Vickroy Hall
Duquesne University

Donna Kent
Structural Option

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Building: Vickroy Hall
Location: Duquesne University
Pittsburgh, PA 15282
Date: January 31, 2007
Title of Report: Thesis Proposal
Faculty Consultant: Dr. Boothby

Executive Summary

Vickroy Hall is an eight story living/learning center at Duquesne University. It houses up to 280 students and allows them places to study and socialize. The building is constructed of structural steel with moment connections for its main supporting element. These connections guard against lateral loading such as wind and seismic effects and also transfer loads through the building to the ground. The floor system is a composite system of metal decking and lightweight concrete.

After exploring multiple structural systems in previous technical assignments, it was decided that a pre-cast hollow core planking system supported by load bearing masonry walls will be further analyzed for comparison to the original system.

The redesign of the system will include the removal of all moment connections, the addition of shear walls around stair wells, elevator shafts, and between suites. The masonry bearing walls will be placed around the perimeter as well, with the brick façade remaining as a curtain wall. Finally, a floor system consisting of pre-cast hollow core planks will replace the existing composite floor. Lateral loads will be superimposed on the system and it will be evaluated for both gravity and lateral loading.

The masonry walls will be designed using the Empirical Method for Designing Masonry walls. The wall designs will then be adjusted as new methods are learned in classes. Finally, the new structural system will be analyzed using ETABS to determine how the building reacts to the loads superimposed upon it. Drift, story drift, strength, and serviceability will be checked according to code and industry standards.

Within the process of redesigning the system, the appropriateness of whether or not the new system could effectively replace the old will be determined. The final report and presentation will comment on the results of the analysis and comparison of the two systems, including the structural redesign and both breadth topics.

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Executive Summary

Two breadth topics will be investigated.

The first breadth topic is an in depth schedule comparison. The original system and the new system will be scheduled on the computer program Primavera. They will then be compared to each other. This breadth may lead to an answer as to why moment frames were used as the original system. Since steel is constructed faster than masonry, this may be the answer to that specific question and others that may be posed throughout the execution of the proposal.

The second breadth topic will be to redesign the lighting in a popular lounge room on the ground floor. This will be done using the computer program called Luxicon. The original and new design will then be compared and contrasted.

The new building system will be evaluated with not only the structural changes, but also the impact on the other major architectural engineering options. In this sense, the building will be analyzed as a community of options instead of only structures to determine if the new system could effectively stand in for the original system.

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Introduction

Background Information

Vickroy Hall is an eight story, 77,000 square foot Living/Learning Center at Duquesne University in Pittsburgh, PA. Completed in 1997, Vickroy Hall provides living quarters as well as 'learning spaces' such as study rooms for up to 280 upper class students. The living quarters consist of two double rooms with an adjoining bathroom. The learning spaces are an assortment of meeting rooms and lounge rooms with tables and comfortable seating areas respectively. The Hall also provides offices for departmental and administrative use on the two lower stories. Floors three through eight are typical with student suites, laundry facilities, and meeting places.

Vickroy Hall and surrounding buildings

This 105' building is nestled among many other buildings, but stands out with its award winning brick façade. The distinctive two-story columns at the base provide the building with additional aesthetic appeal. The columns are an aesthetic addition to the bands of concrete accents at each floor level, and dark, dramatic windows. There is not a typical bay size, but the building is basically symmetrical based on the two primary axes. The first two stories are the only asymmetric floors due to the mechanical equipment in the back of the building.

