IAC/InterActiveCorp Headquarters

New York, NY

Revised Thesis Proposal

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Structural Option

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EXECUTIVE SUMMARY

The IAC Headquarters is an 11-story office building that serves InterActiveCorp, an internet and media conglomerate. It is located on West 18th Street in the Chelsea neighborhood of Manhattan and is positioned along the Hudson River. At approximately 130,000 sq ft in size and 150 feet high, the IAC/InterActiveCorp Headquarters stands out along the New York City skyline because of its unique sculptural shape.

The current structural system of the IAC Headquarters is a two-way reinforced concrete flat-plate system with reinforced concrete shear walls. The proposed thesis will include a redesign of the entire floor system as post-tensioned, which will, in turn, result in changes to the shear wall core. There were a number of design concerns that dictated the decision to redesign using a post-tensioned system. For instance, the soil is very poor on the site, which resulted in unforeseen costs and time spent during construction of the foundations. Additionally, the building undergoes substantial torsional motion under lateral loading. The redesign is intended to remedy these issues. Because a post-tensioned system will require lower slab thicknesses, the weight of the building will decrease, resulting in reduced load on the foundations. Another point of potential concern was to design a more efficient transfer slab at the sixth floor setback. Instead of the two-way flat-plate design, the uplift from the tendons in a post-tensioned system will reduce the likelihood of long-term creep, and lessen significant deflections or vibrations.

The post-tensioned system will be redesigned using RAM Concept, while ETABS will be used to model the lateral system. Investigations will be made to determine if changes to the shear walls or post-tensioning systems will help to alleviate the torsion acting on the building. Because torsion can cause large loads on the lateral system of the building, it would be advantageous to redesign the building so that it undergoes less torsional motion. Changes to the shear wall locations or sizes will be considered as a possible solution to alleviate torsion, as will designing the post-tensioned system to carry a portion of these loads. Additionally, the use of different concrete strengths throughout the building will be studied in both the shear walls and the columns. This could potentially lead to the optimization of the shear walls and could create uniformity in column sizes so that forms can be reused.

Additional breadth topics are also proposed in this report that focus on other architectural engineering disciples. One of these studies will focus on a cost and scheduling comparison to determine the feasibility of the post-tensioned system versus the original flat-plate design. The other study will be to develop a blast-resistant glass facade and determine the thermal, lighting and acoustical implications of this redesign. This was decided upon because the building's facade is entirely glass and was designed by world-renowned architect, Frank Gehry.

BUILDING DESIGN SUMMARY

Floors	Floor Height(ft)
Cellar	14.5
Ground	20.33
2nd	12.83
3rd	12.83
4th	12.83
5th	12.83
6th	14.50
7th	14.50
8th	14.50
9th	14.50
10th	11.00
11th	9.00

Figure 1- Floor heights at each level

The IAC/InterActiveCorp Headquarters is a 130,000 square foot office building in Manhattan, New York. More specifically, it is located along the Hudson River in the neighborhood of Chelsea. Because it was built on land outside of the original Manhattan shoreline, the soil at this location is very poor, which resulted in the need for both piles and mini-caissons. It is 11 stories and has one cellar, which contains a parking area. The ground level, at approximately 30,000 square feet, opens to an immense lobby space mostly unfurnished and 20-feet high. The second through ninth levels, whose floor plates become progressively smaller at higher stories, provide office space for the 400+ IAC employees and is designed as an open floor plan. On the sixth floor, the executive floor, resides an outdoor terrace which is a byproduct of the setback at that level. The tenth and eleventh floors primarily contain the mechanical units and are known as the "mechanical penthouse". The roof is accessible and contains much of the large HVAC equipment, as well as a large window washing unit. These programmed spaces and their respective square footages are displayed in the tables on the following page. Floor heights are shown in Figure 1 above.

