Donna Kent
Structural Option
Building: Vickroy Hall
Location: Duquesne University
Pittsburgh, PA 15282
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Title of Report: Thesis Proposal
Faculty Consultant: Dr. Boothby

Executive Summary

After exploring multiple structural systems in previous technical assignments, it was decided that a pre-cast hollow core planking system on concrete supports with steel columns will be further analyzed for comparison to the original system.

The redesign of the system will include a modification to two column lines, the removal of all moment connections, the addition of shear walls around stair wells and elevator shafts, and finally, a floor system consisting of pre-cast hollow core planks. The support for the floor system will also change from a steel frame to pre-cast concrete beams. The preliminary beam sizes were determined in Technical Assignment 2. However, lateral loads were not superimposed on the system and it must be re-evaluated for the additional loads.

The new structural system will be analyzed first using RAM to determine preliminary column sizes. The system will then 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.

Two breadth topics will be investigated. The first is an in depth cost efficiency comparison with take-offs from the new system which will then be compared to the cost of the original system. The second breadth topic will be to investigate whether the mechanical system is impacted greatly and if the system could be improved by new means of routing ducts, etc.

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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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' 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 between many other buildings, but stands out with its award winning brick façade. The distinctive two-story columns at the base provide the building with even more aesthetic beauty. 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

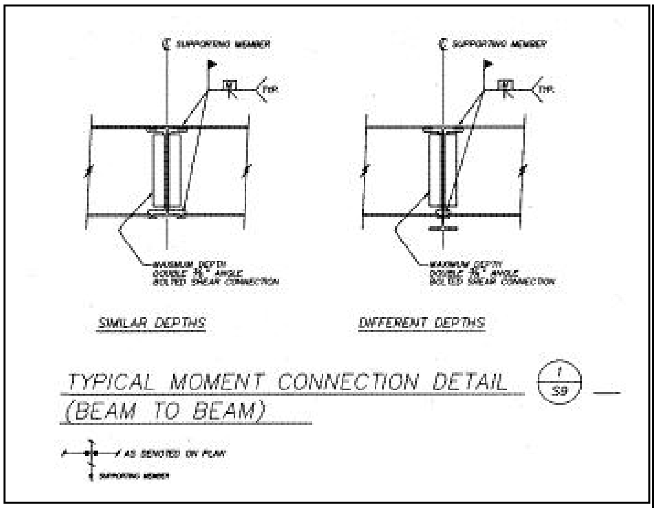
The facade is primarily made up of brickwork (4,000 psi strength) accented with bands of concrete. Behind the façade, there are 6" – 16 gage structural metal studs with batt insulation between the framing components. Relief angles are positioned at every floor to prevent the cracking of the façade. The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