Vickroy Hall - Facade

Existing Lateral System

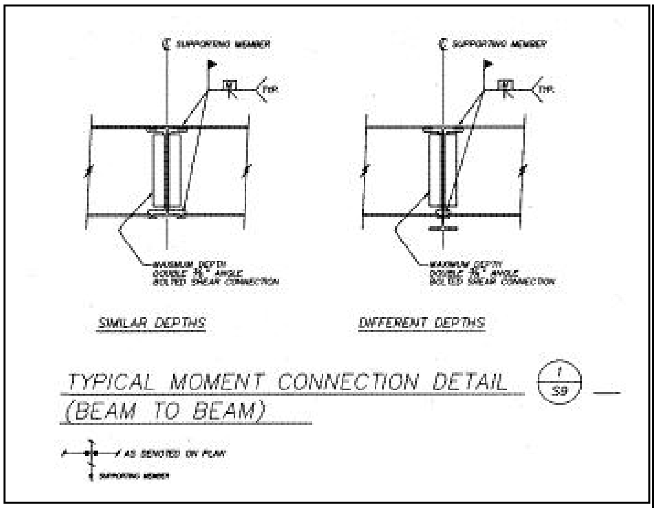
The facade is primarily made up of brickwork (4,000 psi strength) accented with bands of concrete. Behind the façade, there are 6" – 16 gage structural metal studs with batt insulation between the framing components. Relief angles are positioned at every floor to prevent the cracking of the façade. The windows are composed of aluminum with plastic laminate sills.

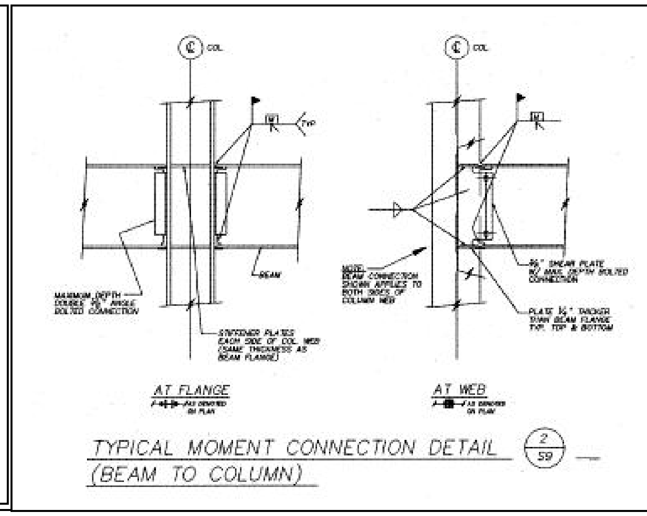
Typical Floor System

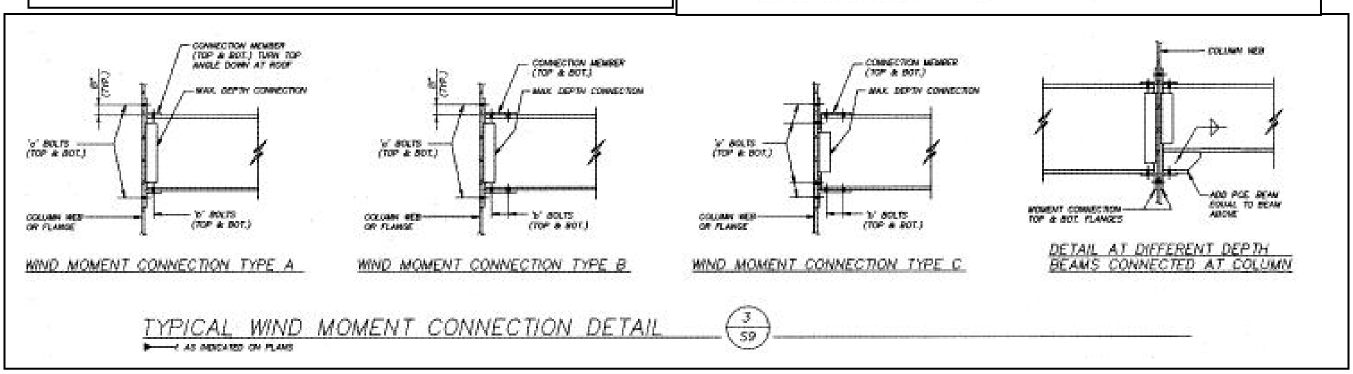
The façade is supported by a structural steel frame consisting of C-channels and W-shapes. The W-shapes are the framing for typical members and the C-channels provide support for the cantilevers and other protrusions. They are usually oriented perpendicularly to the other framing members. The main members extending from column to column are detailed as moment connections. These moment connections are either classified as a wind moment connections or a moment resisting connections.