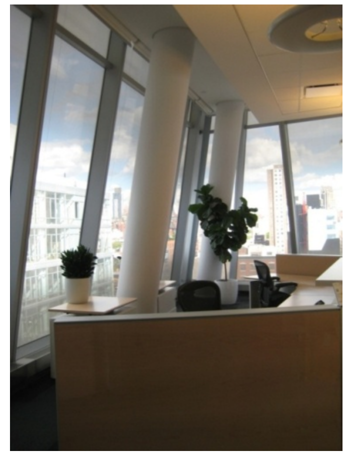


Figure 2- Photo of interior office space, showing the columns sloping parallel to the facade

The IAC Headquarters is designed to express the artistic vision of the architect, Frank Gehry. The facade, designed by Permasteelisa, is the signature of the building and includes over 1,400 exterior glass panels that had to be cold-warped on site. Completely clad with laminated, double-glazed, fritted panels, the concrete superstructure provides its function while being completely dictated by the architectural intent. This is especially apparent in the column locations. In order to accommodate the sloped, gradual building setbacks, the circular perimeter columns slope to preserve a desired architectural interior space. They also, however, create significant torsion, which must be considered when evaluating the structural design of the IAC Headquarters. Because each column must be spaced a distance of 10" from the curtainwall connections, the locations of the exterior columns cannot be moved. These columns slope parallel to the glass surface, as shown in Figure 2 above. At the edges of the building, the concrete slabs are each uniquely shaped and are cantilevered.

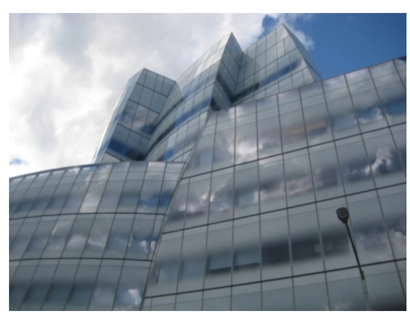


Figure 3- Photo of exterior glass facade

1st Floor	Area (ft^2)
Retail/Assembly	17902
Loading/Corridor&Lobby	1495
Loading Dock	980
Entry	1570
Ramp	200
Planter	309
Exterior	550
Garden	2023
Entry	666
Sidewalk	2800
Entry	650
Garden	592
Stair	68
Stair	195
Total	30000
2nd Floor	
Office	19256
Lobby	250
Services	820
Stair	502
Mechanical	550
Total	21378
3rd Floor	
Office	18944
Lobby	250
Services	820
Stair	502
Mechanical	550
Total	21066
4th	
Office	18505
Lobby	250
Services	820
Stair	502
Mechanical	550
Total	20627
5th	
Office	17968
Lobby	250
Services	820
Stair	502
Mechanical	550
Total	20090

6th	
Office	10089
Lobby	250
Services	820
Stair	502
Mechanical	550
Terrace	7126
Total	19337
7th	
Office	9332
Lobby	250
Services	820
Stair	548
Mechanical	550
Total	11500
8th	
Office	8622
Lobby	250
Services	820
Stair	548
Mechanical	550
Total	10790
9th	
Office	7907
Lobby	250
Services	820
Stair	548
Mechanical	550
Total	10075
10th	
Mechanical	7536
Services	900
Stair	537
Office	250
Total	9223
11th	
Elevator Machine Room	650
Stairs	225
Mechanical	2040
Total	2915
Roof	6397

Figure 4- Programmed architectural spaces and square footages

STRUCTURAL SYSTEM SUMMARY

Floor System:

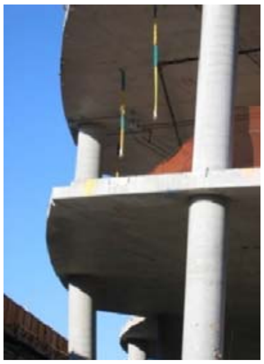


Figure 5- Close-up of IAC flat-plate system

The floor system of the IAC/InterActiveCorp Headquarters is a cast-in-place two-way concrete flat-plate system. This type of system is primarily used in residential construction because it allows for ease of coordination between trades. More importantly, however, it allows the designer to place columns with relative ease in locations that would optimize the interior space. Despite the advantages of a flat-plate system, it is, nevertheless, fairly unusual that this commercial building was designed in this system.

The 5000 psi strength concrete slabs have thicknesses that are shown in the figure to the right. These slabs are typically reinforced with #5 @ 12" o.c. top and bottom bars. Additional top and bottom rebar is placed at the columns and midspans of the panels where necessary. At the sixth floor, where the building is set back, the slab is much thicker. It is at this location that the column layout changes much more radically. This thicker slab acts as a transfer diaphragm, which, in addition to supporting vertical live, dead, and snow loads, transfers lateral forces. At locations where columns are no longer stacked on top of each other, the slab must act as a transfer slab to carry loads from the upper columns to the lower ones. The use of transfer beams was impractical because of the non-uniform placement of the columns, so the structural engineers decided to use a 2'-0" thick transfer slab instead. Because flat-plate systems typically do not transfer large lateral loads, this slab thickness was necessary. In other words, in order to avoid long-term creep deformations, the slab was thickened. The concrete strength at this level is 5000 psi as well, but the top and bottom reinforcing bars are typically #7 @ 12" o.c.