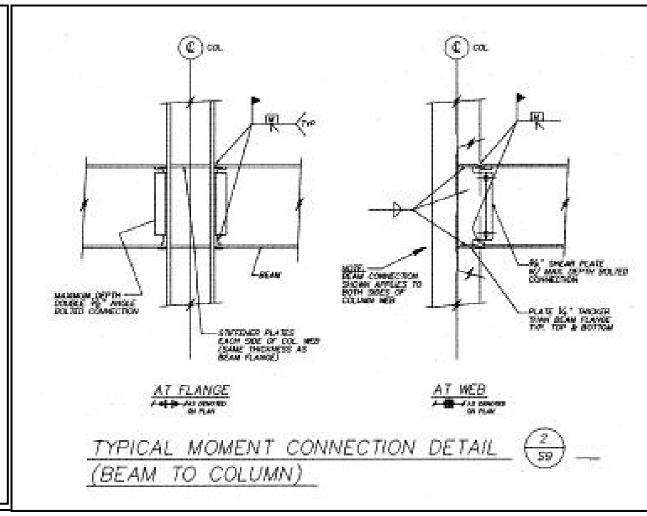
Typical Floor System

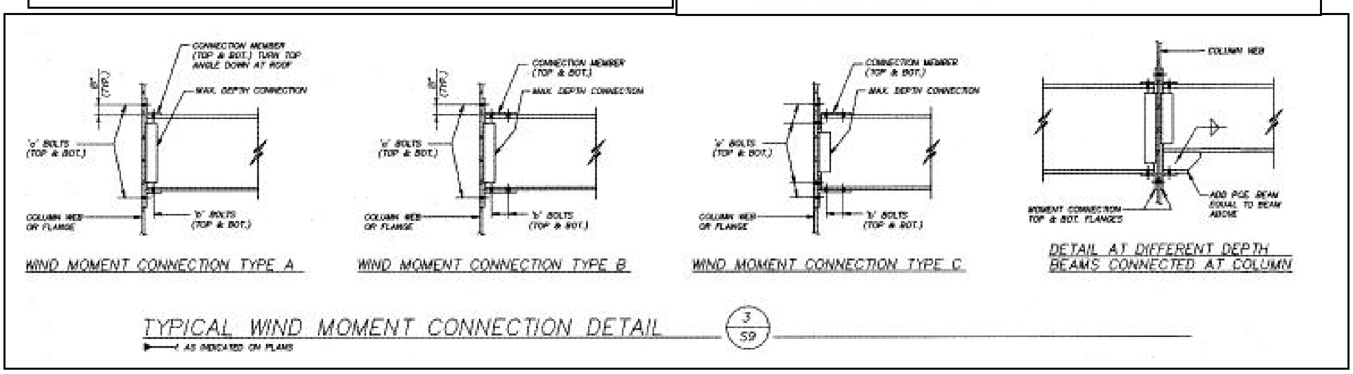
The façade is supported by a structural steel frame consisting of C-channels and W-shapes. The W-shapes are the framing for typical members and the C-channels provide support for the cantilevers and other protrusions. They are usually oriented perpendicularly to the other framing members. The main members 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

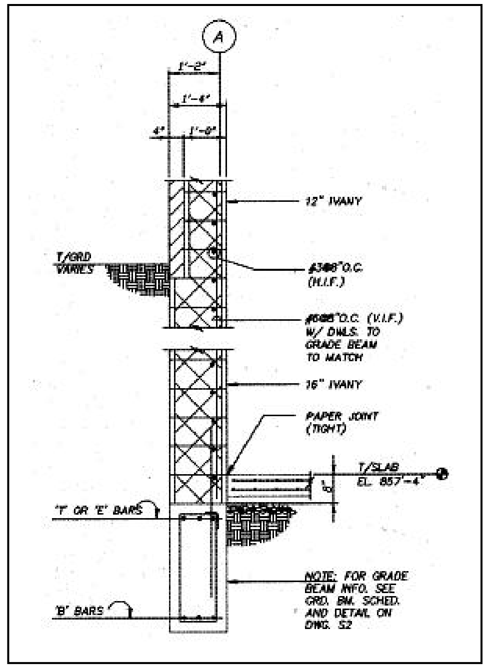
The columns from the above mentioned lateral system are supported by piers, which are, in turn, supported by grade beams and slabs on grade formed on top of caissons.

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.

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.



Foundation Wall

Problem Statement

Vickroy Hall was built extremely well with moment frames and a brick façade. Although the moment frame has withstood the test of time, there are other systems that may have worked to the same degree of proficiency. However, the other systems could be more efficient economically; allowing a greater floor to ceiling height, additional flexibility with the floor plan, a reduced amount of load on the foundations, and finally, a possible reduction of cost.