The typical floor plan generally calls for W12 to W16's. The strength called for is 36,000 psi minimum yield for all steel shapes (W-shapes, channels, angles, plates, and connections) unless otherwise noted. There are no shear walls present in the building due to the ability of the moment frames (see figures below) to take the necessary lateral loads and moments.

The floor system is a composite metal and concrete deck. On a typical floor, the deck consists of a 2" – 20 gage corrugation with 3-1/4" light weight concrete and 6x6 – W2.9 x W 2.9 welded wire fabric.







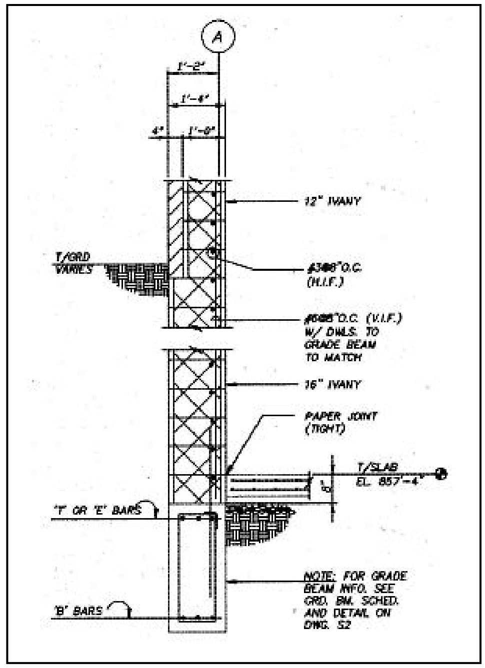
Finally, what appears to be a hipped roof is actually light gage metal framing with standing seam metal panels attached. This system is called a 'screen wall'. The framing is mounted to the floor system below, which is the same as a typical floor. The framing is attached through embedded anchor bolts within the concrete. Around the perimeter of the roof is a ten inch parapet. This is composed of concrete masonry units with a metal coping covering. The floor system is covered with tapered insulation, EPDM, and ballast.

Existing Structural System

The columns from the above mentioned lateral system are supported by piers, which are, in turn, supported by grade beams and slabs on grade formed on top of caissons.

The caissons are composed of reinforced concrete with a capacity of twenty-five tons per square foot. The caissons range in size from thirty to fifty-four inches in diameter with a strength of 4,000 psi.

The grade beam widths are from twelve to sixteen inches wide with an average depth of thirty-four inches, but with a maximum depth of eighty-eight inches with a strength of 4,000 psi. The deep grade beams are in and around the elevator shafts and mechanical rooms because of the greater amount of support needed in those areas.



Foundation Wall

The slabs on grade are generally four inches thick (3,000 psi strength) with 6 x 6 – W2.9 x W2.9 welded wire fabric reinforcing over six inches of compacted sand and gravel sub base with a vapor barrier. Beneath the mechanical equipment rooms and elevator shafts, the slabs are thicker, but the depth was not revealed on the structural drawings due to the unknown weights of the equipment at the time that the drawings were distributed.

The foundation wall is a reinforced unit masonry system with 16" Ivany blocks below grade and 12" Ivany blocks above grade with a strength of 3,000 psi. The reinforcement strength was to have a minimum yield strength of 60,000 psi. In front of the Ivany block (above grade level), the wall system changes to that of a brick façade. However, the facade then changes to the above mentioned lateral system at the first floor level.

Problem Statement

Vickroy Hall was built with moment frames as its internal supporting structure. Although this type of construction worked well within the building, there are other methods of design and construction that are more typical to the type of building. The main occupation of the building is to provide living quarters for students. This type of building is typically constructed using masonry, pre-cast concrete, cast in place concrete, or wood or light gauge metal framing. Moment frames are generally an expensive solution to a building design. As such, it is unknown as to why this design was chosen. However, the method will serve as a basis for comparison to the proposed system.