Level	Thickness (in)
Cellar	24
Ground	12
2	12
3	12
4	12
5	12
6	24
7	14
8	14
9	14
10	14
11	14
Roof	14

Figure 6- Slab Thicknesses

An unusual aspect of the slab reinforcing details is that unlike typical American Concrete Institute standard details which involves rotating rebar to match specific edge angles, the structural designers chose to design the reinforcing steel in the north-south and east-west orthogonal directions. This was done in an effort to improve the constructability of the building by eliminating the necessity to rotate rebar in various directions because of the unusual edge shape. Through the use of additional top and bottom bars in necessary locations and the overall uniformity of the bar layout, it seems that orienting the bars orthogonally is a plausible solution.

Gravity System:

Figure 7: Flat plate system during construction of the IAC Headquarters

While the IAC building has a fairly uniform design amongst floors, all of the structural floor plans differ slightly because of the gradual building setback, including a more noticeable setback at the sixth floor. In order to accommodate this setback and allow for columns to be placed in desirable locations, most of the columns in the building's superstructure are sloped, making the building tend to twist counter-clockwise under its own weight. This causes significant torsional rotation, which needed to be taken into consideration during the initial design process. In fact, a number of short-term and long-term studies were made through three-dimensional computer simulations to design the lateral system and predict curtain wall displacements.

The columns in the basement are primarily 28" in diameter for the perimeter columns and 34" to 38" in diameter for the interior columns. This range of column diameters is fairly consistent throughout the ground through fifth floors, but at the sixth floor the sizes are reduced to 20" to 24". Columns are typically spaced 25 to 30 feet apart and all are specified as 5950 psi strength concrete. The reason for this unusual column strength is because buildings constructed in New York City with strengths greater than 6000 psi must undergo more frequent testing; therefore, by specifying a strength just under 6000 psi, less tests would be necessary.

At the sixth floor, the building setbacks become more distinct and, therefore, the columns begin to slope much more significantly in an effort to keep the columns along the perimeter and out of the way of the open office space. In addition a number of columns are displaced at the sixth floor level, resulting in column offsets up to 8'-0" long.

The figure shown above, effectively displays the coordination of the flat plate slab and the circular columns along the perimeter.

Lateral System

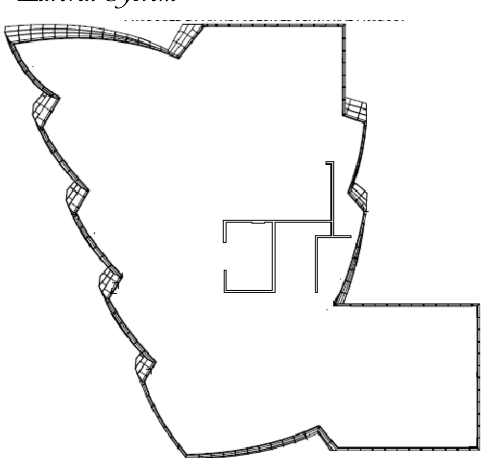


Figure 8: Typical shear wall layout (4th floor)

The columns carry the gravity loads while the shear walls, that encase the elevator and stair core, carry the lateral forces. These shear walls are between 12" and 14" thick with 3000 psi strength concrete. This core, with numerous shear walls acting in each direction, works together with the reinforced slab to carry wind and seismic lateral loads. The shear walls typically span from the cellar level up to the roof. Figure 8, to the left, shows the basic layout for shear walls. In addition to this shear wall core, the slab acts as a diaphragm in order to help distribute lateral loads.

This is necessary because the shear wall core is so concentrated and would likely be ineffective without the contribution of the slab to distribute loads across the entire floor plan.

Foundation System

There is one below-grade basement level in the IAC building with a slab thickness of 24 inches. It was designed as a pressure slab in order to resist hydraulic uplift forces. A 48" thick structural mat supports the building core. This core mat is primarily reinforced at the top and bottom by #9's and #11's at 6" on center. In order to oppose lateral forces from the soil, the foundation wall is 18" thick with #4 bars primarily as reinforcement. All of the concrete in the foundation is 5000 psi concrete.

The gravity columns are supported on concrete-filled steel pipe piles (with a conical tip, as agreed upon with NYSDEC because of environmental sensitivity). These piles have a 175 ton capacity to provide the required axial capacity. There are also twenty-three 18" diameter caissons that end bear on the bedrock. Because the building is located below the 100-year flood elevation, much concern was taken with the waterproofing, as well as a hydraulic flood gate designed to seal the entrance ramp of the parking garage when needed. In addition, it was also contaminated from a ConEdison Manufactured Gas Plant facility previously on the site, so containment was very important.

Roof System

The roof is composed of 14" thick, 5000 psi concrete. Twenty-inch diameter columns support the roof along the perimeter, along with 14x14 inch posts intermittently positioned to support mechanical equipment. To provide additional reinforcement for the roof level, HSS10*10*1/2" square tubes were used on the eleventh floor (mechanical mezzanine level) along the perimeter of the building. A fairly large window washing unit to service the entire building facade is located on the roof; however, information has not yet been found providing the unit's weight. A CMU wall and steel W-shapes are also used on the eleventh floor mechanical mezzanine level to support the mechanical equipment.

The figures shown on the following pages display the typical structural floor plans for the IAC Headquarters.

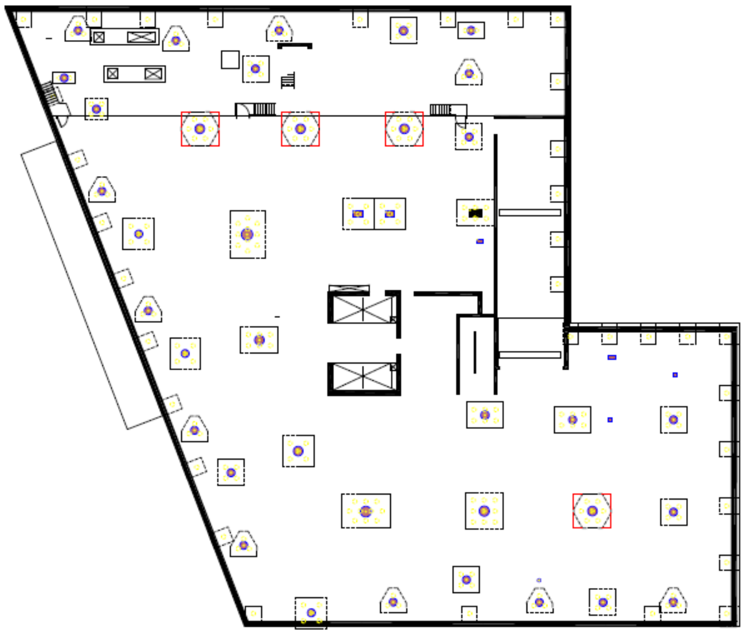


Figure 9: Foundation Plan

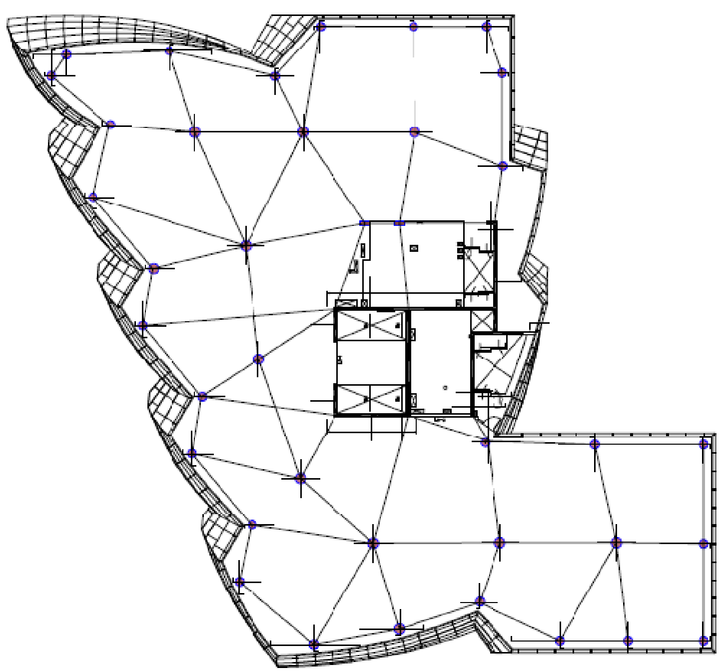


Figure 10: Fifth Floor Plan (note: very similar to first through fourth floor plans)

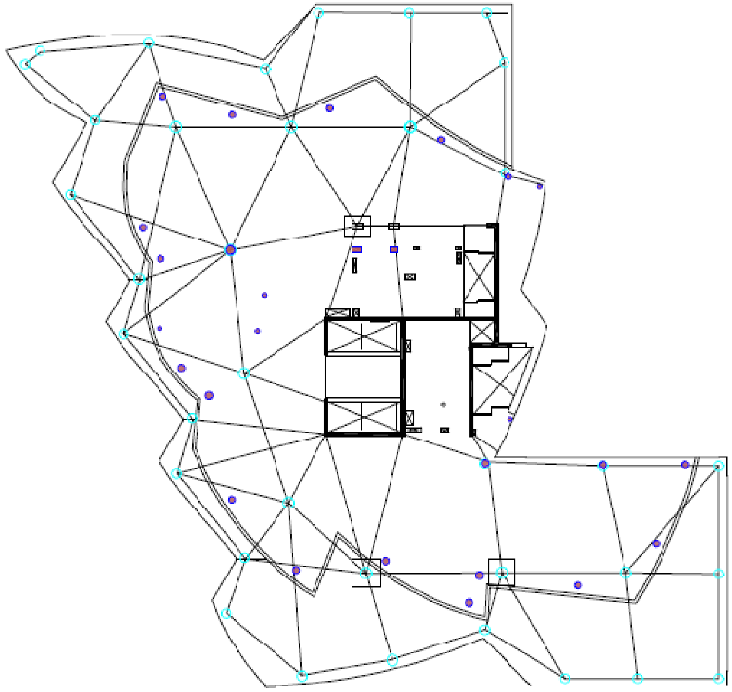


Figure 11: Sixth Floor Plan (note: very similar column layout to seventh through tenth floors)

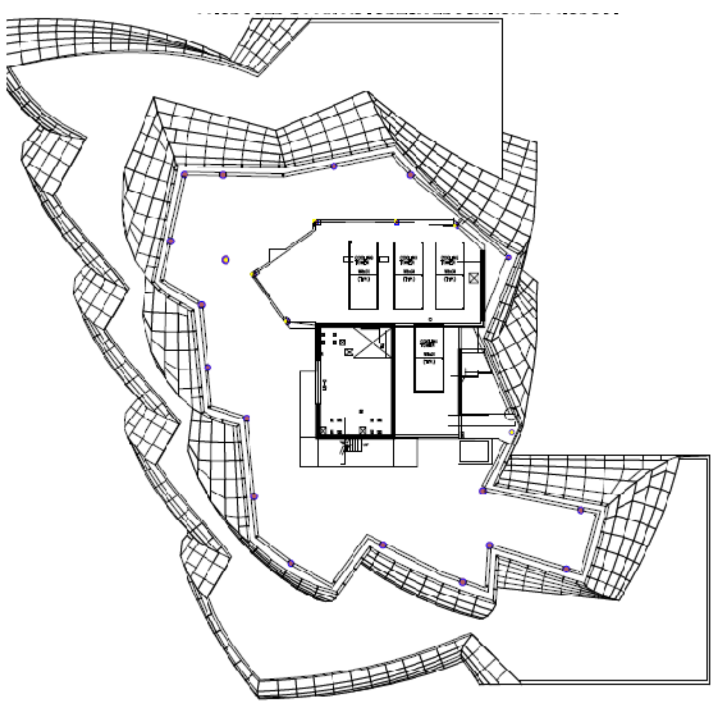


Figure 12: Eleventh Floor Plan

PROBLEM STATEMENT

Project Goal: To design a structural system that could effectively resist torsion and reduce the dead load of the building.

The designers of the IAC Headquarters had to overcome a number of challenges when designing this structure. Because the soil was very poor and contaminated, the foundations posed a number of problems with the scheduling and cost of the building. By reducing the weight of the building, it would be easier to design a foundation system to carry the building loads. Additionally, a significant amount of torsion had to be counteracted. Based on results from Technical Report #3, the prominent mode of motion for the building was torsion. With all the columns in the building sloped, it essentially creates a cork-screw effect. Torsion is an issue because it can lead to significant increases in the loads on the building's lateral system.

PROPOSED SOLUTION

Proposal: To redesign the IAC Headquarters using a post-tensioned system in coordination with newly designed shear walls to effectively reduce the torsion in the building.

A very in-depth analysis was conducted by the structural engineers on the project to identify the best structural system to be implemented in the IAC Headquarters. However, because the city of New York does not have experienced post-tensioning laborers, a post-tensioned building was not a possibility unless laborers were brought in from outside of the city. For the purposes of this project, it will be assumed that experienced laborers would be available to construct the building as a post-tensioned system.

Based on the results of Technical Report #2, the slab thickness could be reduced by about one-third if a post-tensioned system were to be utilized. This, in turn, would significantly decrease the weight of the building, which could have played a considerate role in reducing the issues with the poor soil and foundations, which plagued the contractors and owner during the initial stages of construction.

Additionally, because of the uplift forces due to the tendons, creep deformations would be less likely. With effective deflection and crack control and the liberty to place columns in various places in the plan without repercussion, the post-tensioned system could resolve many of the issues that initially dictated the design of the IAC Headquarters. In office buildings with a two-way, flat plate, post-tensioned system with spans between 25' and 35', it is suggested by design professionals that shear caps are integrated above the columns. This is aspect will be taken into consideration when designed in the spring semester. Like the flat plate system, the post-tensioned system will contribute to the shear wall core by carrying some of the lateral loads. Also similar to the existing flat plate system, a post-tensioned flat-plate system has a flat, exposed concrete ceiling which would enable easy coordination of trades and would not require a finish. Additionally, because it is cast-in-place, it can be implemented in buildings, like the IAC Headquarters, with irregular geometries.

Changing the gravity system of the IAC Headquarters would also directly affect the lateral design. By reducing the seismic dead load of the building, less lateral resistance would be necessary. Therefore, an additional study would be to optimize the shear walls. This could include changing the sizes of the walls from floor-to-floor or their respective concrete strengths.

An additional focus would be to further study the torsion of the building and how the design of the lateral and floor systems could effectively resist torsion. In order to do this, investigations will be conducted to learn how the post-tensioned system could carry some of the lateral loads. Additionally, studies of the shear walls will be conducted to determine if they could better resist torsion if they were moved or their sizes changed in any way. It is important to note that if the shear walls are changed, then an additional architectural breadth topic will have to be taken into consideration.

Lastly, the columns will still be designed as circular reinforced columns; however, attempts will be made to standardize the diameter sizes as much as possible. This would involve experimenting with different concrete strengths. The benefit of this alteration is that it would enable the reuse of formwork and would eliminate any potential confusion with numerous differing column sizes.

Breadth Topics

Construction: To determine the time and costs necessary to redesign the IAC building with a post-tensioned floor system.

Changing the gravity system of the IAC Headquarters will drastically alter the construction process and, thus, the scheduling and costs associated with it. This topic will involve composing a construction schedule using Microsoft Project and comparing its critical path to that of the actual construction. Additionally, the costs of both systems will be analyzed. Another issue to address is that there are not construction workers currently working in New York City that are familiar with building a post-tensioned floor system. For this reason, it will also be important to evaluate whether or not it would be worthwhile to bring experienced workers in from outside of the city in order to construct the building, based on what is found from the scheduling and cost study.

Building Envelope: To develop a blast-resistant glass façade, while considering the thermal, acoustical, and lighting effects of the facade change.

Frank Gehry, a world renowned architect, designed the InterActiveCorp/IAC Headquarters and, though it stands at only 150 feet tall, its sculptural quality makes it a high-profile building in the New York City skyline. This breadth topic will focus on utilizing skills learned in the AE542-Building Enclosures course to design a blast-resistant system for the IAC Headquarters' all-glass facade. This would include determining standoff distances and computing the thickness of the glass to resist blast. This is especially important in buildings with all glass in order to avoid the 'wet-blanket' effect. Additionally, basic thermal and lighting calculations will be preformed to evaluate the difference between the current glass facade and that which is being proposed.

This topic also affects the structural system of the building because, in order to make the blast-resistant glass a worthwhile alternative, the building's structure must also be able to sustain blast loads. The shear walls will take into account blast load when designed. Additionally, if there is time permitting, a structural study of progressive collapse will also be performed.

In the event of a substantial change to the shear walls, an architectural breadth will be necessary.