Proposed Solution

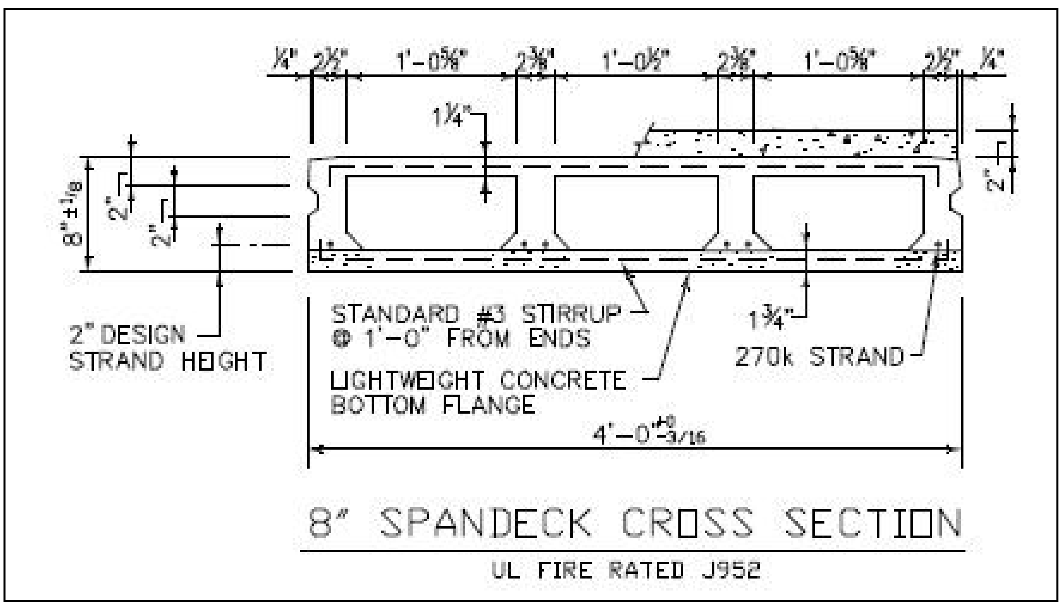
The redesign of the system includes first and foremost, the removal of the moment connections. To compensate for the loss of the moment frames, shear walls will be added around the elevator shafts and stairwells, with possible walls at the bottom levels for extra stability. The shear walls will be composed of reinforced concrete.

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 pre-cast concrete beams and steel columns.

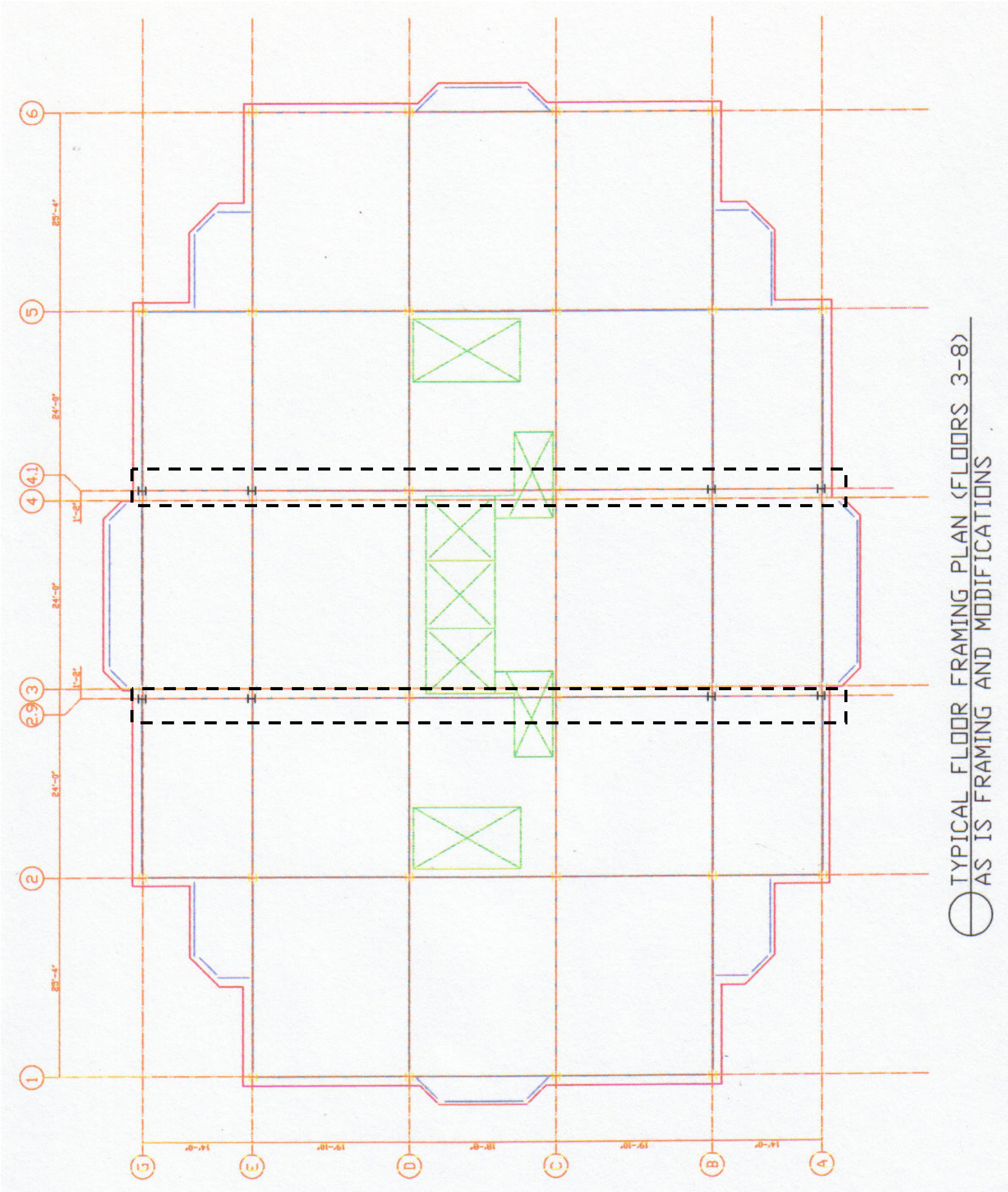
The geometry of the building will stay untouched so as to keep the architectural splendor of the building. However, one aspect of the structure will be modified. This modification will leave the geometry the same. The reason for this change is to accommodate the elevator shafts and still keep straight column lines. The column lines of the two sets of columns in the center will become the new lines for all of the columns of that particular row. This will also result in a three feet gain in span in the center bays. The other original column lines will remain intact. Please see the figure on the next page to see this modification. The black columns in the center bay are the proposed columns. The light gray columns to the immediate right or left are the originals.