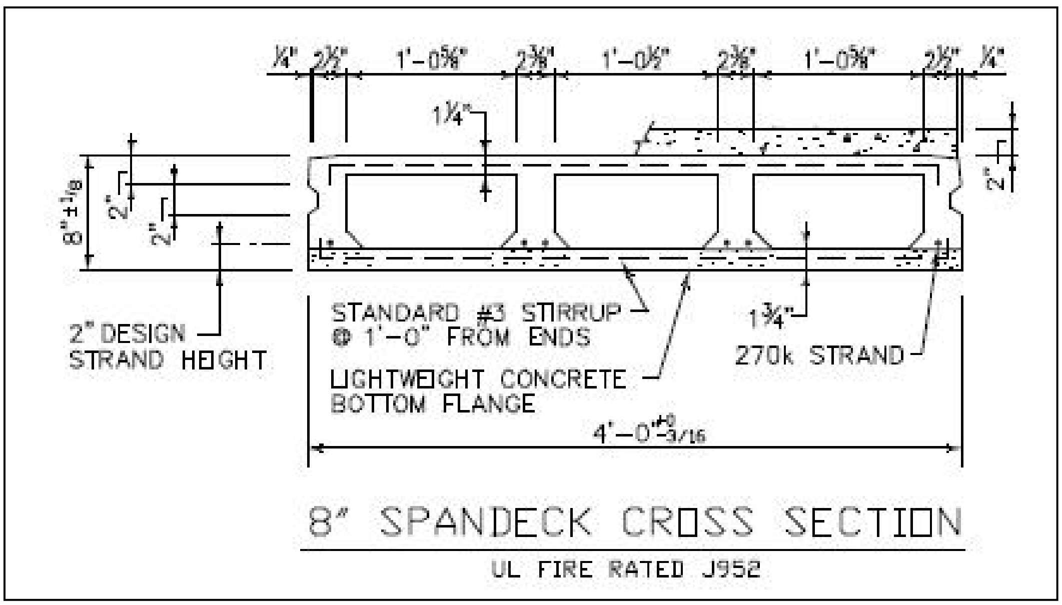
Proposed Solution

The major redesign constituent of the system starts with the removal of the moment connections. The moment connections serve as the major supporting element to the structure. To compensate for the loss of the moment frames, shear walls will be added around the elevator shafts and stairwells. Additional select walls between suites, etc. will also be treated as shear walls. The remaining walls will also be constructed of masonry, but will only be partitioning walls, not bearing walls. The shear walls will be composed of reinforced concrete and/or reinforced masonry.

The floor system will also be changed from a composite deck to that of a pre-cast hollow core planking system. This floor system will be supported by the load bearing masonry walls on each level as dictated by a redesign of the floor plan.

The preliminary member sizes will consist of 4' wide x 8" deep hollow core planks with a 2" topping. The technical name for this plank is the J952 Plank from Nitterhouse Concrete. Lengths will be determined based on bay sizes. Further analysis will be completed using lateral loadings from IBC 2003. Masonry design will be based on ACI 318-05, NCMA Tek Notes, and ASTM standards.

Finally, the current foundation (caissons) will be checked to see if it is still within the limits of its design criteria. A redesign of the foundations may be necessary to carry the loads in a fashion different than the original.



J952 Typical Plank

Solution Method

To determine whether the new system can support the loads imposed on Vickroy Hall, hand calculations will be used to establish member sizes. Hand calculations will be completed using ACI 318-05, ASTM standards, NCMA Tek notes, and the Third Edition LRFD AISC Steel Manual. Loads will be established using ASCE 7-02 as previously completed in past technical reports. As a preliminary basis, the masonry bearing walls will be designed using the Empirical Method for Designing Masonry Walls. The limitations imposed on the method will be adhered to as they are implicated in ACI 530 – Chapter 5. As they are learned, sophisticated methods will amend calculations from the Empirical Method. This will adjust the very conservative method to more practical solutions in construction. The finished system will be analyzed according to standard limitations and codes on drift, story drift, strength, and serviceability.

Breadth topic one will be a comparison on the impact of scheduling for the original system and the revised system. This comparison will utilize the computer scheduling program called Primavera.

Breadth topic two will be a comparison of a redesigned lighting scheme in a popular lounge on the ground floor. This comparison will utilize the computer lighting program called Luxicon.

Tasks and Tools

The major tasks of redesigning the current system to reflect the new system are outlined below.

1. Plan Redesign
   A. Layout new floor plan with minimal alterations to column locations.
   B. Ensure that new column lines will work throughout each floor and with existing architecture.
2. Remove Moment Connections, add Shear Walls (Lateral Resisting System)
   A. Shear walls will be placed around elevator shafts and stairwells (see yellow lines on the Typical Floor Plan on Page 8).
   B. The masonry walls designed as bearing walls will also serve as shear walls.
   C. Shear walls will be designed using the Empirical Design Method, according to ACI 318-05, ACI 530, and NCMA Tek Notes with proper proportions and reinforcement.
3. Design Ground Level/ Foundations
   A. Columns will be removed.
   B. A new bearing system must be implemented to carry the loads above and must work with the existing mechanical system.
4. Check Exterior Walls for Lateral Bearing Capacity
   A. Check to make sure the walls comply with the Empirical Design Method.
   B. Modify thickness of walls if need be to withstand lateral forces.
5. Modify Loads per ACI 318-05 and the ultimate strength method
   A. May trim the thickness of the walls that is required for the Empirical Design Method.
6. Breadth 1 – Construction Schedule Comparison
   A. Develop a detailed schedule of the construction of the new system.
   B. Develop a detailed schedule of the construction of the existing system.
   C. Compare to the scheduling times needed for the construction of both systems.
   D. Analyze impact and concerns of the new system compared to the existing system.
7. Breadth 2 – Lighting Design
   A. Redesign the Lighting in a popular meeting room on the ground floor (see Architectural Floor Plan on Page 9).

B. Model the room in a lighting program such as Luxicon.
C. Model the existing lighting in Luxicon
D. Analyze impact and concerns of the new system as compared to the existing system.

8. Finalization
   A. Compile material into final report.
   B. Compile material into final presentation.
   C. Finalize CPEP site.
9. Present to Faculty
10. CPEP Update, ABET Evaluations and Thesis Reflection.

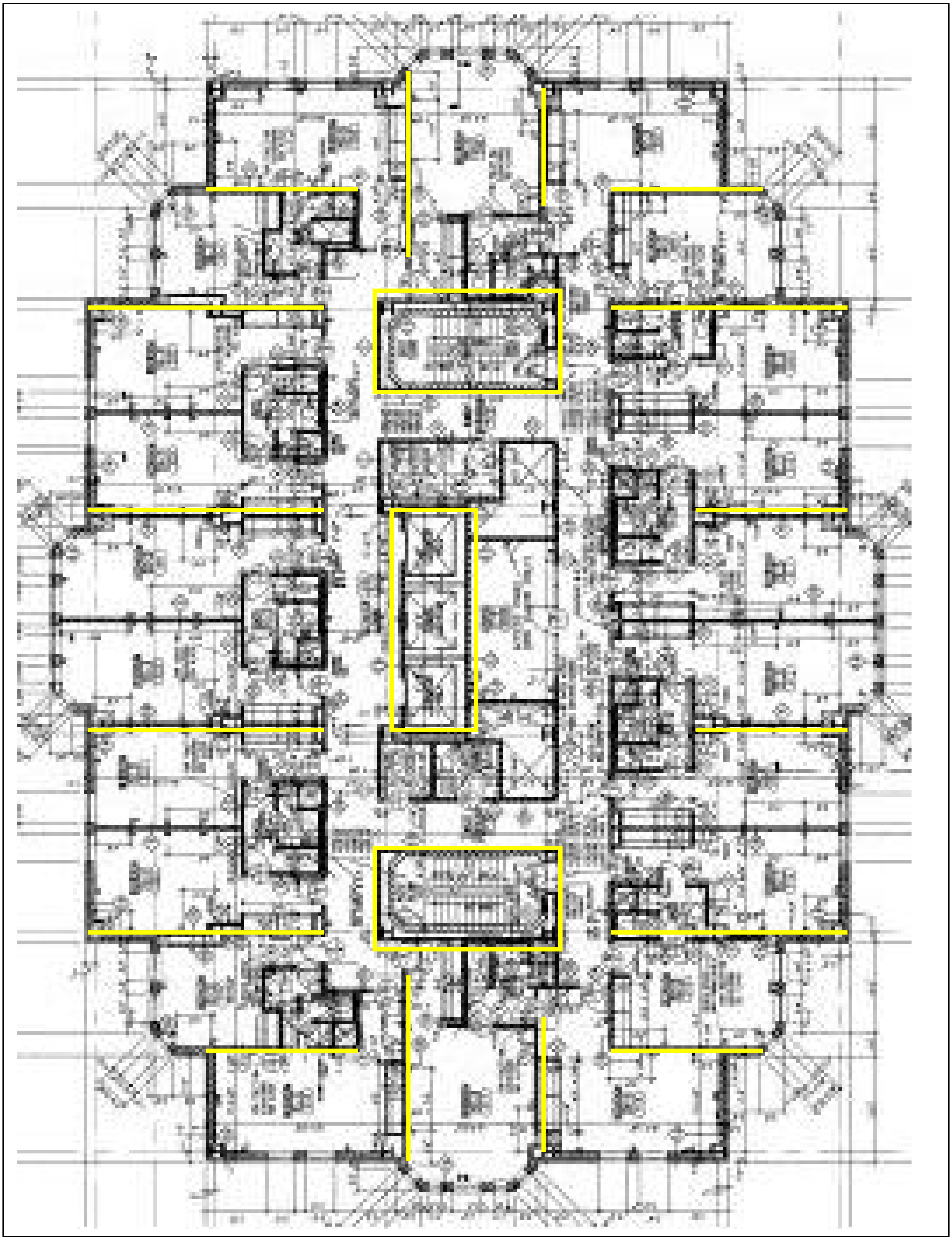
Schedule of Tasks

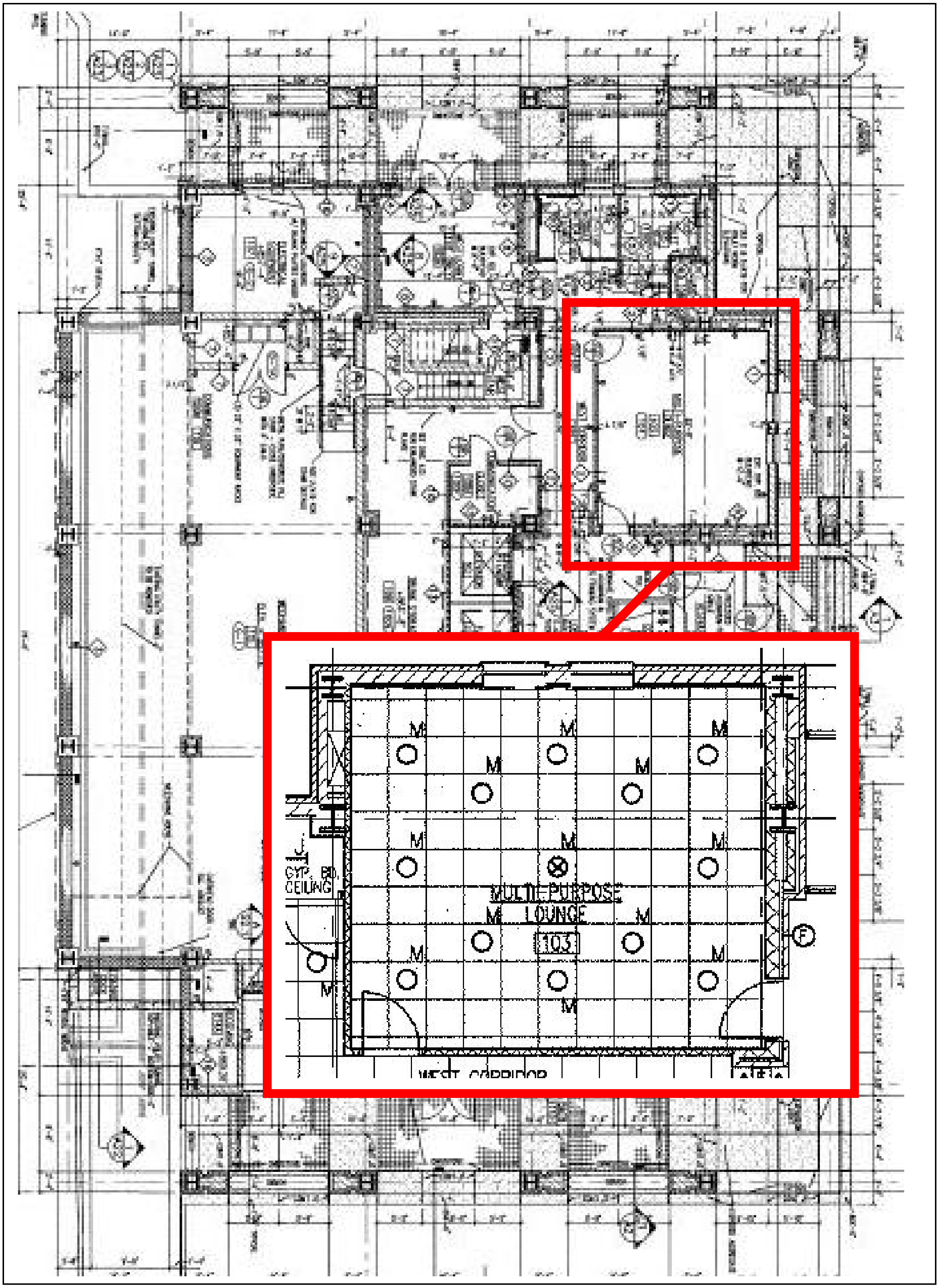
The major tasks above will be placed in a timetable to ensure that the thesis project is executed in a timely fashion. See Schedule on Page 7.

Conclusion

After exploring multiple structural systems in previous technical assignments, it was decided that a pre-cast hollow core planking system supported by load bearing masonry walls will be further analyzed for comparison to the original system. The redesign will be approximately executed to the above schedule. Within the process of redesigning the system, the appropriateness of whether or not the new system could effectively replace the existing will be determined. The final report and presentation will comment on the results of the analysis and comparison of the two systems, including the structural redesign and both breadth topics.

Activity	Date															
	January		February					March					April			
	21-27	28-31	1-3	4-10	11-17	18-24	25-28	1-3	4-9	10-18	19-24	25-31	1-7	7-13	14-20	21-27
Resubmit Proposal	X															
Check Lateral Loads	X	X														
Recalculate Pre-cast Loads		X														
Locate/Design Partition Walls (Empirical Design Method-EDM)				X												
Locate/Design Shear Walls (EDM)				X												
Design Exterior Load Bearing Walls (EDM)					X											
Design Ground Level/Foundations					X											
Check Exterior Walls for Lateral Bearing Capacity (wind loads)						X										
Modify Gravity Loads per MSJC						X										
Modify Walls per Gravity Loads							X									
Check foundations for modified loads							X									
Breadth 1: Schedule Impact Comparison									X							
Spring Break										X						
Breadth 2: Redesign Lighting in Ground Floor Lounge											X					
First Submission of Report												X				
Revision of Report/Finalize Presentation, practice Presentation													X	X		
Present to Faculty															X	
CPEP Update, ABET Evaluations, Reflection																X

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