MAE Course-Related Study

The MAE requirement for this project will be fulfilled through the design of the blast-resistant building facade. Methods taught in the AE542: Building Enclosures course will be used to determine glass type and thicknesses. Additionally, use of the AE597A: Computer Modeling course will be vital when modeling the IAC Headquarters. Though RAMConcept was not taught in this modeling course, the concepts learned, such as semi-rigid diaphragms and meshing, will be implemented in the redesign of the IAC Headquarters.

Solution Method

The redesign of the IAC Headquarters will be implemented using ASCE 7-05, ACI 2008, and PCI. The post-tensioned floor system will be designed based on the existing column grid and live loads, as they were found to be adequate in Technical Report #1. Design of post-tensioning will be conducted using RAM Concept, which is a finite element program. This will require becoming familiar with the RAM Concept program, which has already begun through studying tutorials and program handbooks. This design would incorporate concepts such as pattern loading and load combinations. RAM Concept would be used in conjunction with hand-methods, as well as basic rules of thumb, such as L/h= 45. Checks of the post-tensioned anaylsis will be performed to confirm adequate design output. Columns will be designed using PCA column. The shearwalls will be designed using an ETABS model, and will also be supplemented by hand-calculated checks. Additionally, the slope columns will be studied in ETABS to determine how much torsion they cause.

Tasks And Tools

Depth

1. Design of Post-Tensioned Floor System:
    - Create RAM Concept model
    - Determine required slab thickness
    - Design post-tensioned tendon layout
    - Consider special areas, such as the cantilevered edges
    - Attempt to reduce torsional effects
    - Evaluate deflections and shear and moment capacities
2. Design Concrete Columns:
    - Determine loads from the new floor system (based on Task 1)
    - Determine building torsion due to sloped columns using ETABS
    - Design columns using PCA Column
3. Design Shear Walls:
    - Develop lateral loads using ASCE 7-05 (determine a blast load to use)
    - Determine forces at each story
    - Design shear walls using ETABS
    - Experiment with various concrete strength and wall locations/sizes to reduce torsion
    - Check deflections
4. Evaluate effect of new loads on foundation
    - Check mini-caissons and piles for applied loads from shear walls and columns respectively
5. Investigate whether the building is able to withstand progressive collapse (time permitting)

Breadth

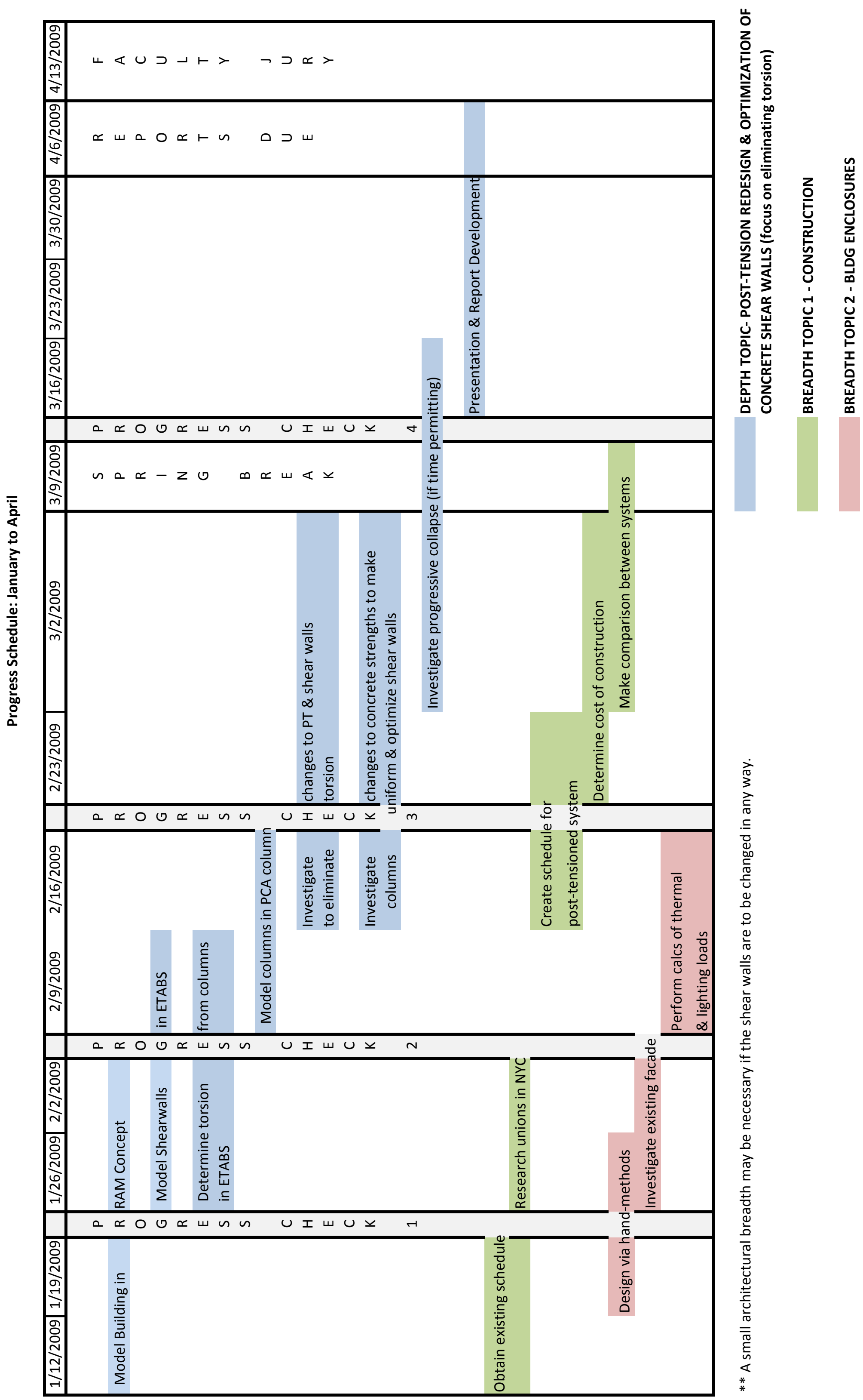
Construction

1. Obtain schedule and cost information for the building as constructed
2. Create schedule and cost information for the structural redesign and compare with the existing
3. Research unions in NYC and the feasibility of bringing construction workers in from elsewhere

Building Enclosures

1. Further investigate facade of IAC Headquarters
2. Research blast loads and properties
3. Design using methods learned in AE542- Building Enclosures ("Blast-Resistant Glazing Design" by H. Scott Norville & Edward Conrath in <u>ASCE Journal of Architectural Engineering</u>)
4. Calculate thermal and lighting loads of the glass
5. Compare current system to the proposed, determining possible effects on lighting and mechanical loads.

TIME TABLE


Progress Schedule: January to April
1/12/2009
1/19/2009
1/26/2009
2/2/2009
2/9/2009
2/16/2009
2/23/2009
3/2/2009
3/9/2009
3/16/2009
3/23/2009
3/30/2009
4/6/2009
4/13/2009
PROGRESS CHECK 1
PROGRESS CHECK 2
PROGRESS CHECK 3
SPRING BREAK
PROGRESS CHECK 4
REPORTS DUE
FACULTY JURY
Model Building in RAM Concept
Model Shearwalls in ETABS
Determine torsion in ETABS from columns
Model columns in PCA column
Investigate changes to PT & shear walls to eliminate torsion
Investigate changes to concrete strengths to make columns uniform & optimize shear walls
Investigate progressive collapse (if time permitting)
Presentation & Report Development
Obtain existing schedule
Research unions in NYC
Create schedule for post-tensioned system
Determine cost of construction
Make comparison between systems
Design via hand-methods
Investigate existing facade
Perform calcs of thermal & lighting loads
DEPTH TOPIC- POST-TENSION REDESIGN & OPTIMIZATION OF CONCRETE SHEAR WALLS (focus on eliminating torsion)
BREADTH TOPIC 1 - CONSTRUCTION
BREADTH TOPIC 2 - BLDG ENCLOSURES
** A small architectural breadth may be necessary if the shear walls are to be changed in any way.

CONCLUSION

For the spring semester, an alternative gravity system will be designed and compared to the existing system. The main intent of this proposal is to reduce the building's weight and torsional motion. Specifically, this will be accomplished through the use of a post-tensioned flat-plate concrete floor system. It will involve modeling the building in RAM Concept, in addition to optimizing the shear walls using ETABS. Attempts will be made to reduce the torsion through the redesign of the post-tensioned floor and the shear walls. The breadth studies will focus on a determination of scheduling and costs associated with the structural redesign. The other topic will examine blast-resistant glass because of the high-profile nature of the IAC Headquarters. If time permits, a progressive collapse study will also be performed.