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. Typical pre-cast beam sizes, determined from Technical Assignment 2, are either 16" x 16" or 12" x 10". These sizes are based on gravity loading only as required by ASCE 7-02. Further analysis will be completed using lateral loadings from IBC 2003. All pre-cast members will be checked to comply with ACI 318-05.

Finally, the current foundation (caissons) will be checked to see if it is still within the limits of its design criteria. The new system should not exceed the design stress for the caissons.



J952 Typical Plank


TYPICAL FLOOR FRAMING PLAN (FLOORS 3-8)
AS IS FRAMING AND MODIFICATIONS

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 and the Third Edition LRFD AISC Steel Manual. These sizes will then be input into a computer program along with imposed loads including gravity and lateral loads. RAM will be used to determine preliminary member sizes for columns. ETABS is the chosen program that will model the building and its behavior under these loads. Loads will be established using ASCE 7-02 as previously completed in past technical reports. The building will then be analyzed according to standard limitations and codes on drift, story drift, strength, and serviceability.

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.
    - B. Shear walls may be placed on ground floor where no windows are currently placed.
    - C. Shear walls will be designed according to ACI 318-05 with proper proportions and reinforcement.
3. Design Preliminary Member sizes
    - A. Determine loads through the use of ASCE 7-02 and IBC 2003.
    - B. Ensure that pre-cast hollow core planks can withstand the loads determined in A.
    - C. Determine loads from planks to be carried by beams.
    - D. Determine beam sizes from Tables in CRSI, ensuring capability to withstand loads and forces.
    - E. Determine column sizes using RAM with loads found above superimposed on the structure.
4. Model Building
    - A. Model Building in ETABS.
    - B. Spot check members to ensure proper strength and serviceability.
    - C. Spot check building to ensure that drift and story drift comply with accepted standards and code limitations.
5. Breadth 1 – Construction Cost Impact
    - A. Develop detailed take-offs from the new system.
    - B. Determine an approximate cost for the new system.
    - C. Compare to the approximate cost for the existing system.
    - D. Analyze impact and concerns of new system.

6. Breadth 2 – Mechanical Impact
    A. