering the HVAC redesign the design team also reviewed several instances where active chilled beams have been used successfully. One such case involved the 15 story office building at 250 South Wacker Drive in Chicago pictured on the right. The 250 South Wacker project provides valuable information in regards to how an active chilled beam system might work with the New York Times project. Similar to the New York Times Building, 250 South Wacker has a floor to ceiling glazing system which creates high thermal envelope loads on the building. It also has a similar open floor plan for tenant office space.

http://250southwacker.com/acb.html

In 2006 a renovation project began which replaced the older HVAC system with a new active chilled beam system. According to the owners, because of a drastic reduction in fan energy, the active chilled beam system is saving them roughly 77% in energy costs compared to the previous VAV system. Other reported benefits include improved air movement throughout the space, uniform temperatures in the offices, excellent indoor air quality and odor control, very low noise levels, and space savings in their open office floor plan.

Multiservice Chilled Beam System

Ultimately, a multiservice chilled beam system could be selected from either *Frenger Systems* or *Halton* which both offer highly integrated systems (See Figures 46 and 47 below). Frenger is based in the United Kingdom and has specialized in the development and design of heating and cooling systems for nearly 70 years. Halton is headquartered in both Finland and the United States and has operations in 23 countries. These multiservice beams allow the lighting, fire protection and HVAC system to be fully integrated (See Figures 48 and 49 below). In many cases offsite pre-manufacturing techniques for these types of chilled beams can provide increased coordination in construction and lower total installed costs. Appendix A.1, A.2 and A.3 include a detailed component diagram, typical construction sequence and a full cut sheet with specifications for multiservice chilled beams.

Figure 46
www.frenger.co.uk

Figure 47
www.halton.com

Figure 48
www.halton.com

Figure 49
www.halton.com

One advantage of using the Frenger system is their patented Drypac™ system which allows the chilled beam coils to drop below dew point levels without causing harmful condensation buildup. The unique system works by using a capillary structured coating material to capture and remove condensation that builds up on the coils. The unwanted moisture is then released into the room atmosphere in a cyclic manner as described below in Figure 50. Figure 51 shows the difference between coils with and without the condensation controlling coating material.

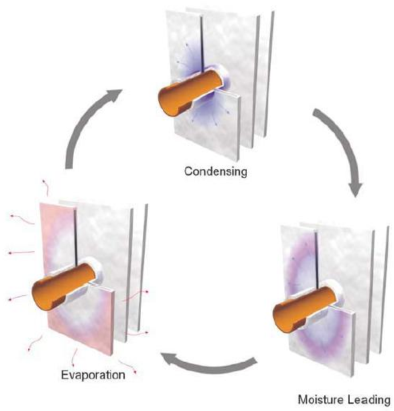


Figure 50
www.frenger.co.uk

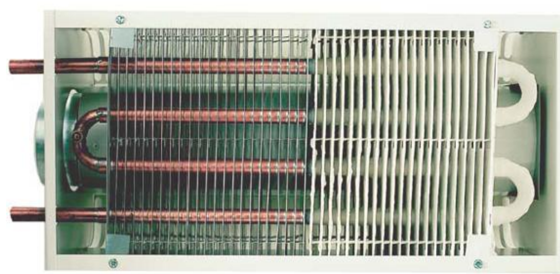


Figure 51
www.frenger.co.uk

Primary Energy Use Analysis

While saving floor to floor space was the primary reason for utilizing the four-pipe, active chilled beam system; several other factors were taken into account during the selection process. It was necessary to analyze energy use, total emissions and overall lifecycle costs associated with the system in order to fully determine its viability as an acceptable alternative. An energy model and emissions analysis was done in Trane TRACE in order to determine the overall cost and sustainability benefits of the active chilled beam system.

As previously noted, the first 28 floors of the building are currently served with an underfloor air system while the remaining 22 occupied floors are served with an overhead variable air volume system. Within the energy model a comparison was done between the two existing HVAC systems and the active chilled beam system. Analysis has shown that the active chilled beam system is predicted to outperform both the existing VAV and UFAD systems in energy consumption, associated emissions and overall operating costs.

Initially this analysis was done for a single floor of the building, and as seen in Figure 52 the chilled beam system shows significant site and source energy consumption savings in MBtu/yr compared to the existing systems. In regards to energy consumption, the chilled beams system outperforms the VAV system by roughly 16.2% and the UFAD system by roughly 10.0%. Extrapolated for the entire building HVAC redesign Figure 53 shows a total annual site energy savings of 15,363 MBtu/yr and an annual source energy savings of 25,134 MBtu/yr.

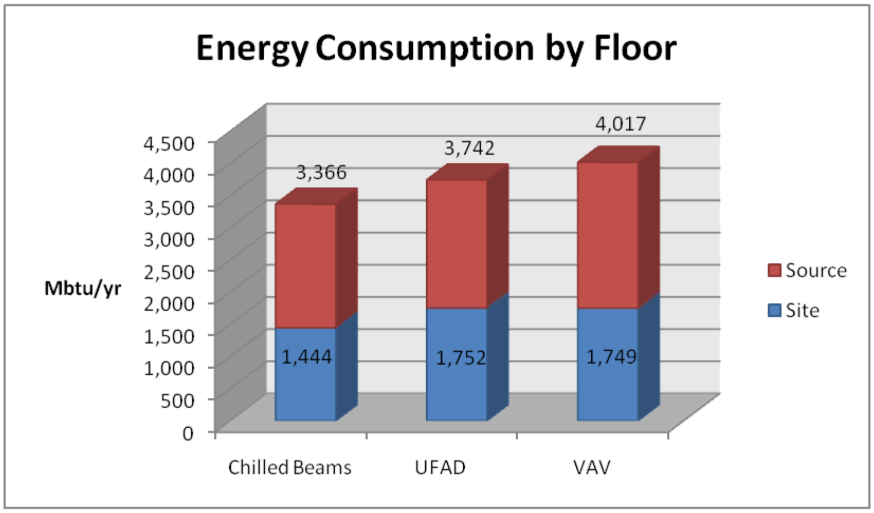


Figure 52: Energy Consumption by Floor

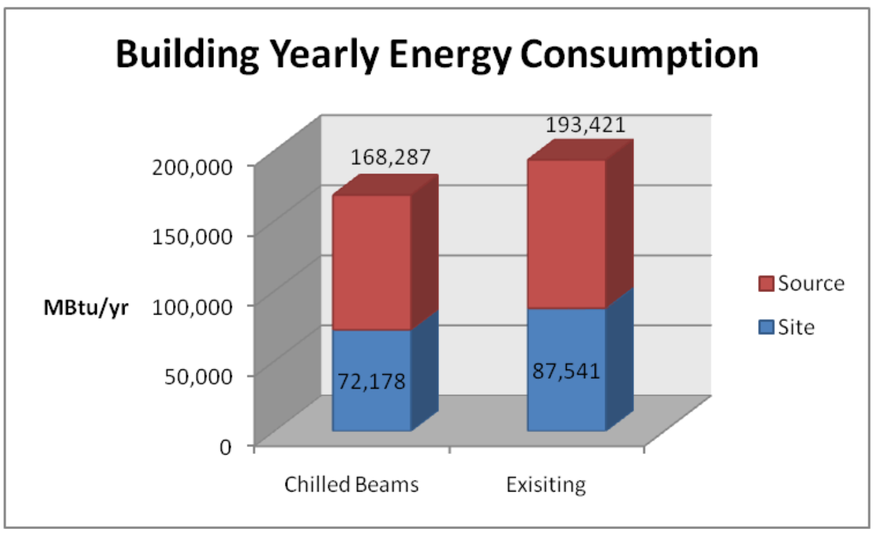


Figure 53: Building Yearly Energy Consumption

Source Energy Associated Emissions Analysis

Emissions analysis was vital in the redesign process because it allowed for a detailed view on the sustainability of the new design. Emissions associated with HVAC energy use were analyzed on the basis of pounds of carbon dioxide equivalent and nitrous oxide pollutants. Figure 54 shows a 7.8% decrease in CO_2e associated emissions for the chilled beam system compared to the UFAD system and a 16.0% decrease compared to the VAV system. Similarly Figure 55 shows a 7.8% decrease in NO^x associated emissions for chilled beam system compared to the UFAD system and a 16.0% decrease compared to the VAV system. When extrapolated to the entire building the design team is predicting an annual decrease in HVAC associated emissions of 10,138,660 lbs of CO_2e and 17,480 lbs of NO^x for the new chilled beam system (See Figures 56 and 57)

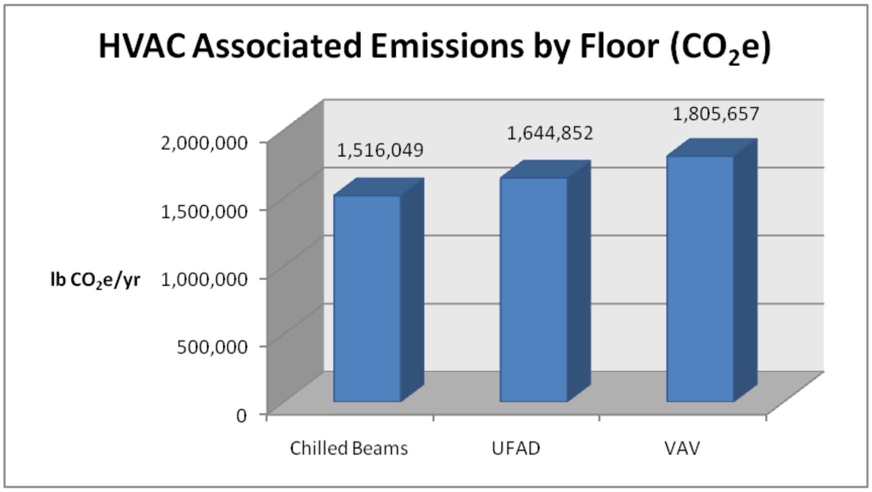


Figure 54: HVAC Associated Emissions by Floor

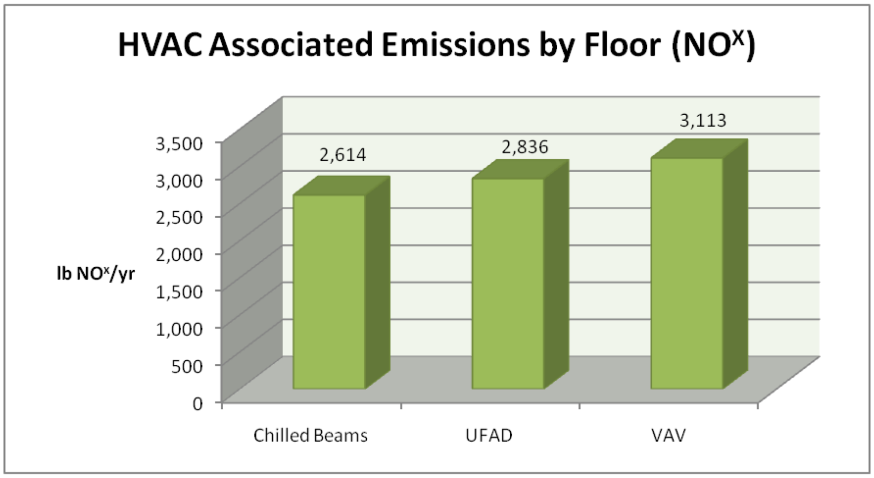


Figure 55: HVAC Associated Emissions by Floor

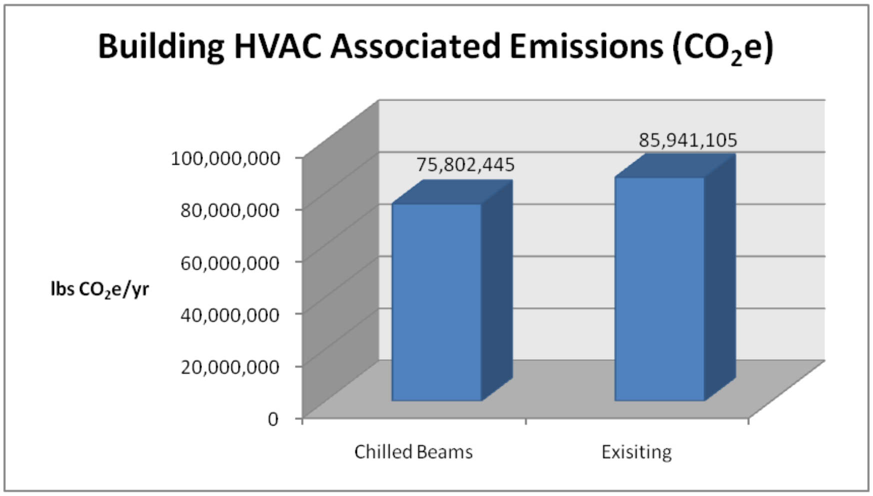


Figure 56: Building HVAC Associated Emissions

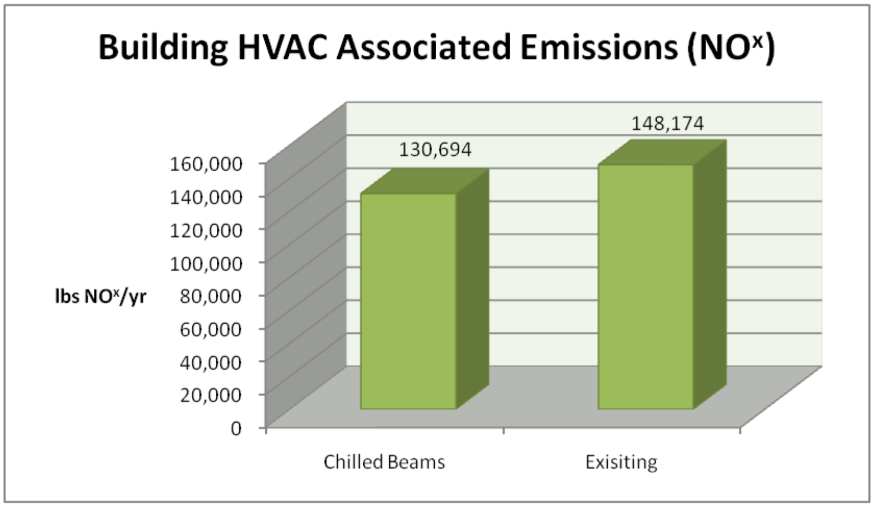


Figure 57: Building HVAC Associated Emissions

CHILLED BEAM LIFECYCLE COST ANALYSIS

When analyzing the lifecycle cost of a chilled beam system initial, energy and operating costs were all taken into account. According to the chilled beam manufacturer, Dadanco, increased initial costs for the chilled beam system will approximately equalize with the decreased cost of ductwork, fans and air handling units. Dadanco also says that because of easy commissioning and little to no required regular maintenance, a chilled beam system can be maintained at an equivalent cost to a conventional terminal unit system. Therefore, for the purpose of the analysis, the design team has neglected any difference in initial and maintenance costs between the chilled beam and the existing systems. Instead, differences in energy costs was the driving factor in the HVAC redesign cost analysis.

As seen in Figure 58, the chilled beam system outperforms the VAV system by roughly 16% and the UFAD system by roughly 11% in yearly operating costs. This data was then extrapolated for the entire building assuming a typical floor layout and fairly constant thermal loads through each floor. An annual operating cost savings of $565,800 associated with the replacement of an active chilled beam system is predicted for the building. This savings would translate into an energy cost savings of $47,150 per month for the building. In addition, it is predicted that over a 20 year lifecycle the chilled beam replacement would save an approximate $4,910,572 for the New York Times Company and $6,405,505 for the Forest City Ratner Company.

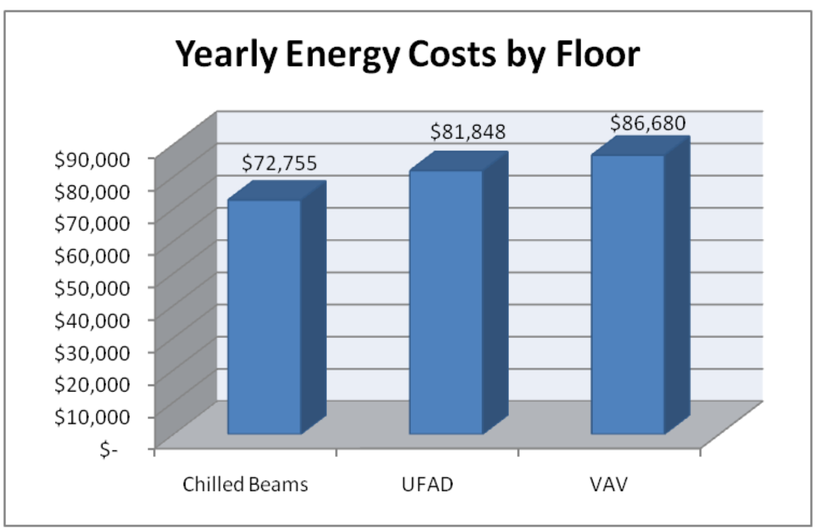


Figure 58: Yearly Operating Costs by Floor

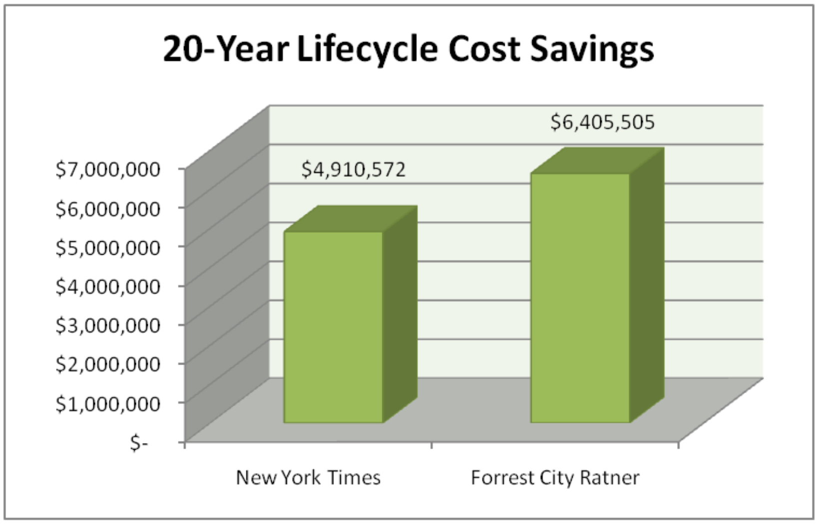


Figure 59: Twenty-Year Lifecycle Cost Savings

BIM/IPD Implementation

BIM coordination played a key role in the HVAC redesign process. The chilled beam layout was done in Revit MEP, and coordination happened with the lighting and structural system. Because of the multiservice integrated design of the chilled beams themselves, coordination with the lighting design became a first priority. An integrated project delivery approach was needed in order to meet lighting and HVAC requirement simultaneously. In addition, coordination with the structural system was of key importance in the effort to save space in the floor sandwich. By using three dimensional modeling the design team was able to coordinate piping and ductwork with the castellated beam structural system. Figure 60 below shows a screenshot from a Revit model developed for this project, which depicts the tight tolerances between mechanical, structural and lighting systems.

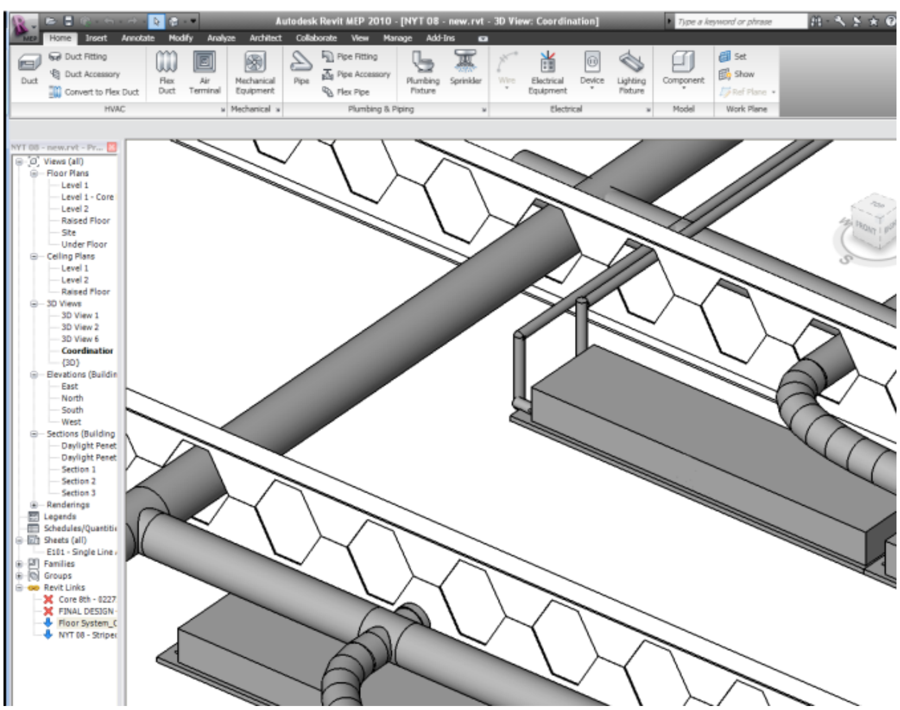


Figure 60: Chilled/Castellated Beam Coordination in Revit

Figure 61 below shows the multiservice chilled beam layout in Revit for a typical floor. This floor plan shows all 155 chilled beams and how they are laid out in the offices and open office areas. The key challenge when laying out the chilled beams was coordination of the HVAC needs with the lighting needs of the space.

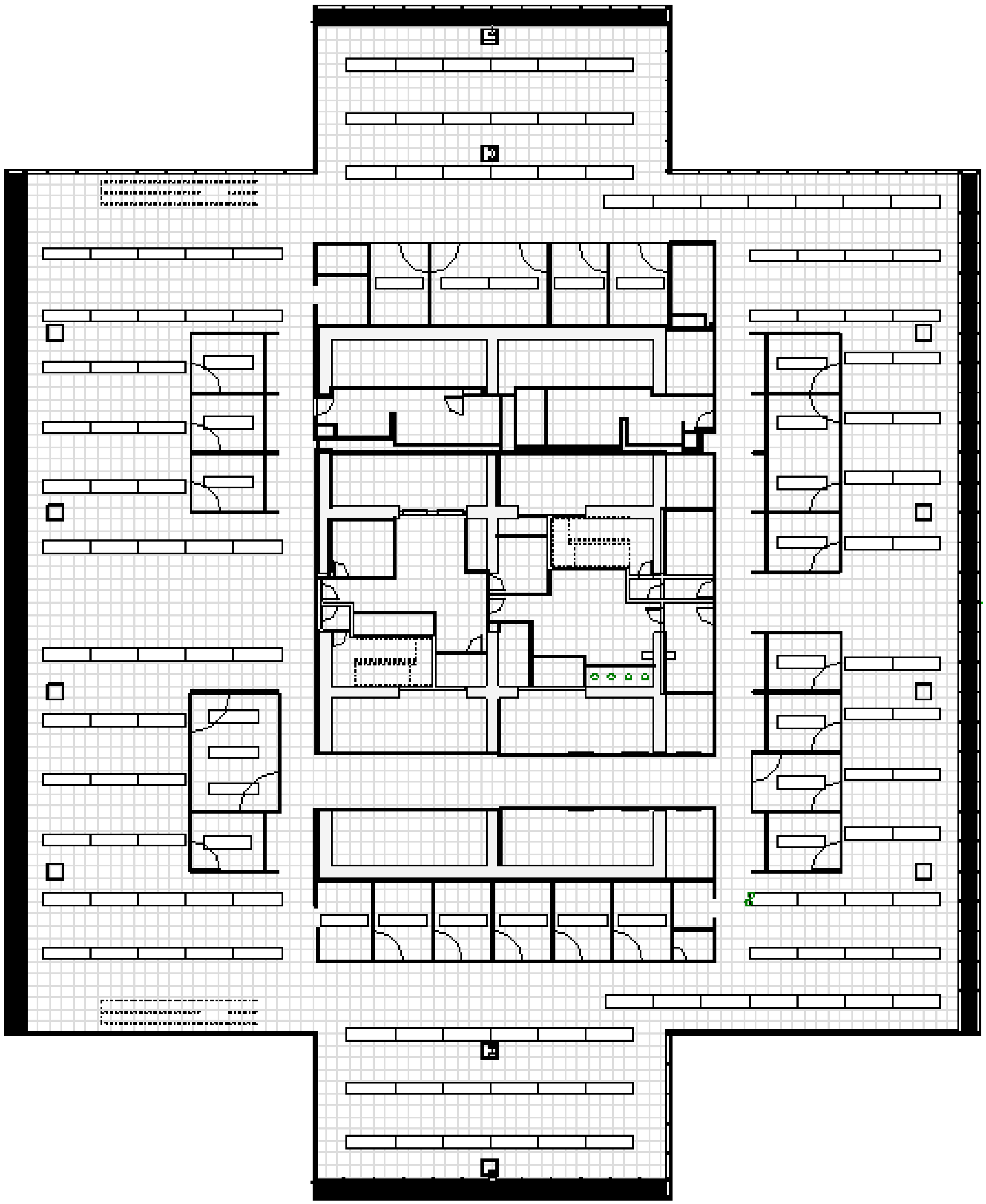


Figure 61: Chilled Beam Typical Layout

3D Coordination

3D coordination using Building Information Modeling has been established as one of the BIM uses with a large payback on projects throughout the industry. The ability to catch a large number of clashes in preconstruction before they get out into the field provides a huge savings to the contractors and the owner. The ability of integrated design teams to perform coordination in 3D has made systems like the one proposed by the group feasible. Coordination of the mechanical and lighting distribution through the castellations in the structural framing increases the need for a heavily integrated design and construction team.

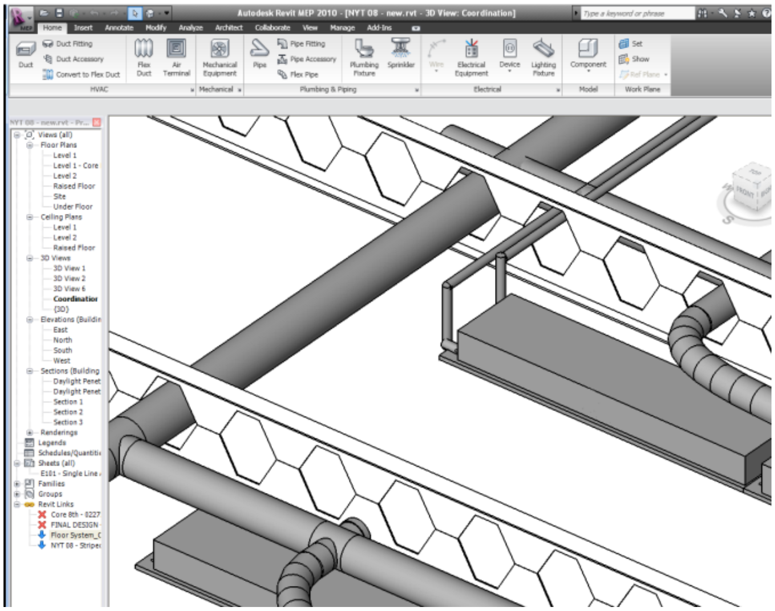


Figure 62: Coordinating Systems in Revit

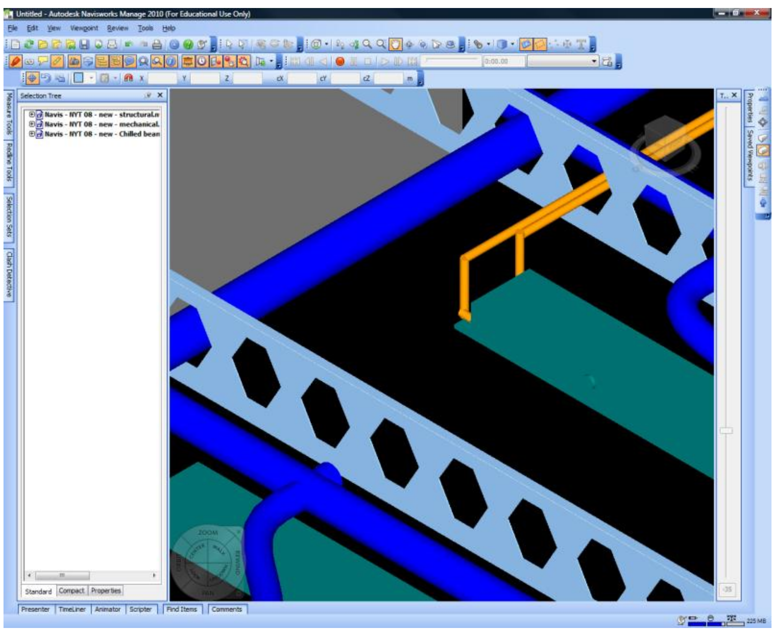


Figure 63: Coordinating Systems in Navisworks

With an IPD type contracting method it would be a joint interest of the whole team to make this system work for the owner. By striving to make this system work, the design team is providing the most value to the owner. The design team can help manage the risk of such a complex system by setting up 3D coordination with BIM. Buy in from the structural, mechanical, plumbing, and electrical designers is imperative. These team members have to create 3D models for coordination. This must be done in an efficient manor in order to help keep the upfront cost to the designers to perform BIM for coordination. This can be done by coming up with a BIM Project Execution Plan early on in the project that provides guidance to the design team about the extent of modeling needed and the proper amount of details needed from each of the designers. The models from each of the designers can be imported into a program like Navisworks Manage where clashes between systems can be detected and reported. Coordination meetings are held to work out clashes in the 3D virtual model of the building before the drawings reach the field. This eliminates a large the amount of reengineering and rework that has to occur during construction. These clashes, when not caught in preconstruction, reach the field and cause large problems in delays and rework by laborers. This can cost the project team a lot of money.

The design team did a coordination exercise as an example of what could be done over the whole building. The scope of the exercise included modeling the distribution system of the chilled beams and the lighting fixtures for a typical structural bay. The models were created in Autodesk Revit and imported into Navisworks Manage. Within Manage a process of clash detection was setup and run by the design team. There were very few meaningful clashes that showed up. It is thought that this occurred because the design team worked closely together to develop these models and were aware that clashes would be a problem. Due to the academic nature of this project it is believed that this would be performed very differently in the industry. An Integrated Project Delivery system could help to bring the design team closer together and produce results that would be similar to the results seen in this project.

OFFICE LIGHTING DESIGN

Spatial Summary

The office floors of the NYT Building are typical for most of the tower. Office floors vary depending on which elevators service the level. Each floor plan is similar in that it is open office space surrounding the structural core. Private offices and conference rooms surround the core on each side, which creates a 6' open corridor around the space. No office or conference room is surrounded by four walls. The exterior is visible from any point in the office space. The glass curtain wall completely surrounds each office floor and provides continuous daylight penetration. Office floors are only accessible to building occupants.

Activities/Tasks

Tasks in the office floors consist of moderate to intense VDT use. Moderate reading and writing are also key tasks to take into consideration. Private offices and conference rooms also require the consideration of reading, writing, and moderate VDT use. Circulation areas will require appropriate illuminace for walking, communication, and facial recognition.

Surface/Furnishing Reflectance

**All values assumed due to lack of information*

- Ceiling: 80%
- Glass Walls: 1%
- Painted Walls: 40%
- Carpeted Floor: 20%

- Desks: 40%
- Partitions: 50%
- Filing Cabinets: 30%

Design Concept

The existing lighting design used recessed linear fluorescents. These luminaires were run in tandem rows that were unbroken between partitions and glass walls. This design created a clean consistent look that highlighted the length of the room and guided individuals to look through the space.

In the redesign, the team decided to use multiservice active chilled beams with integrated luminaires. The original plan was to utilize a chilled beam design that provided direct/indirect lighting in a pendant fashion. Upon researching this type of system, products which provided that combination of elements were clearly being used in the industry; however, little information was given on specific lighting characteristics. To accommodate to the IPD/BIM thesis and create an integrated project, the team decided to continue with the use of multiservice chilled beams. Unfortunately, the manufacturer that offered adequate lighting performance data only supplied chilled beams with a direct luminaire component. This hindered the design plans in regards to the lighting aspects but provided sufficient results for both the mechanical and structural students. In implementing chilled beams, the team thought that the design would portray a commitment to innovation, which was a value the New York Times Company wanted to advertise.

The original design concept was to illuminate the ceiling and create the feeling of openness. The method of creating long runs of luminaires to highlight the length of the space was also going to be pursued. The reasoning for these techniques was to enhance the idea of transparency and lightness. The concept of separating the core from the rest of the building was also a design goal to be expressed in the office spaces.

Design Criteria

- IESNA Recommendations: Open Office (Intensive VDT)
  - Horizontal Illuminance – 300 lux (30fc)
  - Vertical Illuminance – 50 lux (5fc)

- ASHRAE Recommendations: Open Office
  - Lighting Power Density – 1.1 W/ ft^2

Design Considerations

Psychological Impression
Impression of Visual Clarity

- Bright, uniform lighting mode
- Some peripheral emphasis, such as with high reflectance walls or wall lighting

Appearance of Space and Luminaires (Important)
The office space should appear active and lively. The design should focus on providing bright, uniform, area lighting. The architectural design provides views of the exterior from any location in the space. The luminaires should be flush with the ceiling to create a smooth, flat surface. The fixtures should also be of similar color to the finished ceiling.

Color Appearance (Important)
Lamps should have a high CRI to pull out the rich color of the desks. Luminaires should provide a cooler color temperature to promote an active environment. The ceiling and walls should appear very bright.

Daylight integration and Control (Important)
Daylight is a major component of the office design. Dimming controls should be used to properly harvest the benefits of daylight. Luminaires should individually respond to the changing exterior environment and provide appropriate lighting levels. In addition to controlling the lumianires, the daylight also needs to be controlled. Solar shades are used across each of the facades. The ultra clear glazing necessitates absolute control of the daylight entering the space.

Direct Glare (Very Important)
All forms of direct glare from daylight or luminaires should be avoided. Glare accessories should be incorporated into the lighting design to remove any glaring sources. This will provide a comfortable workplace for all individuals in the space.

Flicker (Important)
The tasks of computer use and reading or writing require that light sources do not flicker. Any luminaires that caused this occurrence would create an uncomfortable situation and reduce productivity.

Light Distribution on Surfaces (Important)
All surfaces should receive uniform, area lighting. This will provide appropriate illuminance for individuals working in the space. This uniform design should be present throughout the floor with little to no deviations. The design should create a lively environment.

Light Distribution on Task Plane (Important)
The task plane should receive a uniform distribution to create a comfortable work setting. Individuals working at their desks will want to be able to easily focus on tasks without being distracted with varying lighting levels.

Luminance of Room Surfaces (Very Important)
Room surfaces should appear bright to promote an active atmosphere. The ceiling and walls should have a uniform luminance. This will help in creating a completely uniform environment to work in.

Modeling of Faces or Objects (Important)
Social interaction is important in this workspace. Facial expressions and hand or body motions should be easily seen. The use of area lighting should illuminate the entire space so that these factors will be of no issue. To properly model faces, there must be some contribution of vertical illuminance.

Reflected Glare (Very Important)
Reflected glare should be complete removed from the space. Glare can effect an individual's ability to work and feel comfortable. Avoid luminaires that create glaring conditions from windows or desktops.
Glaring controls should also be utilized.

Shadows (Important)
No shadows should be present in this space. Fluorescent sources should be used to create a diffuse lighting solution. Shadows can create uncomfortable working conditions and reduce productivity. Shadows from daylight should also be addressed in this space.

Source/Task/Eye Geometry (Very Important)
Furniture should be spaced out so that luminaires are not directly in front of or behind individuals. Veiling reflections can occur on computer screens or glossy papers if luminaires are located in inappropriate spots.

Maintenance
Luminaires should have lamps with long life to reduce the time between replacement. Proper color temperatures should always be provided to keep the lighting design consistent and uniform. The average height ceiling provides easy access to the fixtures. Luminaires should be able to be relamped or replaced easily to reduce office distractions.

Luminaire Schedule *(Full, enlarged schedule located in the Appendix C.1)*

Type	Image	Product Title	Manufacturer	Catalog Number	Description	Lamp	Ballast	Input Watts	Voltage
O1		Wall/Slot 8400	LiteControl	84-14T8-R/SGL-CWM-G-DA/MK7-WCS-277	4' Recessed perimeter fixture with regressed soft glow lense, matte white finish	FO32/735/SL Osram Sylvania: 21678 OCTRON T8 Fluorescent	Philips Advance VEL-1P32-SC STANDARD ELEC Instant Start	32	277
O1a		Wall/Slot 8400	LiteControl	84-14T8-R/SGL-CWM-G-DA/MK7-WCS-EF-277	4' Recessed perimeter fixture with regressed soft glow lense, matte white finish, integrated emergency fluorescent ballast that powers one T8 lamp for 1	FO32/735/SL Osram Sylvania: 21678 OCTRON T8 Fluorescent	Philips Advance VEL-1P32-SC STANDARD ELEC Instant Start	32	277
O2		Mod-22xa	LiteControl	P-ID-0214T5HO/14T5HO-BW-TCWM-1CWQ-277	4' Pendant-mounted indirect/direct fixture with blade baffles, two-piece extruded aluminium, textured matte white finish	FP54/850/HO/SI/ECO Osram Sylvania: 21022 PENTRON High Output T5 Fluorescent	Philips Advance VEZ-2S54 MARK-10 POWERLINE Elec Dim Programmed Start	24/125	277
O3		CCE Chilled Beam	Halton	CCE	Multiservice Active Chilled Beam with integrated direct luminaire positioned into the bottom panel of the beam, available dimming ballast installation	FP35/841/ECO Osram Sylvania: 20927 PENTRON T5 Fluorescent	Philips Advance ICN-2S28@277 CENTIUM T5 Electronic Programmed Start	41	277

Refer to Appendix C.2 for Luminaire Cut Sheets

Light Loss Factors

12 Month Cycle and Clean Environment

Type	Lamp	Mean Lumens	BF	LDD		RSDD	Total LLF
O1	T8	2444	.92	Category V	.88	.98	.79
O1a	T8	2444	.92	Category V	.88	.98	.79
O2	T5HO	3946	1.00	Category II	.93	.94	.87
O3	T5	3069	1.01	Category V	.88	.98	.87

Lighting Plans

All lighting plans located in Appendix C.3

Office Performance Data

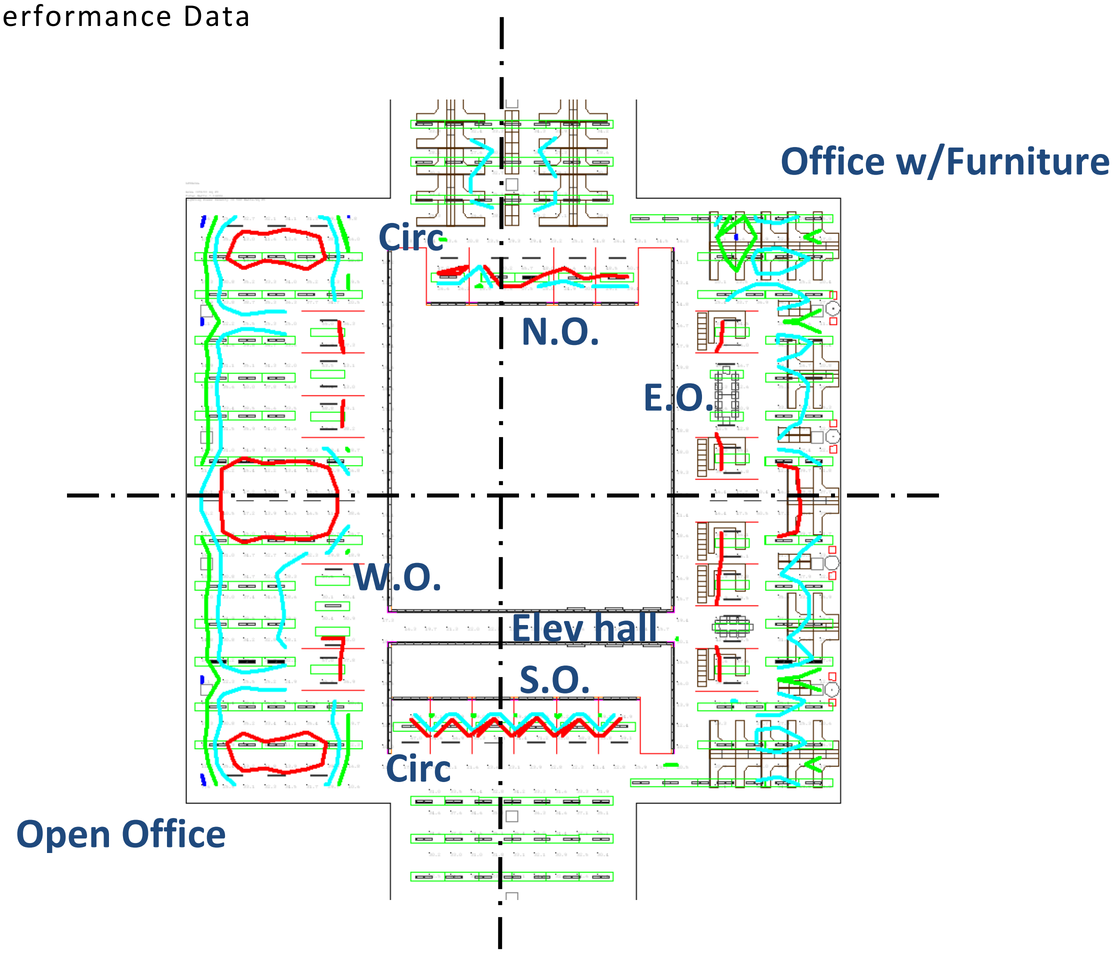
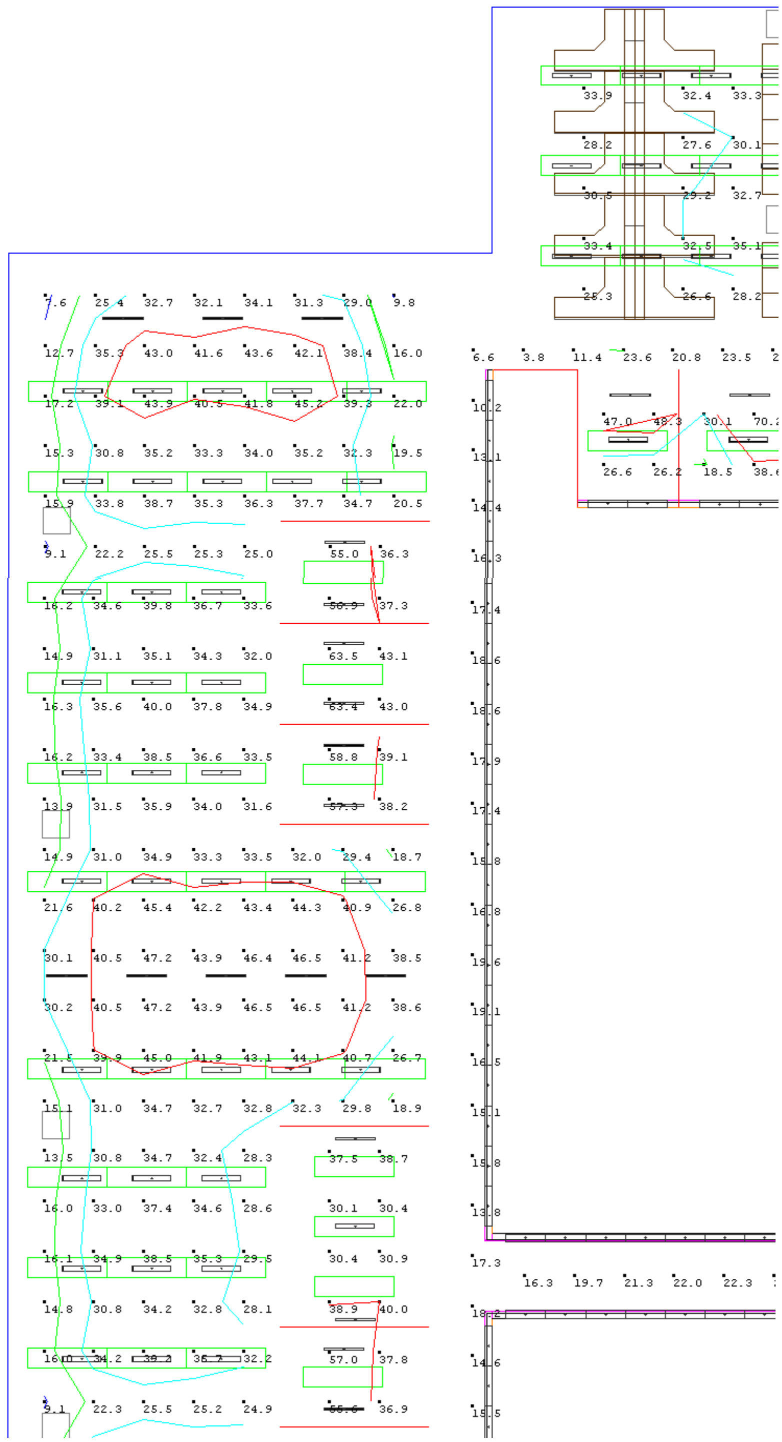


Figure 64: Eighth Floor Office Illuminance Calculation Grid

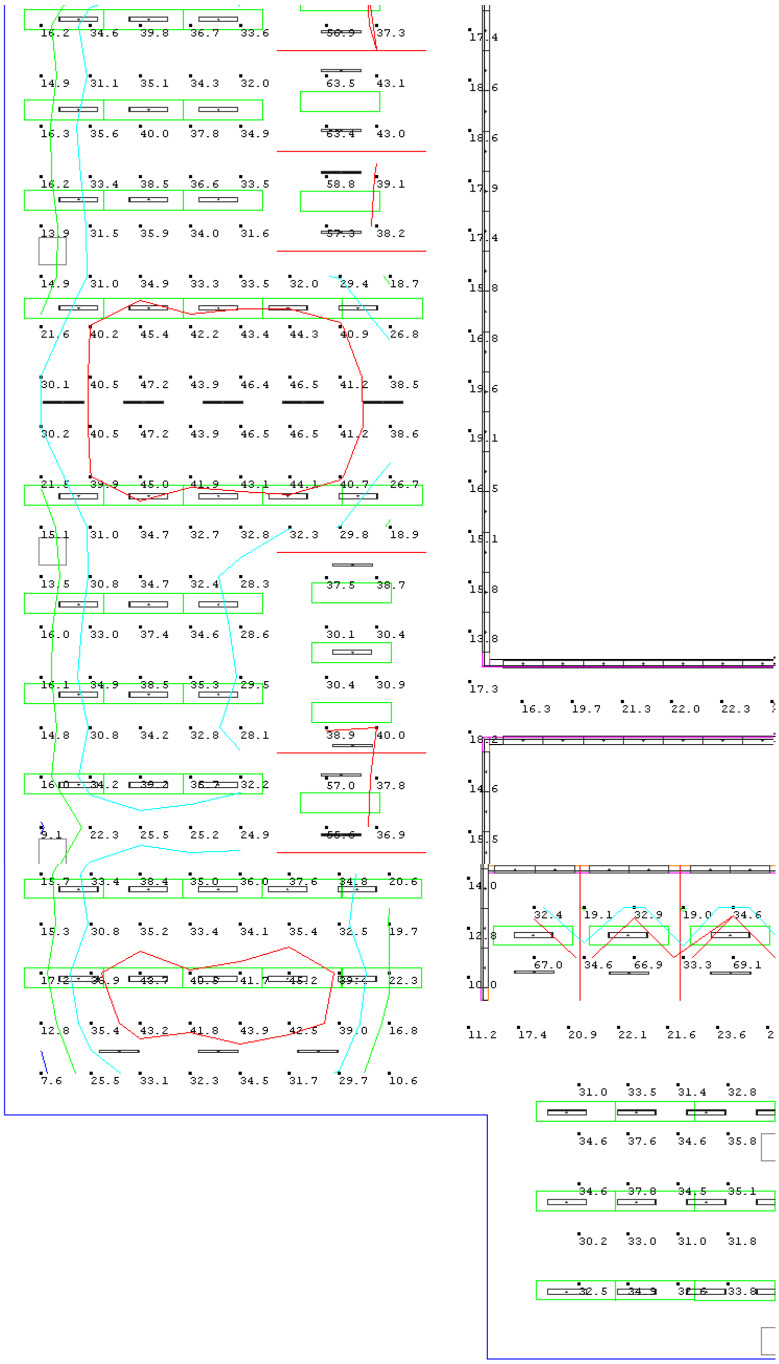
Illuminance Values (Fc)

Space	Average	Max	Min	Avg/Min	Max/Min	Uniform Gradient
Open Office	31.78	47.2	7.6	4.18	6.21	3.36
Open Office w/Furniture	29.64	50.5	9.6	3.09	5.26	2.79
Circulation	18.04	29.4	3.8	4.75	7.74	3.00
Elevator Hall	20.18	22.4	15.7	1.29	1.43	1.21
North Offices	39.64	70.2	18.5	2.14	3.79	2.68
South Offices	39.95	71.2	18.2	2.20	3.91	2.77
West Offices	49.33	63.5	36.3	1.36	1.75	1.53
East Offices	44.08	56.9	33.7	1.31	1.69	1.62

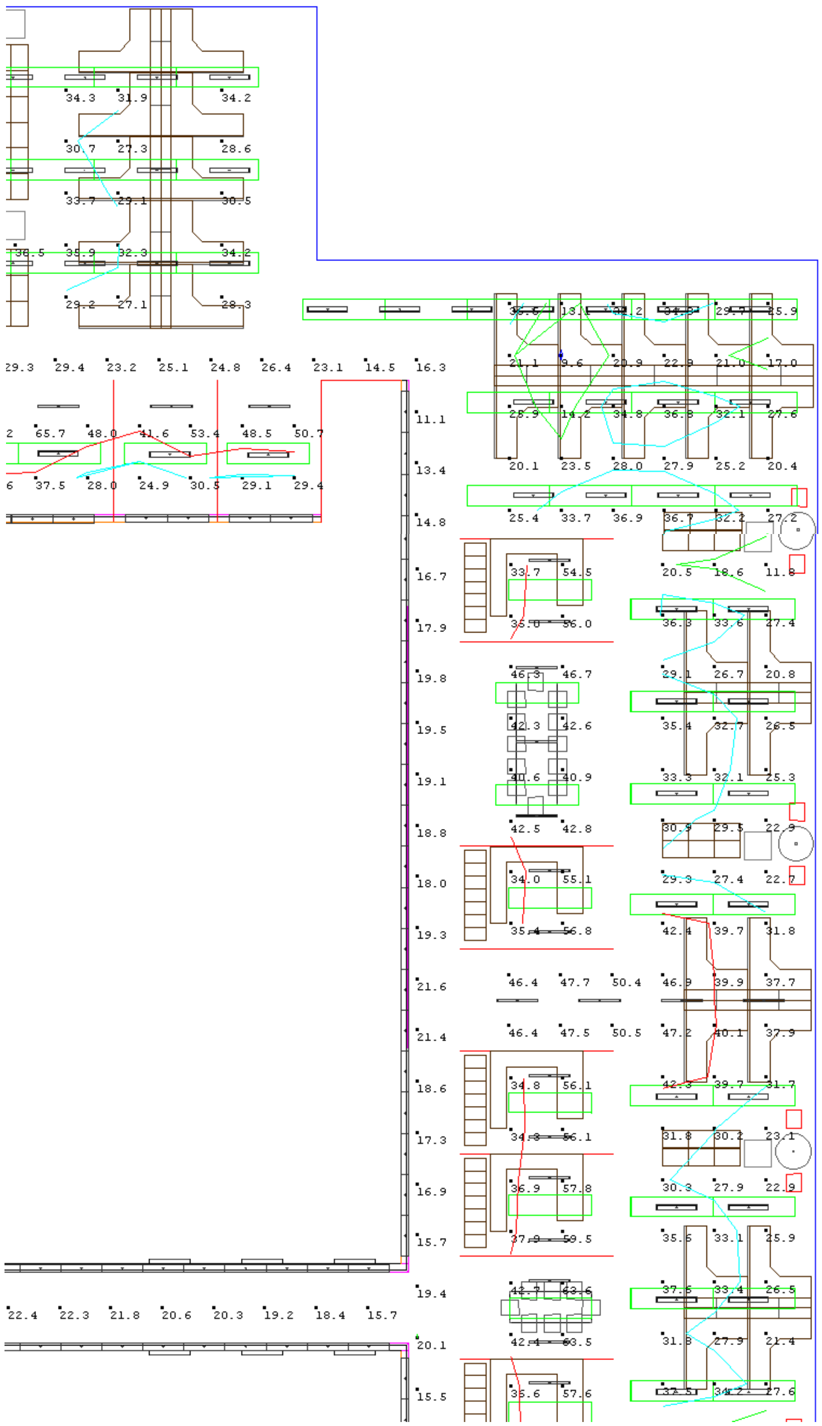
North West Office Enlarged



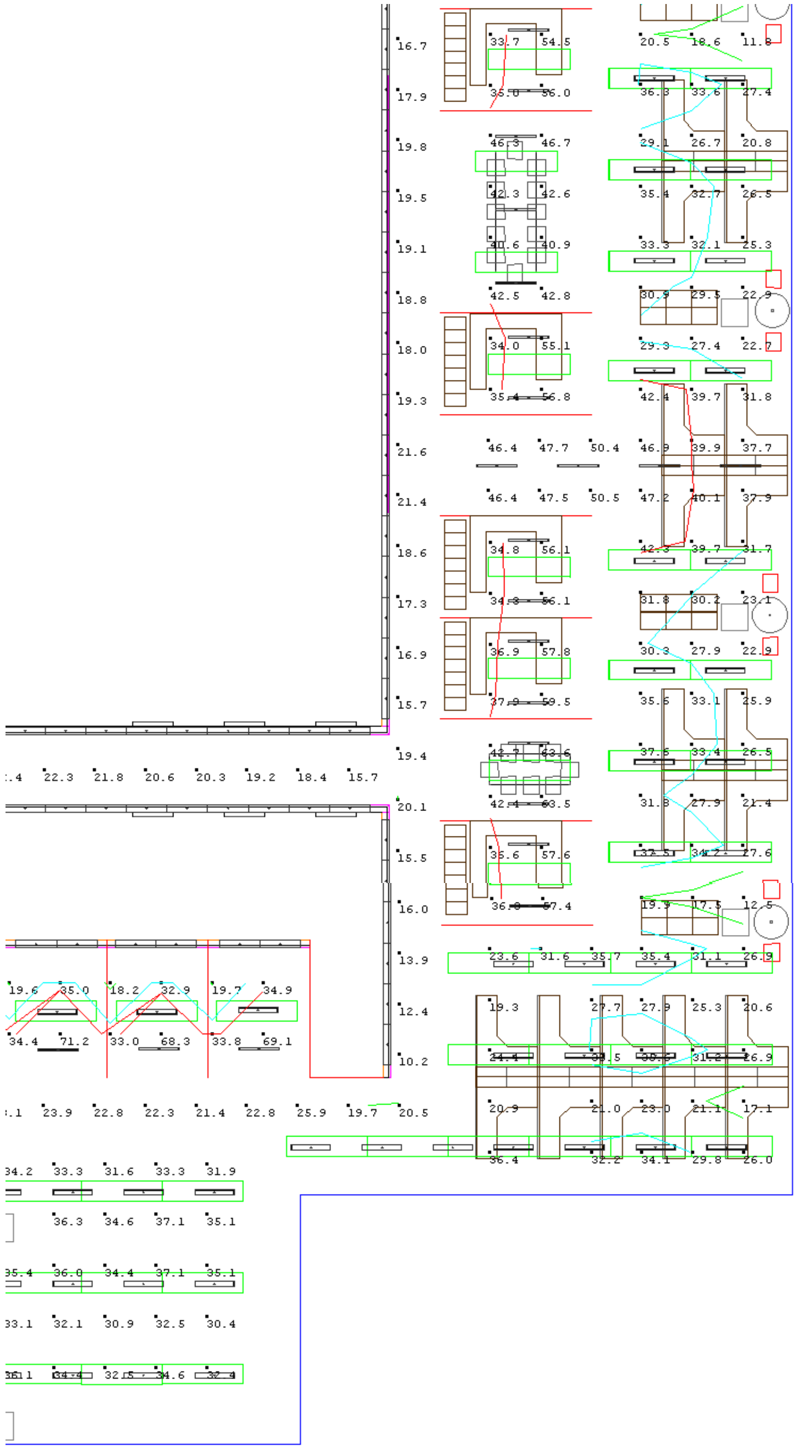
South West Office Enlarged



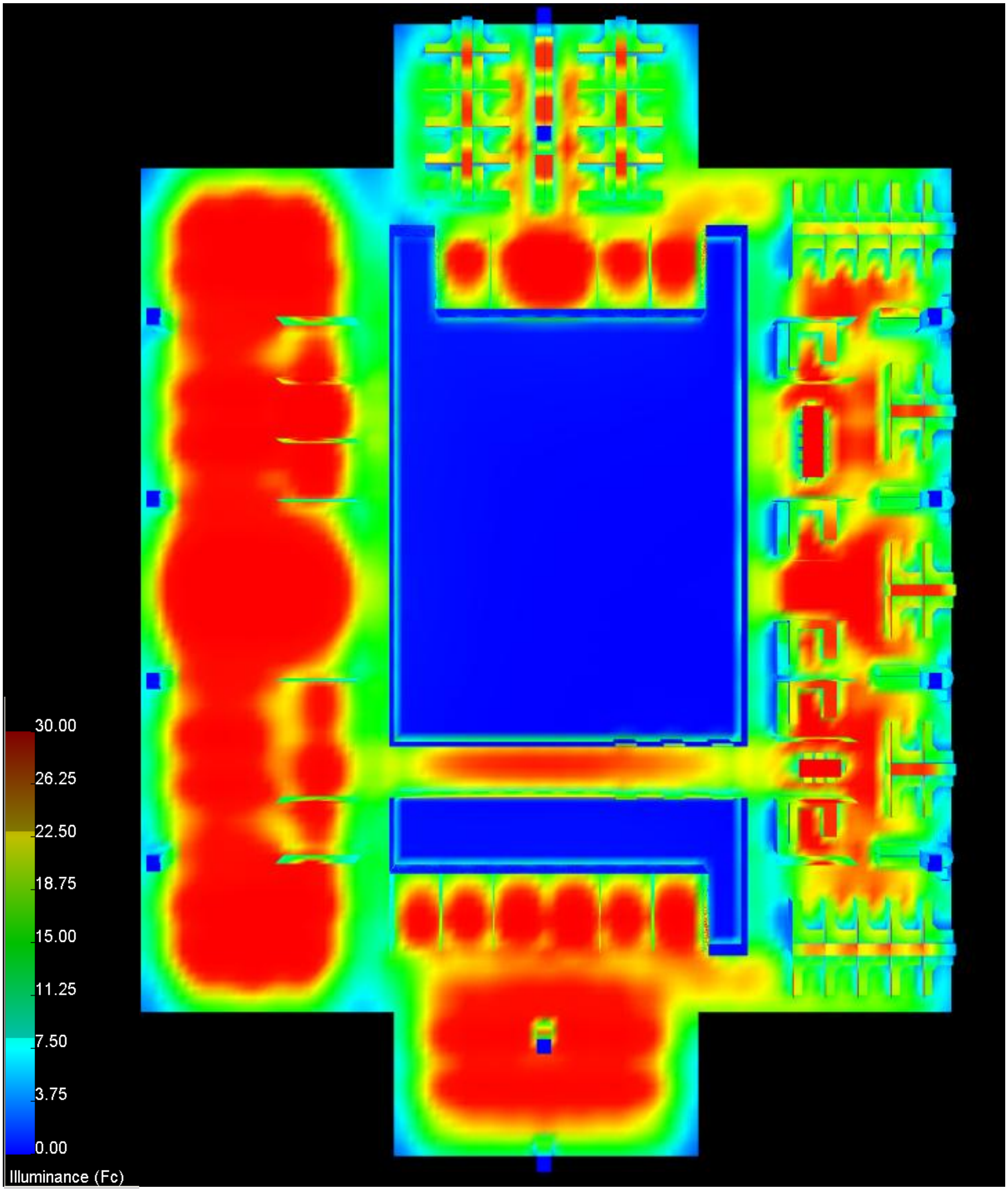
North East Office Enlarged



South East Office Enlarged



Eight Floor Office Pseudo Color



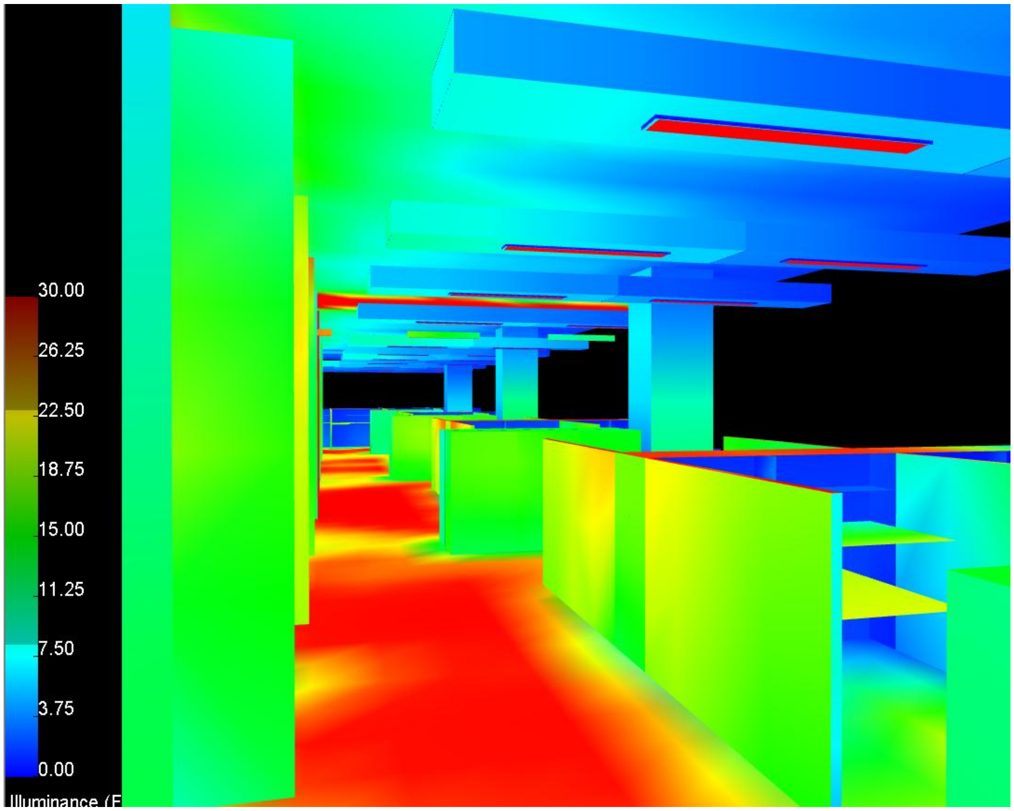


Figure 66: Open Office Pseudo Color

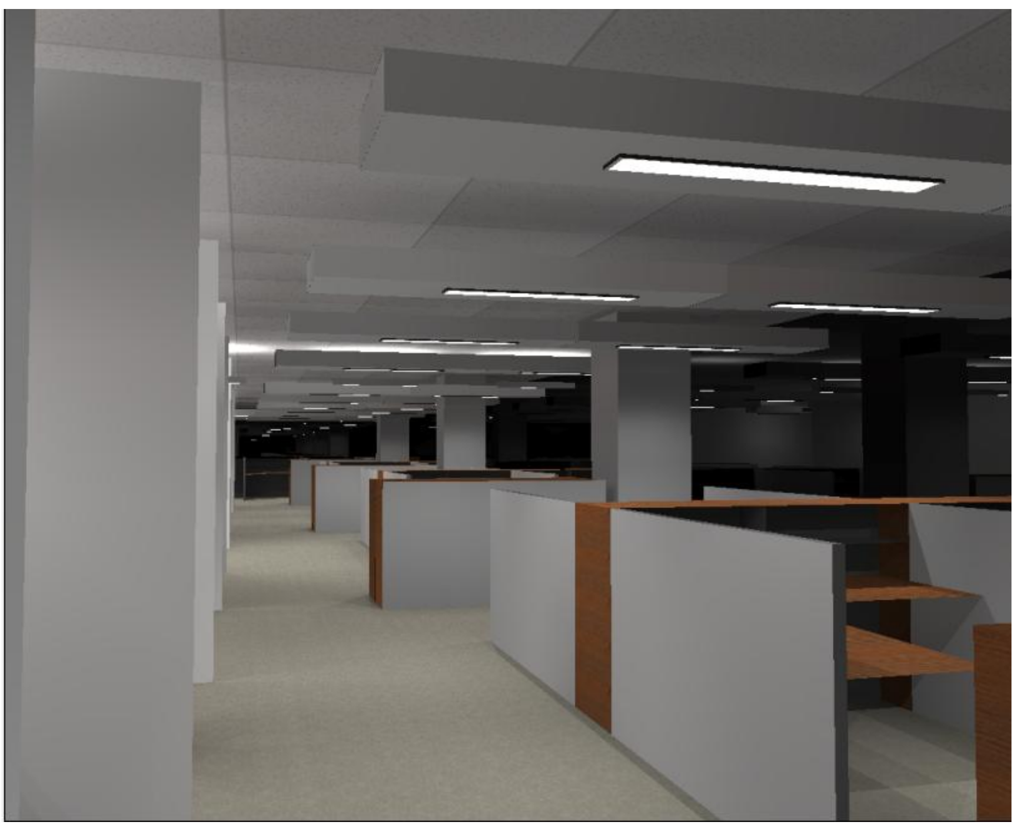


Figure 65: Open Office Rendering

Figure 67: Office Corridor Rendering

Figure 68: Open Office Rendering

Figure 69: Private Offices w/o Furniture Rendering

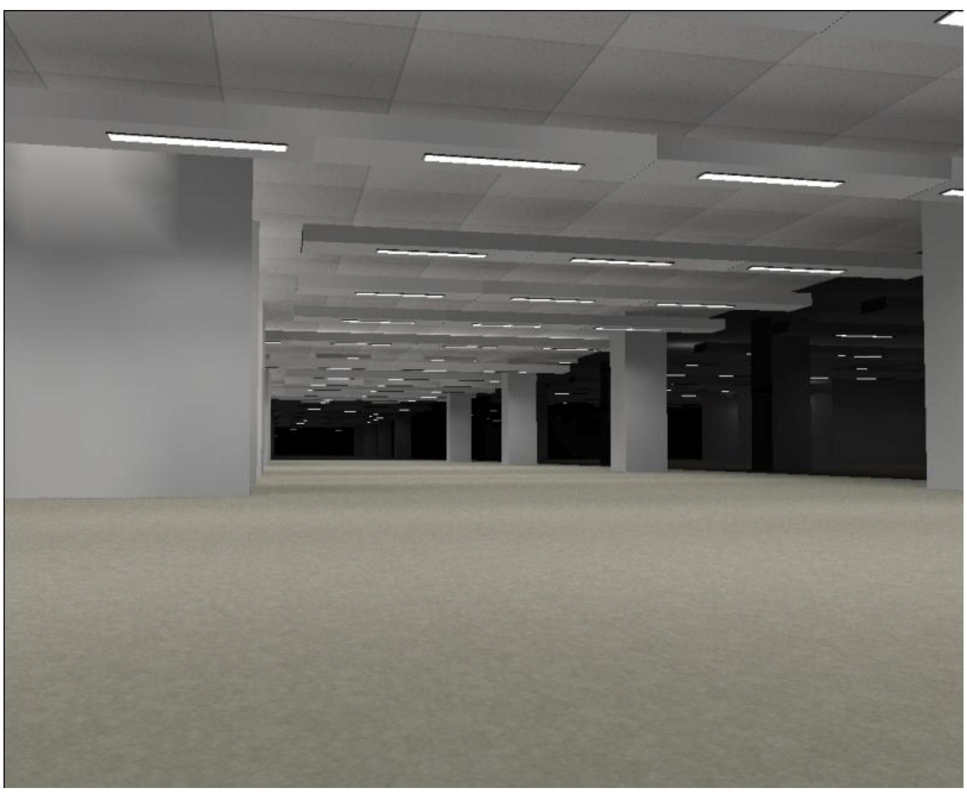


Figure 70: Open Office w/o Furniture Rendering

ASHRAE Compliance (*Required LPD < = 1.1 W/Ft^2*)

Lighting Power Density

Area (*Ft^2*) = 25153
Total Watts = 14894
LPD (*W/Ft^2*) = 0.592

Performance Summary

In using the multiservice chilled beams, the design was driven by the heating and cooling needs. There were a total of 150 chilled beams required for an office space of this size. These were positioned in rows spaced 8 – 10 feet apart. In designing the layout, symmetry was hard to achieve. The best solution was to keep a consistent design between columns and between the glazing and partitioned offices. With this layout, continuous runs throughout the entire floor could not be achieved. The private offices and conference rooms also did not align with the rows of chilled beams. This created a staggered look between the open office and the partitioned sections. The beams also needed to meet code for an open office, private offices, and conference rooms. This added to the uneven distribution of beams between the open plan and the partitioned sections.

Besides obvious aesthetic flaws, the chilled beam layout caused problems with the ability to uniformly light the space. With full height glazing on two sides of the private offices and conference spaces, the lighting design needed to address those spaces as if they were a part of the open plan. This posed as a problem since the rooms did not align with the chilled beam layout. One chilled beam could not provide enough illuminance in a private office or create enough light output to contribute to the open plan distribution. A design using only chilled beam luminaires did not provide adequate illuminance or a uniform distribution. To compensate for the lack of light output, low-profile direct/indirect luminaires were added to several areas in the floor plan. The luminaire component was removed from each chilled beam in both the private offices and conference spaces. Upon addition of the pendant fixtures, the entire office floor received a more uniform illuminance. Areas where the pendants were located create hot spots of higher illuminance levels.

Even though the results are not ideal, the overall look of the space still portrays the themes Renzo Piano wanted instill. The chilled beam design displays a unique approach to building design that represents the New York Time's commitment to innovation. The different lighting techniques create an interesting contrast between the partitioned offices and the open plan. Each private office and conference room has an illuminated ceiling that seems to separate them from the rest of the space. Behind the partitioned spaces, the core walls are illuminated with the same cove lighting used in the lobby. This idea again seems to separate the rest of the building from the structural core. These lighting techniques help to create the feeling of transparency. The open plan, partitioned spaces, and the core are all illuminated in a different way. The glass walls help to create the illusion that a view through the office is actually a view through three different spaces.

The lighting design meets the requirements set forth by the IESNA Handbook. An average of 30fc is present across a plane in the open office area. Where furniture is located in the model, this value in not as uniform; however, most desks seem to receive adequate illuminance. The partitioned spaces receive higher values than are required. The DALI system can reduce these levels to a more appropriate value. The design also complies with ASHRAE standards in regards to lighting power density.

OFFICE ELECTRICAL REDESIGN

The new lighting design replaced all existing luminaires in the space. Each circuit in the previous design was reused except for the circuit powering the rooms in the core spaces. All fixtures operate at 277V.

Controls

The office floors utilize a digitally addressable lighting interface (DALI) system with dimmable ballasts to harvest the benefits of daylight. There are 16 zones per floor, each with their own photosensor. Every luminaire within a zone takes input from the respective photosensor and dims accordingly. The system also allows for the programming of individual luminaires to accommodate to varying lighting needs. Refer to Appendix C.5 for Lutron Quantum information.

Circuiting Layout

Refer to Appendix C.3 for full size drawings of the electric layout and circuiting

Existing Panelboards/ Modified Circuits

The following figures depict the existing panelboards with the modified lighting circuits highlighted. Due to the lack of information provided for the IPD/BIM thesis, no other loads were able to be added to the panelboards. Refer to Appendix C.4 for a listing of all redesigned panelboards and feeders.

Panelboard Tag	Voltage	Normal/Emergency
EHV-8	480Y/277	Yes
P-8-1	480Y/277	No
P-8-2	480Y/277	No

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	EHV-8	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	100A	PANEL LOCATION:	EAST ELECTRICAL ROOM	OPTIONS:	
SIZE/TYPE MAIN:	100A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
		0	20A/1P	1	*			2	20A/1P	0		
		0	20A/1P	3		*		4	20A/1P	0		
		0	20A/1P	5			*	6	20A/1P	0		
		0	20A/1P	7	*			8	20A/1P	0		
		0	20A/1P	9		*		10	20A/1P	0		
		0	20A/1P	11			*	12	20A/1P	0		
		0	20A/1P	13	*			14	20A/1P	0		
		0	20A/1P	15		*		16	20A/1P	0		
		0	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	1300	9TH FLOOR	Emerg. LTG. 9th floor
0	0	0	20A/1P	27		*		28	20A/1P	1200	9TH FLOOR	Emerg. LTG. 9th floor
0	0	0	20A/1P	29			*	30	20A/1P	1300	8TH FLOOR	Emerg. LTG. 8th floor
0	0	0	20A/1P	31	*			32	20A/1P	1200	8TH FLOOR	Emerg. LTG. 8th floor
		0	20A/1P	33		*		34	20A/1P	1100	7TH FLOOR	Emerg. LTG. 7th floor
		0	20A/1P	35			*	36	20A/1P	1400	7TH FLOOR	Emerg. LTG. 7th floor
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A Ph.	2.50	TOTAL DESIGN LOAD (KW)	9.00
CONNECTED LOAD (KW) - B Ph.	2.30	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	2.70	TOTAL DESIGN LOAD (AMPS)	14

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	P-8-1	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	100A	PANEL LOCATION:	WEST ELECTRICAL ROOM	OPTIONS:	
SIZE/TYPE MAIN:	100A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
DL-08-01	N1, N2	1520	20A/1P	1	*			2	20A/1P	1120	N2	DL-08-02
DL-08-03	W1	1200	20A/1P	3		*		4	20A/1P	1840	W2	DL-08-04
DL-08-05	W3	1760	20A/1P	5			*	6	20A/1P	1840	W4	DL-08-06
DL-08-07	W5	1160	20A/1P	7	*			8	20A/1P	1080	N1	DL-08-08
PERIMETER COVE	NORTH	480	20A/1P	9		*		10	20A/1P	560	WEST	PERIMETER COVE
PERIMETER COVE	WEST	560	20A/1P	11			*	12	20A/1P	2100	CORE	
STAIR COVE	W1	250	20A/1P	13	*			14	20A/1P	250	W5	STAIR COVE
		0	20A/1P	15		*		16	20A/1P	0		
		0	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A Ph.	5.38	TOTAL DESIGN LOAD (KW)	18.86
CONNECTED LOAD (KW) - B Ph.	4.08	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	6.26	TOTAL DESIGN LOAD (AMPS)	28

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	P-8-2	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	100A	PANEL LOCATION:	EAST ELECTRICAL ROOM	OPTIONS:	
SIZE/TYPE MAIN:	100A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
DL-08-09	S1,S2	1520	20A/1P	1	*			2	20A/1P	1080	S2	DL-08-10
DL-08-11	E1	1480	20A/1P	3		*		4	20A/1P	1840	E2	DL-08-12
DL-08-13	E3	1800	20A/1P	5			*	6	20A/1P	1800	E4	DL-08-14
DL-08-15	E5	1520	20A/1P	7	*			8	20A/1P	1120	S1	DL-08-16
PERIMETER COVE	SOUTH	480	20A/1P	9		*		10	20A/1P	560	EAST	PERIMETER COVE
PERIMETER COVE	EAST	560	20A/1P	11			*	12	20A/1P	400	CORE	
	0	0	20A/1P	13	*			14	20A/1P	0	0	
		0	20A/1P	15		*		16	20A/1P	0		
		0	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A Ph.	5.24	TOTAL DESIGN LOAD (KW)	16.99
CONNECTED LOAD (KW) - B Ph.	4.36	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	4.56	TOTAL DESIGN LOAD (AMPS)	26

New Panelbaords/ Modified Circuits

PANELBOARD SCHEDULE

VOLTAGE:	48-Y/277V,3PH,4W	PANEL TAG:	EHV-8	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	100A	PANEL LOCATION:	EAST ELECTRICAL ROOM	OPTIONS:	
SIZE/TYPE MAIN:	100A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
		0	20A/1P	1	*			2	20A/1P	0		
		0	20A/1P	3		*		4	20A/1P	0		
		0	20A/1P	5			*	6	20A/1P	0		
		0	20A/1P	7	*			8	20A/1P	0		
		0	20A/1P	9		*		10	20A/1P	0		
		0	20A/1P	11			*	12	20A/1P	0		
		0	20A/1P	13	*			14	20A/1P	0		
		0	20A/1P	15		*		16	20A/1P	0		
		0	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	1300	9TH FLOOR	Emerg LTG 9th floor
0	0	0	20A/1P	27		*		28	20A/1P	1200	9TH FLOOR	Emerg LTG 9th floor
0	0	0	20A/1P	29			*	30	20A/1P	588	8TH FLOOR	Emerg LTG 8th floor
0	0	0	20A/1P	31	*			32	20A/1P	474	8TH FLOOR	Emerg LTG 8th floor
		0	20A/1P	33		*		34	20A/1P	1100	7TH FLOOR	Emerg LTG 7th floor
		0	20A/1P	35			*	36	20A/1P	1400	7TH FLOOR	Emerg LTG 7th floor
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A Ph.	1.77	TOTAL DESIGN LOAD (KW)	7.27
CONNECTED LOAD (KW) - B Ph.	2.30	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	1.99	TOTAL DESIGN LOAD (AMPS)	11

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	P-8-1	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	100A	PANEL LOCATION:	WEST ELECTRICAL ROOM	OPTIONS:	
SIZE/TYPE MAIN:	100A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
DL-08-01	N1, N2	656	20A/1P	1	*			2	20A/1P	690	N2	DL-08-02
DL-08-03	W1	703	20A/1P	3		*		4	20A/1P	1037	W2	DL-08-04
DL-08-05	W3	953	20A/1P	5			*	6	20A/1P	828	W4	DL-08-06
DL-08-07	W5	703	20A/1P	7	*			8	20A/1P	690	N1	DL-08-08
CORE COVE	WEST	672	20A/1P	9		*		10	20A/1P	416	ELEV HALL	CORE COVE
CORE COVE	WEST	192	20A/1P	11			*	12	20A/1P	2100	CORE	
STAIR COVE	W1	250	20A/1P	13	*			14	20A/1P	250	W5	STAIR COVE
0		0	20A/1P	15		*		16	20A/1P	0		0
		0	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A Ph.	3.24	TOTAL DESIGN LOAD (KW)	12.17
CONNECTED LOAD (KW) - B Ph.	2.83	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	4.07	TOTAL DESIGN LOAD (AMPS)	18

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	P-8-2	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	100A	PANEL LOCATION:	EAST ELECTRICAL ROOM	OPTIONS:	
SIZE/TYPE MAIN:	100A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
DL-08-09	S1,S2	738	20A/1P	1	*			2	20A/1P	690	S2	DL-08-10
DL-08-11	E1	533	20A/1P	3		*		4	20A/1P	955	E2	DL-08-12
DL-08-13	E3	1123	20A/1P	5			*	6	20A/1P	789	E4	DL-08-14
DL-08-15	E5	533	20A/1P	7	*			8	20A/1P	460	S1	DL-08-16
CORE COVE	EAST	672	20A/1P	9		*		10	20A/1P	448	EAST	CORE COVE
CORE COVE	ELEV HALL	192	20A/1P	11			*	12	20A/1P	400	CORE	
	0	0	20A/1P	13	*			14	20A/1P	0	0	
		0	20A/1P	15		*		16	20A/1P	0		
		0	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A Ph.	2.42	TOTAL DESIGN LOAD (KW)	9.04
CONNECTED LOAD (KW) - B Ph.	2.61	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	2.50	TOTAL DESIGN LOAD (AMPS)	14

PANELBOARD SIZING WORKSHEET

Panel Tag-------------------------->					EHV-8	Panel Location:		EAST ELECTRICAL ROOM		
Nominal Phase to Neutral Voltage------->					277	Phase:		3		
Nominal Phase to Phase Voltage-------->					480	Wires:		4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A				0	w		0	0	
2	A				0	w		0	0	
3	B				0	w		0	0	
4	B				0	w		0	0	
5	C				0	w		0	0	
6	C				0	w		0	0	
7	A				0	w		0	0	
8	A				0	w		0	0	
9	B				0	w		0	0	
10	B				0	w		0	0	
11	C				0	w		0	0	
12	C				0	w		0	0	
13	A				0	w		0	0	
14	A				0	w		0	0	
15	B				0	w		0	0	
16	B				0	w		0	0	
17	C				0	w		0	0	
18	C				0	w		0	0	
19	A				0	w		0	0	
20	A				0	w		0	0	
21	B				0	w		0	0	
22	B				0	w		0	0	
23	C				0	w		0	0	
24	C				0	w		0	0	
25	A				0	w		0	0	
26	A	Emerg LTG 9th floor	3	9TH FLOOR	1.3	kw		1300	1625	
27	B					kw		0	0	
28	B	Emerg LTG 9th floor	3	9TH FLOOR	1.2	kw		1200	1500	
29	C					kw		0	0	
30	C	Emerg LTG 8th floor	3	8TH FLOOR	0.588	kw		588	735	
31	A					kw		0	0	
32	A	Emerg LTG 8th floor	3	8TH FLOOR	0.474	kw		474	593	
33	B				0	kw		0	0	
34	B	Emerg LTG 7th floor	3	7TH FLOOR	1.1	kw		1100	1375	
35	C				0	kw		0	0	
36	C	Emerg LTG 7th floor	3	7TH FLOOR	1.4	kw		1400	1750	
37	A				0	w		0	0	
38	A				0	w		0	0	
39	B				0	w		0	0	
40	B				0	w		0	0	
41	C				0	w		0	0	
42	C				0	w		0	0	
PANEL TOTAL								6.1	7.6	Amps= 9.1

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					1.8	2.2	29%	8.0
PHASE TOTAL	B					2.3	2.9	38%	10.4
PHASE TOTAL	C					2.0	2.5	33%	9.0

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		6.1	7.6		6.1	7.6	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
Total Demand Loads						6.1	7.6			
Spare Capacity			20%			1.2	1.5			
Total Design Loads						7.3	9.1	0.80	Amps=	10.9

PANELBOARD SIZING WORKSHEET

Panel Tag----------------->	P-8-1	Panel Location:	WEST ELECTRICAL ROOM
Nominal Phase to Neutral Voltage---->	277	Phase:	3
Nominal Phase to Phase Voltage---->	480	Wires:	4

Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	DL-08-01	3	N1, N2	656	w		656	820		
2	A	DL-08-02	3	N2	690	w		690	863		
3	B	DL-08-03	3	W1	703	w		703	879		
4	B	DL-08-04	3	W2	1037	w		1037	1296		
5	C	DL-08-05	3	W3	953	w		953	1191		
6	C	DL-08-06	3	W4	828	w		828	1035		
7	A	DL-08-07	3	W5	703	w		703	879		
8	A	DL-08-08	3	N1	690	w		690	863		
9	B	CORE COVE	3	WEST	672	w		672	840		
10	B	CORE COVE	3	ELEV HALL	416	w		416	520		
11	C	CORE COVE	3	WEST	192	w		192	240		
12	C		3	CORE	2.1	KW		2100	2625		
13	A	STAIR COVE	3	W1	0.25	KW		250	313		
14	A	STAIR COVE	3	W5	0.25	KW		250	313		
15	B				0	w		0	0		
16	B				0	w		0	0		
17	C				0	w		0	0		
18	C				0	w		0	0		
19	A				0	w		0	0		
20	A				0	w		0	0		
21	B				0	w		0	0		
22	B				0	w		0	0		
23	C				0	w		0	0		
24	C				0	w		0	0		
25	A				0	w		0	0		
26	A				0	w		0	0		
27	B				0	w		0	0		
28	B				0	w		0	0		
29	C				0	w		0	0		
30	C				0	w		0	0		
31	A				0	w		0	0		
32	A				0	w		0	0		
33	B				0	w		0	0		
34	B				0	w		0	0		
35	C				0	w		0	0		
36	C				0	w		0	0		
37	A				0	w		0	0		
38	A				0	w		0	0		
39	B				0	w		0	0		
40	B				0	w		0	0		
41	C				0	w		0	0		
42	C				0	w		0	0		
PANEL TOTAL								10.1	12.7	Amps=	15.3
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					3.2	4.0	32%	14.6
PHASE TOTAL			B					2.8	3.5	28%	12.8
PHASE TOTAL			C					4.1	5.1	40%	18.4

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		10.1	12.7		10.1	12.7	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
	Total Demand Loads					10.1	12.7			
	Spare Capacity		20%			2.0	2.5			
	Total Design Loads					12.2	15.2	0.80	Amps=	18.3

PANELBOARD SIZING WORKSHEET										
Panel Tag------------------------->				P-8-2	Panel Location:			EAST ELECTRICAL ROOM		
Nominal Phase to Neutral Voltage------->				277	Phase:			3		
Nominal Phase to Phase Voltage-------->				480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	DL-08-09	3	S1,S2	738	w		738	923	
2	A	DL-08-10	3	S2	690	w		690	863	
3	B	DL-08-11	3	E1	533	w		533	666	
4	B	DL-08-12	3	E2	955	w		955	1194	
5	C	DL-08-13	3	E3	1123	w		1123	1404	
6	C	DL-08-14	3	E4	789	w		789	986	
7	A	DL-08-15	3	E5	533	w		533	666	
8	A	DL-08-16	3	S1	460	w		460	575	
9	B	CORE COVE	3	EAST	672	w		672	840	
10	B	CORE COVE	3	EAST	448	w		448	560	
11	C	CORE COVE	3	ELEV HALL	192	w		192	240	
12	C		3	CORE	0.4	KW		400	500	
13	A				0	w		0	0	
14	A				0	w		0	0	
15	B				0	w		0	0	
16	B				0	w		0	0	
17	C				0	w		0	0	
18	C				0	w		0	0	
19	A				0	w		0	0	
20	A				0	w		0	0	
21	B				0	w		0	0	
22	B				0	w		0	0	
23	C				0	w		0	0	
24	C				0	w		0	0	
25	A				0	w		0	0	
26	A				0	w		0	0	
27	B				0	w		0	0	
28	B				0	w		0	0	
29	C				0	w		0	0	
30	C				0	w		0	0	
31	A				0	w		0	0	
32	A				0	w		0	0	
33	B				0	w		0	0	
34	B				0	w		0	0	
35	C				0	w		0	0	
36	C				0	w		0	0	
37	A				0	w		0	0	
38	A				0	w		0	0	
39	B				0	w		0	0	
40	B				0	w		0	0	
41	C				0	w		0	0	
42	C				0	w		0	0	
PANEL TOTAL								7.5	9.4	Amps= 11.3

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					2.4	3.0	32%	10.9
PHASE TOTAL	B					2.6	3.3	35%	11.8
PHASE TOTAL	C					2.5	3.1	33%	11.3

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		7.5	9.4		7.5	9.4	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
Total Demand Loads						7.5	9.4			
Spare Capacity			20%			1.5	1.9			
Total Design Loads						9.0	11.3	0.80	Amps=	13.6

COST

The cost analysis for the floor system was done by comparing the upfront costs and cost savings of each of the system alternatives and the resulting energy savings or rental income the systems obtain annually. It was found that adding an additional floor would cost an additional $12.3 million.

	New Floor System
Structure	$ 2,988,000.00
Raised Floor	$ 885,000.00
HVAC Cost	$ 3,328,000.00
Plumbing Cost	$ 303,000.00
Electrical Cost	$ 2,915,000.00
Communications	$ 1,027,000.00
Interiors	$ 607,000.00
Furnishing	$ 215,000.00
	$ 12,268,000.00

This upfront cost can be offset by some of the benefits to adding another floor. These benefits include additional income from renting the floor, and the reduced energy consumption of the chilled beams. These two benefits amount to $ 1.8 million per year, producing a payback of just under 10 years.

Additional Rent	$ 1,260,000
Energy Savings	$ 565,800
Annual Income/Savings	$ 1,825,800
Payback Period	9.75 years

METRICS OF SUCCESS: FLOOR SYSTEM

The goal of the floor system redesign was to take advantage of a great opportunity to provide benefit to the owner by reducing the height of the typical floor sandwich in both the New York Times and the Forrest City Ratner sections of the building. A reduction in floor/ceiling assembly height can provide the opportunity of adding additional floors to the building. Assuming that the New York Times has no need for additional floor space, additional floors can be used by Forrest City Ratner to lease to possible tenants and accrue additional income.

Utilizing active chilled beams, the mechanical system redesign has successfully helped meet the objective of lowering floor to floor heights. By replacing the underfloor air distribution system in the New York Times Company floors and the variable air volume system in the Forrest City Ratner Company, the chilled beam system provides several advantages. These advantages include removing the 16" underfloor plenum and a reduction in energy consumption, cost and associated emissions. The redesigned system also allows for more offsite pre-manufacturing and increased coordination during construction. In addition, the chilled beam system will provide better indoor air quality and lower overall operating costs for the building.

The goal of the lighting redesign for the office was to instill the concepts of transparency and lightness while also providing appropriate illuminance levels. The new design also needed to address the reduction of the floor sandwich. In using the multiservice chilled beam system, the plenum was able to be reduced by a significant amount. Unfortunately, the chilled beam system posed a problem for the lighting design. The spacing and number of chilled beams limited the lighting potential. Additional luminaires were required to create a uniform design. The overall end result was successful in that it reflected an new innovative design that reduced the the amount of required plenum space and aided in the themes of transparency and lightness.

CORE REDESIGN

REDESIGN GOALS

The group determined that redesigning the core in order to increase the rentable space within the New York Times Building would be a viable investigation. Increasing the rentable space on each floor would increase the owner's annual income. It was proposed by the group to shrink the core footprint by investigating alternative architectural layouts and structural configurations.

There were many alterations that were looked at in order to reduce the core footprint. Some were proved to be more successful than others, both in adding rentable space, as well as sustaining the functionality of the architectural layout. The architecture of the core really dictated the amount of change that could be done to reduce the area of the core. One area of interest for the building's architectural feel was the lobby of the building. It was important to always be conscious of what each change would do to the lobby. Therefore, the core alternate that was finally used had minimal impact on the lobby layout.

CORE ALTERNATE OPTIONS

The first option that was weighed was to reduce the size of the core both in the North-South direction and the East West direction. With the architecture controlling the design of the core, it was found to be very difficult to noticeably shrink the core in the North-South direction. Reducing the size of elevator corridors was one way of reducing size, but it was found that it would take away too much from the interior feel that the architect was going for. The only other area that could be reduced in the North-South direction was the service area of the core. It was difficult to reduce this area without having to reduce corridor area and access areas in the mechanical and electrical service rooms. The other area that was affected was the lobby on the first floor. Any type of reduction in size would drastically affect the architectural feel of the lobby and entrance area. It was important to the group to not impact the architecture and openness of the lobby space.

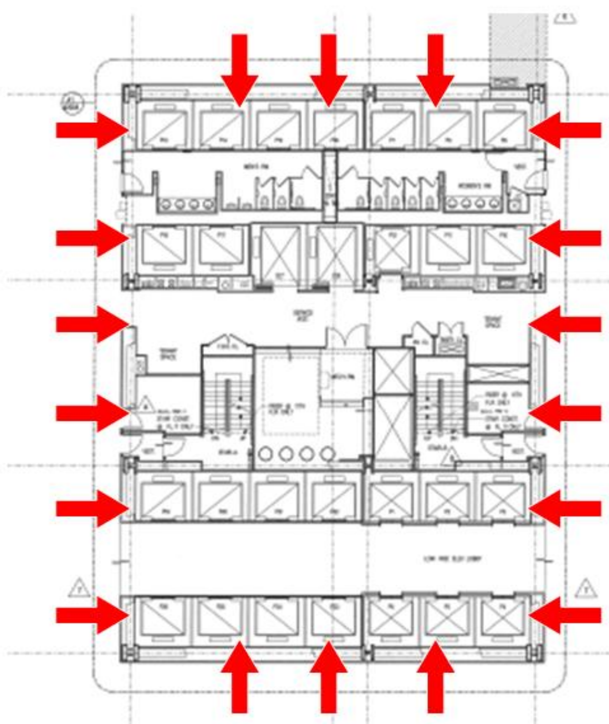


Figure 71

This option also used an eccentric concrete core in order to keep the elevators in the existing layout, while still trying to design a concrete core. The issue that was presented with this core layout was that the eccentricity of the central returns would cause an eccentric center of rigidity which would cause torsional effects under lateral loadings. For these reasons, it was felt that a symmetric core configuration would be a better alternative.

Reduction in core size would have to be achieved in the East West direction of the building. There is some opportunity to study the layout of the elevators in order to reduce core space and add additional rentable area to the building, especially in the Forrest City Ratner portion of the building. The group has made the assumption that there is a demanding market for leasable space in New York City. This assumption has been made in order to account for a market that is closer to the market demand that was seen during the time that this project was being developed in 2003 and 2004.

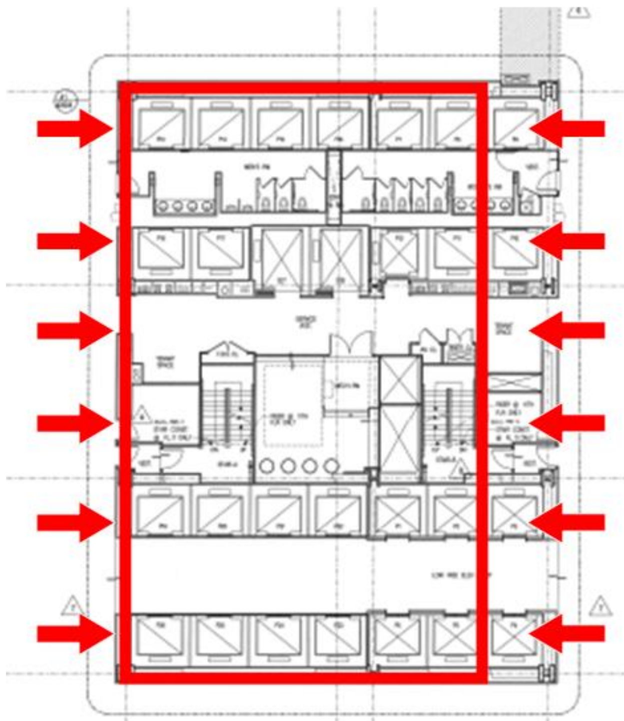


Figure 72

The group looked into trying to eliminate the number of elevators that were needed in the building. The width of the core is controlled by the amount of elevators needed, so by reducing the number of elevators by four the width of the core could be reduced. Various factors had to be looked at in order to reduce the number of elevators while keeping the wait times in a reasonable range. These included the speed of the elevators, the capacity of the elevator, and the call system used for vertical transportation. Speaking to various industry members on this topic made it evident that the system is one of the more advanced and efficient vertical transportation systems that are used in the industry. It would be very difficult to improve the current system enough to reduce the numbers of elevators needed.

Finally, the configuration that was used has a symmetrical structural core that surrounds six elevators in each of the four rows. The seventh in each of the rows is place outside of the structural core. This makes the overall footprint of the core asymmetrical. It was decide to proceed with the change due to its advantages for reducing the footprint in the Forrest City Ratner floors. The asymmetry in the core only occurs in the New York Times portion of the building. When the low and mid-low rise elevator banks drop off on the 17th and 29th floors, respectively, the architectural core become contained within the structural core. The group wanted to maintain the existing flexibility of the leasable space of the Forrest City Ratner floors within the core. Openings were made in the core on the north and south core walls. These cutouts provide the tenant flexibility to access the spaces that are opened up when elevators drop out.

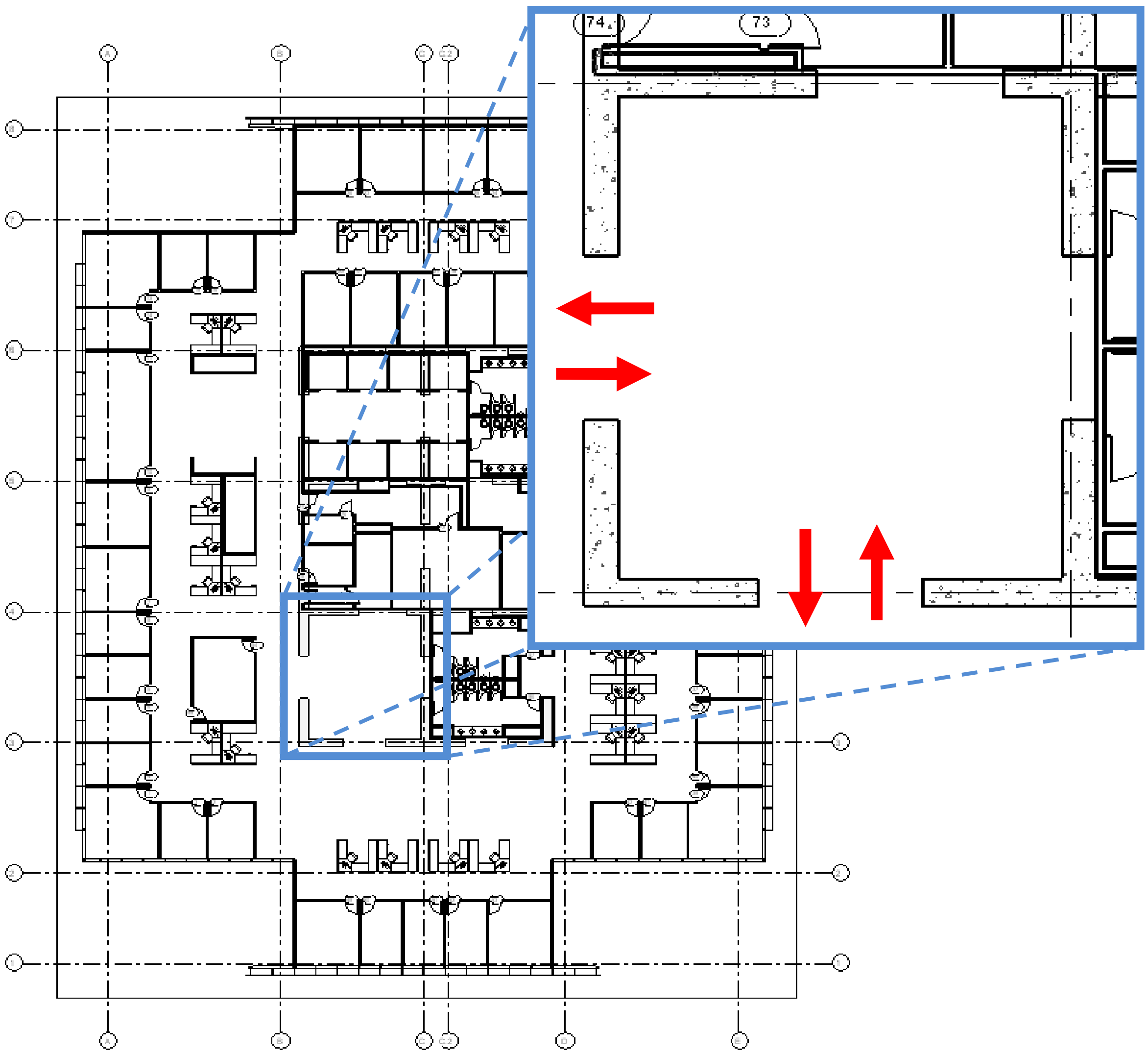


Figure 73

In order to achieve the overall goal of increasing rentable space, the team decided to reconfigure the core of the New York Times Building. To achieve this, the group decided to decrease the width of the structural core from 65' to 56' (center-of-wall to center-of-wall) in the East/West direction.

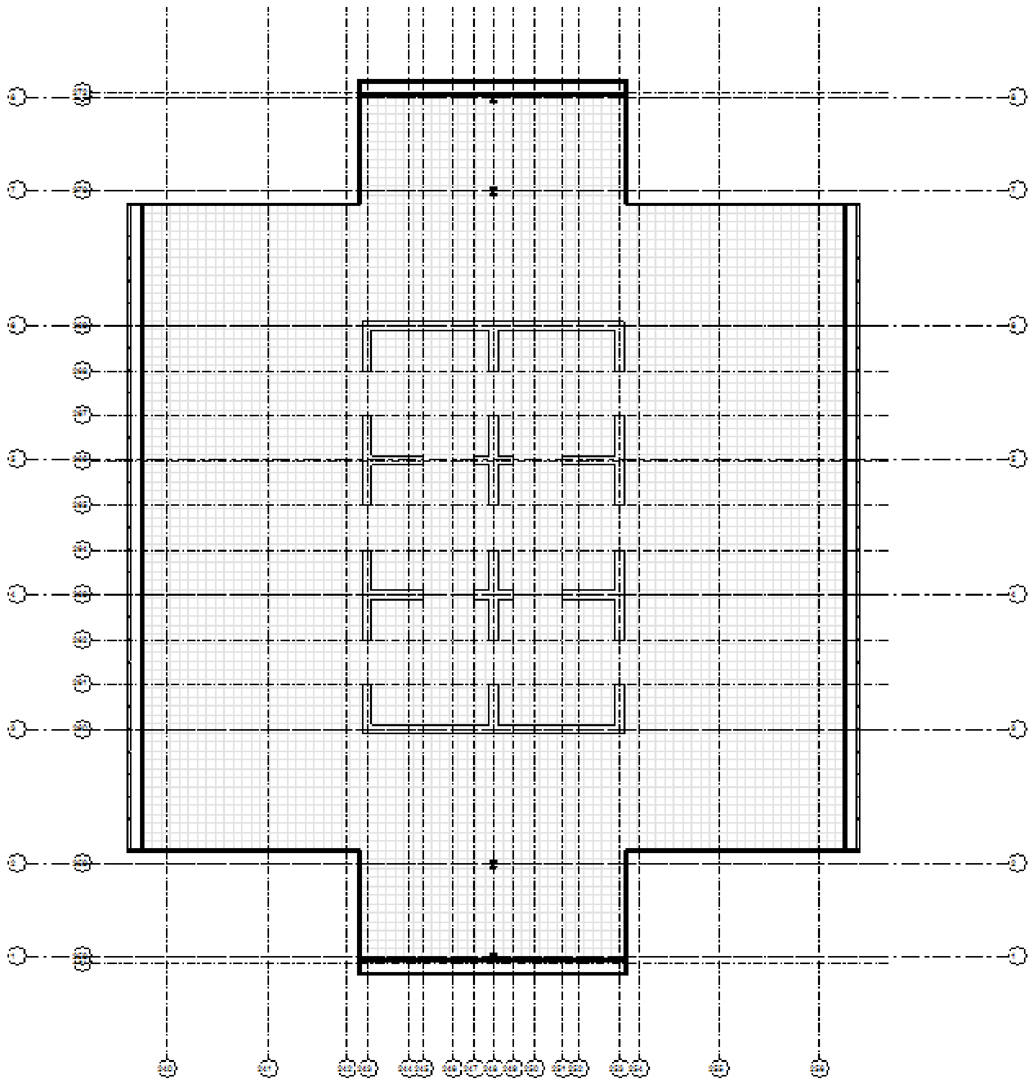


Figure 74

By constraining the core in this manner, it was determined that the required number of elevators would not fit within the structural core. Therefore, the final core configuration investigated by the team was that of a symmetrical structural core throughout the entire height of the new design while using an eccentric architectural core configuration on the New York Times levels of the tower. A symmetrical core configuration is very advantageous due to the fact that torsional effects due to lateral loads would be minimized.

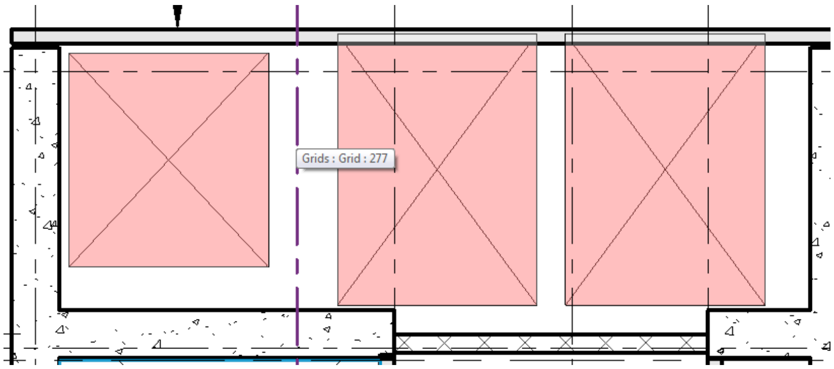


Figure 75

The location of the service elevators was also an issue when reconfiguring the core structurally. Due to the location of the service elevators, 11’-0” penetrations through the shear walls were required in order to allow access into the service corridor. The location of this penetration alone would result in the eccentricity of the core which would increase the torsional impacts due to lateral loads. Therefore penetrations were placed symmetrically about the core.

Figure 76

In order to maintain the existing architectural transparency of the lobby space structural considerations were required. The entrance to the lobby transitioned into a very open space that was located at the center of the core. This caused some issues with the structural core layout. Though it was not analyzed explicitly the configuration was assumed to be able to transfer the load around the opening through the shear walls in the North/South direction. If this design were to be accepted by the owner, a more in depth analysis would need to take place.

This configuration provides the Forrest City Ratner floors with 5,864 SF of additional rentable space.

Floor	Occupant	Existing Leasable Area (SF)	New Leasable Area (SF)	Difference (SF)
50	FCRC	21,943	22,126	183
49	FCRC	21,943	22,126	183
48	FCRC	21,943	22,126	183
47	FCRC	21,943	22,126	183
46	FCRC	21,943	22,126	183
45	FCRC	21,943	22,126	183
44	FCRC	21,650	22,126	476
43	FCRC	21,650	22,126	476
42	FCRC	21,650	22,126	476
41	FCRC	21,650	22,126	476
40	FCRC	21,244	21,456	212
39	FCRC	21,244	21,456	212
38	FCRC	21,244	21,456	212
37	FCRC	21,244	21,456	212
36	FCRC	21,244	21,456	212
35	FCRC	21,244	21,456	212
34	FCRC	21,244	21,456	212
33	FCRC	21,244	21,456	212
32	FCRC	21,244	21,456	212
31	FCRC	21,244	21,456	212
30	FCRC	21,244	21,456	212
29	FCRC	20,429	20,959	530
		472,371SF	**478,235 SF**	**5,864 SF**

Figure 77: Existing FCRC Floor Configurations

Figure 78: Existing FCRC Floor Configurations

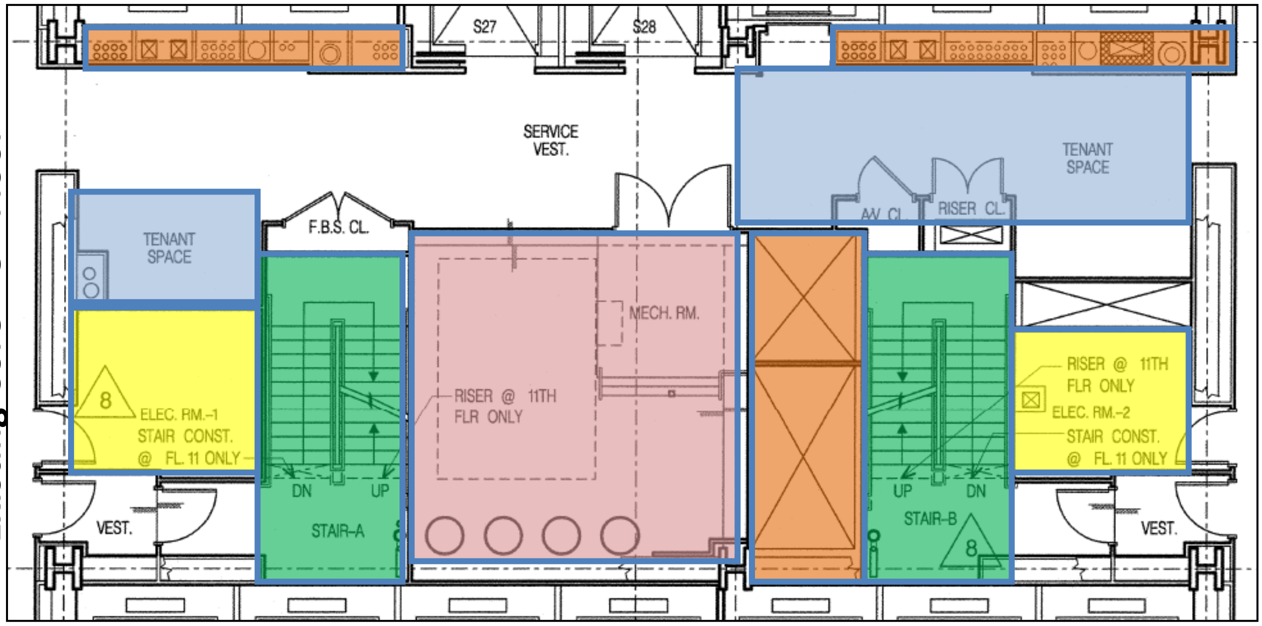
The overall goal of redesigning the core was to possibly reduce the footprint and open up leasable area for the owner. By redesigning the core the group was able to gain 5,864 additional square feet of leasable area in the Forrest City Ratner section of the building. An assumption that was made before doing this analysis was that there was a demand for office space in New York City. An article was found that led the group to safely assume that office space in a Class A office building in New York would be around $60 / SF per month. Therefore, the additional square footage that was freed up by the core change would provide the owner with **$1.26 million annually**.

Additional Rent Annually	5864 SF	$60 / SF Year	$ 1,258,00 Year

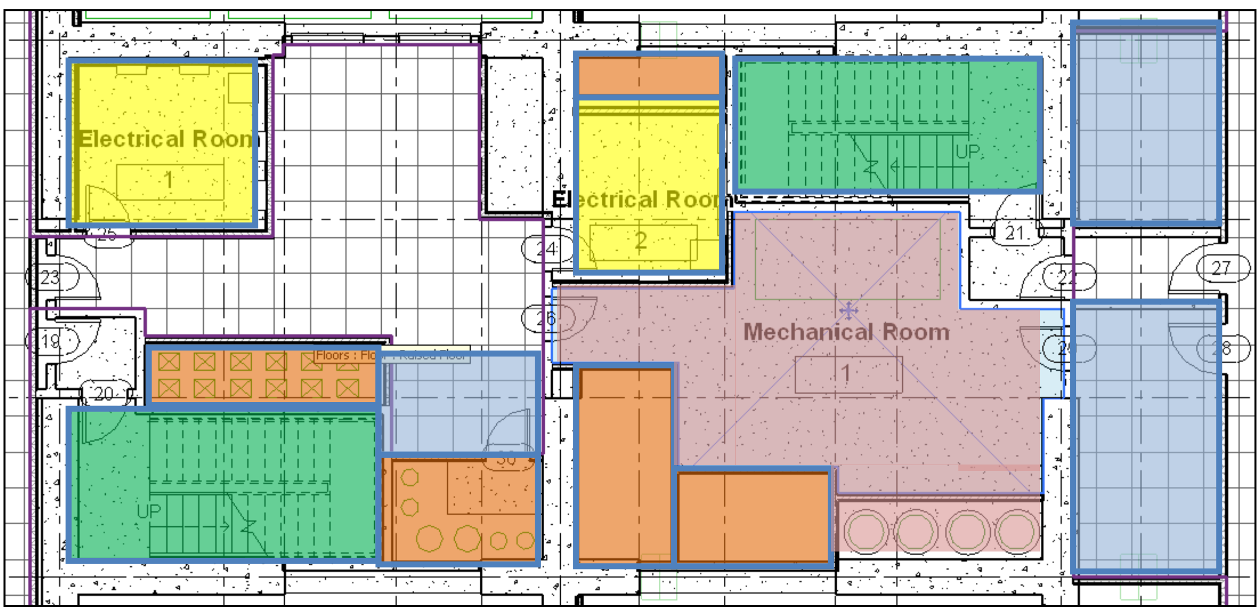
Service Core Layout

There is a need for reconfiguring the service spaces within the core in order to limit the access to the core through 10’ wide opening at the east and the west ends of the service space of the core. By reconfiguring the layout of the mechanical and electrical rooms and stairwells in the core, the services spaces were arranged in order to fit within the structural core.

Existing Core – 8th Floor



New Core – 8th Floor



Area	Existing SF	New SF
Mechanical	360 SF	347 SF
Electrical	180 SF	182 SF
Risers	235 SF	206 SF
Stairs	297 SF	303 SF
Tenant Space	277 SF	267 SF

Restroom Layout

The other spaces that needed to be investigated were the restrooms on each of the floors. These restrooms are nestled into some tight spaces within the core. With a shortage of space within the core it was important to make the restrooms as efficient as possible while still following code and occupancy needs. The layouts of all of the restrooms abide to the handicapped codes within the International Building Code.

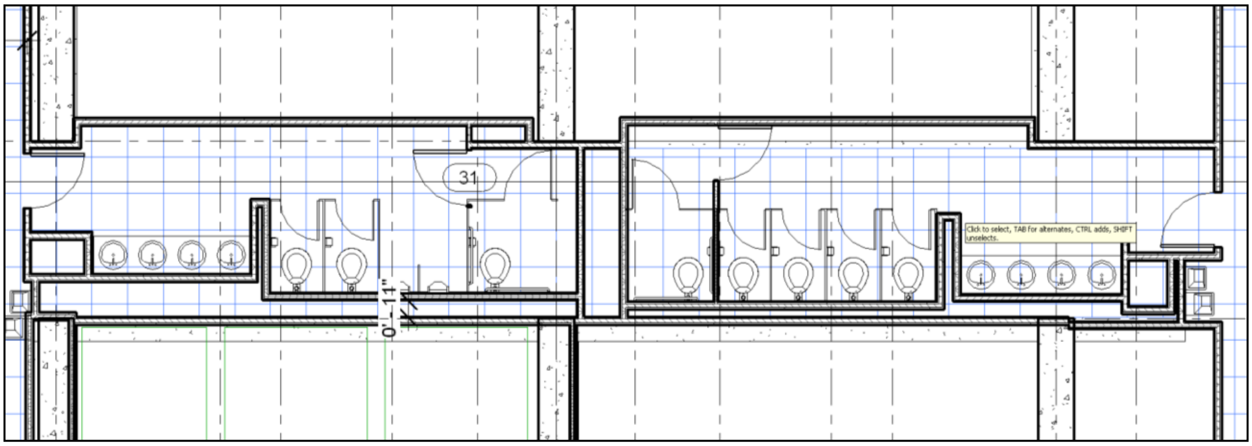


Figure 79 - Typ. Restroom NYT Floors 4 - 12

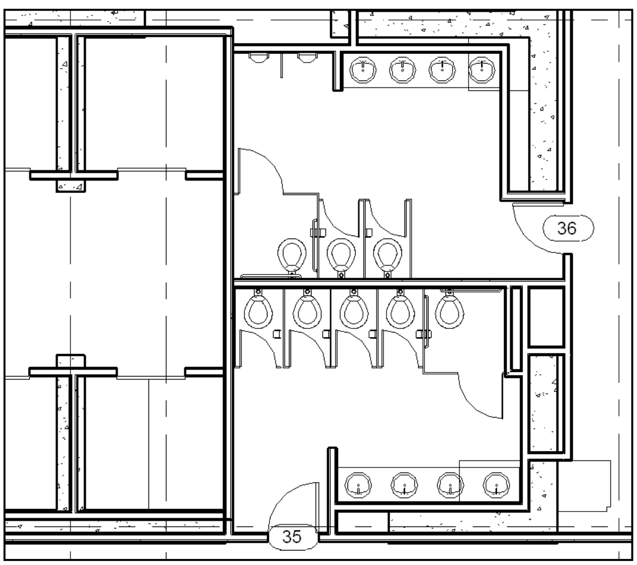


Figure 81 - Typ. Restroom 18 - 38

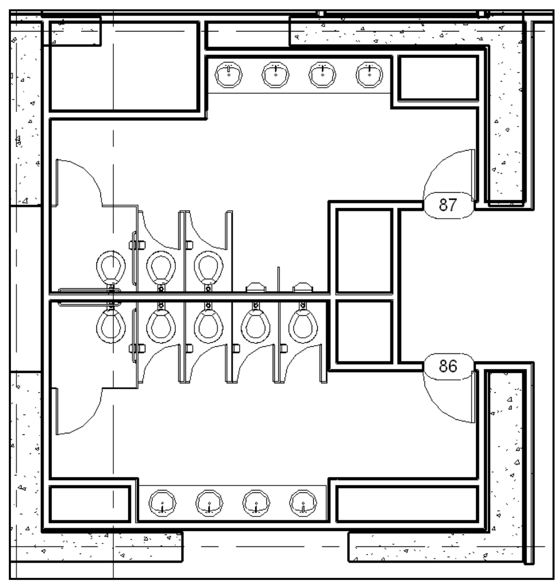


Figure 80 - Typ. Restroom Floors 39 - 50

CORE STRUCTURAL DESIGN SUMMARY

The final core solution proposed for the New York Times Building was designed with concrete shear walls ranging in thickness from 30" to 20" as well as steel outriggers at the 28th level mechanical floor. In addition, the concrete compressive strength of the shear walls is 10,000 psi from the Base to Level 30 and changes to 8,000 psi at Level 31. Refer the chart below for details pertaining to varying wall thickness and concrete compressive strengths throughout the height of the building.

The design resulted in a core layout which is 56 feet wide in the East/West direction and 90 feet long in the North/South direction. Penetrations in the shear walls were required at several different locations throughout the height of the structure in order to allow access and flexibility throughout the core. Refer to figures below for dimensions and locations of these penetrations.

The design utilized eight outriggers in the East/West direction and the two outriggers with belt trusses in North/South direction. These 28th floor outriggers are depicted on the plan in magenta with the belt trusses in cyan. In addition to the outriggers, concrete coupling beams were added at each level in order to allow for the shears walls to act as a system, rather than individual entities. All coupling beams were designed with a depth of 36" and range in thickness as well as concrete compressive strength with their corresponding shear wall supports. A summary of the resulting period of vibration, SRSS, building drift due to 0.7W and acceleration are reported in the charts below.

Level	f'_c (ksi)	Wall t, E/W Direction (in)	Wall t, N/S Direction (in)
Base - 30	10	24	30
31-40	8	24	24
41-53	8	20	24

Period of Vibration		
Mode	Direction	T(sec.)
1	E/W	7.31
2	N/S	6.57
3	Tor	5.51
SRSS		11.2677
% of Existing		4.417
Compliance?		Yes

Building Drift (due to 0.7 W)	
Direction	Displ. (in)
N/S	10.9
E/W	6.99

Acceleration		
11.5	milli-g	ok

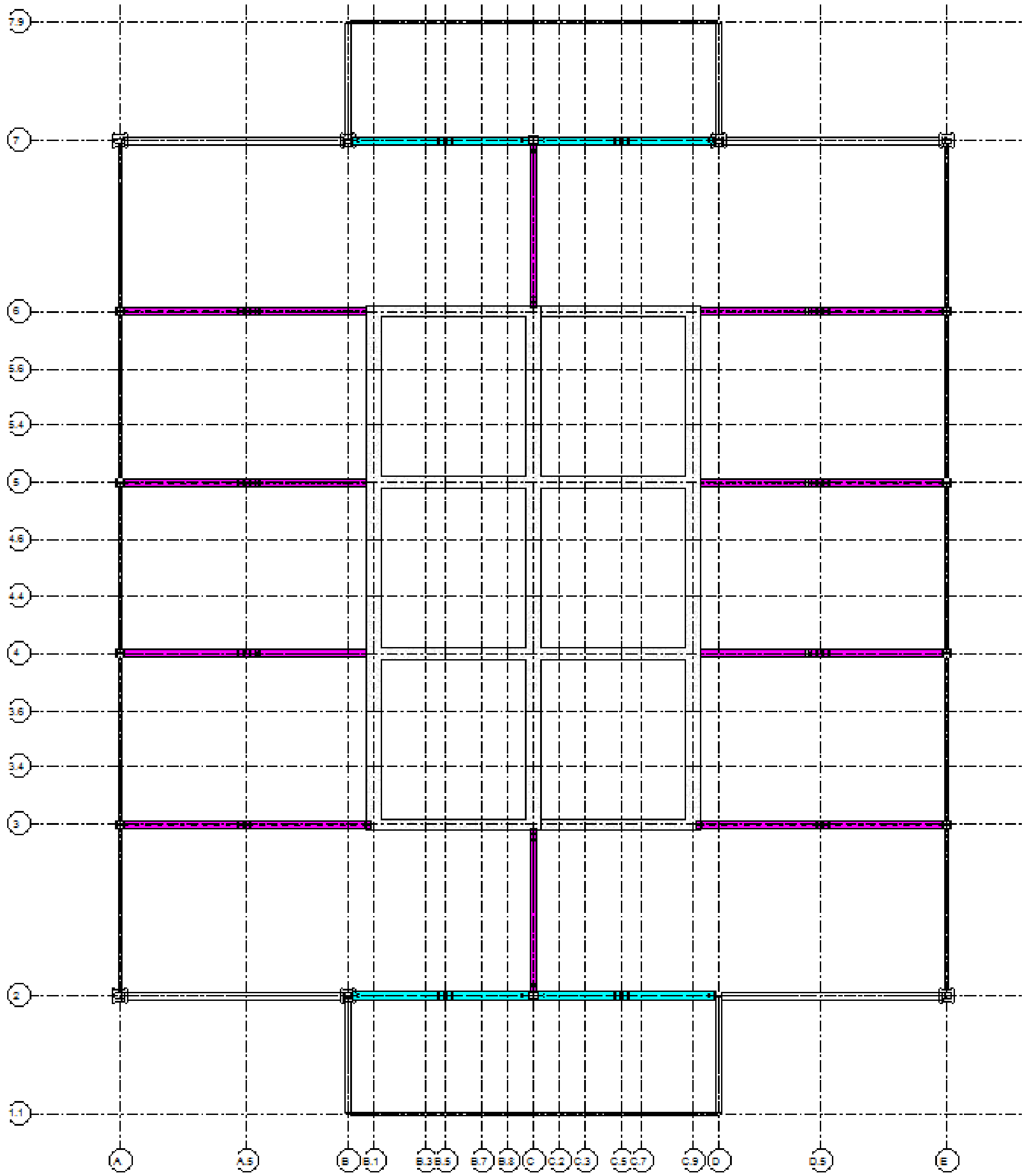


Figure 82: Outriggers and Core at 28th Mechanical Floor

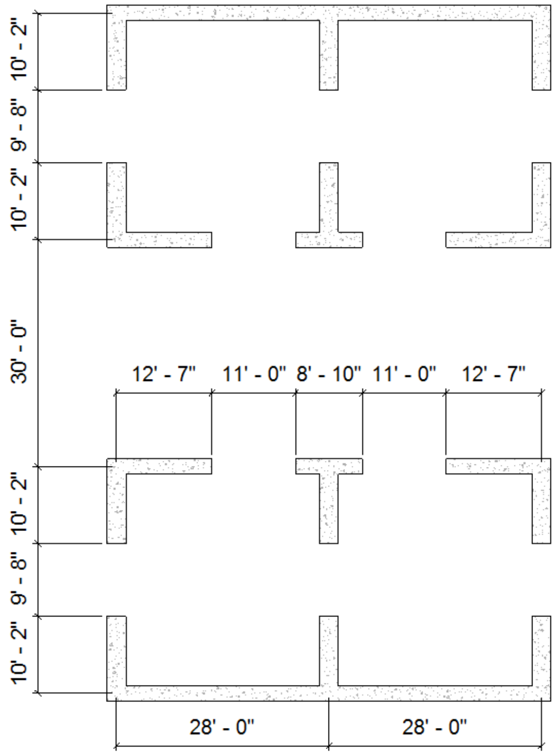


Figure 85: Core at Base

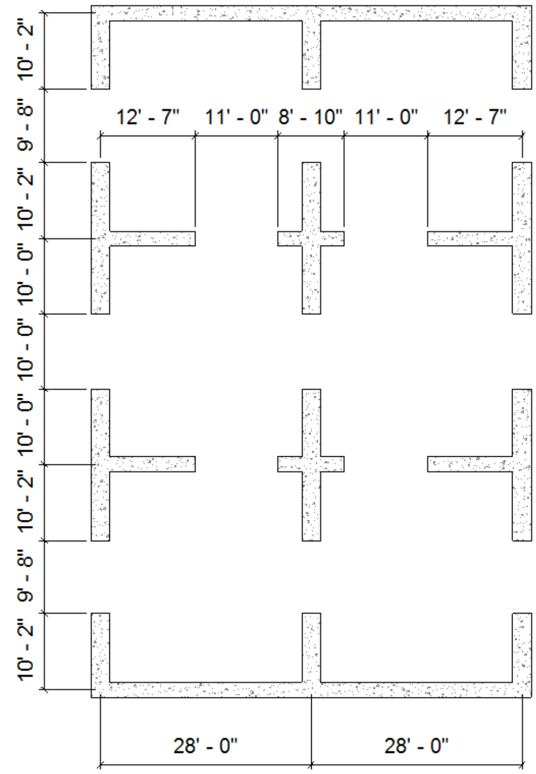


Figure 84: Core, Level 2 to 30

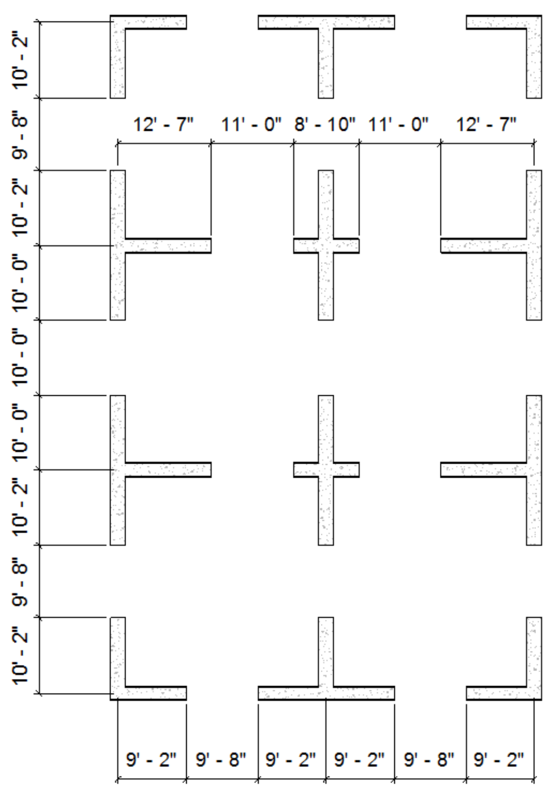


Figure 83: Core. Level 31 to 53

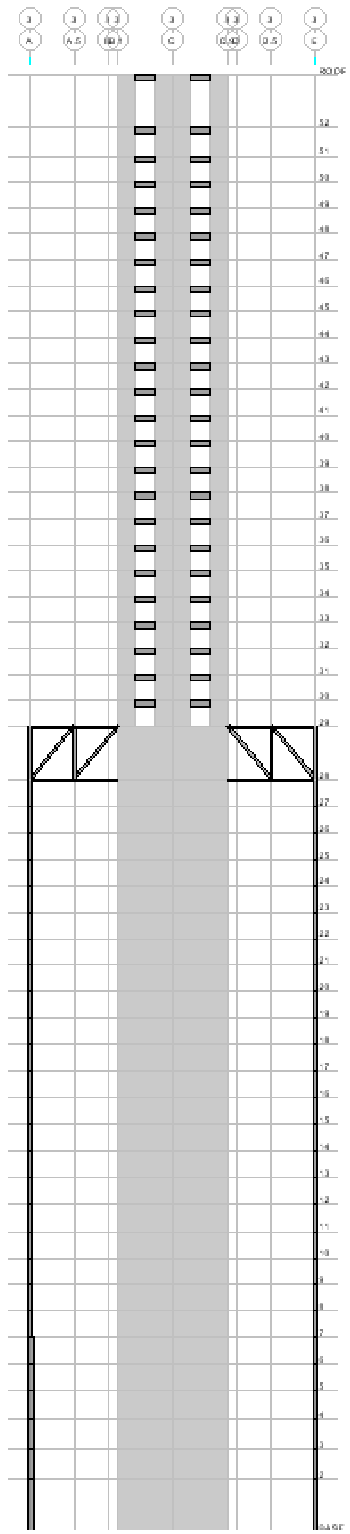


Figure 87: Core Elevation on Grid Lines 3 and 6

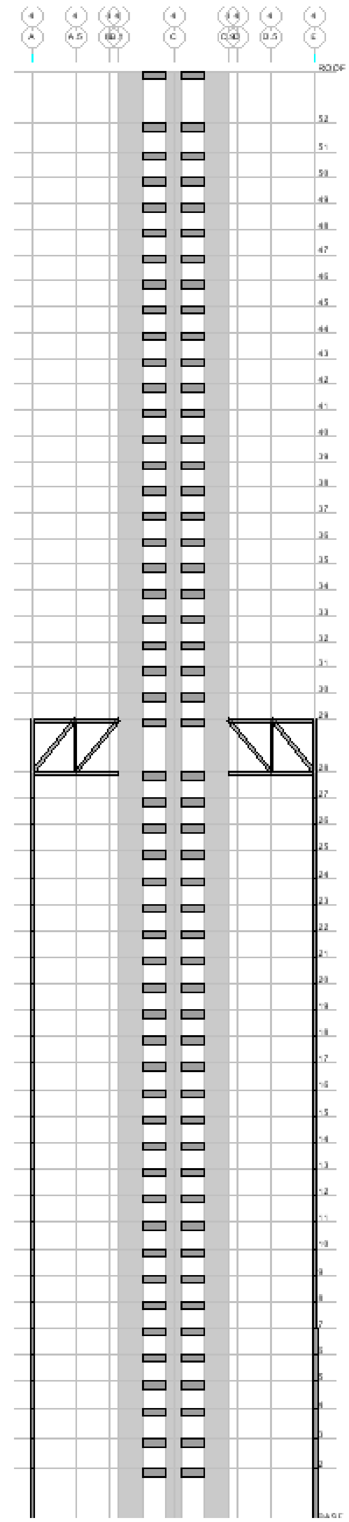


Figure 86: Core Elevations on Grid Lines 4 and 5

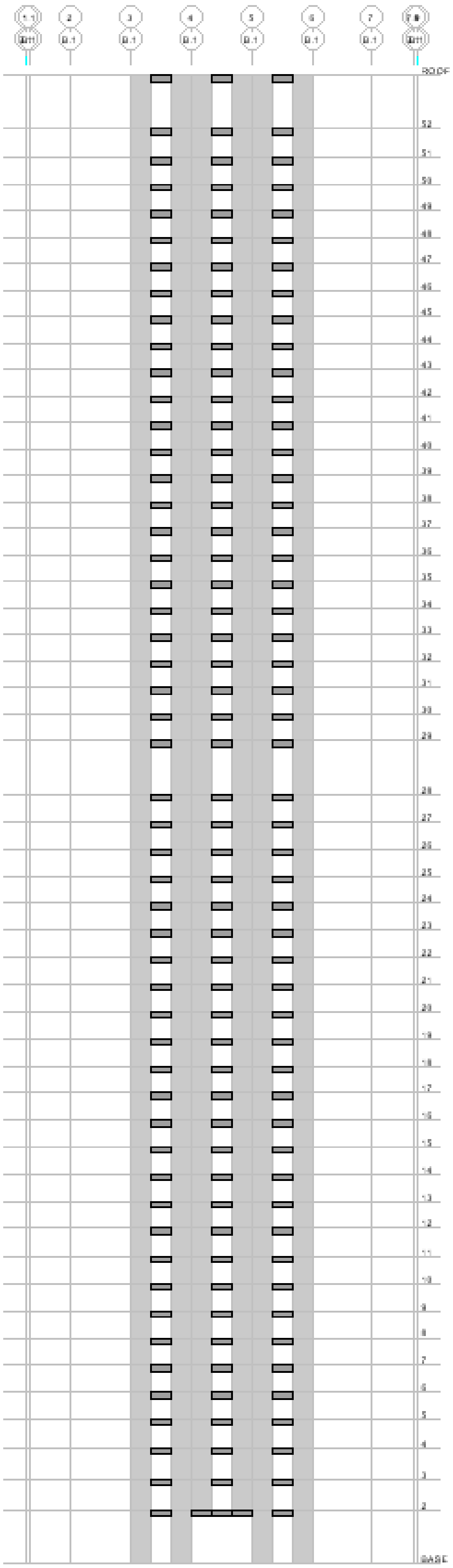


Figure 89: Building Elevation on Grid Lines B.1 and C.9

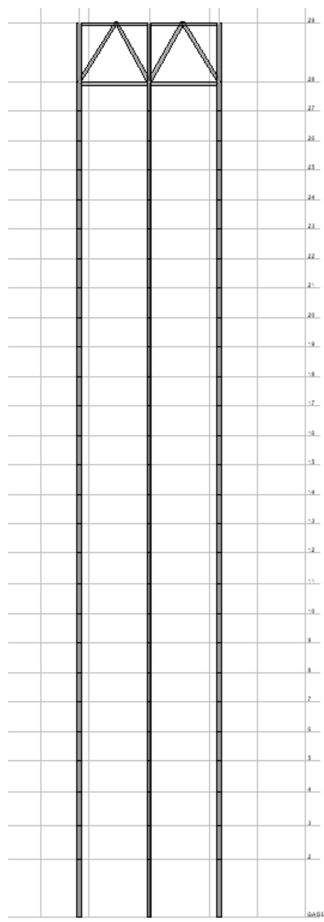


Figure 90: Belt Truss Elevation

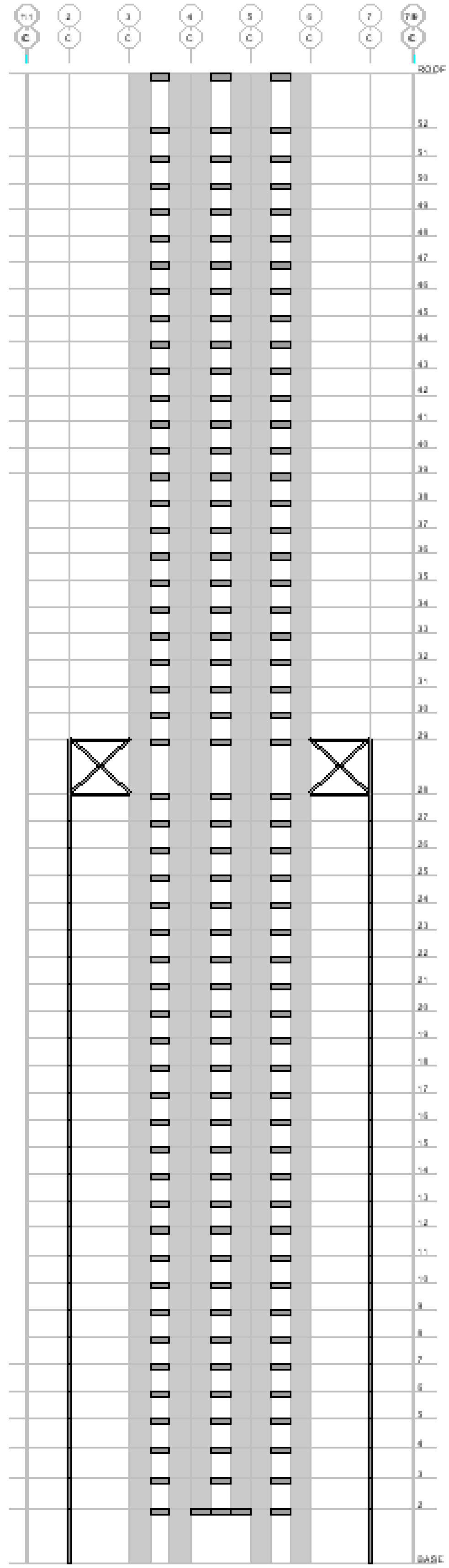


Figure 88: Building Elevation on Grid Line C

DESIGN LOADINGS

LRFD Design Load Combinations (ASCE 7-05)

1.4 (D+F)
1.2 (D+F+T) + 1.6 (L+H) + 0.5 (Lr or S or R)
1.2 D + 1.6 (Lr or S or R) + (L or .8W)
1.2 D + 1.6 W + L + .5 (Lr or S or R)
1.2 D + 1.0 E + L + .2S
.9 D + 1.6 W +1.6 H
.9 D + 1.0 E + 1.6 H

D= dead load Lr= roof live load W= wind load
E= earthquake load L= live load T= self-straining force
R= rain load S= snow load F= load due to fluids
H= load due to lateral earth pressure, ground water pressure, or pressure of bulk materials

Note: These combinations do not apply to the castellated beams which were designed using ASD.

Application of Lateral Loads

When designing the new lateral force resisting system, it was initially assumed that the center of rigidity, center of mass and center of pressure would align with the center of geometry, CG, due to the symmetry of the core configuration. Therefore, all lateral loads where applied at (or eccentrically from) the center of geometry. After the design was modeled in ETABS, this assumption was confirmed.

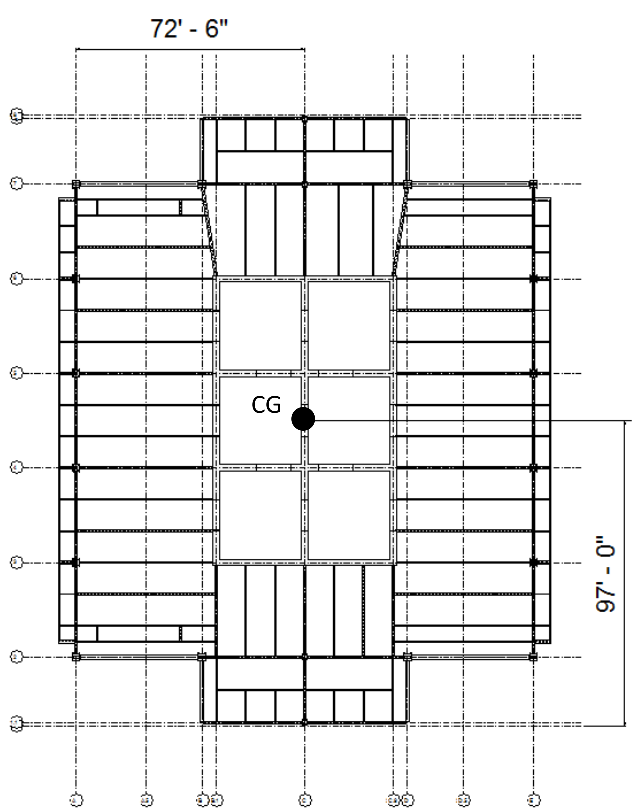
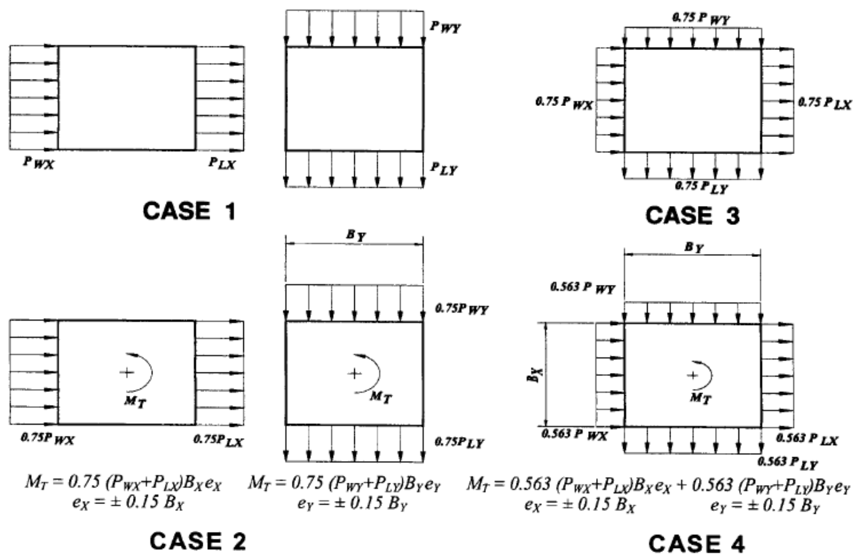


Figure 91: Center of Geometry

Wind Loads

The wind pressures used for the redesign of the lateral force resisting system were initially calculated using Method 2 per ASCE 7-05. However, in order to achieve a more comparable design to that of the existing braced frame core, the base shears provide by the designer of 3968 kips in the East/West direction and 3278 kips in the North/South direction resulting from wind tunnel testing were extrapolated through the height of the tower. The base shears were also modified by 1.15 to incorporate the importance factor used in the calculated wind loads per ASCE 7-05. The resulting wind pressures were used throughout the redesign process. The wind pressures and loads shown here are those resulting from this modification. Refer to Appendix D.6 to review the calculated wind load per the ASCE 7-05 Method 2. Wind load cases 1, 2, 3 and 4 shown here from Figure 6-9 in ASCE 7-05 were applied in the lateral analysis. This resulted in a total of 12 wind load cases after considering bearing and over turning.



Wind Load Profile Multiplier					
	TT Base Shear	Import. Fact.	Modified Base	ASCE 7 Method	**Mult.**
E/W	3450	1.15	3967.50	8535	**0.46**
N/S	2850	1.15	3277.50	6788	**0.48**

Modified Wind Forces on Tower {Using TT Base Shears}							
Level	Height Above Ground (ft)	Load (kips)		Shear (kips)		Moment (ft-kips)	
		E/W	N/S	E/W	N/S	E/W	N/S
Screen *	802 & 819	206	230	---	---	---	---
Roof	745.50	284	295	284	295	211393	219842
52	718.92	119	97	403	392	85896	70074
51	704.25	80	66	484	458	56690	46238
50	690.99	76	62	560	520	52646	42933
49	677.72	76	62	636	582	51463	41962
48	664.46	76	62	711	644	50284	40995
47	651.19	75	61	787	705	49110	40032
46	637.93	75	61	862	766	47940	39073
45	624.67	75	61	937	828	46775	38117
44	611.40	75	61	1011	888	45614	37165
43	598.14	74	61	1086	949	44459	36218
42	584.88	74	60	1160	1009	43308	35274
41	571.61	74	60	1234	1069	42162	34335
40	558.35	73	60	1307	1129	41021	33400
39	545.08	73	60	1380	1189	39885	32469
38	531.82	73	59	1453	1248	38754	31543
37	518.56	73	59	1526	1307	37628	30621
36	505.29	72	59	1598	1366	36508	29703
35	492.03	72	59	1670	1424	35393	28791
34	478.76	72	58	1741	1483	34283	27882
33	465.50	71	58	1813	1540	33179	26979
32	452.24	71	58	1884	1598	32081	26081
31	438.97	71	57	1954	1656	30989	25187
30	425.71	70	57	2024	1713	29903	24299
29	412.44	107	87	2131	1799	44019	35761
28	385.19	106	86	2238	1886	41015	33308
27	371.69	70	57	2308	1943	26094	21182
26	358.10	70	57	2378	2000	25081	20354
25	344.50	70	56	2447	2056	23981	19456
24	330.90	69	56	2517	2112	22889	18564
23	317.31	69	56	2585	2168	21805	17679
22	303.71	68	55	2654	2223	20729	16801
21	290.11	68	55	2721	2278	19661	15930
20	276.51	67	54	2789	2333	18602	15067
19	262.92	67	54	2855	2387	17552	14211
18	249.32	66	54	2922	2440	16511	13363
17	235.72	66	53	2987	2493	15480	12523
16	222.13	65	53	3052	2546	14459	11692
15	208.53	64	52	3117	2598	13449	10869
14	194.93	64	52	3181	2650	12449	10056
13	181.33	62	50	3243	2700	11314	9135
12	168.08	63	51	3306	2751	10626	8574
11	153.83	63	51	3370	2802	9731	7847
10	140.24	61	49	3431	2851	8550	6890
9	126.64	60	48	3491	2900	7615	6132
8	113.04	59	48	3550	2947	6696	5387
7	99.44	58	47	3608	2994	5794	4657
6	85.85	57	46	3665	3040	4910	3942
5	72.25	57	46	3723	3086	4154	3331
4	57.93	60	48	3783	3134	3466	2775
3	42.46	60	48	3843	3182	2554	2041
2	26.99	79	59	3922	3241	2121	1591
Ground	0.00	46	36	3968	3278	0	0
Total		3968	3278	3968	3278	1646548	1386740

* Loads from the screens are superimposed on to the Roof level.

Wind Case 1						
Level	E/W			N/S		
	P (kips)	e (ft)	M_t (kip-ft)	P (kips)	e (ft)	M_t (kip-ft)
Roof	283.56	0	0	294.89	0	0
52	119.48	0	0	97.47	0	0
51	80.50	0	0	65.66	0	0
50	76.19	0	0	62.13	0	0
49	75.93	0	0	61.92	0	0
48	75.68	0	0	61.70	0	0
47	75.41	0	0	61.47	0	0
46	75.15	0	0	61.25	0	0
45	74.88	0	0	61.02	0	0
44	74.61	0	0	60.79	0	0
43	74.33	0	0	60.55	0	0
42	74.05	0	0	60.31	0	0
41	73.76	0	0	60.07	0	0
40	73.47	0	0	59.82	0	0
39	73.17	0	0	59.57	0	0
38	72.87	0	0	59.31	0	0
37	72.56	0	0	59.05	0	0
36	72.25	0	0	58.78	0	0
35	71.93	0	0	58.51	0	0
34	71.61	0	0	58.24	0	0
33	71.28	0	0	57.96	0	0
32	70.94	0	0	57.67	0	0
31	70.59	0	0	57.38	0	0
30	70.24	0	0	57.08	0	0
29	106.73	0	0	86.70	0	0
28	106.48	0	0	86.47	0	0
27	70.20	0	0	56.99	0	0
26	70.04	0	0	56.84	0	0
25	69.61	0	0	56.48	0	0
24	69.17	0	0	56.10	0	0
23	68.72	0	0	55.72	0	0
22	68.25	0	0	55.32	0	0
21	67.77	0	0	54.91	0	0
20	67.27	0	0	54.49	0	0
19	66.76	0	0	54.05	0	0
18	66.23	0	0	53.60	0	0
17	65.67	0	0	53.13	0	0
16	65.09	0	0	52.64	0	0
15	64.49	0	0	52.12	0	0
14	63.86	0	0	51.59	0	0
13	62.40	0	0	50.38	0	0
12	63.22	0	0	51.01	0	0
11	63.25	0	0	51.01	0	0
10	60.97	0	0	49.13	0	0
9	60.14	0	0	48.42	0	0
8	59.24	0	0	47.66	0	0
7	58.26	0	0	46.83	0	0
6	57.19	0	0	45.92	0	0
5	57.50	0	0	46.11	0	0
4	59.84	0	0	47.91	0	0
3	60.16	0	0	48.07	0	0
2	78.58	0	0	58.94	0	0
Ground	45.97	0	0	36.40	0	0

Wind Case 2						
Level	E/W			N/S		
	P (kips)	+/- e (ft)	M_t (kip-ft)	P (kips)	+/- e (ft)	M_t (kip-ft)
Roof	212.67	29.1	6188.661	221.17	23.55	5208.533
52	89.61	29.1	2607.653	73.10	23.55	1721.594
51	60.37	29.1	1756.836	49.24	23.55	1159.634
50	57.14	29.1	1662.833	46.60	23.55	1097.424
49	56.95	29.1	1657.277	46.44	23.55	1093.602
48	56.76	29.1	1651.643	46.27	23.55	1089.727
47	56.56	29.1	1645.929	46.11	23.55	1085.796
46	56.36	29.1	1640.133	45.94	23.55	1081.809
45	56.16	29.1	1634.251	45.76	23.55	1077.762
44	55.95	29.1	1628.279	45.59	23.55	1073.654
43	55.75	29.1	1622.216	45.41	23.55	1069.483
42	55.53	29.1	1616.057	45.23	23.55	1065.246
41	55.32	29.1	1609.798	45.05	23.55	1060.941
40	55.10	29.1	1603.436	44.86	23.55	1056.564
39	54.88	29.1	1596.966	44.68	23.55	1052.113
38	54.65	29.1	1590.384	44.48	23.55	1047.586
37	54.42	29.1	1583.685	44.29	23.55	1042.977
36	54.19	29.1	1576.865	44.09	23.55	1038.285
35	53.95	29.1	1569.917	43.89	23.55	1033.506
34	53.71	29.1	1562.835	43.68	23.55	1028.634
33	53.46	29.1	1555.614	43.47	23.55	1023.667
32	53.20	29.1	1548.247	43.25	23.55	1018.599
31	52.95	29.1	1540.726	43.03	23.55	1013.425
30	52.68	29.1	1533.043	42.81	23.55	1008.14
29	80.04	29.1	2329.309	65.03	23.55	1531.406
28	79.86	29.1	2323.923	64.85	23.55	1527.288
27	52.65	29.1	1532.17	42.74	23.55	1006.542
26	52.53	29.1	1528.607	42.63	23.55	1003.92
25	52.21	29.1	1519.269	42.36	23.55	997.4964
24	51.88	29.1	1509.669	42.08	23.55	990.8925
23	51.54	29.1	1499.789	41.79	23.55	984.0958
22	51.19	29.1	1489.608	41.49	23.55	977.0924
21	50.83	29.1	1479.104	41.18	23.55	969.8663
20	50.46	29.1	1468.25	40.87	23.55	962.3998
19	50.07	29.1	1457.017	40.54	23.55	954.6727
18	49.67	29.1	1445.373	40.20	23.55	946.6622
17	49.25	29.1	1433.278	39.84	23.55	938.3419
16	48.82	29.1	1420.688	39.48	23.55	929.6813
15	48.37	29.1	1407.553	39.09	23.55	920.6451
14	47.90	29.1	1393.81	38.69	23.55	911.1916
13	46.80	29.1	1361.777	37.78	23.55	889.7638
12	47.41	29.1	1379.734	38.26	23.55	900.9727
11	47.44	29.1	1380.535	38.26	23.55	900.916
10	45.73	29.1	1330.696	36.85	23.55	867.7741
9	45.10	29.1	1312.447	36.32	23.55	855.2201
8	44.43	29.1	1292.816	35.74	23.55	841.716
7	43.69	29.1	1271.523	35.12	23.55	827.0685
6	42.89	29.1	1248.185	34.44	23.55	811.0133
5	43.12	29.1	1254.869	34.58	23.55	814.3406
4	44.88	29.1	1305.915	35.93	23.55	846.1777
3	45.12	29.1	1313.094	36.06	23.55	849.1096
2	58.94	29.1	1715.062	44.20	23.55	1040.942
Ground	34.48	29.1	1003.334	27.30	23.55	642.9356

Wind Case 3							
Level	E/W			N/S			Total
	P (kips)	+/- e (ft)	M_t (kip-ft)	P (kips)	+/- e (ft)	M_t (kip-ft)	M_t (kip-ft)
Roof	212.67	0	0	221.17	0	0	0
52	89.61	0	0	73.10	0	0	0
51	60.37	0	0	49.24	0	0	0
50	57.14	0	0	46.60	0	0	0
49	56.95	0	0	46.44	0	0	0
48	56.76	0	0	46.27	0	0	0
47	56.56	0	0	46.11	0	0	0
46	56.36	0	0	45.94	0	0	0
45	56.16	0	0	45.76	0	0	0
44	55.95	0	0	45.59	0	0	0
43	55.75	0	0	45.41	0	0	0
42	55.53	0	0	45.23	0	0	0
41	55.32	0	0	45.05	0	0	0
40	55.10	0	0	44.86	0	0	0
39	54.88	0	0	44.68	0	0	0
38	54.65	0	0	44.48	0	0	0
37	54.42	0	0	44.29	0	0	0
36	54.19	0	0	44.09	0	0	0
35	53.95	0	0	43.89	0	0	0
34	53.71	0	0	43.68	0	0	0
33	53.46	0	0	43.47	0	0	0
32	53.20	0	0	43.25	0	0	0
31	52.95	0	0	43.03	0	0	0
30	52.68	0	0	42.81	0	0	0
29	80.04	0	0	65.03	0	0	0
28	79.86	0	0	64.85	0	0	0
27	52.65	0	0	42.74	0	0	0
26	52.53	0	0	42.63	0	0	0
25	52.21	0	0	42.36	0	0	0
24	51.88	0	0	42.08	0	0	0
23	51.54	0	0	41.79	0	0	0
22	51.19	0	0	41.49	0	0	0
21	50.83	0	0	41.18	0	0	0
20	50.46	0	0	40.87	0	0	0
19	50.07	0	0	40.54	0	0	0
18	49.67	0	0	40.20	0	0	0
17	49.25	0	0	39.84	0	0	0
16	48.82	0	0	39.48	0	0	0
15	48.37	0	0	39.09	0	0	0
14	47.90	0	0	38.69	0	0	0
13	46.80	0	0	37.78	0	0	0
12	47.41	0	0	38.26	0	0	0
11	47.44	0	0	38.26	0	0	0
10	45.73	0	0	36.85	0	0	0
9	45.10	0	0	36.32	0	0	0
8	44.43	0	0	35.74	0	0	0
7	43.69	0	0	35.12	0	0	0
6	42.89	0	0	34.44	0	0	0
5	43.12	0	0	34.58	0	0	0
4	44.88	0	0	35.93	0	0	0
3	45.12	0	0	36.06	0	0	0
2	58.94	0	0	44.20	0	0	0
Ground	34.48	0	0	27.30	0	0	0

Wind Case 4							
Level	E/W			N/S			Total
	P (kips)	+/- e (ft)	M_t (kip-ft)	P (kips)	+/- e (ft)	M_t (kip-ft)	M_t (kip-ft)
Roof	159.64	29.1	4645.622	166.02	23.55	3909.872	8555.493
52	67.27	29.1	1957.478	54.88	23.55	1292.343	3249.821
51	45.32	29.1	1318.799	36.96	23.55	870.4984	2189.297
50	42.89	29.1	1248.233	34.98	23.55	823.7996	2072.033
49	42.75	29.1	1244.062	34.86	23.55	820.9305	2064.993
48	42.61	29.1	1239.833	34.74	23.55	818.0214	2057.855
47	42.46	29.1	1235.544	34.61	23.55	815.0709	2050.615
46	42.31	29.1	1231.193	34.48	23.55	812.0776	2043.271
45	42.16	29.1	1226.777	34.35	23.55	809.04	2035.817
44	42.00	29.1	1222.295	34.22	23.55	805.9565	2028.252
43	41.85	29.1	1217.743	34.09	23.55	802.8253	2020.569
42	41.69	29.1	1213.12	33.96	23.55	799.6447	2012.764
41	41.53	29.1	1208.422	33.82	23.55	796.4127	2004.834
40	41.36	29.1	1203.646	33.68	23.55	793.1273	1996.773
39	41.20	29.1	1198.789	33.54	23.55	789.7864	1988.575
38	41.03	29.1	1193.848	33.39	23.55	786.3875	1980.236
37	40.85	29.1	1188.82	33.25	23.55	782.9284	1971.748
36	40.68	29.1	1183.7	33.10	23.55	779.4062	1963.106
35	40.50	29.1	1178.484	32.94	23.55	775.8183	1954.302
34	40.32	29.1	1173.168	32.79	23.55	772.1615	1945.33
33	40.13	29.1	1167.748	32.63	23.55	768.4327	1936.181
32	39.94	29.1	1162.218	32.47	23.55	764.6282	1926.846
31	39.74	29.1	1156.572	32.30	23.55	760.7444	1917.316
30	39.55	29.1	1150.805	32.13	23.55	756.777	1907.582
29	60.09	29.1	1748.535	48.81	23.55	1149.576	2898.11
28	59.95	29.1	1744.492	48.68	23.55	1146.484	2890.976
27	39.52	29.1	1150.149	32.08	23.55	755.5773	1905.726
26	39.43	29.1	1147.474	32.00	23.55	753.6094	1901.083
25	39.19	29.1	1140.464	31.80	23.55	748.7873	1889.252
24	38.94	29.1	1133.258	31.59	23.55	743.83	1877.088
23	38.69	29.1	1125.841	31.37	23.55	738.728	1864.569
22	38.43	29.1	1118.199	31.15	23.55	733.4707	1851.67
21	38.16	29.1	1110.314	30.91	23.55	728.0463	1838.36
20	37.88	29.1	1102.166	30.68	23.55	722.4414	1824.608
19	37.59	29.1	1093.734	30.43	23.55	716.641	1810.375
18	37.28	29.1	1084.993	30.18	23.55	710.6277	1795.621
17	36.97	29.1	1075.914	29.91	23.55	704.382	1780.296
16	36.65	29.1	1066.463	29.63	23.55	697.8808	1764.344
15	36.31	29.1	1056.603	29.35	23.55	691.0976	1747.7
14	35.95	29.1	1046.287	29.04	23.55	684.0012	1730.288
13	35.13	29.1	1022.241	28.36	23.55	667.9161	1690.157
12	35.59	29.1	1035.72	28.72	23.55	676.3302	1712.05
11	35.61	29.1	1036.322	28.72	23.55	676.2876	1712.609
10	34.33	29.1	998.909	27.66	23.55	651.4091	1650.318
9	33.86	29.1	985.2099	27.26	23.55	641.9852	1627.195
8	33.35	29.1	970.474	26.83	23.55	631.8482	1602.322
7	32.80	29.1	954.4903	26.36	23.55	620.8527	1575.343
6	32.20	29.1	936.9706	25.85	23.55	608.8007	1545.771
5	32.37	29.1	941.9884	25.96	23.55	611.2983	1553.287
4	33.69	29.1	980.3068	26.97	23.55	635.1974	1615.504
3	33.87	29.1	985.6962	27.07	23.55	637.3982	1623.094
2	44.24	29.1	1287.44	33.18	23.55	781.4006	2068.841
Ground	25.88	29.1	753.1696	20.49	23.55	482.6303	1235.8

Seismic Loads

The seismic loads utilized were calculated according to the Equivalent Lateral Force Method found in ASCE 7-05. Changes in weight of the alternative design were taken in to account throughout the design process. The seismic loads did not control the design of the lateral system for strength or serviceability. As required by ASCE 7-05, the accidental torsion was also considered when for the lateral analysis. As a result, four load cases where applied for the lateral analysis. Refer to Appendix D.6 to view the seismic load calculations.

Gravity Loads

Typical Tower Floor Dead Load			
Load Description	**Design Load**		**Reference**
5.25" Slab with 0.0358" Thick Composite Metal Deck EPIC Deck Type: EPICORE 3k NWC, capacity of 111 psf	63	psf	
Ceiling (Floors have ACT, Drywall, and Special Architectural Ceilings)	5	psf	Thornton Tomasetti, Kyle Krall
Mechanical, Electrical, Plumbing in ceiling	15	psf	Thornton Tomasetti, Kyle Krall
Allowance for Self Weight of Steel Framing + Fireproofing(intumescent paint & cementitious)*	16	psf	
Total Typical Floor Dead Load:	**99**	psf	

Typical Tower Mechanical Floor Dead Load			
Load Description	**Design Load**		**Reference**
6" Slab with 20 GA 3" Composite Metal Deck, Vulcraft Deck Type: 3VL20, Max unshored clear span is 10'-11" with a capacity of 173 psf	57	psf	Thornton Tomasetti, Kyle Krall & Vulcraft Catalog page 48
Ceiling (Floors have ACT and Special Architectural Ceilings)	5	psf	Thornton Tomasetti, Kyle Krall
Mechanical, Electrical, Plumbing	8	psf	Thornton Tomasetti, Kyle Krall
Allowance for Self Weight of Steel Framing + Fireproofing(intumescent paint & cementitious)*	15	psf	
Total Mechanical Floor Dead Load:	**110**	psf	

Exterior Tower Wall System Dead Load (Elevation)			
Load Description	**Design Load**		**Reference**
Double Glazed Façade	30	psf	
Total Exterior Wall Dead Load:	**30**	psf	

Tower Mechanical Area Roof Dead Load			
Load Description	**Design Load**		**Reference**
8" Composite Deck	85	psf	
Allowance for Self Weight of Steel Framing + Fireproofing(intumescent paint & cementitious)*	15	psf	
Total Mechanical Area Roof Dead Load:	**100**	psf	

Normal Tower Roof Dead Load			
Load Description	**Design Load**		**Reference**
8" Composite Deck	85	psf	
Allowance for Self Weight of Steel Framing + Fireproofing(intumescent paint & cementitious)*	15	psf	
Total Normal Roof Dead Load:	**100**	psf	

Tower Roof Live Load			
Load Description	**Design Load**		**Reference**
Ordinary flat roof:	20	psf	ASCE7-05, Table 4-1
Roof gardens:	100	psf	ASCE7-05, Table 4-1
Controlling Roof Live Load:	**100**	psf	

Tower Mechanical Area Roof Live Load			
Load Description	**Design Load**		**Reference**
Mechanical, Electrical, Plumbing:	125	psf	ASCE7-05, Table 4-1
Walkways and elevated platforms:	60	psf	ASCE7-05, Table 4-1
Controlling Roof Live Load:	**125**	psf	

Tower Typical Office Area Live Load			
Load Description	**Design Load**		**Reference**
Office:	50	psf	ASCE7-05, Table 4-1
Partitions:	20	psf	ASCE7-05, Table 4-1
Total Typical Office Area Live Load:	**70**	psf	

Tower Cafeteria Floor Live Load			
Load Description	**Design Load**		**Reference**
Cafeteria:	100	psf	ASCE7-05, Table 4-1
Total Cafeteria Floor Live Load:	**100**	psf	

Tower Core Floor Live Load			
Load Description	**Design Load**		**Reference**
Lobbies:	100	psf	ASCE7-05, Table 4-1
Total Core Floor Live Load:	**100**	psf	

Tower Mechanical Floor Live Load			
Load Description	**Design Load**		**Reference**
Mechanical Room:	125	psf	ASCE7-05, Table 4-1
Total Mechanical Floor Live Load:	**125**	psf	

INITIAL STRUCTURAL DESIGN PARAMETERS

Period of Vibration (SRSS)

After results obtained from the analysis in Technical Report 3, it was determined that serviceability would most likely control the design of the existing system. Therefore, the redesign of the lateral system was initially designed to meet serviceability requirements and then checked for strength.

In order to yield comparable dynamic qualities as the existing system, using the square root of the sum of squares (SRSS) of the first three modes of the period of vibration was the first criterion put into place. According for information obtained from the structural design engineer, the period of vibration of the New York Times Building ranges from 6.2-6.8s with the North/South being the more flexible direction. The third (torsional) mode was extrapolated to an assumed value of 5.6s. Using the following equation:

$$SRSS = [(T_1)^2+(T_2)^2+(T_3)^2]^{0.5}$$

The final assumed SRSS of the existing system was 10.8s. The goal during the design of the alternative structural core was to fall within 10% of the existing system's SRSS. Therefore, the target range for the concrete core solution was 9.7-11.8s.

Drift and Deflection

Wind:
Load combination for short-term effects: D + 0.5 L + 0.7 W (ASCE 7-05, CC.1.2)
Lateral Deflection Range: H/600 to H/400 (ASCE 7-05, CC.1.2)
Existing Design: H/450 (Thornton Tomasetti)

Seismic (ASCE 7-05):

TABLE 12.12-1 ALLOWABLE STORY DRIFT, $\Delta_a^{a,b}$

Structure	Occupancy Category		
	I or II	III	IV
Structures, other than masonry shear wall structures, 4 stories or less with interior walls, partitions, ceilings and exterior wall systems that have been designed to accommodate the story drifts.	$0.025h_{sx}^{c}$	$0.020h_{sx}$	$0.015h_{sx}$
Masonry cantilever shear wall structures [d]	$0.010h_{sx}$	$0.010h_{sx}$	$0.010h_{sx}$
Other masonry shear wall structures	$0.007h_{sx}$	$0.007h_{sx}$	$0.007h_{sx}$
All other structures	$0.020h_{sx}$	$0.015h_{sx}$	$0.010h_{sx}$

Note: Occupancy Category taken as Type III because the occupant load for the New York Times Building is greater than 5000 persons (2006 IBC, Table 1604.5).

Stiffness Modification

When designing reinforced concrete building systems, a reduction in stiffness due to cracking associated with the concrete shear walls must be taken into account. The concrete shear wall sections designed in this report assumed 50% gross section properties while the coupling beams assumed 35% I gross. However, the code allows for a 1.4 modifier to be applied to when designing for lateral loads resulting from wind. Therefore, the concrete shear walls were permitted to use 70% I gross section properties and the coupling beams utilized 50% I gross section properties. (ACI 318 § 8.8 & 10.10.4)

Acceleration

Once the alternative lateral system fell within the target range for period of vibration, an analysis of the buildings acceleration was performed using an analysis found in *Limit States Under Wind Load* by Lawrence Griffiths. The calculated peak acceleration for the lateral design was then compared to that of the assumed peak acceleration of the existing structure of 25 milli-g across a 10 year return period for non-hurricane winds. Refer to Appendix D.6 for more information on the calculation of acceleration.

INITIAL SIZINGS

Initial Sizing of Shear Walls

Required thickness due to shear was the first calculation to be performed. All walls in each direction were assumed to carry the shear loading equally. The strength equation utilized was:

$$Vu \leq 3(f'c)^{0.5}A_{cw}$$

The using an f'c=10ksi, the resulting required thicknesses were 12" for the walls in the East/West direction and the 10" for the walls in the North/South direction. However, it was assumed that shear would not control the design of the lateral system. Therefore, wall thicknesses were initially assumed to be 20" for the walls in the east west direction and 18" for those in the North/South direction.

Initial Sizing of Coupling Beams

The following rule of thumb was utilized when initially sizing the coupling beams.

$$2 < \frac{l_n}{h} < 4$$

By following this aspect ratio, the design of the coupling beams is not constrained by a specific type of reinforcement. According ACI 318-05 § 21.9.7, coupling beam aspect ratios which exceed 4 must be designed as flexural members while beams with ratios less than 2 require diagonal reinforcement if V_u exceeds $4\lambda(f'c)^{0.5} A_{cw}$. Therefore, by sizing the member to fall between an aspect ratio of 2 and 4, a designer will be able to pick between two coupling beam reinforcement options based upon analytical results.

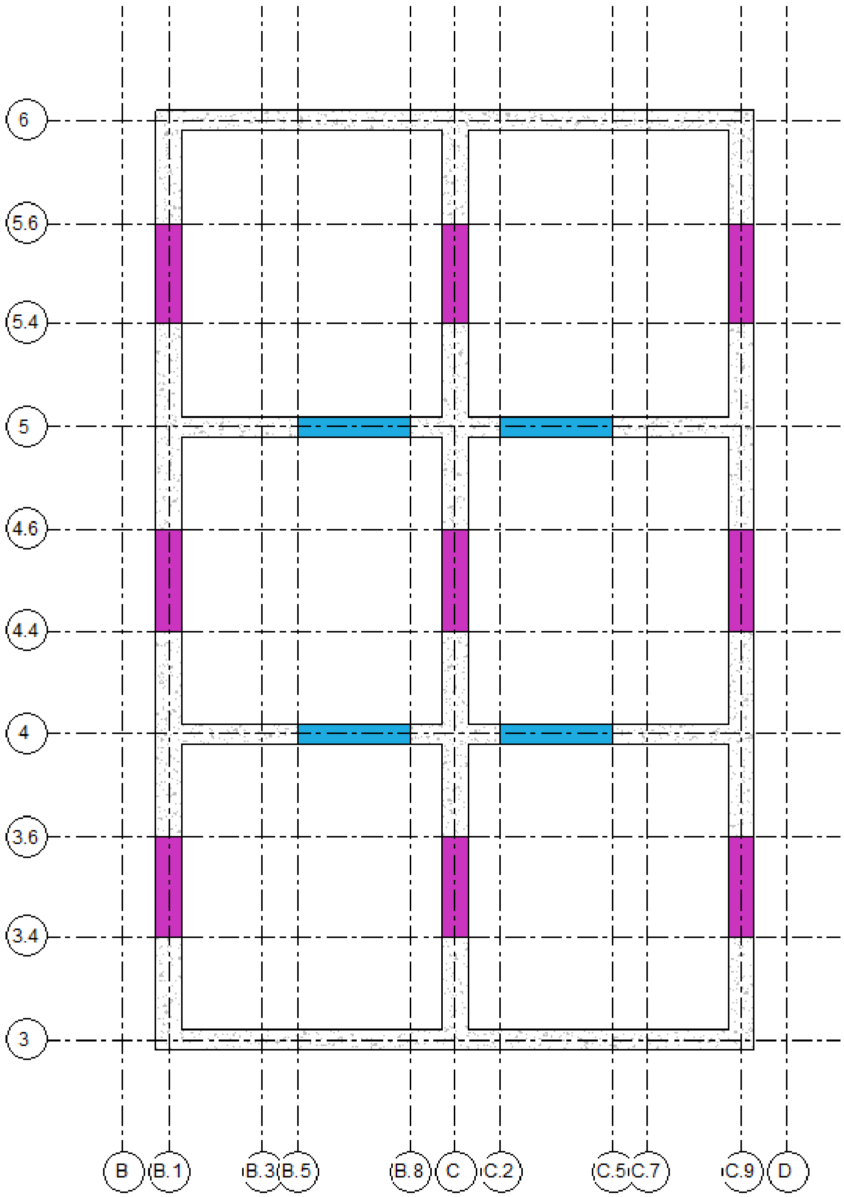
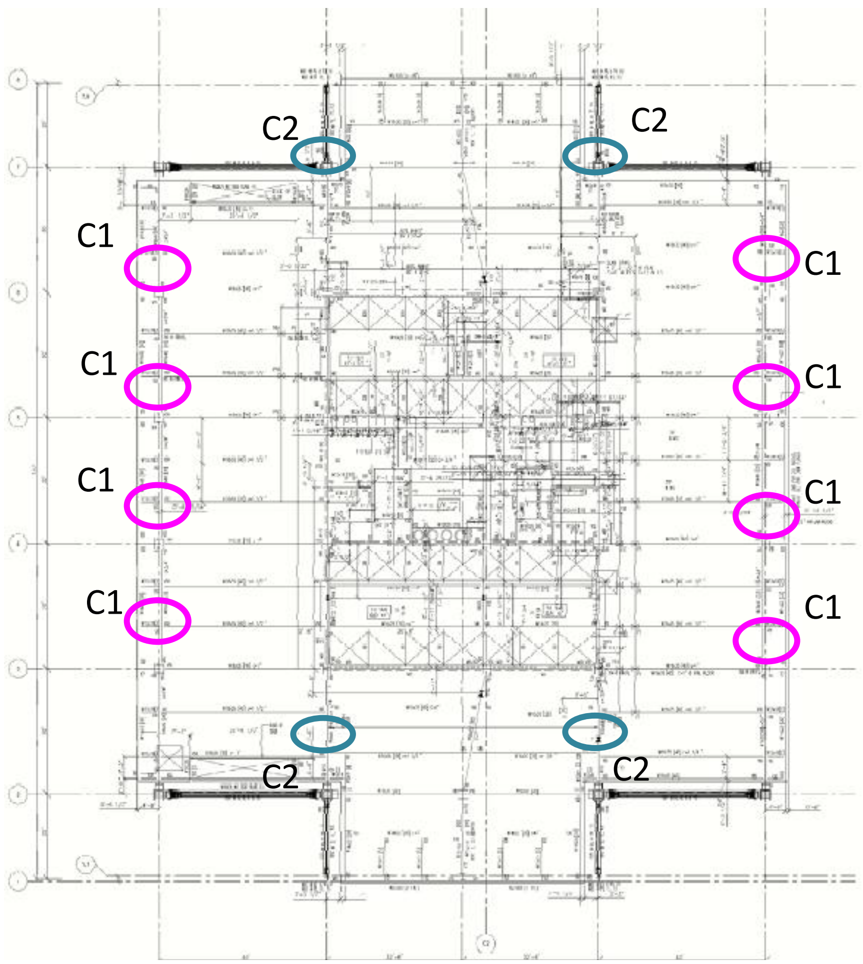


Figure 92: Coupling Beams

After considering this rule of thumb, all coupling beams, with an exception to those depicted in cyan, were initially sized with a height of 36". The coupling beams found on grid lines 4 and 5 were sized with a height of 48". The width of the beams was dependent upon the thickness of the shear walls that the coupling beams were connecting.

Initial Outrigger Sizing

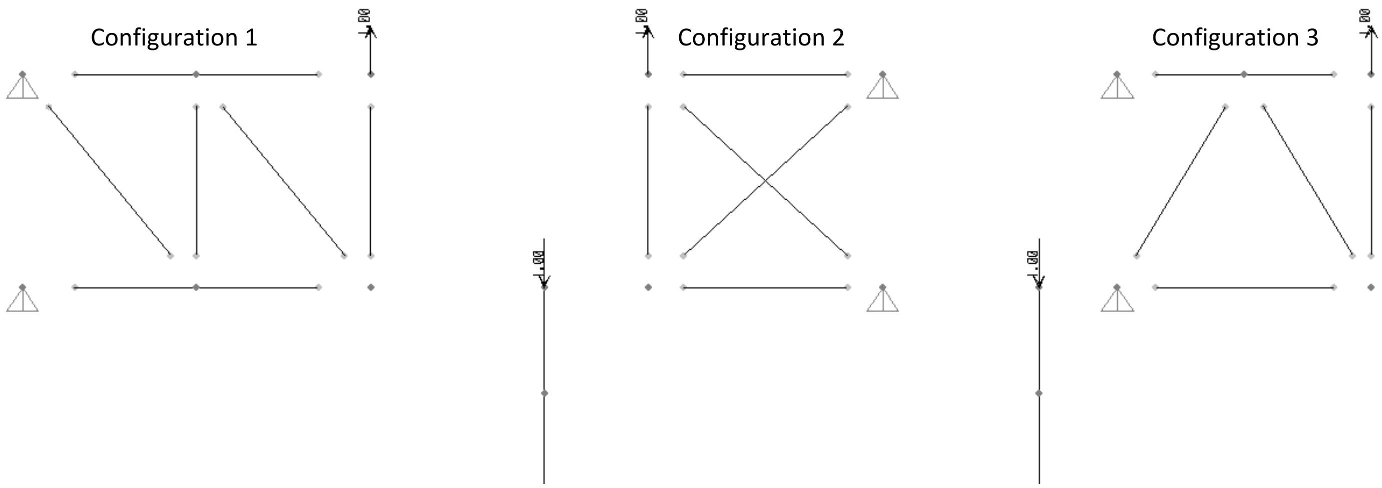
A two-dimensional frame analysis in SAP 2000 was performed in order to size the outriggers. Before the analysis could be performed, some assumed member sizes were utilized as a base. The columns were initially assumed to be that of the existing system.



Existing Columns		
Level	Col 1	Col 2
1-6	30x30 Box, 4"f x2"w	30x30 Box, 4"f x2"w
7-12	W14x665	30x30 Box, 4"f x2"w
13-18	W14x550	30x30 Box, 3.5"f x2.5"w
19-24	W14x500	30x30 Box, 3.5"f x2"w
25-28	W14x500	30x30 Box, 3"f x3"w

The beams and braces were assumed to be W14s. Also, all members assumed a yield strength of 50 ksi. Using these size parameters, the outriggers, belt trusses, brace configurations and existing columns were modeled in

SAP. In order for the outriggers to be considered to work efficiently, the axial stiffness of the columns should be comparable to the stiffness of the respective brace or truss. To achieve this, unit loads were applied to the columns and outriggers as shown below. Element sizes were then modified for each outrigger configuration until the displacements were within 10% of each other. The resulting configurations were those pictured on the following page.



Unit Displacements				
Label	col	OutRigger	% Diff	
1	0.000851	0.000855	0.47	ok
2	0.000496	0.000507	2.17	ok
3	0.000496	0.000478	3.63	ok

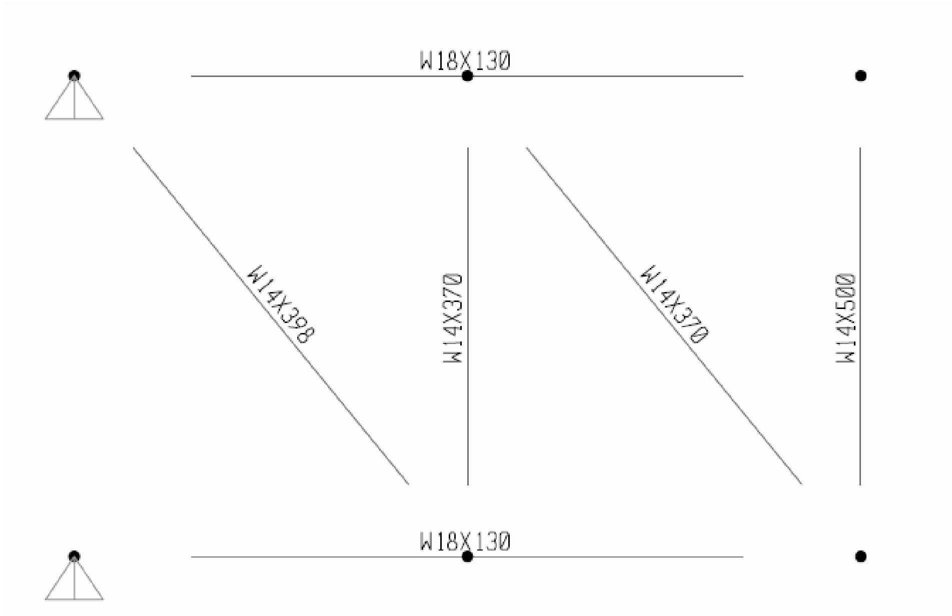


Figure 95: OR Configuration 1 @ Grids 3, 4, 5 & 6

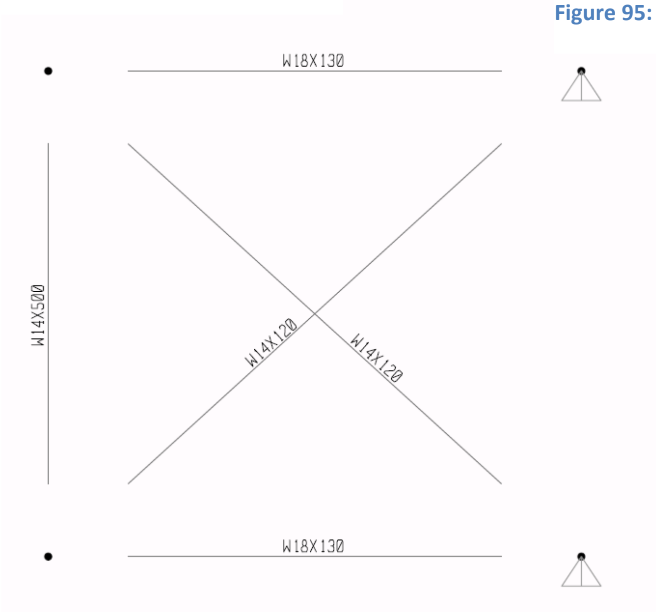


Figure 94: OR Configuration 2 @ Grid Line C

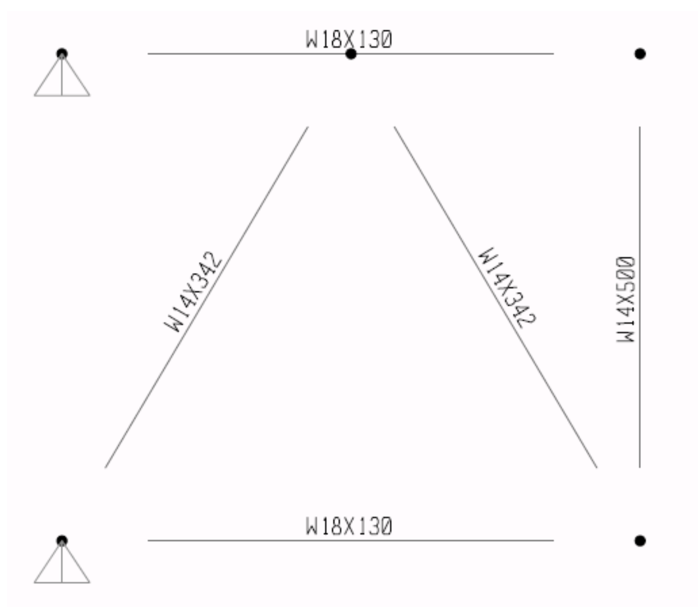


Figure 93: Configuration 3: Belt truss at Grid Lines 2 & 7

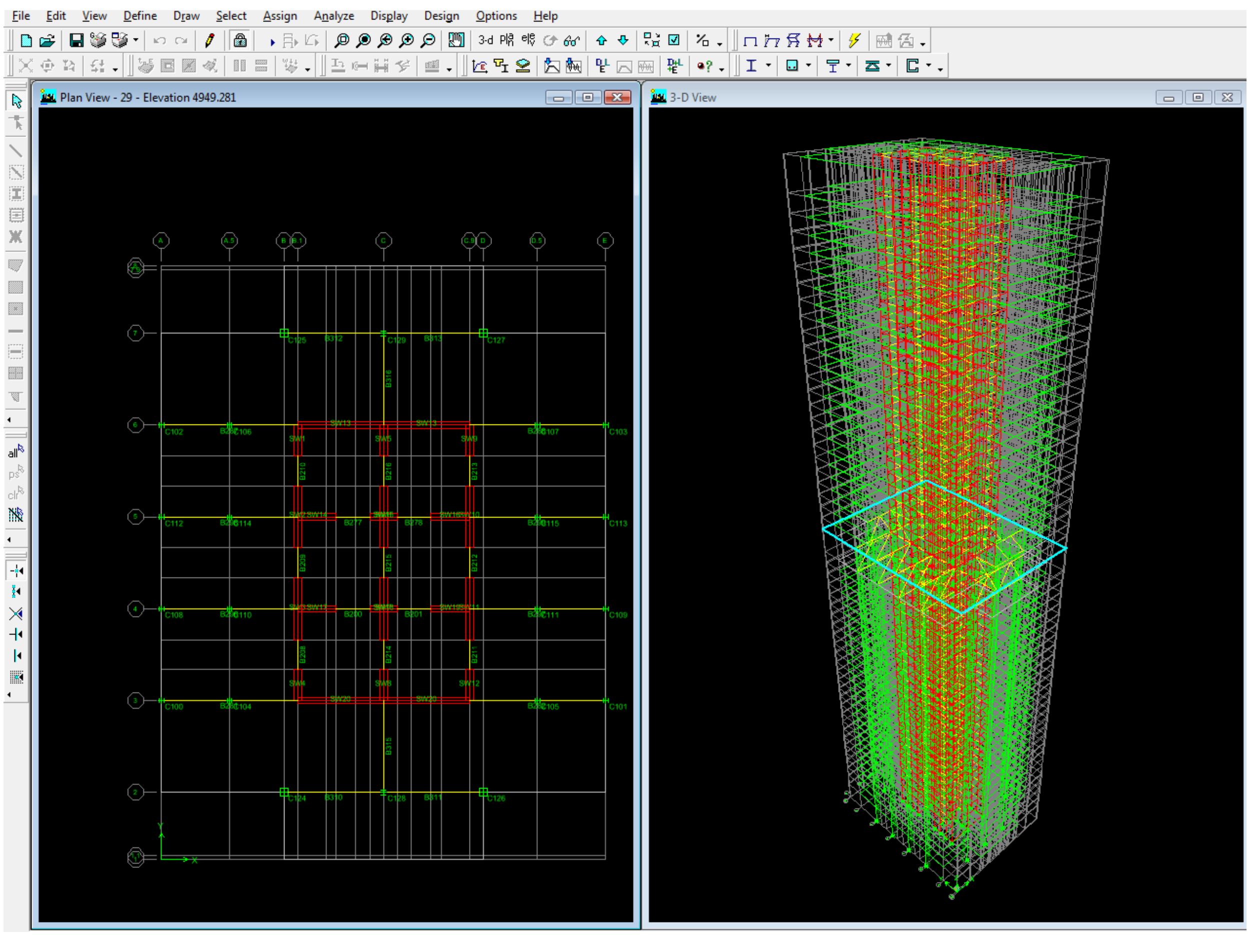
ETABS MODELING

Once the initial shear wall thicknesses and outriggers sizes were determined through the initial base shear calculation and a simple 2-D frame analysis, a three dimensional structural model was produced using ETABS. In addition to the lateral system, a 20” perimeter basement wall with 4,000 psi concrete was modeled in order to replicate a more realistic building response at the base.

When modeling the lateral system in ETABS, all levels, with an exception to those at the base and outrigger levels were modeled as rigid diaphragms. However, the first level as well as the levels above and below the outriggers were modeled as shell elements and meshed. In order to apply the required lateral loads, the levels were assigned as semi-rigid diaphragms. Also, the analysis incorporated P-Delta using a non-iterative method based on mass.

After the structure was modeled in ETABS, the 12 wind and 4 seismic load cases as mentioned previously were then applied to the center of mass or center of pressure correspondingly. Also the drift load cases of D + 0.5 L + 0.7 W and 1.0 E were applied directly to in each direction.

Once a working model was produced, the iterative process went under way to modify the model until the design met the initial design parameters of 10% of the SRSS range of 9.7-11.8s as well as complying with the allowable building drifts due based on short term wind effect (ASCE 7-05, CC.1.2) and seismic loadings. After the model was completed, the ETABS output confirmed that wind loadings control the design.



RESULTING DEFLECTIONS DUE TO WIND AND EARTHQUAKE FORCES

As mentioned, one of the overall parameters for the alternatives to the existing lateral system was for the structure to achieve the same lateral deflection due to wind of H/450 as the existing New York Times Building. The ETABS output was reviewed and found that the lateral deflections due to wind and seismic loads were found to comply with their corresponding limitations. The maximum inter-story drifts were found to be at Level 41 in the North/South direction and at Level 37 in the East/West direction for both wind and seismic loadings. Please note that the D + 0.5 L + 0.7 W load combination was applied for wind drift while seismic drift assumed 1.0 E. Also, stiffness modifiers were applied as mentioned previously. Refer to the Appendix D.8 to review the calculation of inter-story drift due seismic loadings which incorporates accidental torsion.

Direction	Displ. (in)	H/450 (in)	Compliance?
N/S	10.9	19.88	ok
E/W	7.1	19.88	ok

Story Drift Check								
Direction	Level	h_{sx} (ft)	Seismic			Wind		
			0.015 h_{sx}	Calculated SD	Compliance ?	h/450	SD from ETABS	Compliance ?
E/W	41	13.26	0.1989	0.0125	ok	0.029467	0.0009	ok
N/S	37	13.26	0.1989	0.009	ok	0.029467	0.001	ok

DESIGNS FOR STRENGTH

Outrigger Design for Strength

Once the design fell within the 10% of the target SRSS and met drift criterion, the outriggers were checked to see if they were adequately sized for strength. After the governing reactions at the ends of outriggers and belt trusses was determined, the loads were then applied as shown in Figures 96 - 98 to the ends of the outriggers and belt trusses in the 2-D SAP model. Loads due to .9 D + 1.6 W and 1.2 D + 1.6 W + L were applied in order to apply both the maximum tensile and compressive axial load to the outriggers.

Figure 98: Configuration 1: Outrigger at Grid Lines 3, 4, 5 & 6

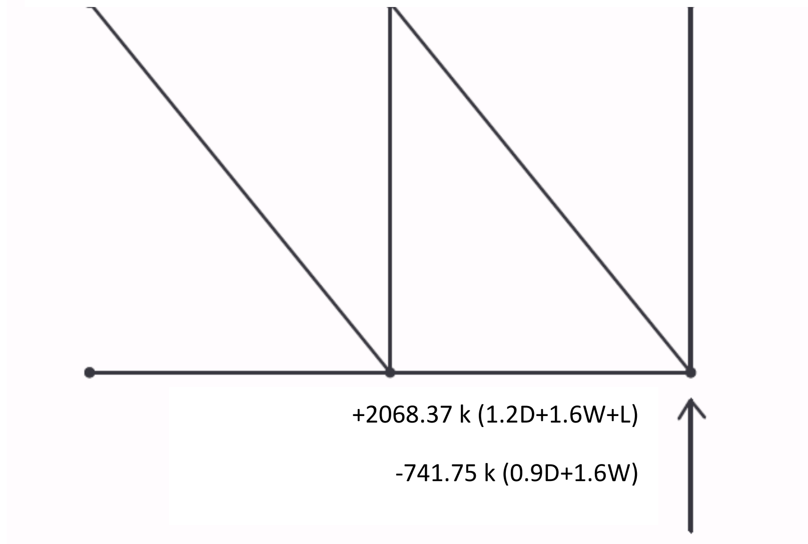


Figure 97: Configuration 2: Outrigger at Grid Line C

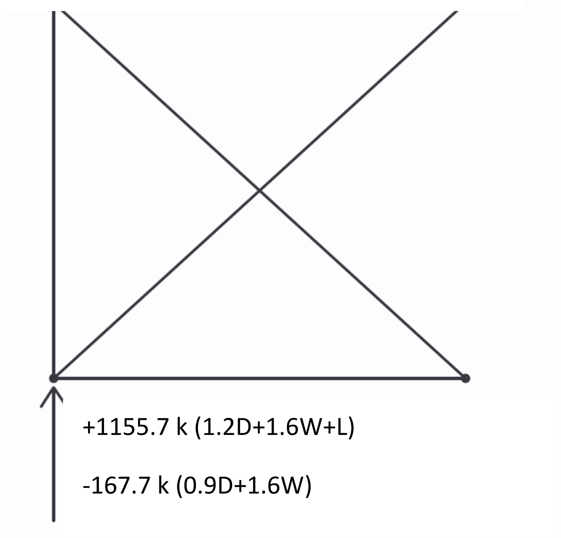
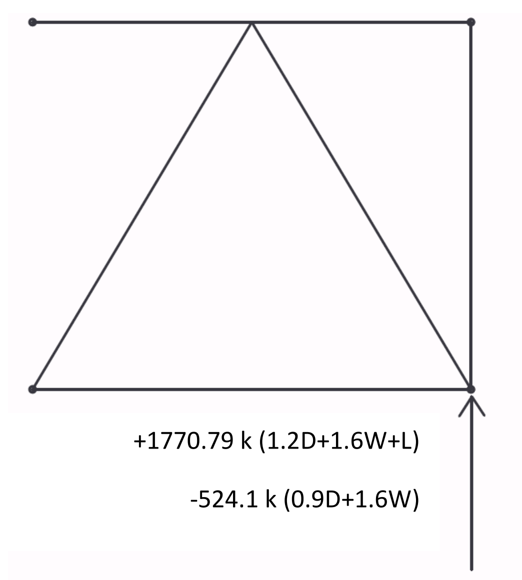
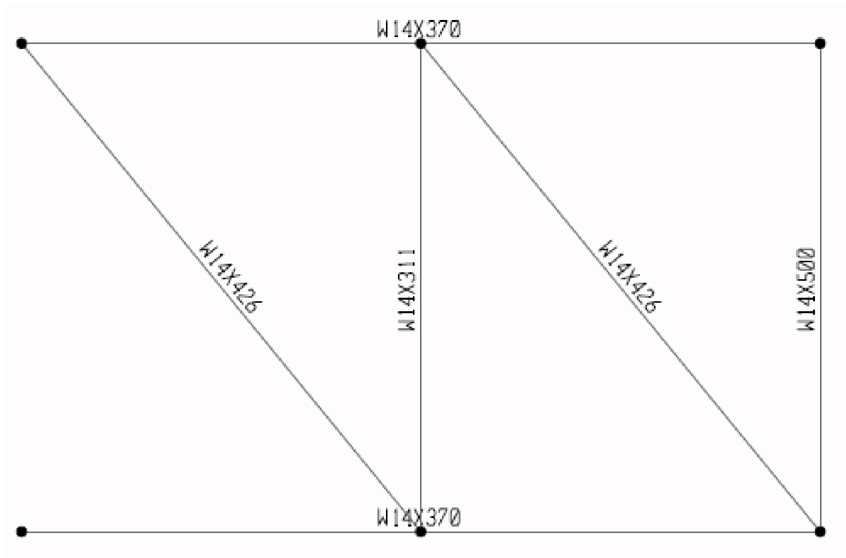


Figure 96: Configuration 3: Belt truss at Grid Lines 2 & 7



With the loads applied as shown, the axial forces of each configuration were viewed after running the analysis. Each member was then checked for tensile and compressive strength using Tables 4-1 and 5-1 in the13th edition of the AISC Steel Construction Manual. The members were then resized appropriately to meet the required capacity. Due to the fact that the modification of a member size would change the stiffness of the structure, the resized outriggers had to be modified in the ETABS model. After rerunning the analysis in ETABS, the outriggers were checked again for capacity. Figures 99 - 101 report a summary of the final member sizes.



East / West Outriggers (Grid Lines 3, 4, 5 & 6)							
Member	Type	kL (ft)	Compression		Tension		Compliance
			P_u (k)	ϕP_n (k)	P_u (k)	ϕP_n (k)	
W14x426	Diag. Brce	36	2677.5	2730	960	5630	ok
W14x311	Vert. Brce	28	739.5	2580	2069	4110	ok
W14x370	Chords	24	1684	3520	690	4910	ok

Figure 99: OR Configuration 1 Strength Check

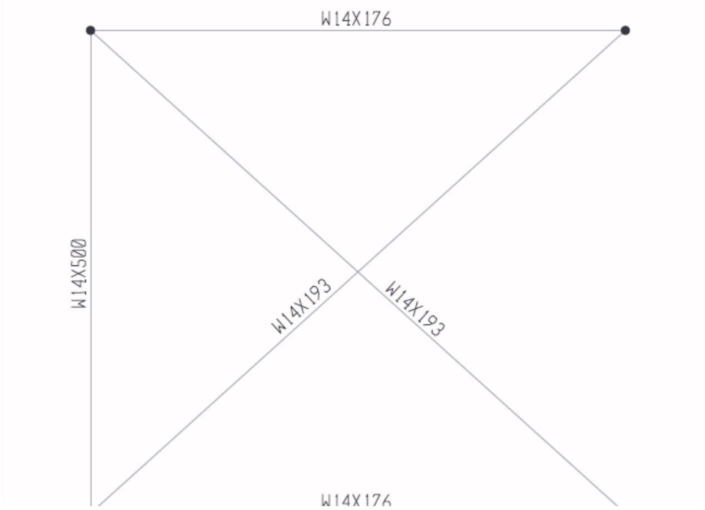
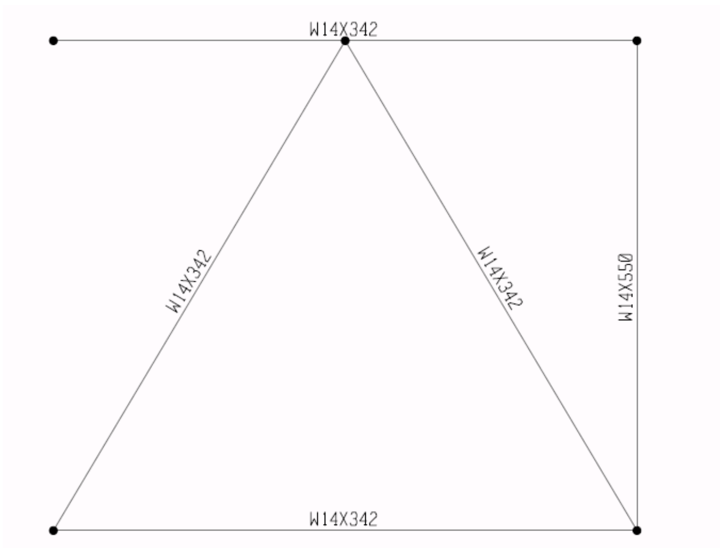


Figure 100: OR Configuration 2 Strength Check

North / South Outriggers (Grid Line C)							
Member	Type	kL (ft)	Compression		Tension		Compliance
			P_u (k)	ϕP_n (k)	P_u (k)	ϕP_n (k)	
W14x176	Brace	30	611	1300	611	2330	ok
W14x193	Chords	40	893	913	827	2560	ok



Belt Trusses (Grid Lines 2 & 7)							
Member	Type	kL (ft)	Compression		Tension		Compliance
			P_u (k)	ϕP_n (k)	P_u (k)	ϕP_n (k)	
W14x426	Braces	32	2071	2500	2064	4550	ok
W14x311	Top Chord	15	2111	3980	625	4550	ok
W14x370	Bot. Chord	30	312	2680	1055	4550	ok

Figure 101: OR Configuration 3 Strength Check

Design for shear

In addition to the outriggers, the concrete shear walls were checked for adequate shear strength. Using the core geometry resulting from the design based on the serviceability requirements as well as ETABS output, a spread sheet was developed to determine the required reinforcement in the shear walls. The spread sheet conformed to the provisions within Chapter 14 and §11.9.9 of ACI 318-08. After reviewing the analysis, it was found that the majority of the shear walls required only minimum shear reinforcement. This confirmed the initial assumptions that shear would not control the design of the structure. Refer to Appendix D.9 to review the shear strength checks.

Column Checks

After designing the outriggers, the initial assumption that the columns of the existing structure would have the adequate strength to carry the lateral and gravity loads of the alternative design required verification. Therefore, the capacity of Column A5 in relation to these new loads was analyzed. After reviewing the ETABS output, the controlling load combination was 1.2D+L+1.6W due to Wind Case 3. Using a spread sheet, a column load take down was performed in to determine the required compressive capacity of the column of interest. The resulting axial loads were then compared to the tabulated allowable compressive strengths for wide-flange members and calculated compressive strength for built-up members per Table 4-1 in the13th edition of the AISC Steel Construction Manual and Chapter E of ANSI/AISC 360-05 respectively. Upon review, it was determined that exiting columns from level 8 -12 and 14-27 would require additional capacity. Refer to chart below for a summary of this analysis and member resizing.

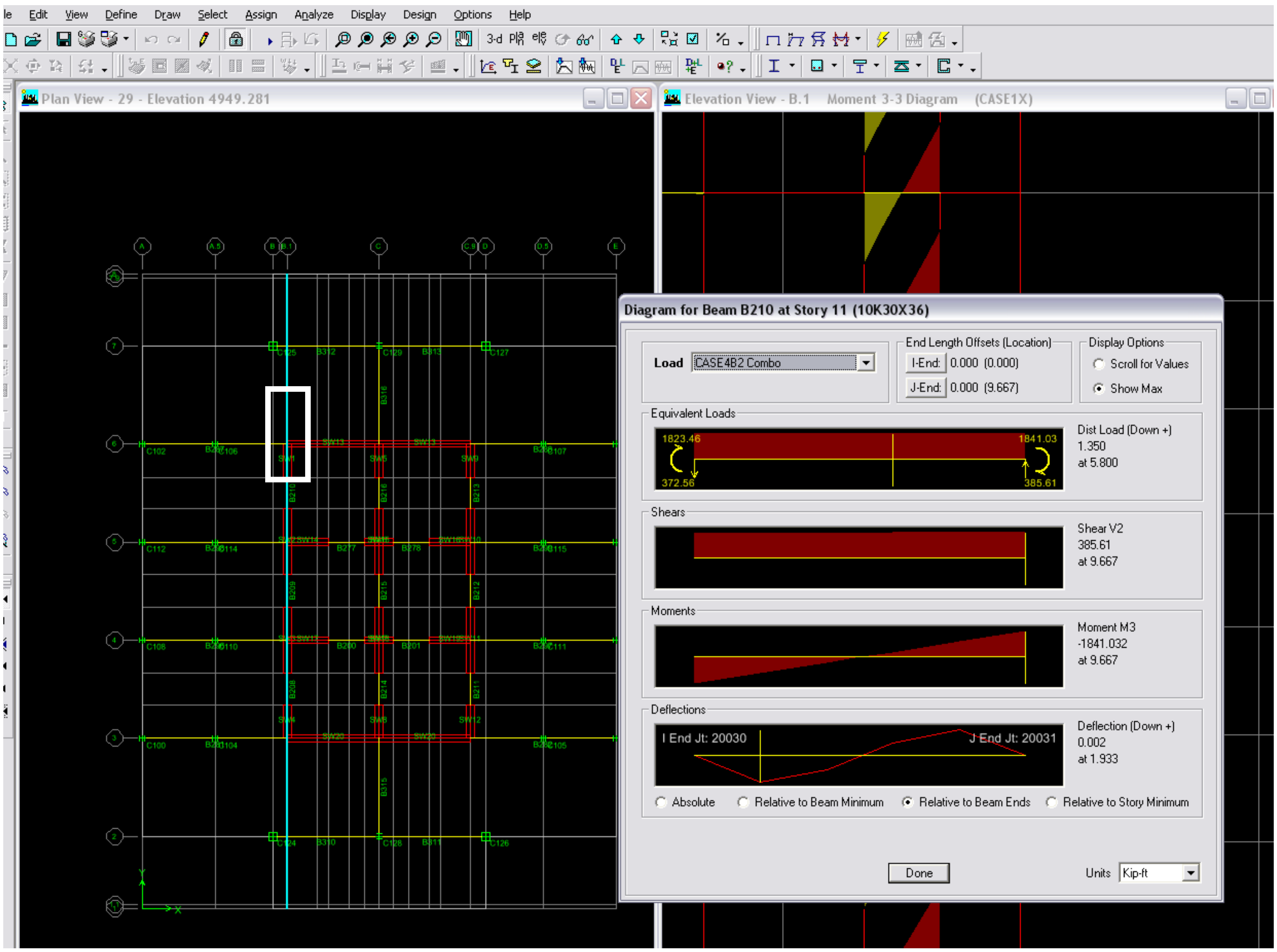
Column A5 - Capacity Check & Resizing Summary									
Level	h (ft)	kL (ft)	P_u (k)	Existing Column			New Column		
				Member	ϕP_n (k)	Capacity	Member	ϕP_n (k)	Capacity
27	13.50	14	6030.35	W14x500	5950	NG	W14x550	6580	OK
26	13.60	14	6167.24	W14x500	5950	NG	W14x550	6580	OK
25	13.60	14	6304.14	W14x500	5950	NG	W14x550	6580	OK
24	13.60	14	6441.03	W14x500	5950	NG	W14x550	6580	OK
23	13.60	14	6577.93	W14x500	5950	NG	W14x550	6580	OK
22	13.60	14	6714.83	W14x500	5950	NG	W14x665	8010	OK
21	13.60	14	6851.72	W14x500	5950	NG	W14x665	8010	OK
20	13.60	14	6988.62	W14x500	5950	NG	W14x665	8010	OK
19	13.60	14	7125.51	W14x550	5950	NG	W14x665	8010	OK
18	13.60	14	7262.41	W14x550	5950	NG	W14x665	8010	OK
17	13.60	14	7399.31	W14x550	5950	NG	W14x665	8010	OK
16	13.60	14	7536.20	W14x550	5950	NG	W14x665	8010	OK
15	13.60	14	7673.10	W14x550	5950	NG	W14x665	8010	OK
14	13.60	14	7869.93	W14x550	5950	NG	W14x665	8010	OK
13	13.60	14	8006.83	W14x665	8010	OK	W14x665	8010	OK
12	13.25	14	8143.35	W14x665	8010	NG	W14x730	8810	OK
11	14.25	14	8280.95	W14x665	8010	NG	W14x730	8810	OK
10	13.60	14	8417.85	W14x665	8010	NG	W14x730	8810	OK
9	13.60	14	8554.74	W14x665	8010	NG	W14x730	8810	OK
8	13.60	14	8691.64	W14x665	8010	NG	W14x730	8810	OK

Due to the spreadsheet size, the full calculation will not be found within this report. However, the calculation is available upon request. Please consult the structural member of this team if review is required.

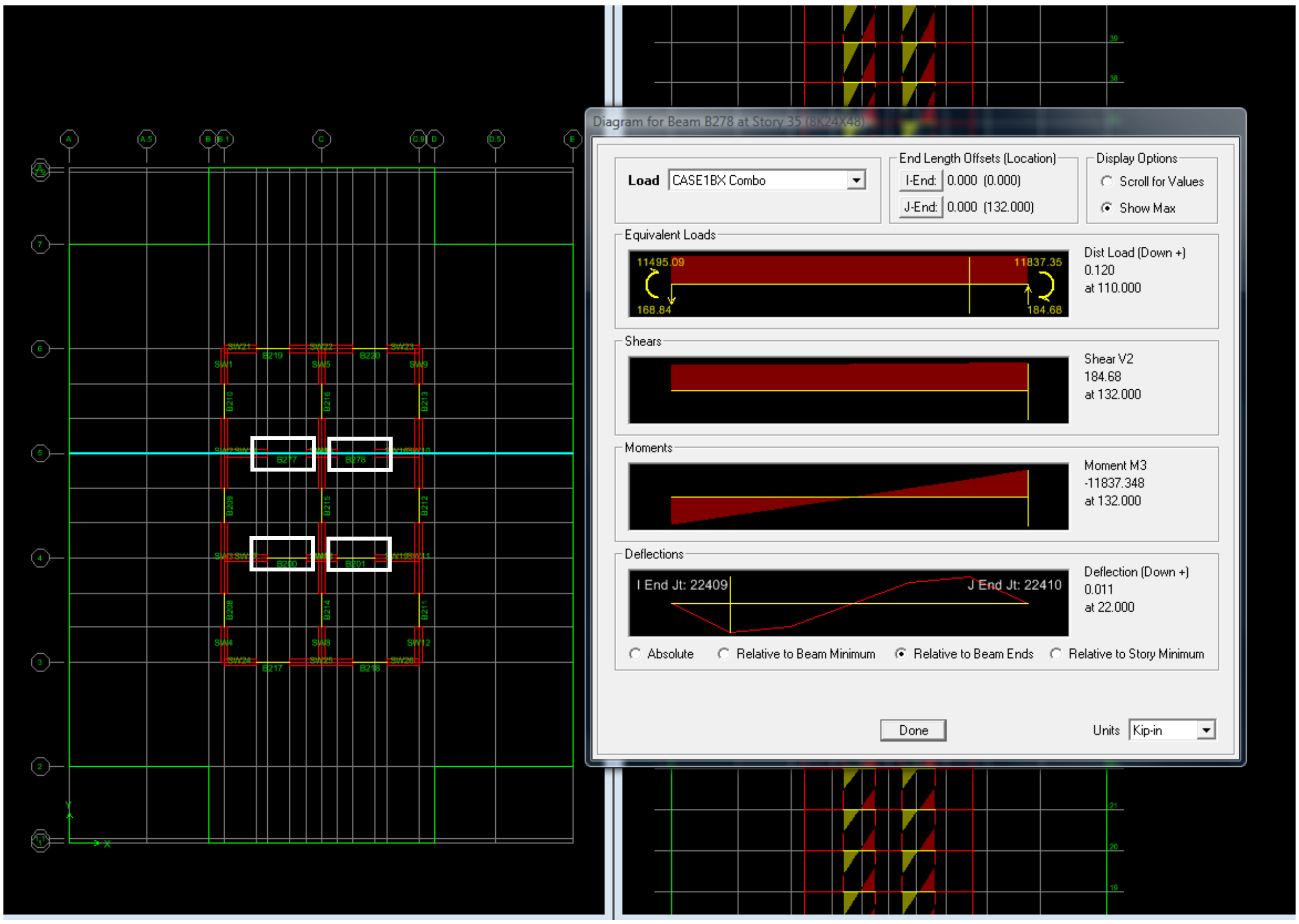
As result of this investigation, it should be assumed that the existing columns at other locations throughout the structure would not have the required compressive strength to carry the new axial loads resulting from this redesign. Therefore, if an investigation of this alternate design were to continue, an analysis similar to that described here must be performed.

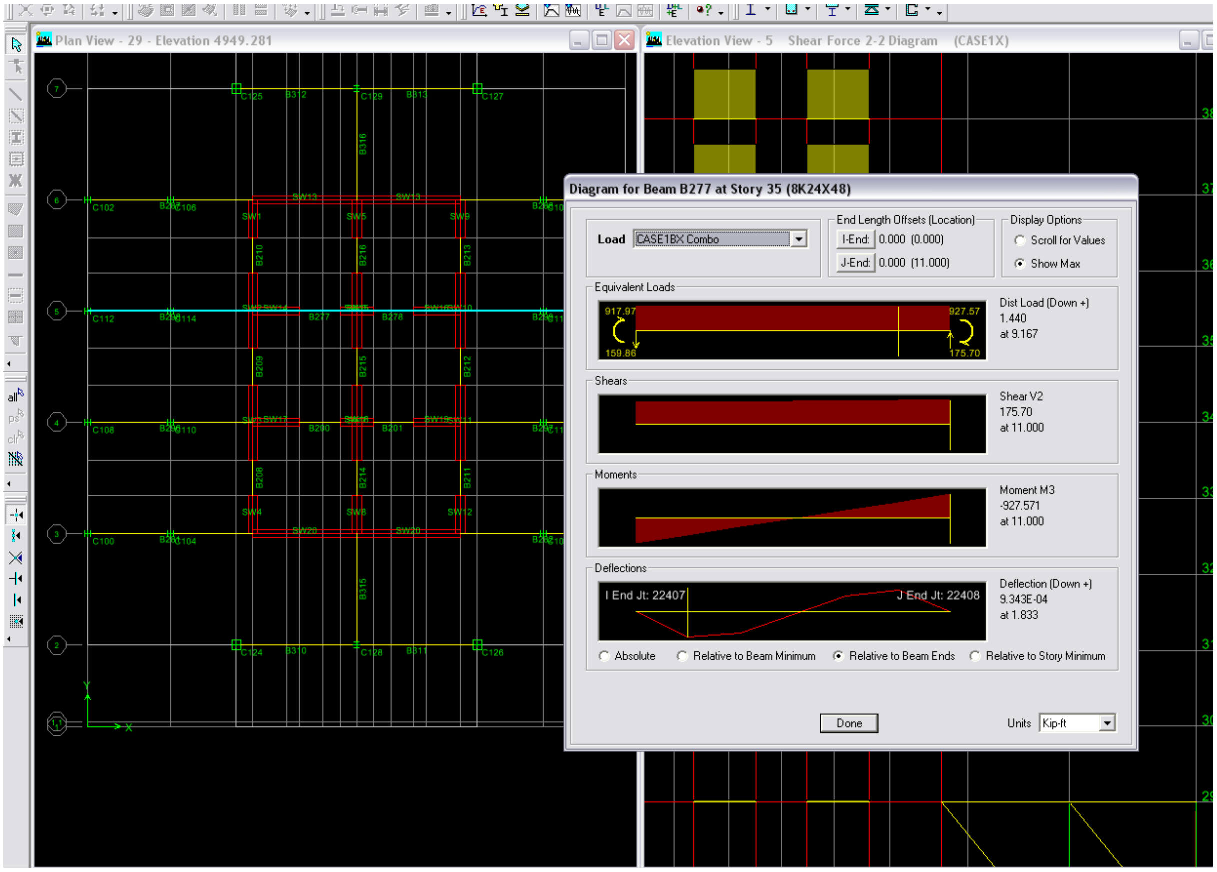
Coupling Beam Checks

An investigation of the coupling beams was also performed. By filtering through the ETABS output, the beams the highest shear loadings were determined throughout the structure. One beam in particular that was investigated is shown below. The member is located on the 11^{th} story and spans the 9'-8" opening shown denoted in white. Being initially sized with an aspect ratio between 2 and 4 (in this case 3.22), the member fell with the provision of ACI 318-08 § 21.9.7.4. $4(f'c)^{0.5}A_{cw}$ for this member was determined to be 432 k using and f'c of 10,000 psi and A_{cw} of 1080 in^2.After comparing this value to the V_u (385.61 k) of the member, diagonal reinforcement was not required. Therefore, the coupling beam would have to be designed as a flexural member per ACI § 318 21.5.2-4.



Also after reviewing the ETABS output, an opportunity was presented to refine the design of the coupling beams initial sized with the depth of 48”. Of these 11’ long coupling beams, denoted below in white, the governing V_u of 184.7 k was found to be at Level 35. The $4(f'c)^{0.5}A_{cw}$ for this member was determined to be 412.1 k using an f’c of 8,000 psi and A_{cw} of 1152 in^2. Since the applied shear was substantially less than that found from $4(f'c)^{0.5}A_{cw}$, the depth of these coupling beams was reduced to 36”.



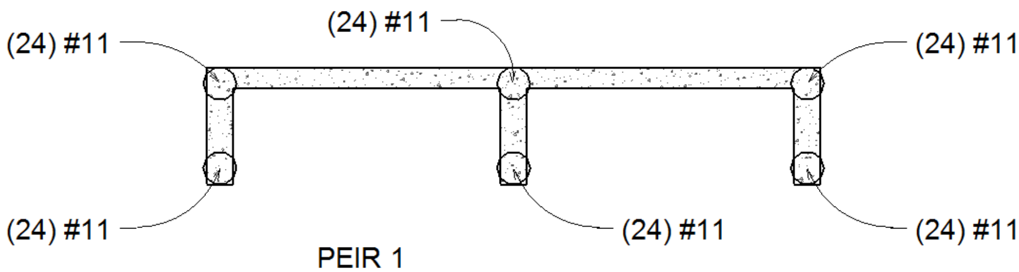


Upon reanalyzing the lateral system in ETABS, the V_u of the member of interest was found to be reduced to 175.7 k. Upon recalculation, the $4(f'c)^{0.5}A_{cw}$ was determined to be 309.1 k meaning coupling beam could still be designed as a flexural member per ACI § 318 21.5.2-4.

It was determined that this change would have little effect on the dynamic properties of the system. Prior to the change, the period of vibration in the East/West direction was 7.27s whereas after, the period of vibration only increased to 7.31s. The SRRS resulting from this change went from 11.24s to 11.26s and still fell within the targeted range of 10% of the existing SRSS.

Design for Flexure

A preliminary analysis was performed to determine the required flexural reinforcement for the shear walls at the base of the structure. The analysis was performed using the basic structural concept of T=C (tension = compression). Based upon this analysis, the required reinforcement due to the governing overturning load of 0.9D+1.6W was determined as schematically shown below. Through the analysis, it was determined that the wind in the North/South direction, governed the design of the reinforcement. The design was then analyzed in PCA column, and the result was confirmed. If this design would be carried out further, a more in depth analysis would need to be conducted according to the provisions found in ACI 318-08 Chapter 21. Refer to Appendix D.10 to review the preliminary calculations.



COST OF CORE CHANGES

A cost analysis had to be done of the proposed core change. In order to do an easy and fairly accurate estimate of the core redesign, it was important to implement the use of Revit to produce structural takeoff numbers. The proposed alternate core was modeled and analyzed in ETABS and exported into Autodesk Revit. Material takeoff schedules for steel and concrete were organized in Revit and exported to excel. First, the cost of the steel that was going to be replaced by the concrete core, as well as the outriggers on the 51st floor that can be eliminated were found. This steel being replaced by the concrete core was found to be approximately **$37.2 million**. A material takeoff was produced from the Revit model and put together with pricing from RS Means. The cost of the concrete core for the material, labor and equipment for the concrete, reinforcing steel and the slip forming came out to be approximately **$18.7 million**. All together the concrete core can save the owner **$18.5 million**.

	Total Building
Steel Being Replaced	$ (37,171,395)
Concrete Additions	$ 18,676,730
Core Savings	**$ (18,494,665)**

SCHEDULE

A detailed schedule of the superstructure can be found in Appendix B.6.

There are some very important schedule implications that have to be accounted for when analyzing a concrete core vs. a steel core. There are a few key decisions made about the construction of the concrete core that need to be discussed before talking about the overall schedule change. It was decided that the slip form that was used for constructing the core would be a two story form. This means that the core will be poured two stories at a time. Each two story pour will last two weeks. This allows that concrete to set and reach its 14 day strength before the next pour takes place. Therefore, the overall duration of the concrete core construction is about 275 days.

Construction of the core will start on December 27, 2004 and end on January 12, 2006. The concrete core has to begin 2.5 months ahead of when the steel core would have begun. This will affect both the site work on the project and the general conditions. The site work was originally staged so that work on the east side of the site was mostly finished by the time the site work was to begin on the west side of the site. For the new concrete core, site work will have to be started earlier on the west side of the site to make room in the schedule for the concrete core to start 2.5 months ahead of schedule. It was assumed that the site work could be done in this fashion with little impact to the general conditions. Manpower my peek higher than before but the overall duration of excavation was shortened.

The concrete core was placed into the schedule with its proper links to the other activities and found that it would not delay the project if it was started on December 27, 2004. This will mean that two cranes that are dedicated to the tower alone will be needed 2.5 months in advance. This will add $81,700 to the general conditions. The other issue that the concrete core will face is pouring during the winter season. It is assumed that this will add approximately $2 million per winter season to the general conditions. Taking a look at the schedule shows that the core construction will occur during two full winter seasons. This will add approximately $4 million dollars to the general conditions.

Item	Quantity	Cost
Steel Core		$ (37,171,395)
Concrete Core	21,500 CY	$ 18,676,730
Crane Addition	2.5 Month	$ 81,700
Temporary Heating	2 Winters	$ 4,000,000
Upfront Savings		**$ (14,412,965)**
***Additional Rent Annually**	5,8464 SF	$ 1.26 million per year

There are some other items that were not considered in this analysis due to insufficient information or access to pricing information. The “X” bracing on the exterior of the building was described as structure that was used to limit acceleration in the building. With the new concrete core there is no need for this “X” bracing. If the group was able to eliminate these “X” braces there would be an upfront savings to this item that cannot be found with the current amount of information provided. Also, steel connections were not considered in these estimates. That includes steel to steel connections, as well as steel to concrete connections that are needed for the structure.

LOBBY LIGHTING DESIGN

Spatial Summary

The lobby is the first interior space experience by all occupants in the building. The space contains reception and security desks, elevator lobbies, and an interactive "movable type" attraction in the center hall. The space is also surrounded by glass on each side allowing individuals to view the exterior from any point in the space. The high ceilings, vibrant colors, and unique architecture create a welcoming environment that portrays the NYT Building as an iconic, innovative structure. The space is accessible by the buildings occupants as well as the public.

Activities/Tasks

The lobby is mainly used as an entrance to the building. Specific tasks in the open floor area would consist of walking and conversing between individuals. The reception and security desks would require appropriate illuminance for reading and facial recognition.

Surfaces/Material Reflectance

**All values assumed due to lack of information*

- Ceiling: 80%
- Wood Walls: 50%
- Glass Walls: 10%
- Painted Walls: 45%
- Floor: 30%

Design Concept

The existing lighting design utilized both uplight and downlight. The result was an attractive, colorful environment that invited guests to explore the space. In my redesign I attempted to highlight the core of the building by creating a cove that surrounded the perimeter of both elevator lobbies and the central hallway. My goal was to aid in the theme of transparency. I wanted to use a lighting technique that would direct an individual to look through the space and allow one to experience the unique architectural design. I also wanted to create the sense that the core of the building was split from the rest of the structure. This idea would enhance the theme of lightness and create a floating structure. This concept would be continued up through each floor of the building and create a reoccurring theme.

Design Criteria

- IESNA Recommendations: Lobby (office)
    - Horizontal Illuminance – 100 lux (10fc)
    - Vertical Illuminance – 30 lux (3fc)
    - Reception Desk – 300 lux (30fc)

- ASHRAE Recommendations: Lobby (office)
    - Lighting Power Density – 1.3 W/ ft^2

Design Considerations

Psychological Impression
Impression of Spaciousness

- Uniform, peripheral (wall) lighting
- Brightness is a reinforcing factor, but not a decisive one

Appearance of Space and Luminaires (Very Important)
Upon entering the building, an individual should immediately experience the change from the crowded streets into the open lobby. The luminaires should be of high quality to reflect the characteristics of the rest of the facility. The idea of lightness should be expressed through the use of concealed fixtures that do not impede the architectural design. The fixtures should also be barely noticeable yet provide bright, vibrant light.

Color Appearance (Important)
Daylight is a major component in the design of the lobby. The lighting should accommodate to this aspect of the space to create an active and exciting environment. Lamps with high CRI values should be used to emphasize the bright colors used on the various surfaces.

Daylight integration and Control (Somewhat Important)
A major theme for the lobby is the idea of transparency. The space is surrounded by a full height, glass wall that provides uninterrupted views to the exterior. Daylight fills the space from every angle. The lighting design should accommodate various daylighting situations and provide ample dimming capabilities.

Direct Glare (Important)
Luminaires shall have no direct glare to allow for a comfortable use of the space. Luminaires should be concealed within architecture or fixed with glare accessories.

Flicker (Somewhat Important)
Flicker should not be visible within the space. The lighting design should express high quality and reflect the characteristics of the building.

Light Distribution on Surfaces (Important)
Uniform lighting should be used along the periphery to emphasize the expanse of the lobby. The ceiling and floor should also receive uniform lighting to create the sense of a larger space.

Luminance of Room Surfaces (Important)
Wall washing should be present across all the walls. The colors and materials used in the space should be emphasized through the lighting design. The floor should also express its bright color and reflective quality. Daylight will create a visually pleasing display that continuously changes throughout the day.

Modeling of Faces or Objects (Important)
The space should promote constant interaction between people. The lighting system should provide good color tone and detail on occupants. Facial Expressions and hand motions should be easily seen.

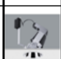
Reflected Glare (Somewhat Important)
Reflected glare should be avoided from the windows and floor. The large amount of glass suggests that luminaires should not be placed close to or aimed at windows. Luminaires should be located at a reasonable height above the floor to reduce harsh reflections. Choose fixtures that can control glare with the use of accessories.

Shadows (Somewhat Important)
Shadows should be avoided around the information and security desks. However, shadows across the ceiling or walls could create an interesting atmosphere. Daylight could also provide shadows from the exterior structure and create visually interesting designs.

Surface Characteristics (Important)
All surfaces should fully express their materials. Due to the material types in the space, the walls should be washed. The space contains no textured surfaces, so grazing should not be used. The ceiling should be illuminated in a way that appears different from the floor. Any texture or detail on the floor should be revealed through the lighting design.

Maintenance
The high ceiling suggests that maintenance could be difficult and tedious. Luminaires should use lamps with long life to reduce the time between relamping. Lamp color consistency should also be a key factor in the lighting design. The time it takes to replace a lamp should also be considered when selecting a light fixture.

Luminaire Schedule (*Full, enlarged schedule located in Appendix C.1)*

Type	Image	Product Title	Manufacturer	Catalog Number	Description	Lamp	Ballast	Input Watts	Voltage
L1		Lightcast Downlight	Erco	22122.000	9" Recessed downlight, cast aluminium housing, designed as heat sink, silver reflector	CF32DT/E/IN/827/ECO Osram Sylvania: 20883 DULUX 32W Triple Compact Fluorescent	Philips Advance ICF2S26M1BSQS@27 7 SMARTMATE Electronic Rapid	36	277
L2		Lightcast Directional Downlight	Erco	22645.000	8" Recessed directional downlight, cast aluminium housing, designed as heat sink, silver reflector	120PAR38/HAL/SP/RP Osram Sylvania: 14873 CAPSYLITE PAR38 Tungsten Halogen	N/A	120	230
L3		Wall/Slot 8400	LiteControl	84-14T8-R/SGL-CWM-DP-DA/MK7-WCS-277	4' Recessed perimeter fixture with regressed soft glow lense, matte white finish	FO32/735/SL Osram Sylvania: 21678 OCTRON T8 Fluorescent	Philips Advance VEL-1P32-SC STANDARD ELEC Instant Start	32	277
L3a		Wall/Slot 8400	LiteControl	84-14T8-R/SGL-CWM-DP-DA/MK7-WCS-EF-277	4' Recessed perimeter fixture with regressed soft glow lense, matte white finish, integrated emergency fluorescent ballast that powers one T8 lamp for 1 1/2hrs	FO32/735/SL Osram Sylvania: 21678 OCTRON T8 Fluorescent	Philips Advance VEL-1P32-SC STANDARD ELEC Instant Start	32	277

Light Loss Factors

12 Month Cycle and Clean Environment

Type	Lamp	Mean Lumens	BF	LDD		RSDD	Total LLF
L1	CFT	2002	.98	Category IV	.89	.95 (i)	.83
L2	PAR38	1800	1.0	Category IV	.89	.95 (i)	.85
L3	T8	2444	.92	Category V	.88	.95 (i)	.77
L3a	T8	2444	.92	Category V	.88	.95 (i)	.77

i – RCR =5.6

Lighting Plans

All lighting plans located in Appendix C.3

Lobby Lighting Performance Data

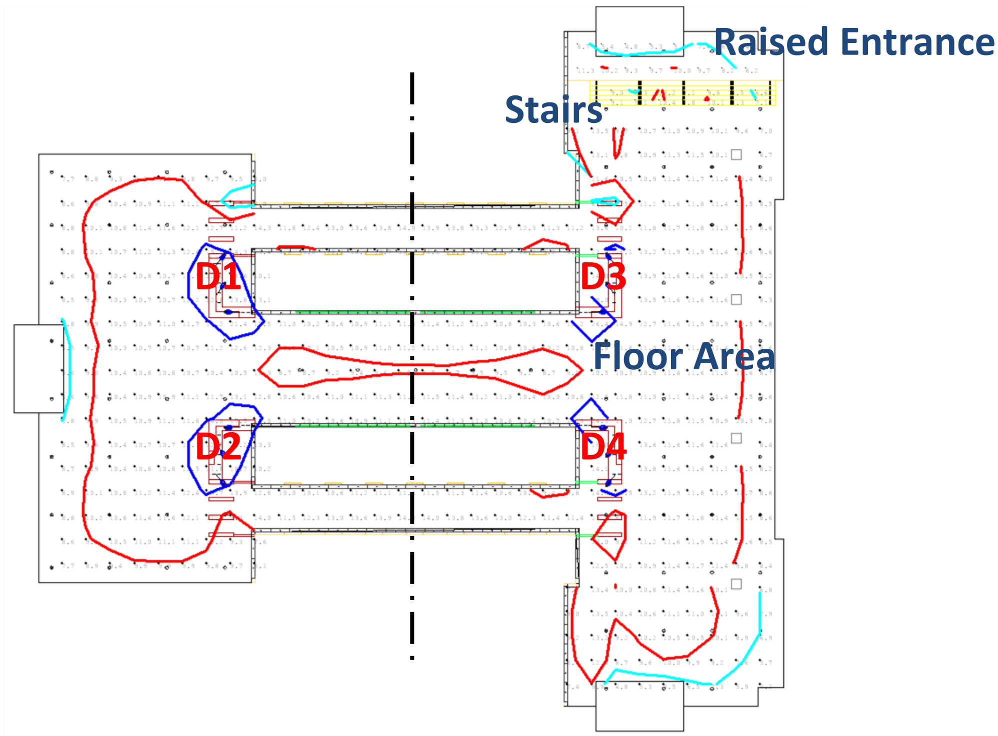
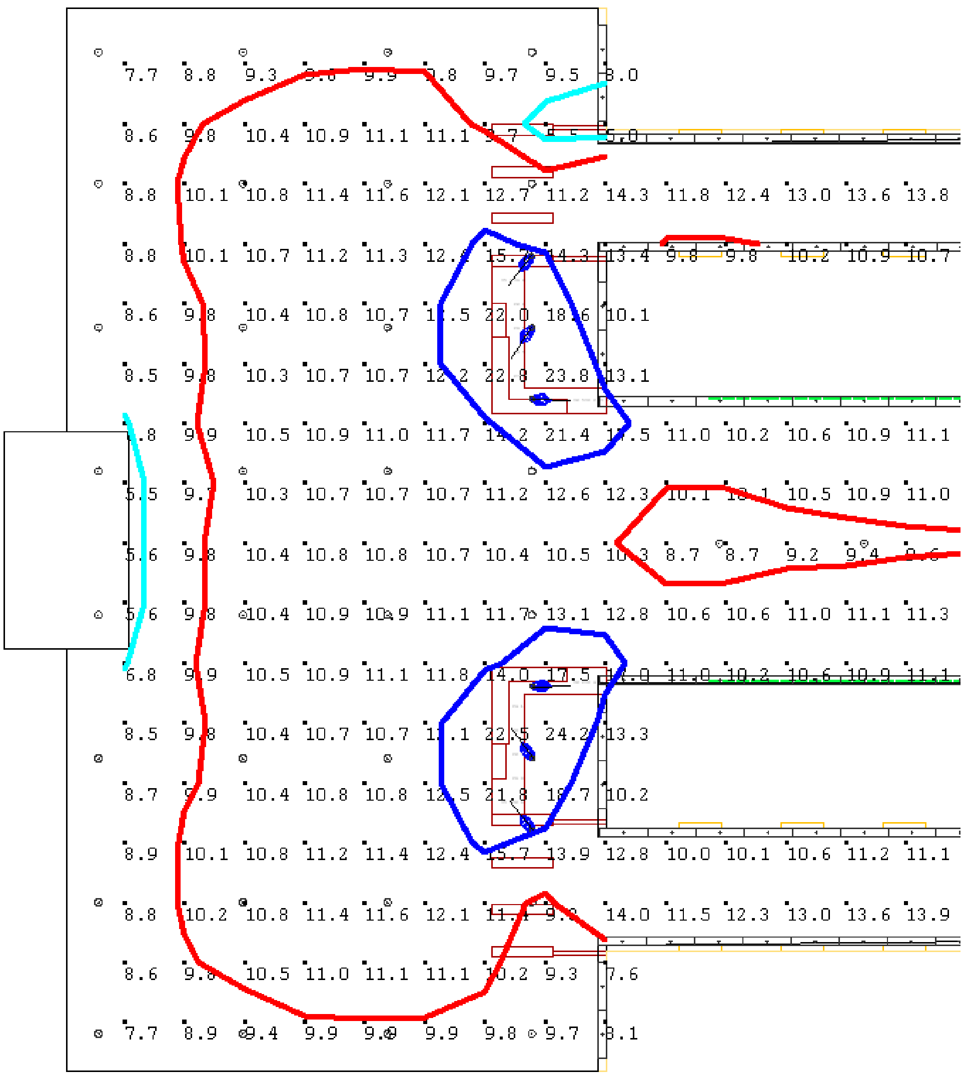


Figure 102: Lobby Illuminance Calculation Grid

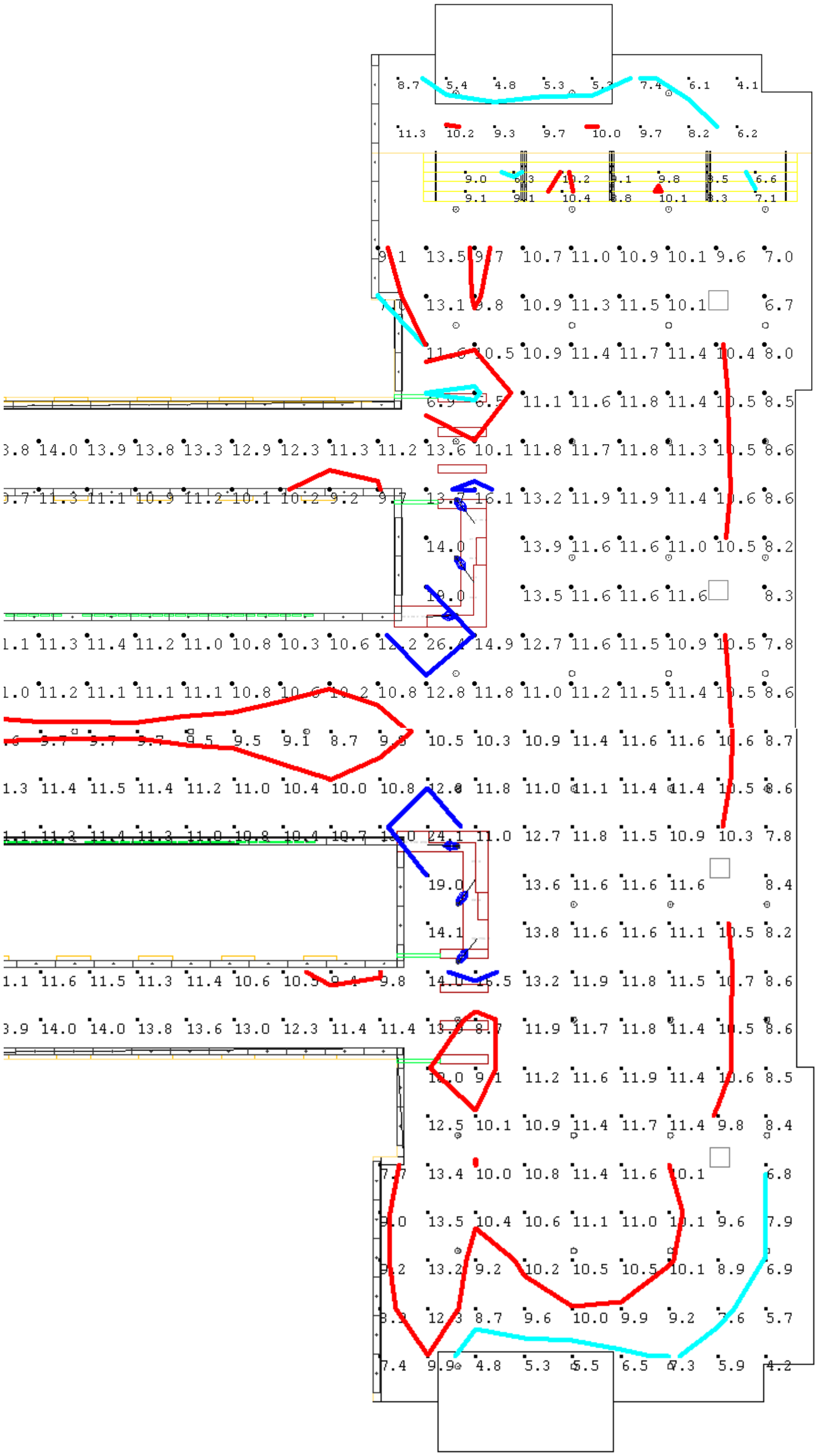
Illuminance Values (Fc)

Space	Average	Max	Min	Avg/Min	Max/Min
Floor Area	10.63	14.9	4.2	2.53	3.55
Desk 1	30.88	37.6	22.6	1.37	1.66
Desk 2	30.46	36.7	22.5	1.35	1.63
Desk 3	31.63	39.1	23.7	1.33	1.65
Desk 4	31.34	38.5	23.5	1.33	1.64
Raised Entrance	9.39	11.3	7.4	1.27	1.53
Stairs	9.13	10.4	7.1	1.29	1.46

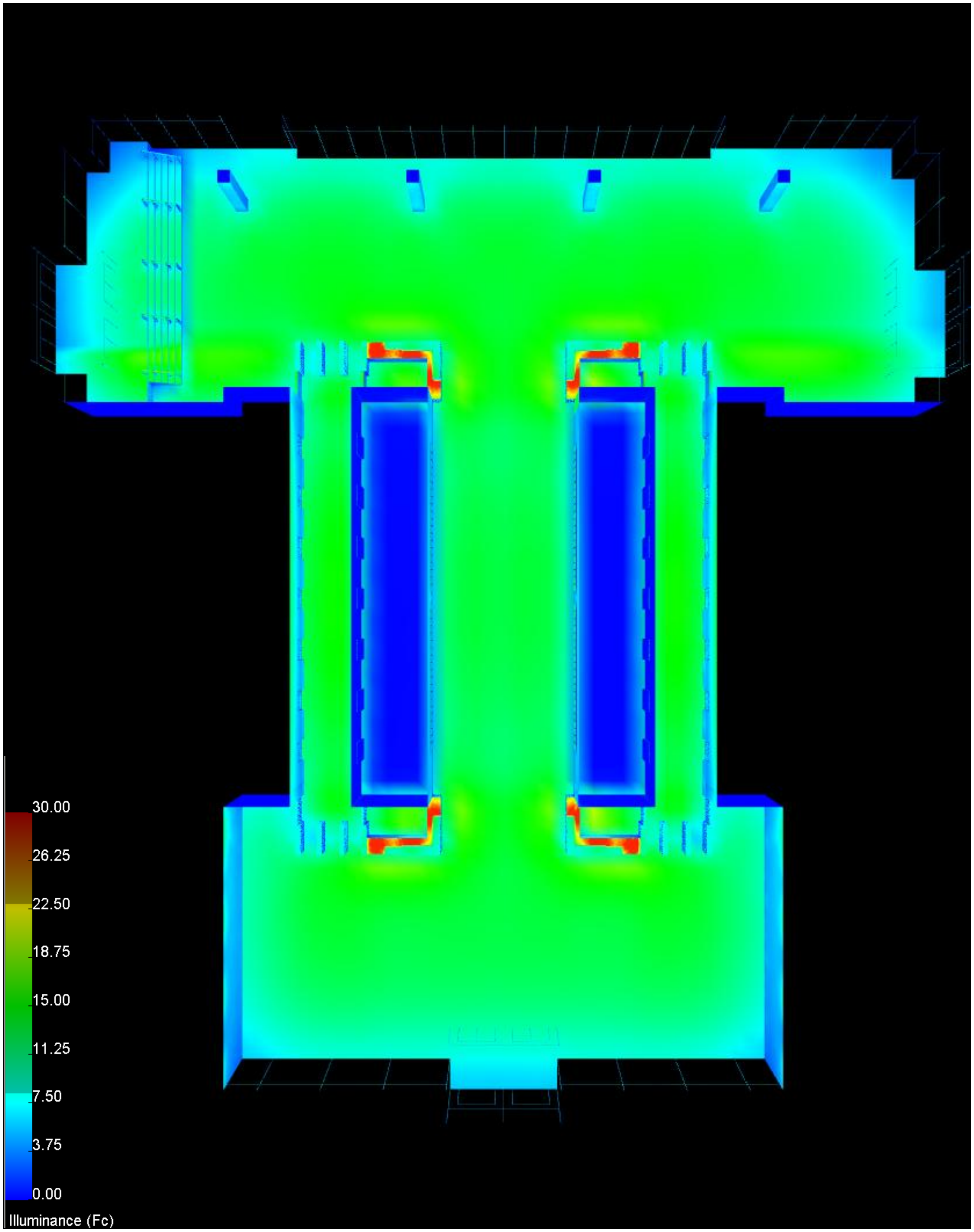
West Lobby Enlarged



East Lobby Enlarged



Lobby Pseudo Color



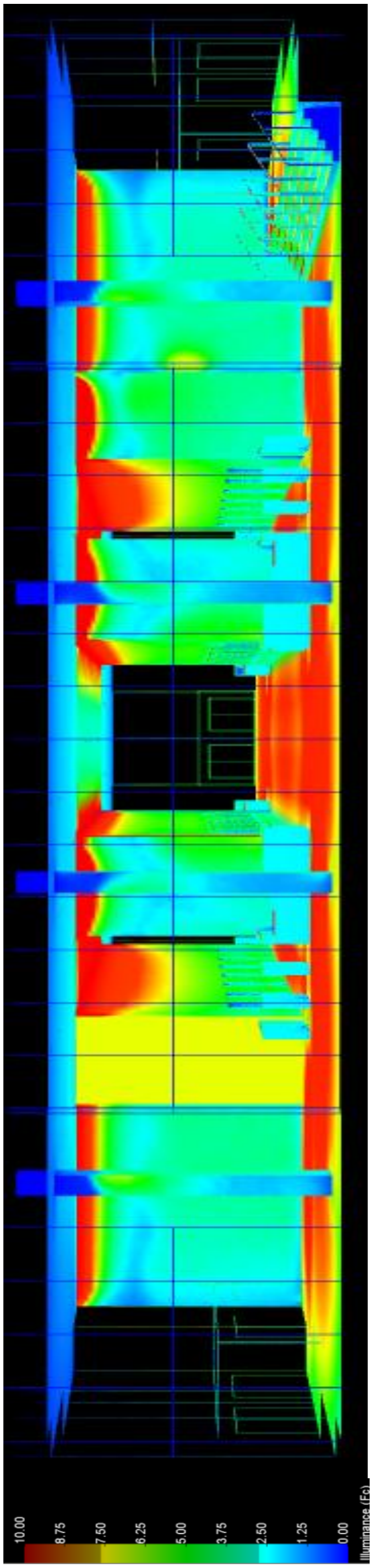


Figure 104: East Lobby Pseudo Color

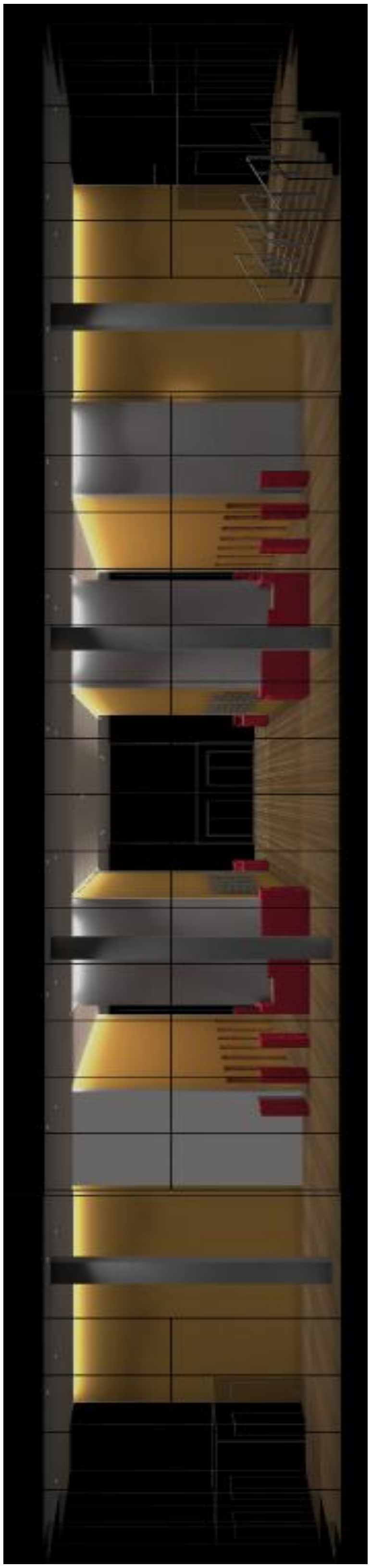


Figure 103: East Lobby Rendering

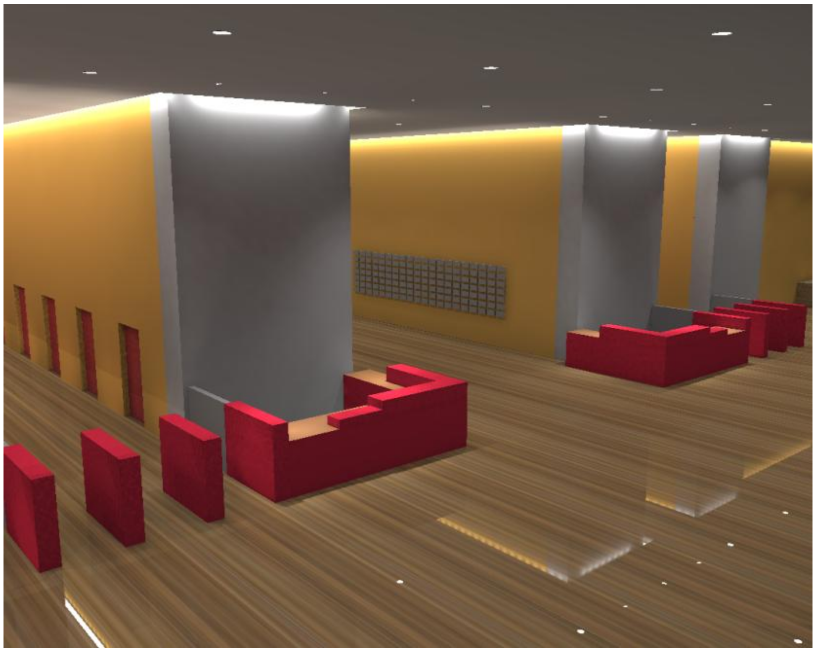


Figure 106: East Lobby Overhead Rendering

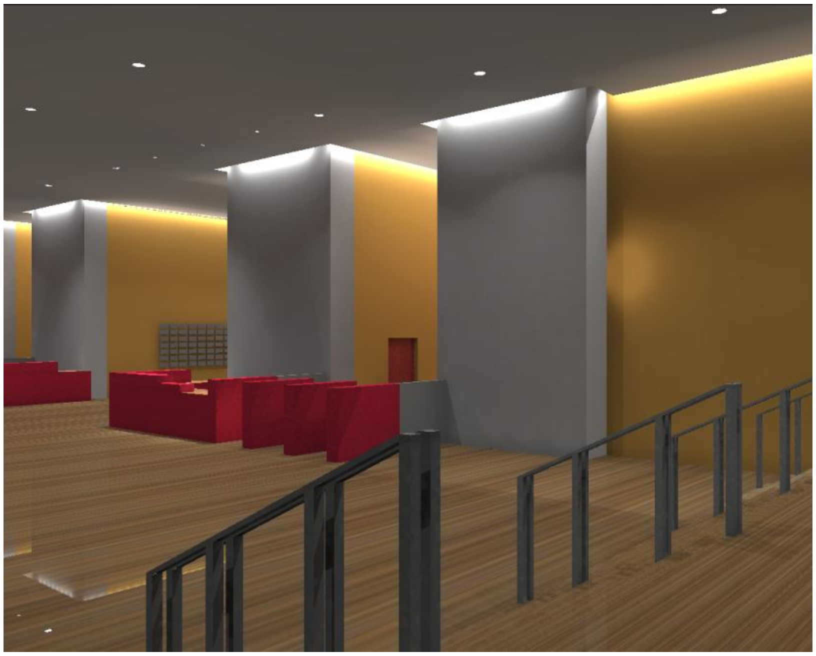


Figure 105: East Lobby Raised Entrance rendering

ASHRAE Compliance (*Required LPD < = 1.3 W/Ft^2*)

Lighting Power Density

Area (Ft^2) = 14551
Total Watts = 9145
LPD (W/Ft^2) = 0.628

Performance Summary

The new lighting design compliments the themes expressed by architect, Renzo Piano. The cove lighting provides an interesting feature that seems to separate the core from the rest of the building. The cove lighting also washes the core walls emphasizing the height and depth of the space. The design highlights the center of the space while also directing individuals to look through the lobby and experience it as a whole. The overall lighting design further develops the concepts of transparency and lightness.

All fixtures are recessed into the architecture to create a smooth plane across the ceiling. Luminaires are adequately spaced away from glazing to reduce any glaring effects. Directional luminaires are aimed to only provide high illuminance levels across the desks and keep a uniform distribution on the floor. The lamps used provide a high CCT and CRI to accommodate to the vibrant colors within the space. The color temperatures and rendering capabilities are also comparable to the high amount of incoming daylight.

The lighting design meets the requirements set forth by the IESNA Handbook. An average of 10fc is present across the floor of the lobby. The security/reception desks receive an average of 30fc across their surface. The design also complies with ASHRAE standards in regards to lighting power density.

LOBBY ELECTRICAL REDESIGN

The new lighting design replaced all existing luminaires in the space. Each circuit in the previous design was reused along with a few additions to the existing panelboards. All fixtures operate at 277V.

Controls

The lobby uses a digitally addressable lighting interface (DALI) system with dimmable ballasts to harvest the benefits of daylight. The system also allows for the programming of individual luminaires to accommodate to varying lighting needs. Due to the lack of information, exact details regarding the control system cannot be commented on.

Circuiting Layout

Refer to the Appendix for full size drawings of the electric layout and circuiting

Existing Panelboards/ Modified Circuits

The following figures depict the existing panelboards with the modified lighting circuits highlighted. Due to the lack of information provided for the IPD/BIM thesis, no other loads were able to be added to the panelboards.

Panelboard Tag	Voltage	Normal/Emergency
EHV-1	480Y/277	Yes
LPD-1	480Y/277	No
LPD-2	480Y/277	No

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	EHV-1	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	100A	PANEL LOCATION:	EAST ELECTRICAL ROOM	OPTIONS:	
SIZE/TYPE MAIN:	100A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
EMERG LGT	WEST	100	20A/1P	1	*			2	20A/1P	1600	EAST	EMERG LGT
EMERG LGT	CORE	200	20A/1P	3		*		4	20A/1P	0	0	0
0	0	0	20A/1P	5			*	6	20A/1P	0	0	0
0	0	0	20A/1P	7	*			8	20A/1P	0	0	0
0	0	0	20A/1P	9		*		10	20A/1P	0	0	0
0	0	0	20A/1P	11			*	12	20A/1P	0	0	0
0	0	0	20A/1P	13	*			14	20A/1P	0	0	0
0	0	0	20A/1P	15		*		16	20A/1P	0	0	0
0	0	0	20A/1P	17			*	18	20A/1P	0	0	0
0	0	0	20A/1P	19	*			20	20A/1P	0	0	0
0	0	0	20A/1P	21		*		22	20A/1P	0	0	0
0	0	0	20A/1P	23			*	24	20A/1P	0	0	0
0	0	0	20A/1P	25	*			26	20A/1P	0	0	0
0	0	0	20A/1P	27		*		28	20A/1P	0	0	0
0	0	0	20A/1P	29			*	30	20A/1P	0	0	0
0	0	0	20A/1P	31	*			32	20A/1P	0	0	0
0	0	0	20A/1P	33		*		34	20A/1P	0	0	0
0	0	0	20A/1P	35			*	36	20A/1P	0	0	0
0	0	0	20A/1P	37	*			38	20A/1P	0	0	0
0	0	0	20A/1P	39		*		40	20A/1P	0	0	0
0	0	0	20A/1P	41			*	42	20A/1P	0	0	0

CONNECTED LOAD (KW) - A Ph.	1.70	TOTAL DESIGN LOAD (KW)	2.28
CONNECTED LOAD (KW) - B Ph.	0.20	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	0.00	TOTAL DESIGN LOAD (AMPS)	3

PANELBOARD SCHEDULE

VOLTAGE:	480/277,3PH,4W	PANEL TAG:	LPD-1	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	100A	PANEL LOCATION:	WEST ELECTRICAL ROOM	OPTIONS:	
SIZE/TYPE MAIN:	100A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
L-4	MAIN HALL	1800	20A/1P	1	*			2	20A/1P	2100	N ELEV	L-1
L-1	S ELEV	2100	20A/1P	3		*		4	20A/1P	900	N ELEV	L-6
L-6	S ELEV	900	20A/1P	5			*	6	20A/1P	0	0	0
0	0	0	20A/1P	7	*			8	20A/1P	0	0	0
0	0	0	20A/1P	9		*		10	20A/1P	0	0	0
0	0	0	20A/1P	11			*	12	20A/1P	0	0	0
0	0	0	20A/1P	13	*			14	20A/1P	0	0	0
0	0	0	20A/1P	15		*		16	20A/1P	0	0	0
0	0	0	20A/1P	17			*	18	20A/1P	0	0	0
0	0	0	20A/1P	19	*			20	20A/1P	0	0	0
0	0	0	20A/1P	21		*		22	20A/1P	0	0	0
0	0	0	20A/1P	23			*	24	20A/1P	0	0	0
0	0	0	20A/1P	25	*			26	20A/1P	0	0	0
0	0	0	20A/1P	27		*		28	20A/1P	0	0	0
0	0	0	20A/1P	29			*	30	20A/1P	0	0	0
0	0	0	20A/1P	31	*			32	20A/1P	0	0	0
0	0	0	20A/1P	33		*		34	20A/1P	0	0	0
0	0	0	20A/1P	35			*	36	20A/1P	0	0	0
0	0	0	20A/1P	37	*			38	20A/1P	0	0	0
0	0	0	20A/1P	39		*		40	20A/1P	0	0	0
0	0	0	20A/1P	41			*	42	20A/1P	0	0	0

CONNECTED LOAD (KW) - A Ph.	3.90	TOTAL DESIGN LOAD (KW)	9.36
CONNECTED LOAD (KW) - B Ph.	3.00	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	0.90	TOTAL DESIGN LOAD (AMPS)	14

PANELBOARD SCHEDULE

VOLTAGE:	480/277,3PH,4W	PANEL TAG:	LPD-2	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	100A	PANEL LOCATION:	WEST ELECTRICAL ROOM	OPTIONS:	
SIZE/TYPE MAIN:	100A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
L-3	WEST	460	20A/1P	1	*			2	20A/1P	320	EAST	L-5
L-5	EAST	280	20A/1P	3		*		4	20A/1P	240	EAST	L-5
0	0	0	20A/1P	5			*	6	20A/1P	0	0	0
0	0	0	20A/1P	7	*			8	20A/1P	0	0	0
0	0	0	20A/1P	9		*		10	20A/1P	0	0	0
0	0	0	20A/1P	11			*	12	20A/1P	0	0	0
0	0	0	20A/1P	13	*			14	20A/1P	0	0	0
0	0	0	20A/1P	15		*		16	20A/1P	0	0	0
0	0	0	20A/1P	17			*	18	20A/1P	0	0	0
0	0	0	20A/1P	19	*			20	20A/1P	0	0	0
0	0	0	20A/1P	21		*		22	20A/1P	0	0	0
0	0	0	20A/1P	23			*	24	20A/1P	0	0	0
0	0	0	20A/1P	25	*			26	20A/1P	0	0	0
0	0	0	20A/1P	27		*		28	20A/1P	0	0	0
0	0	0	20A/1P	29			*	30	20A/1P	0	0	0
0	0	0	20A/1P	31	*			32	20A/1P	0	0	0
0	0	0	20A/1P	33		*		34	20A/1P	0	0	0
0	0	0	20A/1P	35			*	36	20A/1P	0	0	0
0	0	0	20A/1P	37	*			38	20A/1P	0	0	0
0	0	0	20A/1P	39		*		40	20A/1P	0	0	0
0	0	0	20A/1P	41			*	42	20A/1P	0	0	0

CONNECTED LOAD (KW) - A Ph.	0.78	TOTAL DESIGN LOAD (KW)	1.56
CONNECTED LOAD (KW) - B Ph.	0.52	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	0.00	TOTAL DESIGN LOAD (AMPS)	2

Redesigned Panelboards/ Modified Circuits

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W	PANEL TAG: EHV-1	MIN. C/B AIC: 10K
SIZE/TYPE BUS: 100A	PANEL LOCATION: EAST ELECTRICAL ROOM	OPTIONS:
SIZE/TYPE MAIN: 100A/3P C/B	PANEL MOUNTING: SURFACE	

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
EMERG LGT	WEST	224	20A/1P	1	*			2	20A/1P	320	EAST	EMERG LGT
EMERG LGT	CORE	448	20A/1P	3		*		4	20A/1P	0	0	0
0	0	0	20A/1P	5			*	6	20A/1P	0	0	0
0	0	0	20A/1P	7	*			8	20A/1P	0	0	0
0	0	0	20A/1P	9		*		10	20A/1P	0	0	0
0	0	0	20A/1P	11			*	12	20A/1P	0	0	0
0	0	0	20A/1P	13	*			14	20A/1P	0	0	0
0	0	0	20A/1P	15		*		16	20A/1P	0	0	0
0	0	0	20A/1P	17			*	18	20A/1P	0	0	0
0	0	0	20A/1P	19	*			20	20A/1P	0	0	0
0	0	0	20A/1P	21		*		22	20A/1P	0	0	0
0	0	0	20A/1P	23			*	24	20A/1P	0	0	0
0	0	0	20A/1P	25	*			26	20A/1P	0	0	0
0	0	0	20A/1P	27		*		28	20A/1P	0	0	0
0	0	0	20A/1P	29			*	30	20A/1P	0	0	0
0	0	0	20A/1P	31	*			32	20A/1P	0	0	0
0	0	0	20A/1P	33		*		34	20A/1P	0	0	0
0	0	0	20A/1P	35			*	36	20A/1P	0	0	0
0	0	0	20A/1P	37	*			38	20A/1P	0	0	0
0	0	0	20A/1P	39		*		40	20A/1P	0	0	0
0	0	0	20A/1P	41			*	42	20A/1P	0	0	0

CONNECTED LOAD (KW) - A Ph.	0.54	TOTAL DESIGN LOAD (KW)	1.19
CONNECTED LOAD (KW) - B Ph.	0.45	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	0.00	TOTAL DESIGN LOAD (AMPS)	2

PANELBOARD SCHEDULE

VOLTAGE: 480/277,3PH,4W	PANEL TAG: LPD-1	MIN. C/B AIC: 10K
SIZE/TYPE BUS: 100A	PANEL LOCATION: WEST ELECTRICAL ROOM	OPTIONS:
SIZE/TYPE MAIN: 100A/3P C/B	PANEL MOUNTING: SURFACE	

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
L-1	N ELEV	704	20A/1P	1	*			2	20A/1P	512	N ELEV	L-1
L-4	MAIN HALL	608	20A/1P	3		*		4	20A/1P	608	MAIN HALL	L-4
L-6	S ELEV	512	20A/1P	5			*	6	20A/1P	704	S ELEV	L-6
0	0	0	20A/1P	7	*			8	20A/1P	0	0	0
0	0	0	20A/1P	9		*		10	20A/1P	0	0	0
0	0	0	20A/1P	11			*	12	20A/1P	0	0	0
0	0	0	20A/1P	13	*			14	20A/1P	0	0	0
0	0	0	20A/1P	15		*		16	20A/1P	0	0	0
0	0	0	20A/1P	17			*	18	20A/1P	0	0	0
0	0	0	20A/1P	19	*			20	20A/1P	0	0	0
0	0	0	20A/1P	21		*		22	20A/1P	0	0	0
0	0	0	20A/1P	23			*	24	20A/1P	0	0	0
0	0	0	20A/1P	25	*			26	20A/1P	0	0	0
0	0	0	20A/1P	27		*		28	20A/1P	0	0	0
0	0	0	20A/1P	29			*	30	20A/1P	0	0	0
0	0	0	20A/1P	31	*			32	20A/1P	0	0	0
0	0	0	20A/1P	33		*		34	20A/1P	0	0	0
0	0	0	20A/1P	35			*	36	20A/1P	0	0	0
0	0	0	20A/1P	37	*			38	20A/1P	0	0	0
0	0	0	20A/1P	39		*		40	20A/1P	0	0	0
0	0	0	20A/1P	41			*	42	20A/1P	0	0	0

CONNECTED LOAD (KW) - A Ph.	1.22	TOTAL DESIGN LOAD (KW)	4.38
CONNECTED LOAD (KW) - B Ph.	1.22	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	1.22	TOTAL DESIGN LOAD (AMPS)	7

PANELBOARD SCHEDULE												
VOLTAGE:	480/277,3PH,4W			PANEL TAG:	LPD-2					MIN. C/B AIC:	10K	
SIZE/TYPE BUS:	100A			PANEL LOCATION:	WEST ELECTRICAL ROOM					OPTIONS:		
SIZE/TYPE MAIN:	100A/3P C/B			PANEL MOUNTING:	SURFACE							
DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
L-3	WEST	744	20A/1P	1	*			2	20A/1P	712	WEST	L-3
L-5	EAST	680	20A/1P	3		*		4	20A/1P	384	EAST	L-5
L-5	EAST	680	20A/1P	5			*	6	20A/1P	0	0	0
0	0	0	20A/1P	7	*			8	20A/1P	0	0	0
0	0	0	20A/1P	9		*		10	20A/1P	0	0	0
0	0	0	20A/1P	11			*	12	20A/1P	0	0	0
0	0	0	20A/1P	13	*			14	20A/1P	0	0	0
0	0	0	20A/1P	15		*		16	20A/1P	0	0	0
0	0	0	20A/1P	17			*	18	20A/1P	0	0	0
0	0	0	20A/1P	19	*			20	20A/1P	0	0	0
0	0	0	20A/1P	21		*		22	20A/1P	0	0	0
0	0	0	20A/1P	23			*	24	20A/1P	0	0	0
0	0	0	20A/1P	25	*			26	20A/1P	0	0	0
0	0	0	20A/1P	27		*		28	20A/1P	0	0	0
0	0	0	20A/1P	29			*	30	20A/1P	0	0	0
0	0	0	20A/1P	31	*			32	20A/1P	0	0	0
0	0	0	20A/1P	33		*		34	20A/1P	0	0	0
0	0	0	20A/1P	35			*	36	20A/1P	0	0	0
0	0	0	20A/1P	37	*			38	20A/1P	0	0	0
0	0	0	20A/1P	39		*		40	20A/1P	0	0	0
0	0	0	20A/1P	41			*	42	20A/1P	0	0	0
CONNECTED LOAD (KW) - A Ph.		1.46								TOTAL DESIGN LOAD (KW)		3.84
CONNECTED LOAD (KW) - B Ph.		1.06								POWER FACTOR		0.80
CONNECTED LOAD (KW) - C Ph.		0.68								TOTAL DESIGN LOAD (AMPS)		6

PANELBOARD SIZING WORKSHEET										
Panel Tag----------------->				EHV-1	Panel Location:			EAST ELECTRICAL ROOM		
Nominal Phase to Neutral Voltage----->				277	Phase:			3		
Nominal Phase to Phase Voltage----->				480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	EMERG LGT	3	WEST	224	w		224	280	
2	A	EMERG LGT	3	EAST	320	w		320	400	
3	B	EMERG LGT	3	CORE	448	w		448	560	
4	B					w		0	0	
5	C					w		0	0	
6	C					w		0	0	
7	A					w		0	0	
8	A					w		0	0	
9	B					w		0	0	
10	B					w		0	0	
11	C					w		0	0	
12	C					w		0	0	
13	A					w		0	0	
14	A					w		0	0	
15	B					w		0	0	
16	B					w		0	0	
17	C					w		0	0	
18	C					w		0	0	
19	A					w		0	0	
20	A					w		0	0	
21	B					w		0	0	
22	B					w		0	0	
23	C					w		0	0	
24	C					w		0	0	
25	A					w		0	0	
26	A					kw		0	0	
27	B					kw		0	0	
28	B					kw		0	0	
29	C					kw		0	0	
30	C					kw		0	0	
31	A					kw		0	0	
32	A					kw		0	0	
33	B					kw		0	0	
34	B					kw		0	0	
35	C					kw		0	0	
36	C					kw		0	0	
37	A					w		0	0	
38	A					w		0	0	
39	B					w		0	0	
40	B					w		0	0	
41	C					w		0	0	
42	C					w		0	0	
PANEL TOTAL								1.0	1.2	Amps= 1.5

PHASE LOADING							kW	kVA	%	Amps
PHASE TOTAL	A						0.5	0.7	55%	2.5
PHASE TOTAL	B						0.4	0.6	45%	2.0
PHASE TOTAL	C						0.0	0.0		0.0

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		1.0	1.2		1.0	1.2	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
	Total Demand Loads					1.0	1.2			
	Spare Capacity		20%			0.2	0.2			
	Total Design Loads					1.2	1.5	0.80	Amps=	1.8

PANELBOARD SIZING WORKSHEET

Panel Tag------------------------->	LPD-1	Panel Location:	WEST ELECTRICAL ROOM	
Nominal Phase to Neutral Voltage------->	277	Phase:	3	
Nominal Phase to Phase Voltage-------->	480	Wires:	4	

Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	L-1	3	N ELEV	704	w		704	880		
2	A	L-1	3	N ELEV	512	w		512	640		
3	B	L-4	3	MAIN HALL	608	w		608	760		
4	B	L-4	3	MAIN HALL	608	w		608	760		
5	C	L-6	3	S ELEV	512	w		512	640		
6	C	L-6	3	S ELEV	704	w		704	880		
7	A					w		0	0		
8	A					w		0	0		
9	B					w		0	0		
10	B					w		0	0		
11	C					w		0	0		
12	C					w		0	0		
13	A					w		0	0		
14	A					w		0	0		
15	B					w		0	0		
16	B					w		0	0		
17	C					w		0	0		
18	C					w		0	0		
19	A					w		0	0		
20	A					w		0	0		
21	B					w		0	0		
22	B					w		0	0		
23	C					w		0	0		
24	C					w		0	0		
25	A					w		0	0		
26	A					w		0	0		
27	B					w		0	0		
28	B					w		0	0		
29	C					w		0	0		
30	C					w		0	0		
31	A					w		0	0		
32	A					w		0	0		
33	B					w		0	0		
34	B					w		0	0		
35	C					w		0	0		
36	C					w		0	0		
37	A					w		0	0		
38	A					w		0	0		
39	B					w		0	0		
40	B					w		0	0		
41	C					w		0	0		
42	C					w		0	0		
PANEL TOTAL								3.6	4.6	Amps=	5.5
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					1.2	1.5	33%	5.5
PHASE TOTAL			B					1.2	1.5	33%	5.5
PHASE TOTAL			C					1.2	1.5	33%	5.5

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		3.6	4.6		3.6	4.6	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
Total Demand Loads						3.6	4.6			
Spare Capacity			20%			0.7	0.9			
Total Design Loads						4.4	5.5	0.80	Amps=	6.6

PANELBOARD SIZING WORKSHEET										
Panel Tag------------------------->				LPD-2	Panel Location:		WEST ELECTRICAL ROOM			
Nominal Phase to Neutral Voltage------->				277	Phase:		3			
Nominal Phase to Phase Voltage-------->				480	Wires:		4			
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	L-3	3	WEST	744	w		744	930	
2	A	L-3	3	WEST	712	w		712	890	
3	B	L-5	3	EAST	680	w		680	850	
4	B	L-5	3	EAST	384	w		384	480	
5	C	L-5	3	EAST	680	w		680	850	
6	C					w		0	0	
7	A					w		0	0	
8	A					w		0	0	
9	B					w		0	0	
10	B					w		0	0	
11	C					w		0	0	
12	C					w		0	0	
13	A					w		0	0	
14	A					w		0	0	
15	B					w		0	0	
16	B					w		0	0	
17	C					w		0	0	
18	C					w		0	0	
19	A					w		0	0	
20	A					w		0	0	
21	B					w		0	0	
22	B					w		0	0	
23	C					w		0	0	
24	C					w		0	0	
25	A					w		0	0	
26	A					w		0	0	
27	B					w		0	0	
28	B					w		0	0	
29	C					w		0	0	
30	C					w		0	0	
31	A					w		0	0	
32	A					w		0	0	
33	B					w		0	0	
34	B					w		0	0	
35	C					w		0	0	
36	C					w		0	0	
37	A					w		0	0	
38	A					w		0	0	
39	B					w		0	0	
40	B					w		0	0	
41	C					w		0	0	
42	C					w		0	0	
PANEL TOTAL								3.2	4.0	Amps= 4.8

PHASE LOADING							kW	kVA	%	Amps
PHASE TOTAL	A						1.5	1.8	46%	6.6
PHASE TOTAL	B						1.1	1.3	33%	4.8
PHASE TOTAL	C						0.7	0.9	21%	3.1

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		3.2	4.0		3.2	4.0	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
	Total Demand Loads					3.2	4.0			
	Spare Capacity		20%			0.6	0.8			
	Total Design Loads					3.8	4.8	0.80	Amps=	5.8

CORE ELECTRICAL REDESIGN AND SYSTEM ANALYSIS

Bus Duct Study

Background

The following study analyzes the potential benefits of replacing the conduit risers within the NYT portion of the building with bus duct. The current system utilizes nine 3 ½" conduit feeders each with 4-500MCM conductors inside to supply power to the lighting and appliance panels on the 27 floors belonging to the NYT Company. There are also six similar feeders supplying power to the mechanical panels on each floor. The system in place uses one feeder to supply lighting and appliance power to three floors and one feeder to supply mechanical power to four floors. As mentioned, this system is only present in the NYT portion of the building. The tenant, Forest City Ratner, installed a bus duct system to supply power to its 24 floors.

Scope of Work

In realizing that the tenant wished for bus duct rather than conduit feeders, it was questioned as to whether or not this design was less expensive. In this analysis, a cost comparison will be done to determine if the overall expense of bus duct is cheaper than a conduit installation. To determine if bus duct provides additional benefits, maintenance concerns and space savings will also be analyzed.

To determine overall costs for both conduit and bus duct feeder systems, the 2009 Electrical Equipment RS Means will be used as a reference. Material, labor, and overhead costs will be totaled for both systems. The analysis will encompass a feeder design that supports mechanical, lighting, and appliance loads from the 27 NYT floors. The GE Buy Log will be referenced for bus duct specifications.

Due to the lack of information supplied for the IPD/BIM thesis, it was assumed from the riser diagrams that each 480Y/277 panelboard was sized with a 320A circuit breaker. 25% spare capacity was also applied. The resulting breaker size for each 480Y/277 panel was 240A. This loading was then multiplied by the number of feeders.

Lighting and Appliance: 240A * 9 Feeders = 2160A
Use 2500 Amp Bus Duct for Cost Analysis

Mechanical: 240A * 6 Feeders = 1440A
Use 1600 Amp Bus Duct for Cost Analysis

The bus duct design was to use both feeder and plug-in sections. The feeder portion of the bus duct started at the main distribution panel and then ended at the point where it was turned upward into the first floor. From that point on, plug-in bus duct was used. The additional costs of elbows and taps were also incorporated into the analysis.

All remaining calculations were completed using spreadsheets in Microsoft Excel. The following figures show the calculation techniques used to determine total costs.

	1600 Amps			2500 Amp		
	1 Set			1 Set per side		
	1-28			1-28		
	Length/#	Mat Cost	Lab Cost	Length/#	Mat Cost	Lab Cost
Plugin	388	$624.00		388	$923.00	
Feeder	120	$598.00		120	$910.00	
90 L/R	3	$3,380.00		3	$4,387.50	
90 U/D	2	$3,380.00		2	$4,387.50	
Taps	28	$4,192.50		28	$5,850.00	
	Total	$448,162.00		Total	$653,061.50	

13.85714286	2	-	4	5	-	7	8	-	10
	Length/#	Mat Cost and Labor		Length/#	Mat Cost and Labor		Length/#	Mat Cost and Labor	
Conduit	350.8571429	$53.30		434	$53.30		517.1429	$53.30	
Conductor	1403.428571	$21.45		1736	$21.45		2068.571	$21.45	
	Total	$48,804.23	$0.00	Total	$60,369.40	$0.00	Total	$71,934.57	$0.00
	G Total	$48,804.23		G Total	$60,369.40		G Total	$71,934.57	
	11	-	13	14	-	16	17	-	19
	Length/#	Mat Cost and Labor		Length/#	Mat Cost and Labor		Length/#	Mat Cost and Labor	
Conduit	600.2857143	$53.30		683.4286	$53.30		766.5714	$53.30	
Conductor	2401.142857	$21.45		2733.714	$21.45		3066.286	$21.45	
	Total	$83,499.74	$0.00	Total	$95,064.91	$0.00	Total	$106,630.09	$0.00
	G Total	$83,499.74		G Total	$95,064.91		G Total	$106,630.09	
	20	-	22	23	-	25	26	-	28
	Length/#	Mat Cost and Labor		Length/#	Mat Cost and Labor		Length/#	Mat Cost and Labor	
Conduit	849.7142857	$53.30		932.8571	$53.30		1016	$53.30	
Conductor	3398.857143	$21.45		3731.429	$21.45		4064	$21.45	
	Total	$118,195.26	$0.00	Total	##########	$0.00	Total	$141,325.60	$0.00
	G Total	$118,195.26		G Total	$129,760.43		G Total	$141,325.60	

13.85714286	2	-	5	6	-	9	10	-	13
	Length/#	**Mat Cost and Labor**		**Length/#**	**Mat Cost and Labor**		**Length/#**	**Mat Cost and Labor**	
Conduit	189.2857143	$53.30		244.7143	$53.30		300.1429	$53.30	
Conductor	757.1428571	$21.45		978.8571	$21.45		1200.571	$21.45	
	Total	$26,329.64	$0.00	Total	$34,039.76	$0.00	Total	$41,749.87	$0.00
	G Total	$26,329.64		G Total	$34,039.76		G Total	$41,749.87	
	14	-	17	18	-	21	22	-	25
	Length/#	**Mat Cost and Labor**		**Length/#**	**Mat Cost and Labor**		**Length/#**	**Mat Cost and Labor**	
Conduit	355.5714286	$53.30		411	$53.30		466.4286	$53.30	
Conductor	1422.285714	$21.45		1644	$21.45		1865.714	$21.45	
	Total	$49,459.99	$0.00	Total	$57,170.10	$0.00	Total	$64,880.21	$0.00
	G Total	$49,459.99		G Total	$57,170.10		G Total	$64,880.21	
	26	-	28						
	Length/#	**Mat Cost and Labor**							
Conduit	508	$53.30							
Conductor	2032	$21.45							
	Total	$70,662.80	$0.00						
	G Total	$70,662.80							

Total Cost of Aluminum Bus Duct:

(*1)1600 Amp and (1) 2500 Amp* bus

Total - $1,754,285.00

Total Cost of Conduit:

Lighting & Appliance - $855, 584.23

Mechanical - $344,292.37

Total - $1,199,876.60

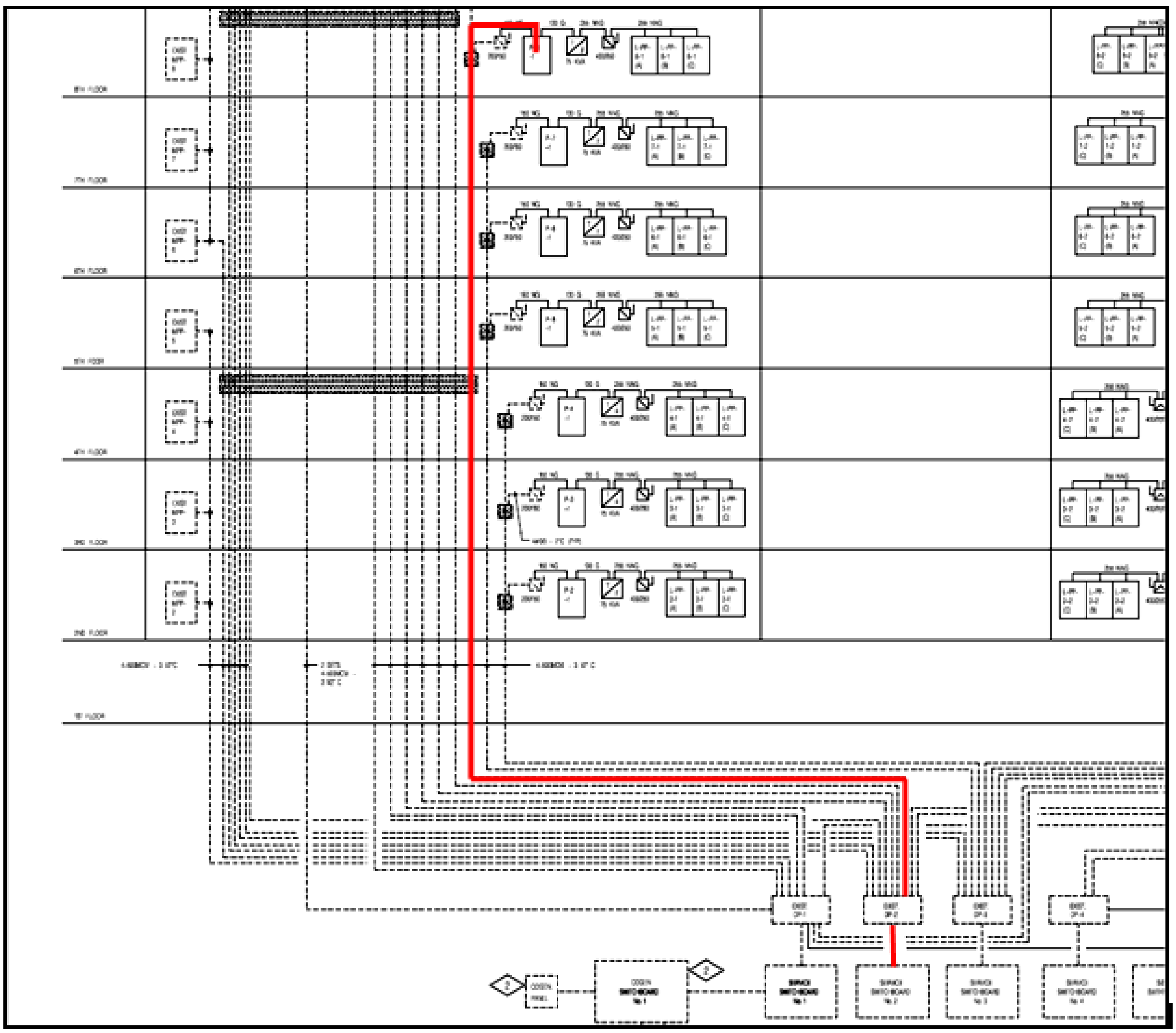
Conclusion

After completing the analysis, it was found that an equivalent aluminum bus duct system would cost an additional \$554,408.40. It can be assumed that a copper bus duct system would cost even more than. With this information, conduit feeders are clearly the better choice; however, bus duct offers additional benefits that can potentially offset the upfront cost. In this analysis, possible space savings were also looked at to determine if the buildings risers could be decreased to aid in increasing rentable space. The existing system used 3 ½" conduit feeders. In material space alone, the current system would take up an area of 144.24in^2 or 12.02Ft^2. The bus duct system would take up an area of 41.625in^2 for the 1600A, 69.75 in^2 for the 2500A and a total of 111.38Ft^2. This again does not seem to provide a large benefit for implementing a bus duct system. An actual space savings could come from the amount of space needed between elements. With 15 separate conduit feeders, there is probably a large difference in the amount of space required for maintenance access and supports. Another benefit that the bus duct system can provide is the possibility for expansion. Bus duct systems offer easy expansion options at each tap location. Additional loads can be simply plugged into an existing bus duct system. This negates the need for the installation of additional feeders, reducing added costs from materials and labor. With less space being required for bus duct systems, adding another feeder to an existing riser is also a possibility. After analyzing all of what a bus duct system can provide, it seems that this design technique could be advantageous in certain situations. In a Class A office tower such as the NYT Building, a bus duct system would prove to be a better solution. The possibility of expansion and adaptability allows for the building to service a wide range of tenants. This design technique seems to be the more ideal solution for new high rise construction.

Short Circuit / Device Coordination / Voltage Drop Study

The figure below depicts the path taken for the following studies. The equipment analyzed begins with an arbitrary lighting load on the 8th floor. The circuit is traced back to lighting panel P-8-2 then into the feeder supplying power to that unit. The path then follows the feeder to main distribution panel DP-2. From DP-2 the path is taken to Service Switchboard No. 2 and then back to the Utility.

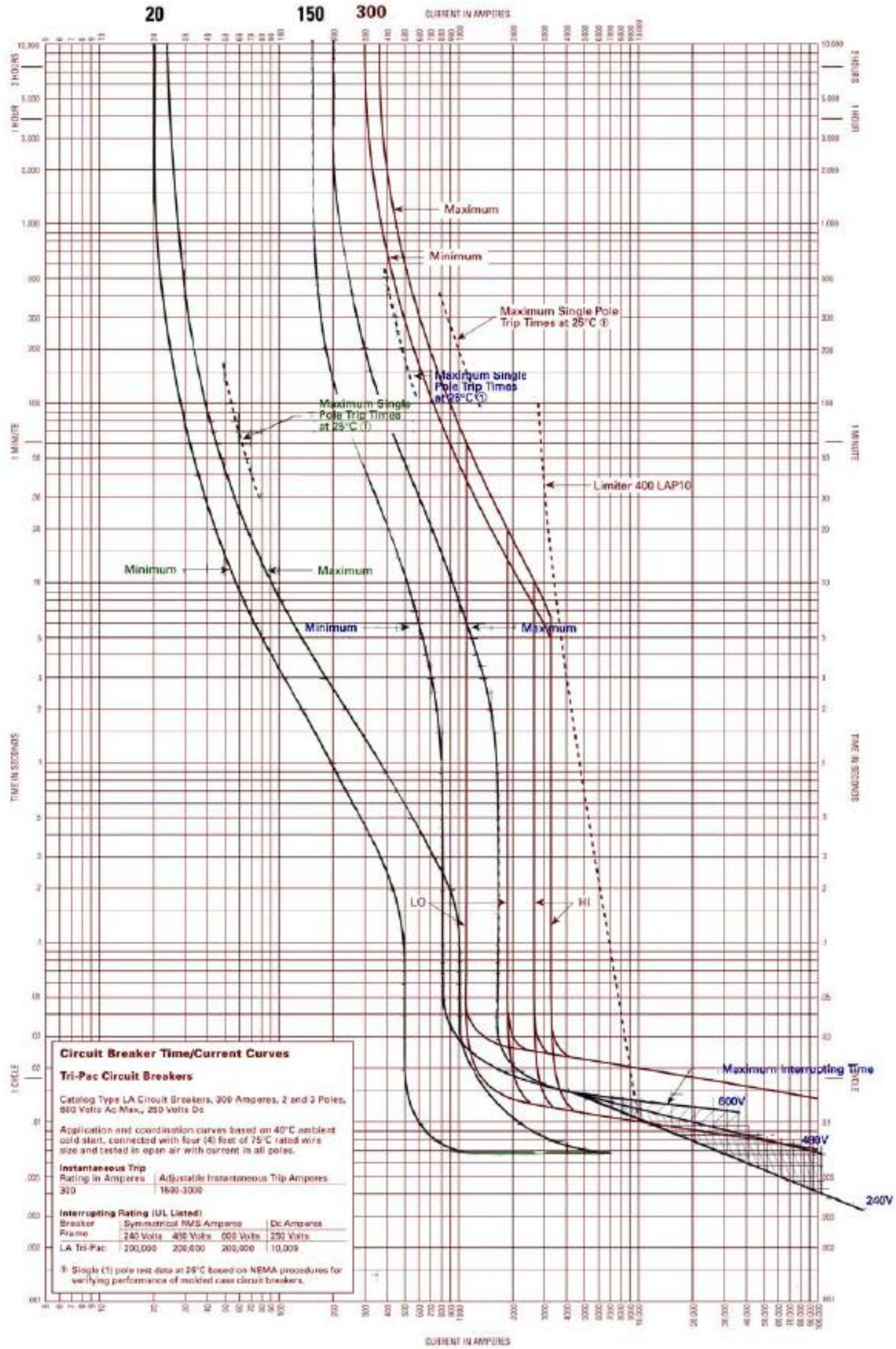
Circuit breakers were specified from the Eaton website. The respective time current curves were overlayed to complete the coordination study. The results of the study reveal that the system was designed fairly well. The 300A circuit breaker will be the last to trip in the case of an arc fault. There is some overlapping within the design between the 300A and 150A breakers. To create a more reliable design, it might be best to choose alternate devices for more precise coordination. It must be noted that the devices chosen were based off of incomplete information. Each device was assumed in order to perform the study.



Short Circuit Study

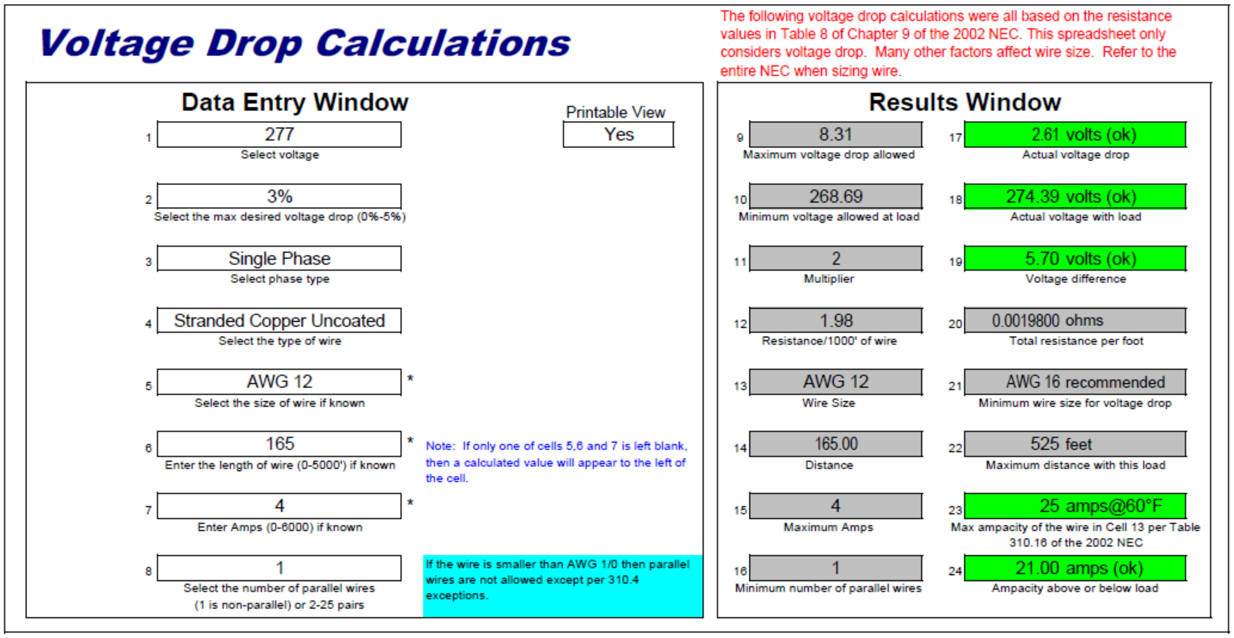
```
                              COM     building type ( COMmercial, INDustrial)

                              500  MVA from utility source (500 typical)        0.0000  utility Zpu
 source        [    ]   or          SCA available from utility
                  |             0.48  pri voltage (kv)
                  |
 source        VVVV              1    kva  [enter 1 if no transf]               0.0000  transf Zpu
 transf        AAAA           liquid  type (liquid,dry)
                  |              480  sec voltage (volts)
                  |               3   phase
                  )               4   wire
                  |                                bus fault #1                      2  motor multiplier factor
----+------+-------+-------+---------- ---------- ---------+--------- X          99999  motor Zpu
    |      |       |                               |
    )      )       )                               )                            0.0001  motor fdr Zpu
    |      |       |                               |
    |      |       |                               |                            0.0000  pu impedance to bus fault
^---------v----------^                             |
mixed load- motors & lights                        |                          601,407  SCA at bus fault #1
                                                   |
     motor load =   0   kva                        X       cable fault #1       0.0001  cable Zpu
                                                   |                            0.0001  pu impedance to cable fault
     avg feeder=>                                  |            length=  447
            length=  447                           |              size=  500     13,244  SCA at cable fault #1
      largest size=  500                           |    wire type(al,cu)=  CU
   wire type(al,cu)=  cu                           |  C type(mag,nmag)=  nmag
C type(mag,nmag)=  mag                             |  config(pipe,cable)=  PIPE
 config(pipe,cable)=  pipe                         |
         no of fdrs=  9                            |
                                                   |
                                                   |
                                                   |      75    kva
                                                 VVVV    DRY    type (liquid,dry)      0.0450  transf Zpu
                                                 AAAA    208    sec voltage (volts)
                                                   |      3     phase
                                                   |      4     wire
                                                   )
                                                   |                            0.0518  Zpu to bus fault
                                              ----+---------------+------ X
                                                                  |   bus fault #2     4,018  SCA at bus fault #2
                                                                  )
                                                                  |
                                                                  X   cable fault #2   0.0064  cable Zpu
                                                                  |                    0.0582  Zpu to cable fault
                                     length=  140                 |
                               largest size=  12                  |                    3,578  SCA at cable fault #2
                            wire type(al,cu)=  CU                 |
                          C type(mag,nmag)=  mag
                          config(pipe,cable)=  PIPE
```

Over-Current Device Coordination Study



Voltage Drop Study

A voltage drop analysis was completed for a lighting load on the 8th floor back to panel P-8-2. The luminaires on this circuit were operating at 277V. The calculated load was 1123W or 4A. The length of the run was assumed to be 165'. The following figure displays the calculation.



Voltage Drop Calculations

The following voltage drop calculations were all based on the resistance values in Table 8 of Chapter 9 of the 2002 NEC. This spreadsheet only considers voltage drop. Many other factors affect wire size. Refer to the entire NEC when sizing wire.

Data Entry Window — Printable View: Yes

1	277	Select voltage
2	3%	Select the max desired voltage drop (0%-5%)
3	Single Phase	Select phase type
4	Stranded Copper Uncoated	Select the type of wire
5	AWG 12 *	Select the size of wire if known
6	165 *	Enter the length of wire (0-5000') if known
7	4 *	Enter Amps (0-6000) if known
8	1	Select the number of parallel wires (1 is non-parallel) or 2-25 pairs

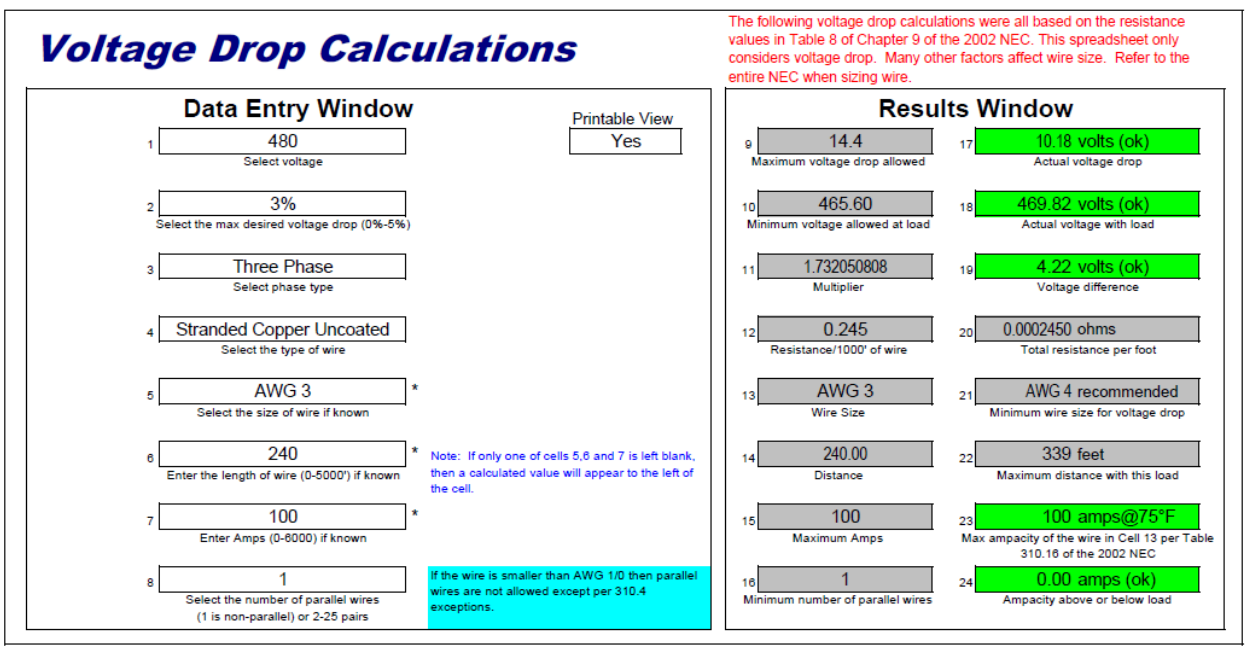
Note: If only one of cells 5,6 and 7 is left blank, then a calculated value will appear to the left of the cell.

If the wire is smaller than AWG 1/0 then parallel wires are not allowed except per 310.4 exceptions.

Results Window

9	8.31	Maximum voltage drop allowed	17	2.61 volts (ok)	Actual voltage drop
10	268.69	Minimum voltage allowed at load	18	274.39 volts (ok)	Actual voltage with load
11	2	Multiplier	19	5.70 volts (ok)	Voltage difference
12	1.98	Resistance/1000' of wire	20	0.0019800 ohms	Total resistance per foot
13	AWG 12	Wire Size	21	AWG 16 recommended	Minimum wire size for voltage drop
14	165.00	Distance	22	525 feet	Maximum distance with this load
15	4	Maximum Amps	23	25 amps@60°F	Max ampacity of the wire in Cell 13 per Table 310.16 of the 2002 NEC
16	1	Minimum number of parallel wires	24	21.00 amps (ok)	Ampacity above or below load

Another voltage drop analysis was completed for a run from panel P-8-2 to main distribution panel DP-2. The loading on the panel was taken from what was calculated in this report. The resulting panel size was 100A. The length of the run was assumed to be 240'. The following figure displays the calculation.



Voltage Drop Calculations

The following voltage drop calculations were all based on the resistance values in Table 8 of Chapter 9 of the 2002 NEC. This spreadsheet only considers voltage drop. Many other factors affect wire size. Refer to the entire NEC when sizing wire.

Data Entry Window — Printable View: Yes

1	480	Select voltage
2	3%	Select the max desired voltage drop (0%-5%)
3	Three Phase	Select phase type
4	Stranded Copper Uncoated	Select the type of wire
5	AWG 3 *	Select the size of wire if known
6	240 *	Enter the length of wire (0-5000') if known
7	100 *	Enter Amps (0-6000) if known
8	1	Select the number of parallel wires (1 is non-parallel) or 2-25 pairs

Note: If only one of cells 5,6 and 7 is left blank, then a calculated value will appear to the left of the cell.

If the wire is smaller than AWG 1/0 then parallel wires are not allowed except per 310.4 exceptions.

Results Window

9	14.4	Maximum voltage drop allowed	17	10.18 volts (ok)	Actual voltage drop
10	465.60	Minimum voltage allowed at load	18	469.82 volts (ok)	Actual voltage with load
11	1.732050808	Multiplier	19	4.22 volts (ok)	Voltage difference
12	0.245	Resistance/1000' of wire	20	0.0002450 ohms	Total resistance per foot
13	AWG 3	Wire Size	21	AWG 4 recommended	Minimum wire size for voltage drop
14	240.00	Distance	22	339 feet	Maximum distance with this load
15	100	Maximum Amps	23	100 amps@75°F	Max ampacity of the wire in Cell 13 per Table 310.16 of the 2002 NEC
16	1	Minimum number of parallel wires	24	0.00 amps (ok)	Ampacity above or below load

METRICS OF SUCCESS: CORE REDESIGN

The goal of the core redesign was to decrease its footprint in order to increase the amount of rentable space for the owner. This was achieved by exploring alternate structural cores while still maintaining the architectural needs on each floor. An intense study of the core structure and architecture produced some positive results. The group was able to save $14.4 million upfront by replacing the steel core with the new concrete core. The rentable area that was gained by the core redesign came out to be 5,864 SF, and can achieve $1.26 million in additional rent.

A goal of the redesign for the core involved both an adjustment to the entrance lobby and an analysis of the existing riser system. In redesigning the lobby lighting, the theme of transparency was enhanced along with providing an appropriate lighting design. The adjusted core posed no problems for the new lighting redesign. The final result was a design that expressed the architect's goals.

The bus duct analysis provided the understanding that upfront costs would be increased but the overall system could provide additional benefits. The ability for easy expansion to the existing system creates the opportunity for reduced renovation costs. The amount of space required for the bus duct system also allowed for a reduction in the riser size to help with reducing the core. The results provided that a bus duct solution would be a viable alternative.

COGENERATION REDESIGN:

INTRODUCTION

The current cogeneration plant provides The New York Times Company's floors with backup power for roughly 40% of their overall power needs. The 1.4 MW natural gas-fired system uses two parallel reciprocating engines to provide the waste heat to run an absorption chiller and to produce heating hot water and domestic hot water for the building. However, the system is limited to only 250 tons of cooling and only provides continuous power for the lobby area and exterior lighting. Analysis has shown that the current cogeneration plant is well designed, but the goal of the cogeneration redesign was to find a system that could provide increased energy, emissions and cost savings for the building owner. Ultimately, the design team wanted to find a system that could provide enough power to keep The New York Times Company portion of the building completely off the electricity grid in order to save on energy costs and decrease associated emissions.

UTILITY DATA

Utility rates are the driving factor when designing a cogeneration system. In many cases in urban environments grid electricity and/or district steam can be replaced by a cogeneration plant which produces both heat and power by burning an alternative fuel. To determine the viability of a cogeneration system a spark gap must be calculated. The spark gap is defined by the difference in cost of 1 million Btu of natural gas compared to electricity. Typically, cogeneration is not considered viable unless the spark gap exceeds $15.00 with natural gas being the less expensive fuel. Table 1 shows utility data for the building site, and as seen in Table 2 the spark gap is extremely high at $61.70.

Utility	Yearly $/Unit	Reference
Natural Gas	$1.392/Ccf	New York State Public Service Commission
Electric	$0.249/kWh	New York State Public Service Commission
Steam	$18.36/Mlb	Consolodated Edison
Water	$2.31/per(748gals)	New York City Water Board

Table 1: Utility Data

Spark Gap (million btu):	
Fuel	Cost
Natural Gas	$ 11.27
Electricity	$ 72.97
Steam	$ 15.40
Gap	$ 61.70

Table 2: Spark Gap

An analysis of New York City utility rates revealed that, because of high electricity costs, cogeneration could be an extremely viable solution for the building. When compared to a national average of 12 cents per kWh, New York City has extremely high electricity rates at roughly 25 cents per kWh. (See appendix A.4) Also, this energy is produced from primarily non-renewable fossil fuels which have varying associated emissions. (See appendix A.5) Therefore, the design team realized that the plant must be optimized to help reduce lifecycle cost and associated emissions from electricity use. Ultimately the plant needed to be sized in order to best balance the electrical needs and the heating and cooling needs of the building while being cost and energy conscious. However, issues such as capital costs, permitting concerns and limited space for additional equipment have played a large role in determining the most viable alternative system.

BUILDING LOADS

After identifying that cogeneration was in fact viable for the building an analysis of building load profiles was needed. Both power and thermal load profiles for the building were needed to help determine what type of cogeneration system would best suit the needs of the building and ultimately provide the best results. These load profiles are important because the new system will need to be able to react to changes in demand for electricity, cooling and heating. Typically flatter load profiles make using cogeneration much easier, because reacting to small changes in load is much easier than handling large differentials.

In order to fully analyze the building load profiles an hourly simulation was performed for a typical year using the Trane Trace energy modeling software and TMY data for the building site. This energy simulation has taken into account the increase in façade performance and HVAC system energy use reduction associated with the building redesign. As seen in Table 3, it was found that the peak thermal load for the building is approximately 71,000 Mbh and the peak power load was found to be approximately 4,800 Kw. Similarly the minimum demand for the building was found to be approximately 4,000 Mbh for thermal and 1,250 Kw for power.

Max Demand		Min Demand	
kW	Mbh	kW	Mbh
4,832	71,100	1,278	4,092

Table 3: Power and Thermal Demands

After identifying minimum and maximum demands for thermal and power loads an analysis was done to study fluctuations in these same loads throughout typical days during every month of the year. It was important to identify fluctuations in building thermal and power loads in order to find a system that could match the load profiles well. Shown below in Figures 107 and 108 are load profiles for the building for a typical weekday during the months of July and December. Load profiles for typical days during all twelve months of the year are listed in Appendix A.6. Theses profiles provided a quick glimpse as to when the heating, cooling and power loads are peaking throughout the day.

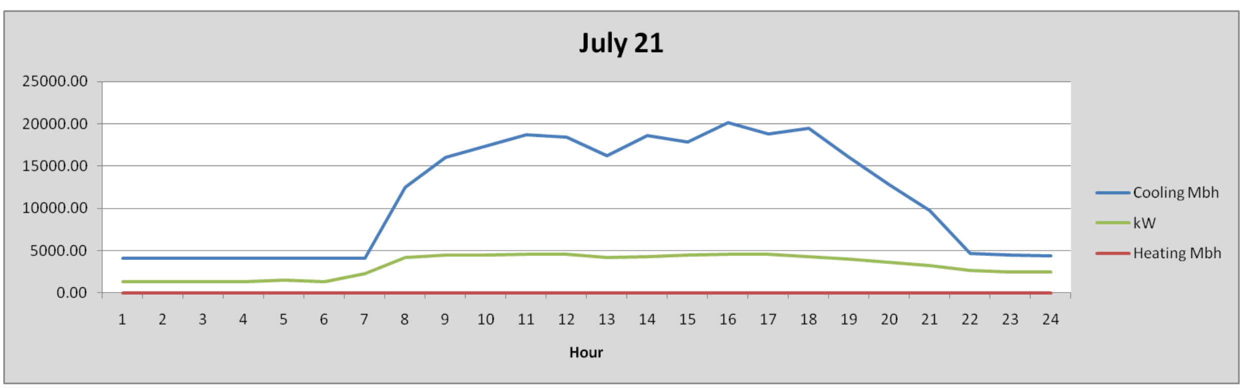


Figure 107: Typical Summer Day Load Profile

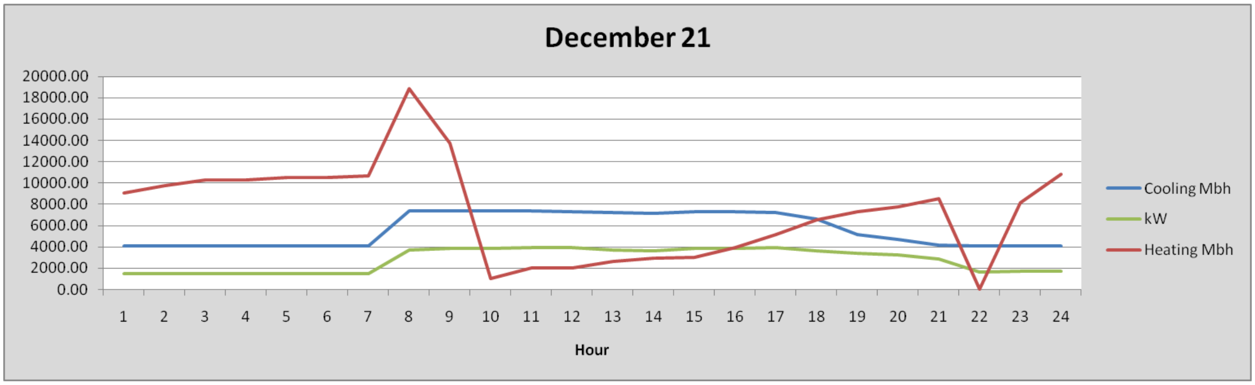


Figure 108: Typical Winter Day Load Profile

The first observation taken from these load profiles is that the base cooling load remains constant throughout the entire year even during non-working hours. In addition, some degree of cooling load exists above the base load during normal work hours throughout the year. It was also noted that the base power demand for the building remains constant throughout the year including non-working hours, and the power demand curve shows similar shape to the cooling demand during each typical day throughout the year. These facts suggest that a cogeneration system, if sized correctly, could help meet these constant cooling and power loads simultaneously throughout the entire year, and thus provide substantial energy and cost savings.

Building thermal and electrical loads were also analyzed on a weekly basis in order to study fluctuations throughout consecutive days. Viewing the weeklong load cycle allowed the design team to better understand the dynamic nature of the thermal and electrical demands for the building, and it also helped to provide insight on how these loads could be handled most effectively. Figure 109 below shows the cooling, heating and power load profiles for a typical week during the summer months. With the heating load at a minimum this profile focuses attention on the cooling and power demand curves. The cycle shows a higher demand for electricity and cooling throughout the week and a slight decrease in demand during the weekend which directly reflects the building occupancy schedule.

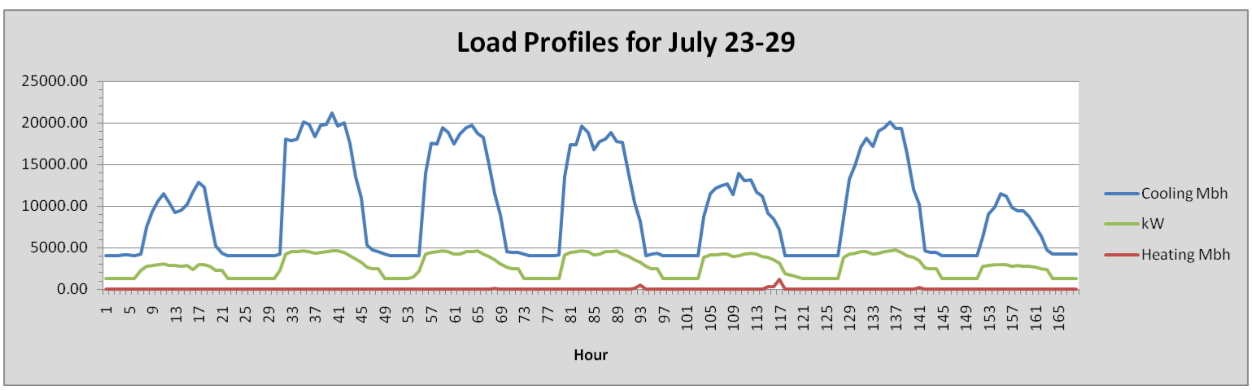


Figure 109: Typical Summer Week Load Profile

In Figure 110 below the load profiles are shown similarly for a typical week during the cooling months. This cycle shows a reverse effect for heating were demand level remain relatively higher during the weekend when the building is a minimum occupancy. The spikes in heating demand throughout the week reveal the need for space preheating in early morning hours shortly before occupants arrive and cooling loads rise. As in the summer months cooling and power demand peaks occur during midday on weekdays.

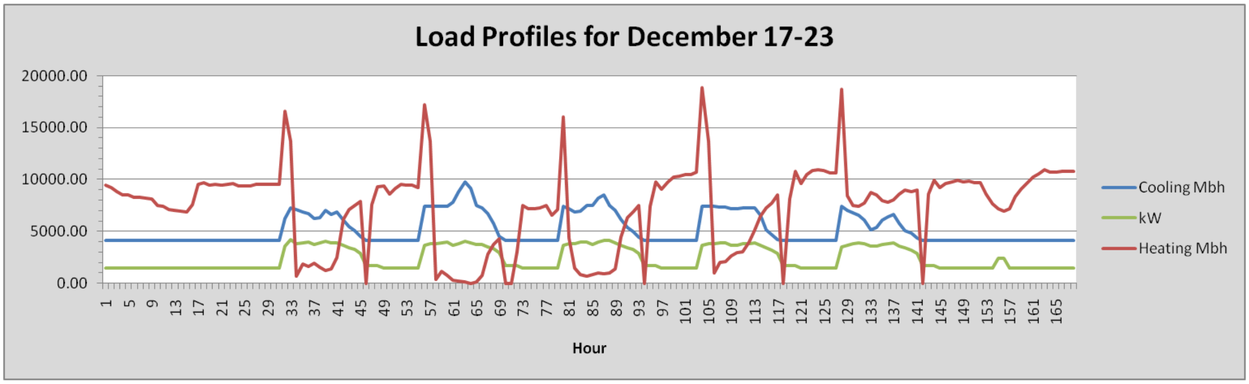


Figure 110: Typical Winter Week Load Profile

As seen by these load profiles, there seems to be an extremely high correlation between the need for cooling and the need for power throughout the entire year. Conversely, the need for power and the need for heating do not closely align if at all during either the cooling months or the heating months. For this reason the design team decided to focus on creating a system that would be able to meet a large portion of both the cooling and power demand simultaneously.

DESIGN ALTERNATIVES

A comparison of alternative systems was needed in order to determine the most effective cogeneration system for the building. The three typical prime movers for cogeneration are reciprocating engines, gas turbines and fuel cells. For the purpose of the cogeneration study reciprocating engines and gas turbines were the focus of the analysis. Data for the reciprocating engines was taken from Caterpillar models G3516 LE and DM5496, and data on the Solar, Saturn 20 natural gas turbine was also used. Yearly data was simulated by hour in order to determine energy inputs and outputs of each alternative. The prime mover, energy, emission and cost data was then compiled for each system and is shown in Table 4 below. Specific data for these models can be found in AppendixA.7 where specification sheets are listed. Pricing for the prime movers was assumed to be $4,000 per installed kW for internal combustion engines and $5,000 per installed kW for gas turbines. These prices include the cost of installation in addition to the following components:

1. Gensets - 480V-3ph gen ends
2. Sound attenuated enclosures
3. Exhaust heat recovery boilers
4. Plate and frame heat exchangers for building hot water loop.
5. Switchgear & paralleling gear
6. Heat dump radiators
7. Exhaust oxidation catalyst and three way catalysts
8. Equipment ship charges to site
9. Utility transformers

Existing System

The existing cogeneration system has the capacity to produce up to 40% of the peak power demand load for the New York Times Company portion of the building. According to yearly load profile analysis, this system has the potential to deliver roughly 12.1 million kW of power and over 12.1 million Mbh of usable thermal output to the building throughout a typical year. In addition, the system consumes roughly 175 Csf/hr of natural gas at peak operation and output. In terms of cost savings, if utilized to its fullest potential, the existing cogeneration system could be saving the building owner up to 16.7% of $13.57 million in building wide energy costs which would total $2.27 million every year. In regards to source energy associated emissions, the existing cogeneration system has the potential for a reduction by roughly 16.2 million pounds of carbon dioxide equivalent pollutants.

As to whether the existing cogeneration system is actually being fully utilized, no real time performance data was obtained in order to study how the owner has operated the system in past. However, clues like the size of the absorption chiller and the backup nature of the electrical output design suggest that the cogeneration system is currently not being fully utilized in terms of power and thermal gain. For example, Figure 111 shows a comparison between the system theoretical potential for cooling and actual potential for cooling limited by the 250 ton absorption chiller for a typical week during the month of July. Ultimately, the current system is well designed, but because of measured data it is unclear how much energy, emissions and cost savings the system is actually achieving.

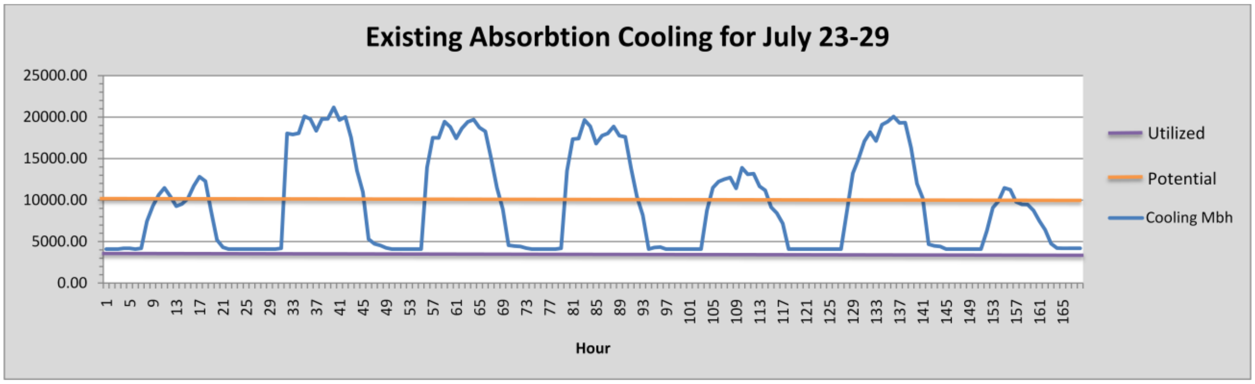


Figure 111: Existing Absorption Cooling for July 23-29

Alternative One

The first alternative cogeneration design involved tripling the size of the plant by adding four more Caterpillar G3516 LE internal combustion engines to the existing two for a total of 6, 700kW engines. The purpose of this study was to analyze the cost saving of cogeneration plant that could deliver nearly all of the building electricity demand on site. This addition would increase the power capacity of the plant by three times to 4,200 kW which could effectively provide roughly 94% of the total building peak demand for electricity. The use of multiple internal combustion reciprocating engines would allow for relatively close electricity load following by the system through peaks and troughs in demand.

According to yearly load profile analysis, this Alternative One has the potential to deliver roughly 22.7 million kW of power and over 80.3 million Mbh of usable thermal output to the building throughout a typical year. In addition, the system consumes roughly 525 Csf/hr of natural gas at peak operation and output. In terms of cost savings, if utilized to its fullest potential, this cogeneration system could save the building owner up to 28.0% of $13.57 million in building wide energy costs which would total more than $3.8 million every year. In regards to source energy associated emissions, this system has the potential for a reduction by roughly 30.46 million pounds of carbon dioxide equivalent pollutants.

CHP System	Existing	Alternative 1	Alternative 2	Alternative 3
Prime Movers				
Recipricating Engine(s)	2 - 700 kW	6 - 700 kW	2 - 700 kW 1 - 1300kW	2 - 700 kW
Gas Turbine(s)	-	-	-	1 - 1300kW
Make, Model	Caterpillar, G3516 LE	Caterpillar, G3516 LE	Caterpillar, G3516 LE Caterpillar, DM5496	Caterpillar, G3516 LE Solar, Saturn 20
Fuel	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Total Floor Area (ft^2)	1,600	4,800	2,970	2,735
Total Weight (lbs)	35,340	106,020	63,720	50,340
Energy / Emissions				
Max Power Output (kW)	1,400	4,200	2,700	2,700
Yearly Power Output (kWh)	12,101,254	22,731,012	18,388,809	7,030,255 11,358,554
Max Thermal Rejection (Mbh)	9,340	28,020	15,240	18,940
Usable Heat Rejection (Mbh/year)	66,509,219	80,267,534	73,141,027	81,940,305
Fuel Consumption (scf/kWh)	12.49	12.49	12.11	13.35
Max Fuel Consumption (scf/hr)	17,485	52,455	32,692	36,045
Emissions Reduction (lbs CO_2e/year)	16,215,680	30,459,556	24,641,004	10,442,812
Costs				
Installed Costs ($)	$5,600,000	$16,800,000	$10,800,000	$12,100,000
Maintenance Costs ($/kWh)	$0.005	$0.005	$0.005	$0.005 $0.015
Maintenance Costs ($/year)	$60,506	$113,655	$91,944	$205,530
Building Energy Costs ($/year)	$11,310,248	$9,766,130	$10,443,122	$10,649,749
Total Energy Cost Savings ($/year)	$2,272,786	$3,816,905	$3,139,912	$2,933,285
Payback Period (years)	0.00	7.83	6.71	14.29

Table 4: Cogeneration Alternatives

As seen in Table 4 above, the estimated cost of this system is $16.8 million in contrast with an estimated $5.6 million for the existing system. Operation and maintenance costs for this system are estimated at $113,655 per year at a $0.005/kWh rate. With all costs factored in, the simple payback period of such a system is estimated at 7.83 years. However, though this system has the potential for substantial savings in energy, emissions and building lifecycle costs, the tripled required floor space for such a large system remains a major disadvantage for this alternative. In addition, as seen in Figure 112 below, the percent of utilized thermal for alternative one is fairly low at 56.7 % compared to the existing system at 82.4%.

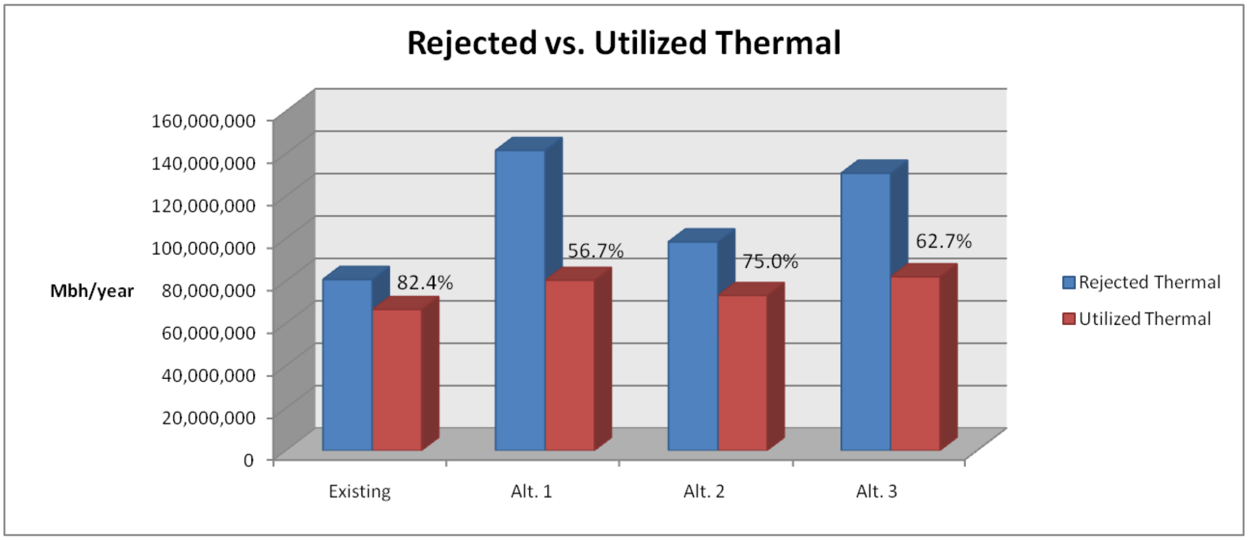


Figure 112: Rejected vs. Utilized Thermal

Alternative Two

The second alternative cogeneration system design involved adding one Caterpillar DM5486 internal combustion engine to the existing two G3516 engines. This 1,300 kW engine would be designed to meet the base power demand load which hovers between 1,250 kW and 1,400 kW through the year while the two remaining 700 kW generators would be designed to follow the electricity demand profile up to 2700 kW of power.

According to yearly load profile analysis, Alternative Two has the potential to deliver roughly 18.4 million kW of power and over 73.1 million Mbh of usable thermal output to the building throughout a typical year. In addition, the system consumes roughly 327 Csf/hr of natural gas at peak operation and output. In terms of cost savings, if utilized to its fullest potential, this cogeneration system could save the building owner up to 23.1% of $13.57 million in building wide energy costs which would total more than $3.1 million every year. As seem in Figure 1 below, alternative two ranks second among other alternatives in yearly energy savings. In regards to source energy associated emissions, this system has the potential for a reduction by roughly 24.64 million pounds of carbon dioxide equivalent pollutants.

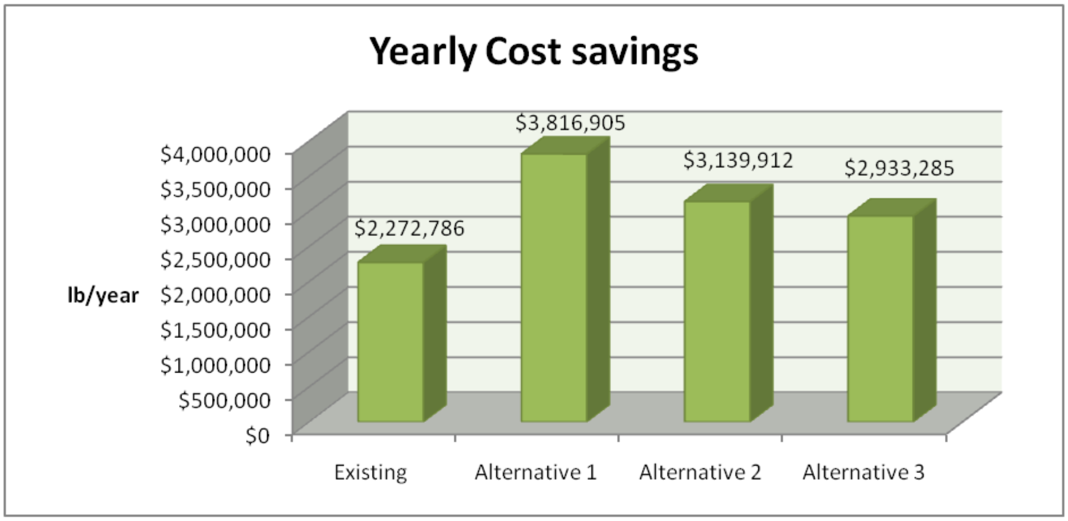


Figure 113: Yearly Cost Savings

The estimated cost of this system is $10.8 million in contrast with an estimated $5.6 million for the existing system. As seen in Table 4 above operation and maintenance costs for this system are estimated at $91,944 per year at a $0.005/kWh rate. With all costs factored in, the simple payback period of such a system is estimated at 6.71 years. The second alternative design has produced promising energy and cost saving numbers, with a smaller payback period than alternative one. Alternative Two also requires significantly less valuable real estate for equipment than Alternative One and the design utilizes a higher percentage of the available thermal output as seen in Figure 113.

Alternative Three

The third alternative cogeneration system design involves the addition of one Solar Saturn 20 natural gas turbine to the existing generators. Similarly to the internal combustion engine in the second alternative, this 1,300 kW turbine would be designed to provide power to meet the base electricity demand load which is present at all times throughout the year while the two remaining 700 kW generators would be designed to follow the electricity demand profile up to 2700 kW of power. The rationale behind using a turbine to meet base load is based on the fact that gas turbines tend to have a more difficult time tracking varying power loads. In addition, turbines are able to produce more heat for every kW of power that is produced than a typical internal combustion engine.

According to yearly load profile analysis, Alternative Three has the potential to deliver roughly 18.4 million kW of power and over 81.9 million Mbh of usable thermal output to the building throughout a typical year. In addition, the system consumes roughly 360 Csf/hr of natural gas at peak operation and output. In terms of cost savings, if utilized to its fullest potential, this cogeneration system could save the building owner up to 21.6% of $13.57 million in building wide energy costs which would total more than $2.9 million every year. In regards to source energy associated emissions, this system has the potential for a reduction of carbon dioxide equivalent emissions by roughly 10.44 million pounds per year. As seen in Figure 1 below, this reduction in carbon dioxide equivalent emissions is the least among all alternative designs including the existing system.

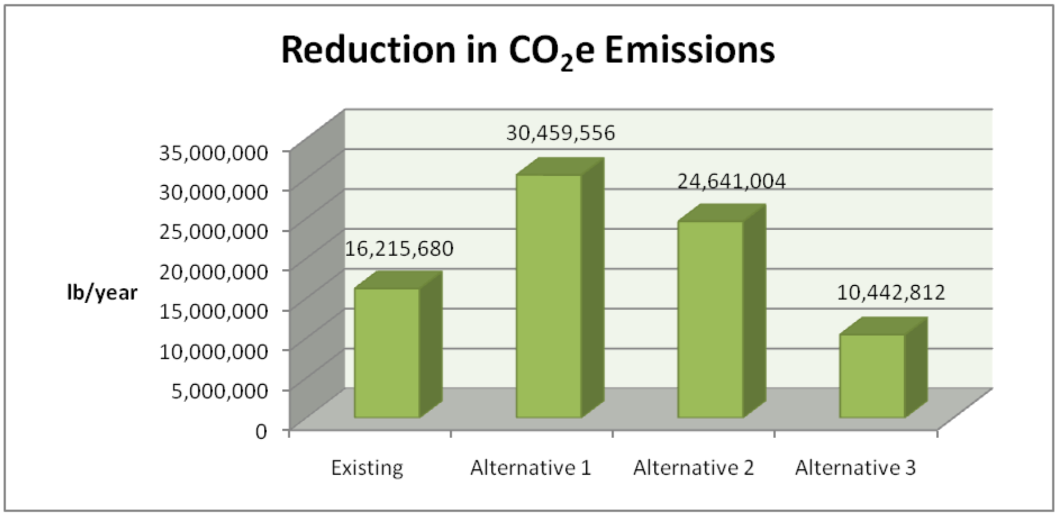


Figure 114: Emissions Reductions

Alternative Three requires significantly less valuable real estate for equipment than Alternative One and the design provides the highest amount of power capacity per square foot of necessary floor area. As seen in Table 4 above, the estimated cost of this system is $12.1 million in contrast with an estimated $5.6 million for the existing system. Operation and maintenance costs for this system are estimated at $205,530 per year at a $0.005/kWh rate for the internal combustion engines and $0.015/kWh rate for the gas turbine. With all costs factored in, the simple payback period of such a system is estimated at 14.29 years which is the longest among all the alternative designs by a significant amount.

In addition to a significantly larger payback period, another weakness of this design is percentage utilized thermal. While producing the same amount of yearly power output as alternative two, the third alternative design utilizes a smaller percentage of the total rejected heat during the year. Figures 115 and 116 below provide an example of a comparison between alternative two and three for utilized thermal for a typical week in July. The orange boxes show the range of potential cooling done by cogeneration rejected thermal from minimum output to maximum output. It is easy to see that the cooling potential for alternative two matches much better with the cooling demand load profile for a typical week during the cooling season than that of alternative three. This is due to the fact that the gas turbine produces much more heat output per kWh produced. Similarly, Figures 117 and 118 below show thermal utilization potential is shown for a typical week in December for both alternative one and alternative two. Therefore, it was determined that the heat to electric ratio of an internal combustion engine works better for this application than that of a gas turbine.

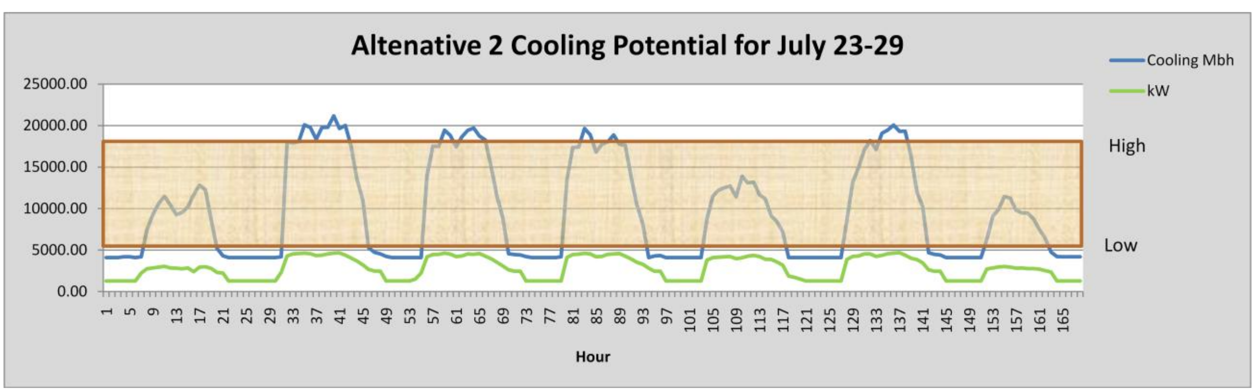


Figure 115: Alternative Two Cooling Potential for July 23-29

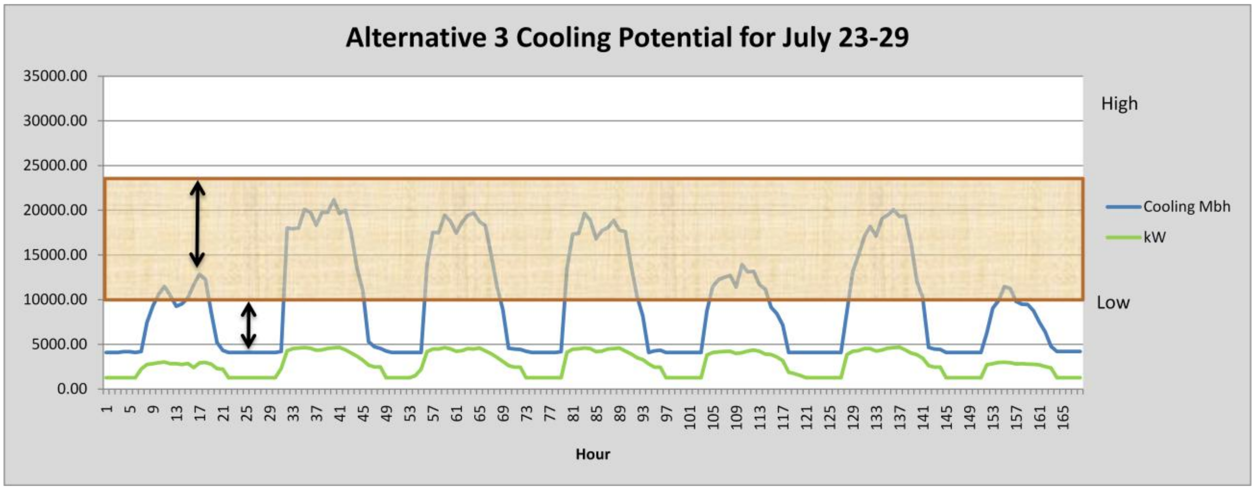


Figure 116: Alternative Three Cooling Potential for July 23-29

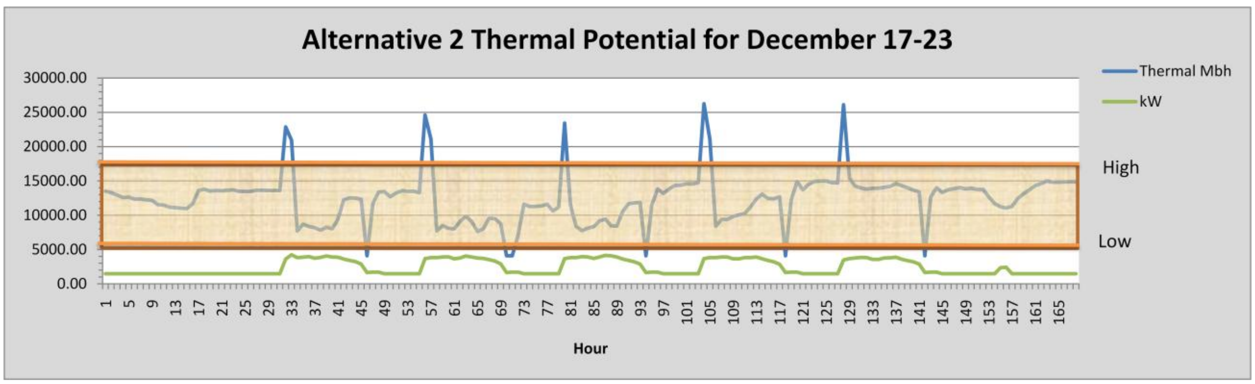


Figure 117: Alternative Two Thermal Potential for December 17-23

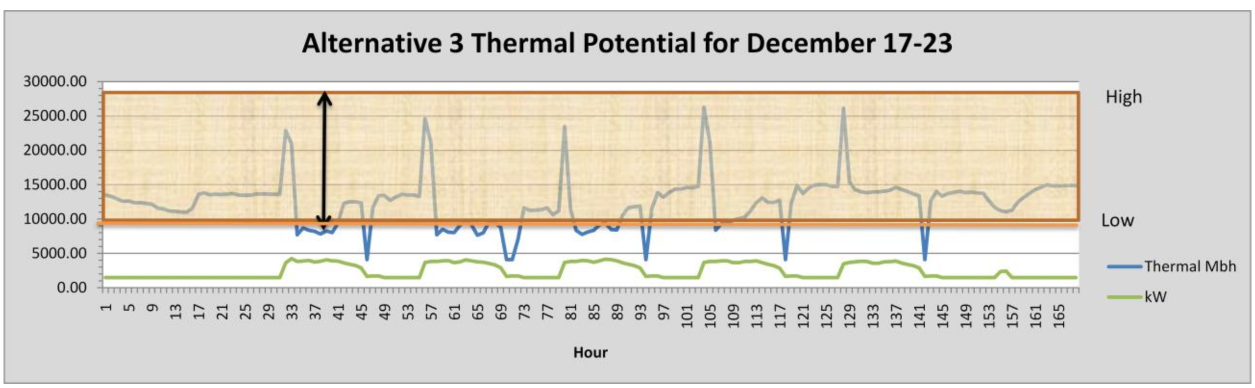


Figure 118: Alternative Three Thermal Potential for December 17-23

Space Constraints

When considering alternative cogeneration plant designs, system footprint played a key factor because of the limited amount of space available on the building site. The existing cogeneration system occupies roughly 1,600 ft^2 of floor space and is located on the East side of the roof of the podium building as outlined in blue on Figure 119 below. Furthermore, the only remaining floor space for any cogeneration plant expansion lies just to the west of the existing plant location. This expansion area is roughly 1400ft^2 in size and is outlined in red on Figure 119 below. Therefore, a maximum of roughly 3,000ft^2 is available for the entire cogeneration plant on the roof of the podium building. Figure 120 below shows a larger scale view of the existing cogeneration plant area and the area for potential expansion.

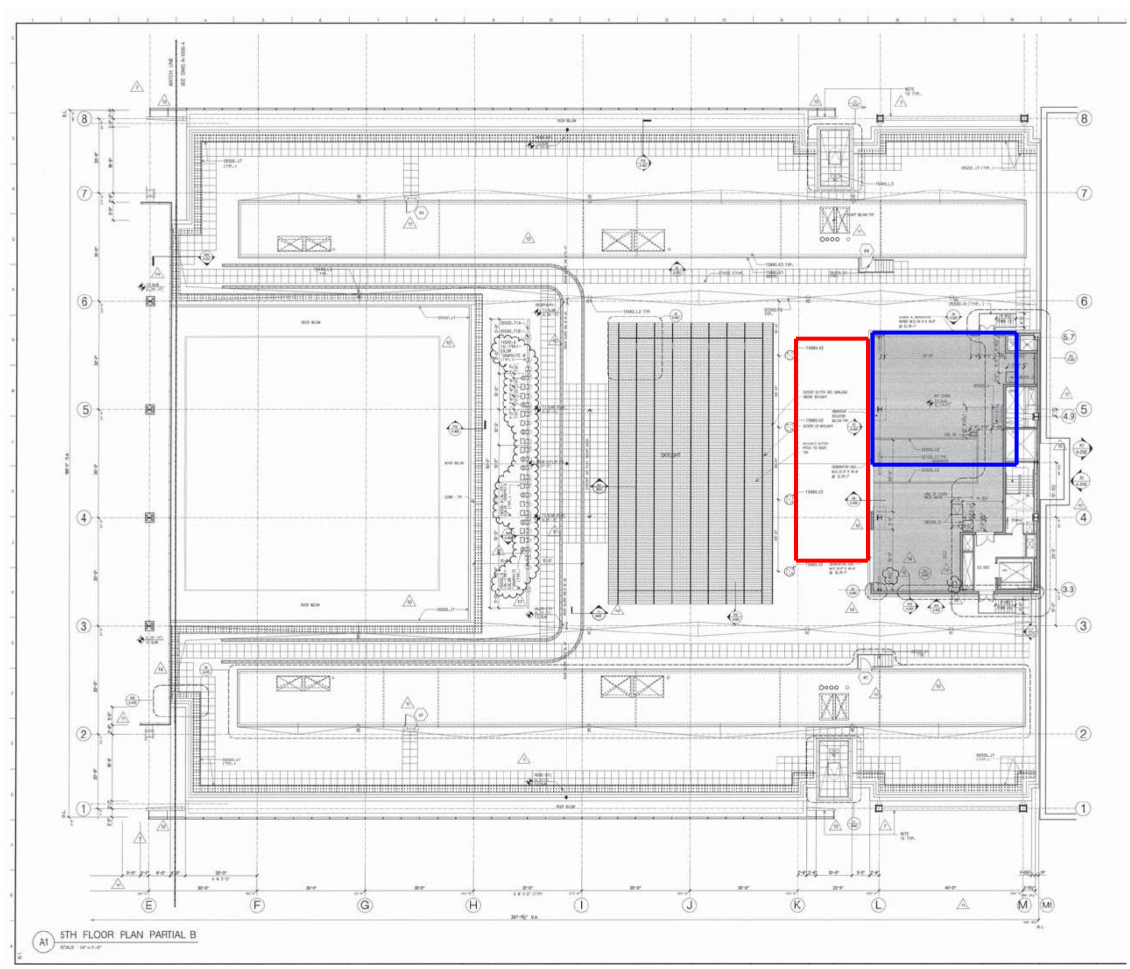


Figure 119: Cogeneration Available Space

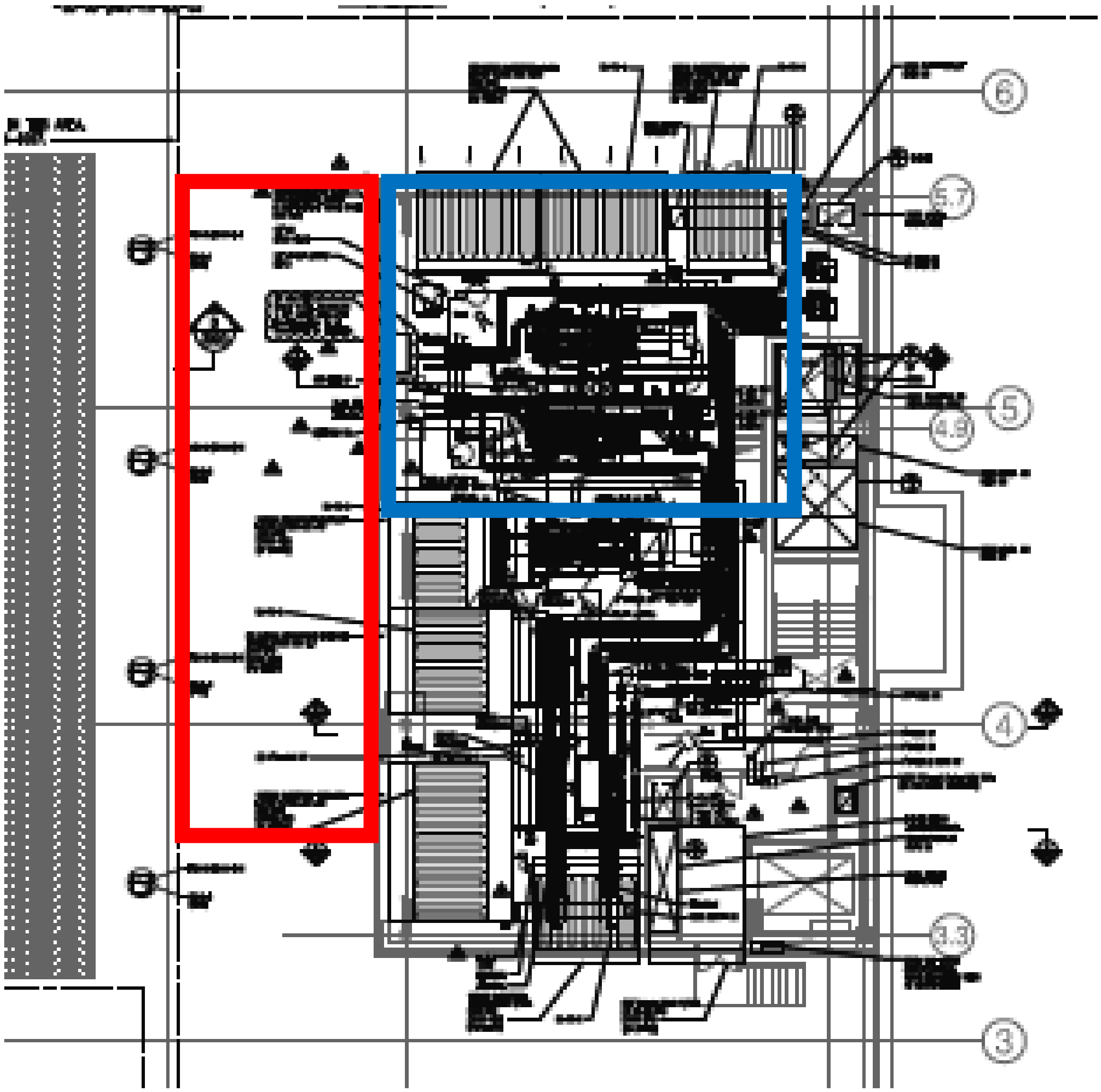


Figure 120: Large Scale Cogeneration Available Space

CONCLUSION

The primary goal of the cogeneration plant redesign was to help reduce building operating costs in order to support the profitability of the building. Secondly, the redesign focused on maintaining or decreasing environmental impacts such as C02e emissions in order to promote a more sustainable image for the building owner and thus increase the marketability of the building. Both alternative one and alternative two have accomplished these goals by cutting yearly energy costs and source energy associated emissions for the building. Though alternative three was able to cut yearly energy costs by nearly $660,000 compared to the existing system, total source energy emissions for this system are higher than those for the current design. The higher performance from both alternatives that utilize only internal combustion engines is due to the fact the heat to electric ratio of internal combustion engines fits better for this application than that of a natural gas turbine. Figure 121 below provides a simple visual aid comparing the alternative systems and the existing system.

Overall Comparison	Existing	Alternative 1	Alternative 2	Alternative 3
Energy Cost	X	☺		
Source Energy Emissions	X	☺		
Payback Period			☺	X
System Footprint	☺	X		

Figure 121: Overall Comparison of Alternatives

Overall, the team believes that alternative two provides the most viable solution for the cogeneration system redesign for several key reasons. Though alternative one provides a higher amount of energy, cost and emissions savings per year than alternative two, the second alternative design is 2/3 the size and is able to provide over 80% of the yearly power output as its counterpart as seen in Figure 122 below. In addition, limited space requirements on the site make alternative two a much more attractive solution. Figure 123 below shows how alternative two provides a larger amount of energy savings per square foot of necessary system equipment footprint. This shows that alternative two is a better use of valuable floor space than the larger alternative one design.

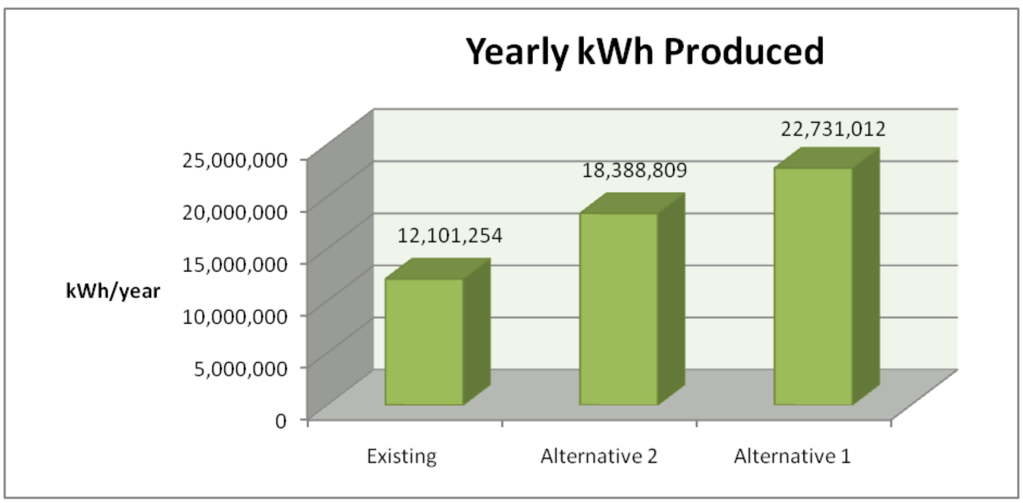


Figure 122: Yearly kWh Produced By Alternatives

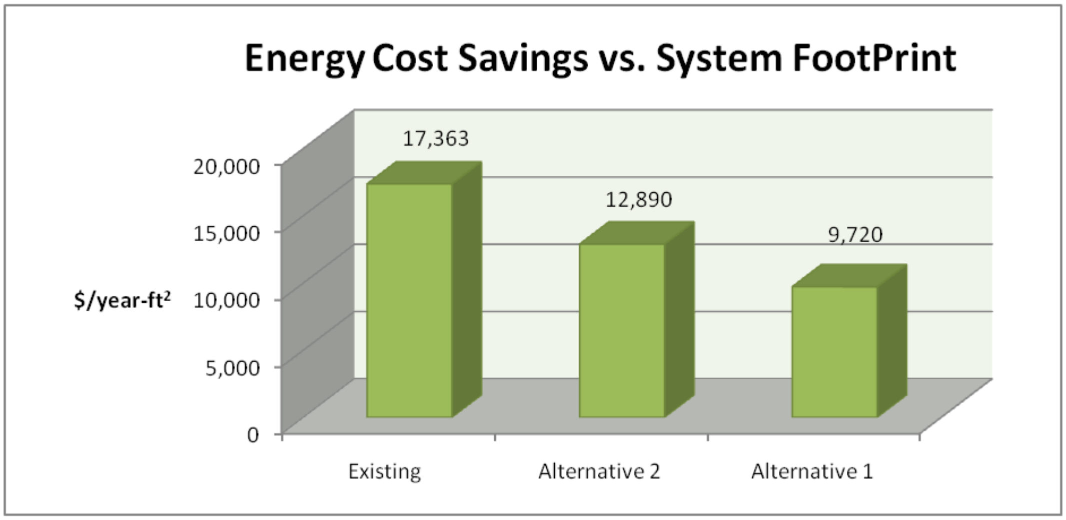


Figure 123: Energy Cost Savings vs. System Footprint for Alternatives

Ultimately, payback period was the factor of highest priority when determining the viability of the cogeneration redesign. Figure 124 below shows the 6.7 year payback for alternative two in the midst of energy cost savings over a twenty year period. The columns in red denote years where energy savings would pay back system installation costs, while green columns denote years after the system has been paid off and all energy cost savings result in profit for the building owner. As noted below the three-engine system has the potential to save the building owner over $10 million over a twenty year period.

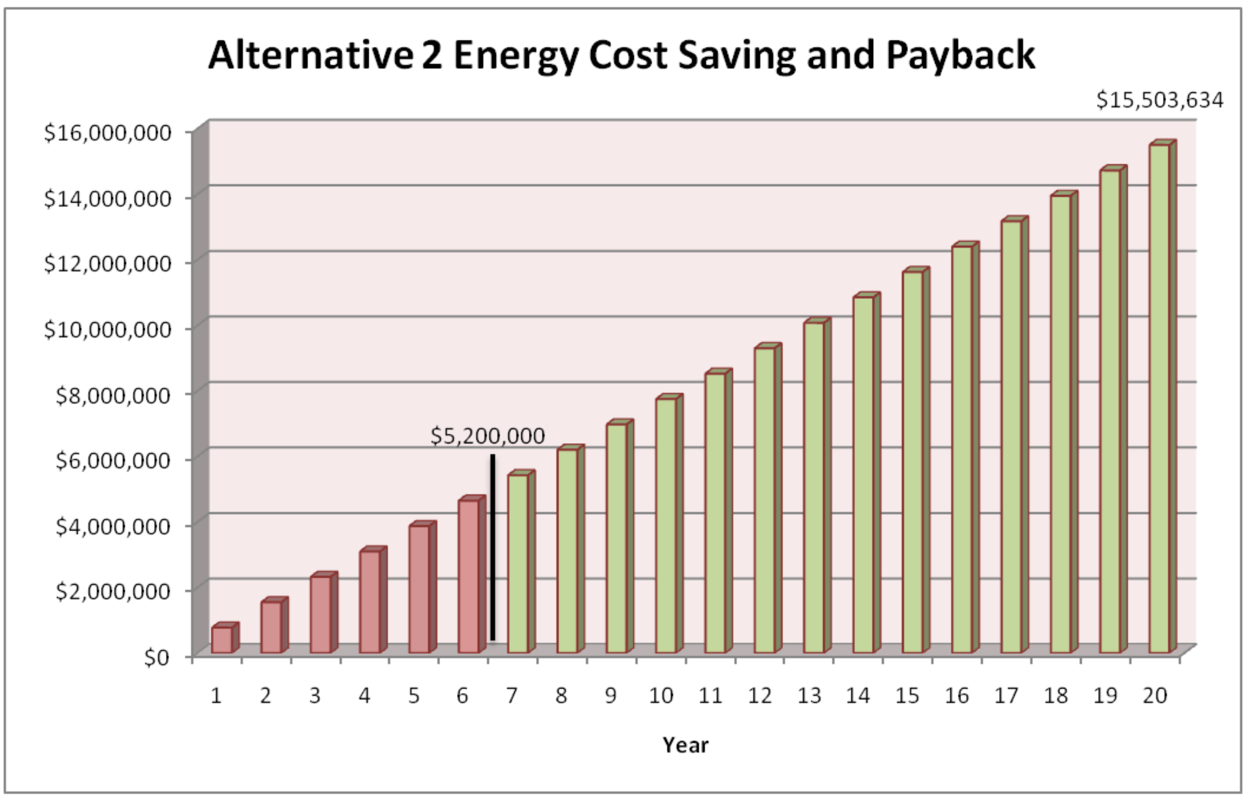


Figure 124: Alternative Two Energy Cost Savings and Payback

ENERGY, COST AND EMISSIONS SAVINGS SUMMARY

Total energy consumption associated with the active chilled beam system was then analyzed with respect to the new double skin façade. Figure 125 below displays the energy consumption by floor for each system, with the existing systems in dark blue and the redesigned systems in light blue. Similarly, Figure 126 below compares the same system with in respect to energy or operation costs. It can be seen that both the redesigned mechanical system and the double skin façade offer substantial energy and cost savings throughout the year.

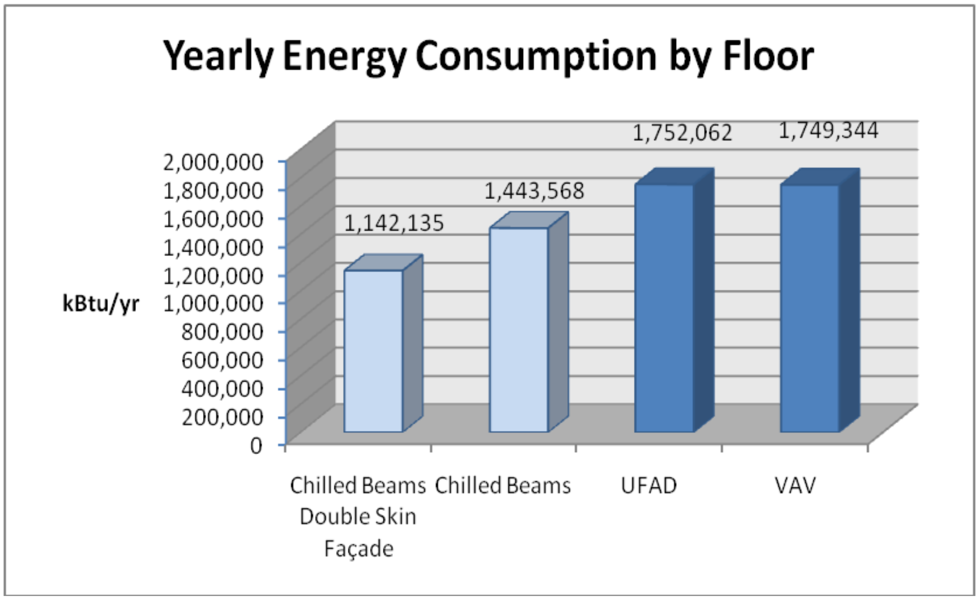


Figure 125: Yearly Energy Consumption by Floor

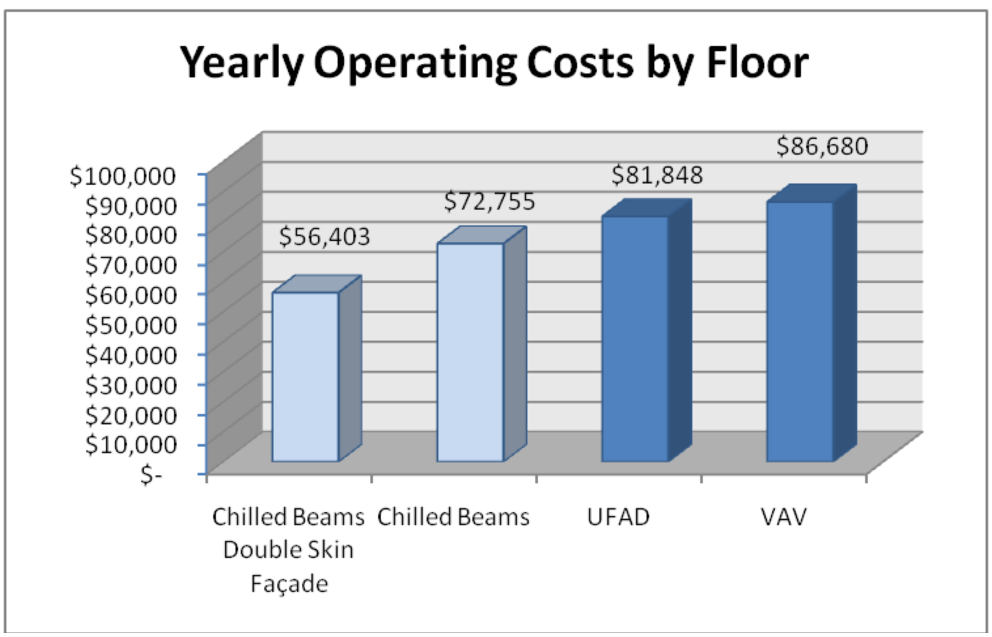


Figure 126: Yearly Energy Cost by Floor

The reduction in HVAC loads via the façade redesign and the chilled beam replacement has also lead to reduced cooling peak loads. With the new façade and chilled beam system the peak cooling load is estimated at 32.3 tons. This is a 55% reduction from the peak cooling load with the existing VAV system with existing façade of 72.6 tons. Similarly, this is a 49% reduction from the peak cooling load with the existing UFAD system with the existing façade of 62.8 tons (See Appendix A.8 for Trane Trace cooling load results). When extrapolated to the entire building, this reduction in cooling load is equal to roughly 1600 tons of cooling at peak demand. This reduction has allowed for the removal of one 1500 ton electric centrifugal chiller from the cooling plant while making room for the additional absorption chillers which are needed in conjunction with the cogeneration plant size increase.

Total HVAC emissions associated with the active chilled beam system was then analyzed with respect to the new double skin façade. Figure 127 below displays the associated emissions in pounds of CO_2e by floor for each system, with the existing systems in dark blue and the redesigned systems in light blue. Similarly, Figure 128 below compares the same system with in respect to associated emissions in pounds of NO^x. It can be seen that both the redesigned mechanical system and the double skin façade offer substantial HVAC associated emissions in both CO_2e and NO^x savings throughout the year.

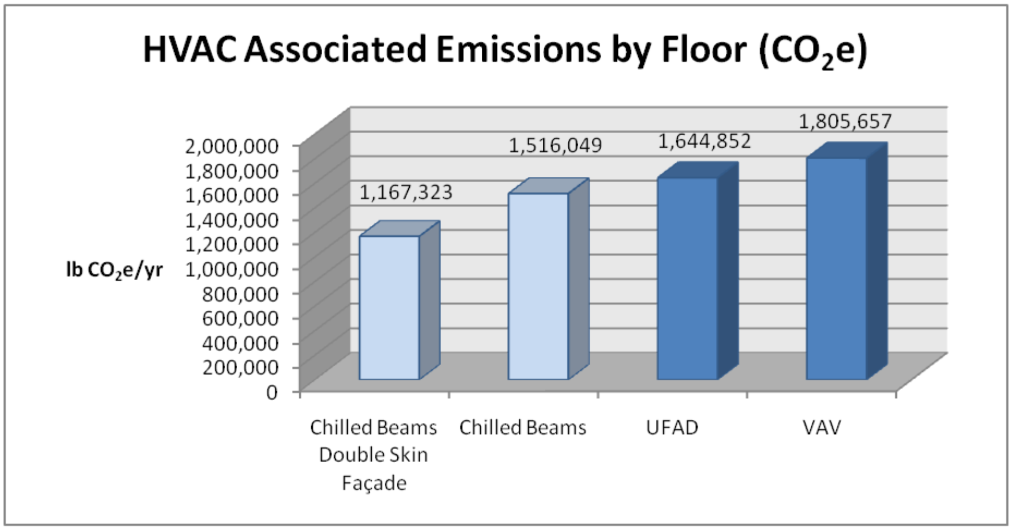


Figure 127: HVAC Associated Emissions by Floor

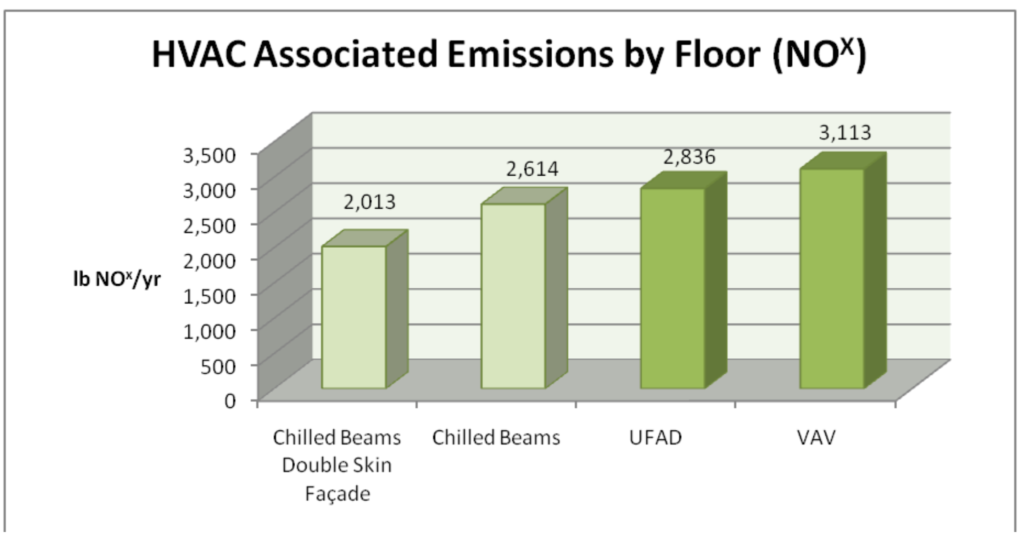


Figure 128: HVAC Associated Emissions by Floor

Figure 129 below shows how the source energy consumption by fuel type for the existing building is dominated by high priced electricity. Figure 130 below shows the estimated source energy consumption by fuel type for the redesigned building which is conversely dominated by less expensive natural gas. This shift in energy fuel type is the result of the increase in size of the cogeneration system which supplies power, heating and cooling to the building. Though more energy will be consumed at the site, less source energy will be needed for building operation.

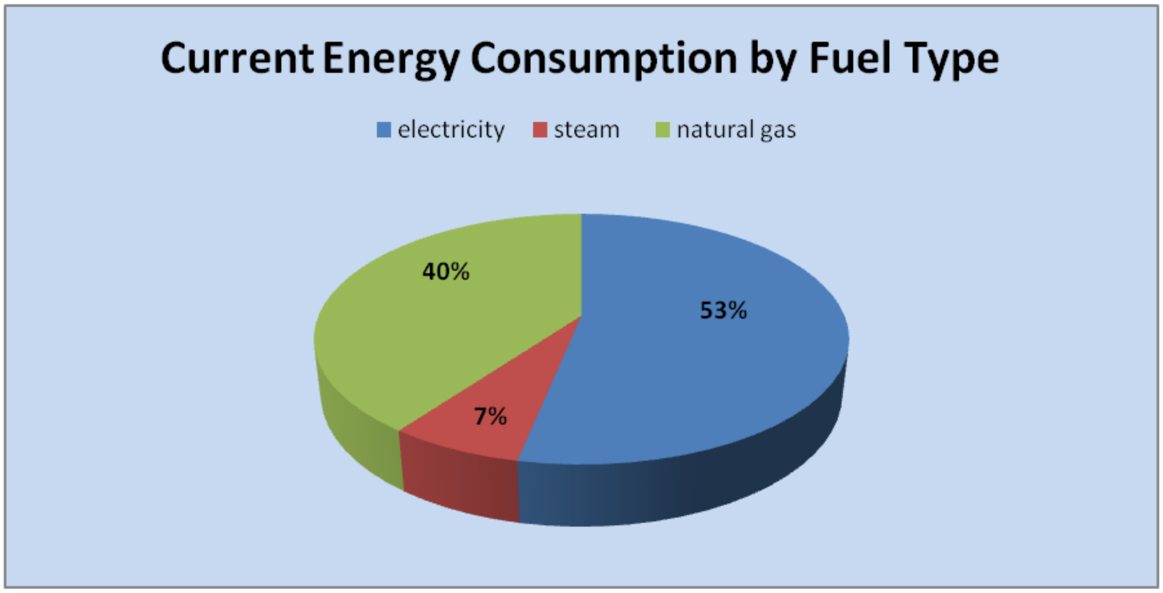


Figure 129: Current Energy Consumption by Fuel Type

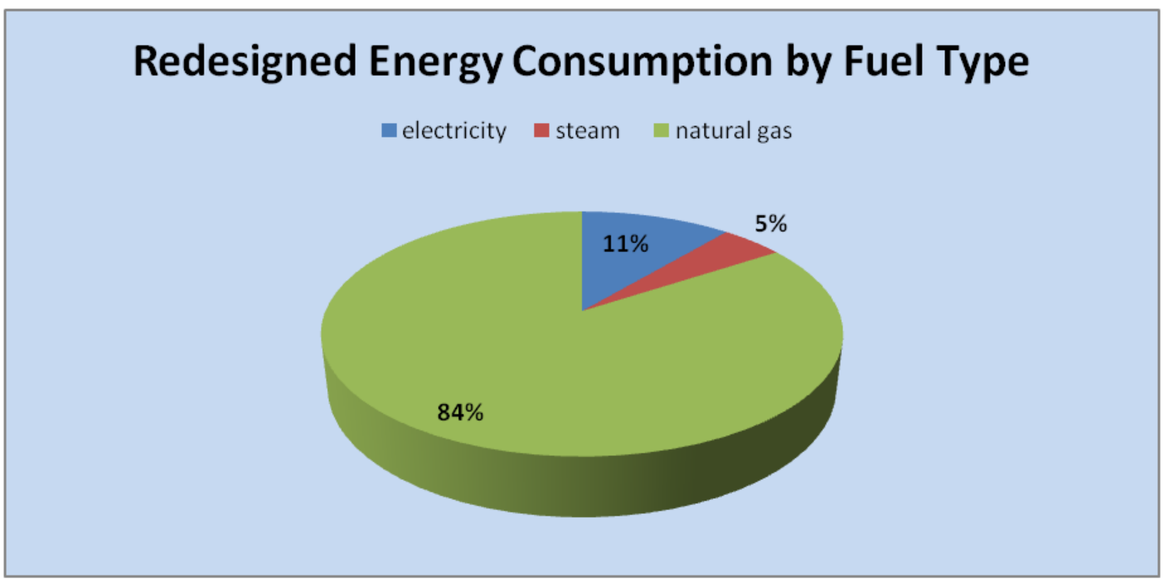


Figure 130: Redesigned Energy Consumption by Fuel Type

Finally, yearly energy cost savings were tabulated by redesign categories which include the chilled beam, double skin façade and cogeneration redesigns. As seen in Figure 131 below, all three categories provide substantial portions of the overall yearly energy savings of roughly $2.23 million compared to the existing design. These savings allow for decreased operational costs for the building owners which make the building more profitable. In addition to increased profitability, these energy saving measures have created a more environmentally sustainable building with a higher marketability.

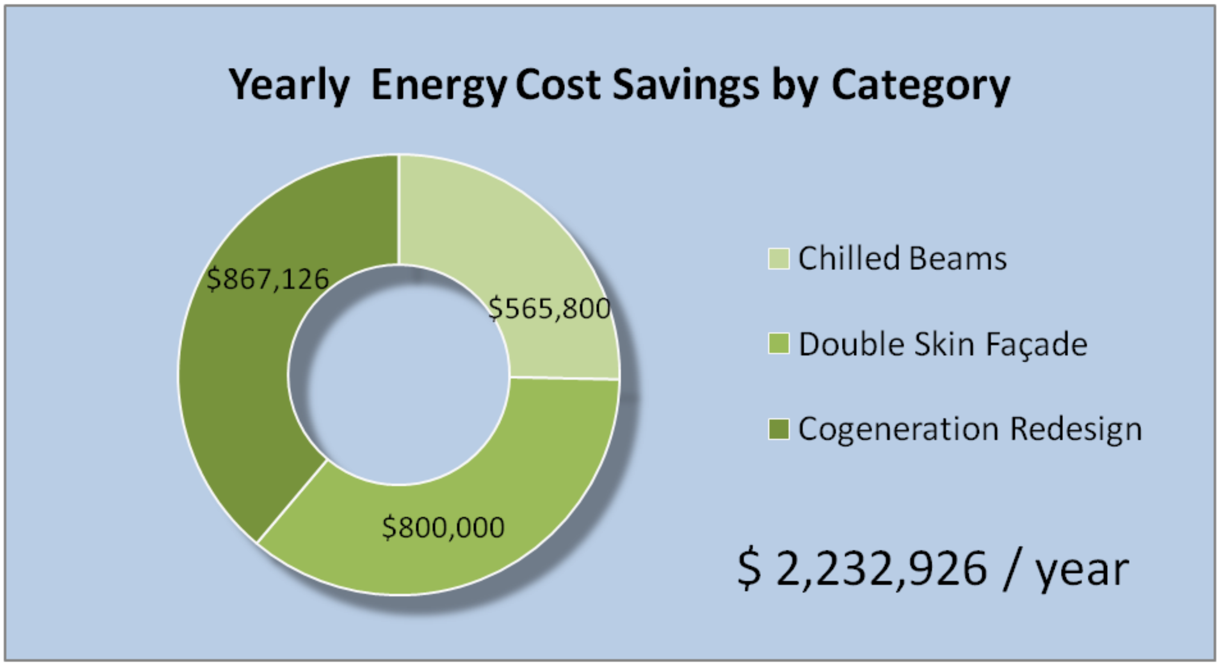


Figure 131: Yearly Energy Cost Savings by Category

LESSONS LEARNED: IPD / BIM

The Thornton Tomasetti Foundation sponsored the new Integrated Project Delivery and Building Information Modeling based thesis program that was introduced this year. This program had some key goals for the students involved in the program. It was important to explore the integrated design process and the use of Building Information Modeling to help aid the integrated process.

INTEGRATED PROJECT DELIVERY PROCESS

The American Institute of Architecture states that, “Integrated Project Delivery (IPD) leverages early contributions of knowledge and expertise through the utilization of new technologies, allowing all team members to better realize their highest potentials while expanding the value they provide throughout the project lifecycle.” The IPD/BIM thesis project gave the students involved a chance to see firsthand how an integrated project team works together and achieves a common goal. The group felt that there was a great opportunity to work together on a few common building areas to improve on the current design and creatively attack it to find the best solution.

Goals and expectations were laid out early on in the process in order to properly balance the workload of each of the members of the group. There was an awareness and a concern that some of the students would have more work than others. It was important to establish scopes of work for each of the four redesign areas. While at the beginning it seemed like the group shared an even workload, it became evident that it was hard to try to forecast the amount of time and work that it took to complete the project.

With the added level of coordination and communication that is needed from an integrated thesis team, it was important that the group held regular meetings in order to update each other about current progress. The group met weekly to discuss progress and communicate what needs each member had from the others. This was found to be very effective in keeping everyone on the same page. The efficiency of these meetings could have increased if the group had set up agendas for each meeting. It would have been very effective if the group had set up and enforced milestones during the spring semester.

The project includes a lot of additional requirements from each of the individual members of the group. It could be valuable for each of the groups to sit down with all of the advisors involved in the semester and coordinate a roadmap for the spring semester. Given the nature of this program being in its first year of existence, there were a lot of expectations from the groups. The faculty involved in this program pulled each of the students in different directions. It is important that lines of communication be open between faculty and advisors in order to streamline the process. There should be an emphasis put on the roadmap for the spring and the deliverables within the proposal.

It is important to understand that Building Information Modeling is a tool that can be used to help the efficiency of the Integrated Project Delivery process. BIM can help aid communication and coordination between design team members. This project is an academic study of how BIM can aid an integrated project group. With that in mind, the group felt it was important to set goals and discover the level of BIM use that was appropriate for the project.

BIM PROJECT EXECUTION PLANNING

There were a few methods that were implemented in order to effectively organize the IPD team. One resource that was used in the planning process of this project was the BIM Project Execution Planning Guide developed by the Computer Integrated Construction Research Program at The Pennsylvania State University. The goal of this procedure is to help guide the early design participants to form consistent plans for the project.

Goal Setting

Weekly meetings were setup early in the planning phase of the project in order to discuss goals and expectations for Building Information Modeling and the project as a whole. Below is a list of goals that the team came up with early on:

Priority (1-3)	Goal Description	Potential BIM Uses
1- High	**Value added objectives**	
1	Alternate Shading Techniques and Glazing	Energy Analysis, Lighting, Cost, design reviews, VM, DA
1	Cost analysis of the façade for design change	Cost, DA, DR
1	Keep the aesthetic appeal of the façade	DR, Programming Existing conditions
2	Increase the constructability of the façade	Structural, cost, phasing
2	Increase the comfortability of the occupants	Lighting analysis, mechanical, cost analysis
2	Capture solar energy for heating degree days	Energy analysis, lighting analysis, Mechanical
2	Look at how to obtain a zero grid energy building	Mechanical, lighting, electrical, energy analysis, cost, site analysis
2	Lateral system alternative	structural, cost, 3D coordination, DR, DA, Code validation, construction system design
3	Utility cost analysis (cogen, natural gas, electricity)	Mechanical, lighting, electrical, energy analysis, cost, site analysis
3	Optimize the CoGen plant	Mechanical, lighting, electrical, energy analysis, cost, site analysis
3	Decrease floor to floor height in order to add additional floors	DR, Programming, Cost, phasing, structural, 3D coordination, DA, Mechanical
3	Investigate serviceability of the structural system	Code validation, 3D coordination, cost, structural

BIM Use Analysis

With these goals in mind, the group was able to do an analysis of what BIM uses would best fit the project team and project scope. The BIM Goal Use Analysis Worksheet provided by the CIC research group was used to identify the BIM uses that would be best for this project. Below is the worksheet used to analyze the BIM uses:

BIM Use*	Value to Project	Resp. Party	Value to Resp. Party	Capability Rating			Additional Resources / Competencies Required to Implement	Notes	Proceed with Use
	High / Med / Low		High / Med / Low	Scale 1-3 (1 = Low)					YES / NO / MAYBE
				Resources	Competency	Experience			
Building Systems Analysis	Med	Mech	High	2	1	1			NO
		L/E	High	2	1	1			
		CM	Med	1	1	1			
Cost Estimation	High	CM	High	2	1	1			NO
Phase Planning	Med	CM	Med	3	2	2			Maybe
3D Coordination (Construction)	Med	CM	High	3	2	2		Considering the same as Design	NO
		Mech	Med	3	1	1			
		Structural	Med	3	1	1			
Engineering Analysis	Med	Structural	High	1	1	1			NO
		Lighting	Med	2	1	1			
		Mech.	Med	2	1	1			
Design Reviews	Med	CM/Arch	High	3	2	1			Maybe
		L/E	High	3	2	2			
		Mech.	Low	1	1	1			
		Structural	Low	1	1	1			
3D Coordination (Design)	High	CM	High	3	2	2			YES
		Mech	Med	3	1	1			
		Structural	Med	3	1	1			
		L/E	Med	2	1	1			
Design Authoring	High	CM	High	3	3	3			YES
		Mech	High	3	2	2			
		L/E	High	3	2	2			
		Structural	High	3	2	2			

* Additional BIM Uses as well as information on each Use can be found at http://www.engr.psu.edu/ae/cic/bimex/

The uses that were marked as "yes" and "maybe" in the table above were selected by the group as possible BIM uses that would benefit the integrated design process throughout the duration of the project. The four BIM uses that were looked at by the group were:

Design Authoring

Description: "A process in which 3D software is used to develop a BIM model based on criteria that is important to the translation of the building's design. Two groups of applications are at the core of BIM-base design process are design authoring tools and audit and analysis tools.

Authoring tools create models while audit and analysis tools analyze or add to the richness of information in a model. Most of audit and analysis tools can be used for Design Review and Engineering Analysis BIM Uses. Design authoring tools are a first step towards BIM and the key is connecting 3D model with powerful database of properties, quantities, means and methods, costs and schedules." *(BIM Project Execution Planning Guide)*

Goal: It was important to use BIM in a way that would best aid the integrated project team throughout the project while avoiding any unnecessary work that would not contribute to the overall goals of the project. The group found that Design authoring would help the group by creating a 3D model that could be updated with every design change. This model would help to keep all of the members on the same page throughout the whole project. This model could help to increase collaboration between the members of the group and can also help to set groundwork for each of the members to build from.

Outcome: An existing conditions model was developed this past summer and included information about the design and system of the building. This model had a lot of good useful information about much of the architecture and structure of the building, but there were also a number of things that were missing from the model.

Factors like an incomplete structural model and very limited mechanical and electrical information in the architectural model made it tough the try to compare a new model with the existing model. Also, managing a full 52 story building within a BIM process can prove to be very difficult. The model has to be broken up into multiple files to make it possible to open up on a typical computer. For this reason it was important to limit the size of the BIM files. The group mainly updated and studied a "typical" floor, in this case the 8th floor of the New York Times Building. The advantages of BIM in this project could be easily seen by limiting the size of the model.

Design authoring helped the group achieve higher level goals and uses throughout the project. Design authoring continuously through the project made it possible to use the model for design reviews, coordination, and estimating.

Design Reviews

Description: "A process in which a 3D model is used to showcase the design to the stakeholders and evaluate meeting the program and set criteria like layout, sightlines, lighting, security, ergonomics, acoustics, textures and colors, etc. Virtual mock-up can be done in high detail even on a part of the building like façade to quickly analyze design alternatives and solve design and constructability issues. If properly executed, these reviews can resolve design issues by offering different options, and cutting down the cost and time invested considering basic construction, making modifications after reviews and final demolition and removal expense.

Evaluation of the designed space can be facilitated by high degree of interactivity in order to get positive feedback from end users and owner. Some of the top criteria in evaluation if the courtrooms are: sightlines, lighting, ADA compliance, safety, security, acoustics, HVAC, ergonomics, aesthetics and millwork tolerances. Real-time modifications of design are enabled based on the end users feedback. Therefore, decision making time is cut in half since the attention focus is on one issue at a time until the consensus is reached." *(BIM Project Execution Planning Guide)*

Goal: The group decided to pursue the Design Review BIM use for its use in lighting design and the ability to showcase any design alteration that was proposed for the building. The Design Review BIM use can help contribute to each of the group members' studies of the New York Times Building.

Outcome: The 3D model was used differently by each of the members of the group to help aid their studies of the building. There was a lot of interoperability between Autodesk Revit and some of the other programs that were used by the students.

Structural and architectural studies were vastly helped by using the 3D model. When reconfiguring the structural core of the building the group members used Autodesk Revit to coordinate spaces within the core. It was easy to move the architectural layout of the core around in Revit by linking the structural core model, which was imported directly from ETABS, to the architectural model. Interior spaces were redesigned while keeping both handicapped access codes and architectural feasibility in mind. The workflow from ETABS, a structural modeling program, into Autodesk Revit is fairly easy to manage. A plug-in has to be loaded into Revit in order to import the ETABS model, but once the plug-in is installed the process is quite easy.

The design authoring the BIM use allowed the group to utilize a 3D model to coordinate design changes between the different disciplines in the group.

3D Coordination

Description: "A process in which Clash Detection software is utilized during the coordination process to determine field conflicts by comparing 3D models of building systems. The goal of clash detection is to eliminate the major system conflicts prior to installation." *(BIM Project Execution Planning Guide)*

Goal: 3D coordination has a huge impact on many projects that utilize BIM from the beginning. It is important for the IPD/BIM thesis team to explore the opportunity to utilize 3D coordination on their project. The team decided that coordination should be done in order to manage the new floor system that is being studied. Due to the need to reduce the height of the floor to ceiling sandwich on each typical office floor there is a large demand on coordination of those spaces.

Outcome: 3D coordination was used by the group to show the feasibility of the proposed floor system. This was done by modeling a typical office floor with the architectural, structural, and mechanical systems in the ceiling spaces. These models were then imported into NavisWorks Manage 2010 to provide a frame work for coordination on the larger scale. It was important to explore the process in order to learn the benefits of using 3D coordination with BIM.

Phase Planning (4D Modeling)

Description: "A process in which a 4D model (3D models with the added dimension of time) is utilized to effectively plan the phased occupancy in a renovation, retrofit, addition, or to show the construction sequence and space requirements on a building site. 4D modeling is a powerful visualization and communication tool that can give a project team much better understanding of project milestones and construction plans." *(BIM Project Execution Planning Guide)*

Goal: Phase Planning and 4D Modeling was seen as outside of the scope of the project for the group. It was decided early on that this BIM use would only be pursued if there was an available time of the construction management student at the end of the project.

Outcome: This BIM use was used in order to demonstrate the schedule impacts that the new concrete core would have on the construction process. A 3D model that had been created by the group for estimating, coordination and design review was used for this application. The 3D model was linked up with a schedule that was developed for a general conditions estimate in order to visually demonstrate the construction sequence to the team. The 4D model was developed within NavisWorks by importing a 3D model from Revit and a project schedule from Microsoft Project.

KEY WORKFLOWS AND INTEROPERABILITY

A goal of the group was to test a number of workflows between programs that were commonly used.

Autodesk Revit to Trane Trace

An attempt was made to incorporate the Revit MEP model with the energy simulation software via the gbXML file format. The gbXML file format is designed to be a link between three dimensional design software and energy analysis software, and its purpose is to streamline the design process by eliminating time consuming manual takeoffs. However, the design team discovered that the file transfer process still contains several flaws which prevent a complete energy analysis. Instead, the energy model geometry was manually configured and the given results were obtained.

ETABS to Autodesk Revit

The proposed alternate core was modeled and analyzed in ETABS and exported into Autodesk Revit. Material takeoff schedules for steel and concrete were organized in Revit and exported to excel. The concrete core model from ETABS was used in order to reorganize the architecture of the core and surrounding areas.

CONCLUSION

The purpose of this senior thesis project was to produce an alternative design for the New York Times Building through an integrated design approach. The integrated design approach was key in creating a viable alternative to the existing design. Each respective discipline was responsible for individual areas of study, while contributing to the overall redesign goal. The alternative concepts have focused on achieving an overall team goal of increasing the profitability and marketability of the building while maintaining its iconic and sustainable image.

As stated earlier, in order to achieve this primary goal, the following three strategies were identified:

1. Decrease the floor to floor height with the intension of adding additional rentable floors.
2. Redesigning the core configuration structurally and architecturally in order to add additional rentable space to each floor while maintaining the efficiency of the lateral system.
3. Improve the sustainability profile of the spaces to add marketability and possibly charge a higher rent.

To achieve a decreased floor to floor height several the design team has modified the structural floor configuration to a castellated composite steel beam system. In addition the underfloor air distribution system was replaced with an active chilled beam system which has been coordinated with the castellated beam system. A feasibility study has been done in order to determine the viability of adding additional rentable floors. This redesign of the floor system has allowed space for one additional floor within the building adding roughly 21,000 ft^2 of rentable space. This additional floor will add $12.3 million to the initial construction costs. However the combined benefit of rent and energy savings from the floor has the potential to save the owner roughly $1.8 million per year which offers a payback period of just under ten years.

The redesign of the core configuration involved an investigation of alternative architectural layouts in order to increase rentable floor area. When changing the architectural configuration of the core the layout of the lateral system was an important consideration. Therefore, the opportunity of redesigning the lateral force resisting system with an alternative solution was presented. The alternative solution involving a concrete core with outriggers on the mechanical floors was explored and analyzed. The investigation of the core also involved an analysis of necessary infrastructure such as elevators and MEP risers.

Improving the sustainability profile has shaped two main redesign tasks. The first involved the façade which currently contributes to a large portion of the overall building cooling and heating loads. The team worked toward developing an alternative design which will optimize energy usage and maintain acceptable daylighting of the space. The second task involved a redesign of the cogeneration system in order to decrease energy costs and associated emissions for the building. The goal for this redesign to supply The New York Times Company floors with 100% of its power needs was met, but ultimately cost, energy use and emissions were the driving factors. In terms of energy cost savings, a reduction of roughly $2.23 million per year was achieved by the collective redesign. In regards to environmental sustainability, an overall reduction in energy use associated emissions of 50.1 million lbs CO^2e has been reached.

It was the responsibility of all of the team members to update a central BIM file that the group used. This model was used to coordinate the different redesigns and efficiently organize the interior spaces of the New York Times Building. It was important to analyze the ways that BIM and an integrated project delivery design approach contributed to the project. Integrating the efforts of each of the team members was of high importance during all phases of this project, and it was essential to keep open the lines of communication between all of the team members. The utilization of BIM to aid methods of analysis has supported an overall integrated project delivery approach to design.

The group utilized BIM on this project in order to explore the benefit that it would provide an integrated project group. The team performed BIM on this project on a limited scale in order to avoid problems associated with the complexity of the New York Times Building. The time commitment that would be involved with performing BIM on the entire project would have limited the amount of design alternatives that the group members could have looked into. Therefore, the overall team consensus is that BIM is a useful tool in an integrated design process when used correctly. Unfortunately, the use of BIM on this project was severely limited by the lack of experience of team members and overall instruction. In addition, as to the future use of BIM in senior thesis more instruction and accountability is needed. Also, in order for students to learn how to collaborate well in an integrated thesis setting, the project must be brought together and organized by instructors who also are working in a collaborative manor.

In the eyes of the design team a successful redesign of the New York Times Building has been achieved. The success of the redesign can be measured by how well the original goal of increasing the marketability and profitability of the building was met. Ultimately, the redesign has increased rentable space, decreased operating costs and given the building a more environmentally sustainable profile.

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APPENDIX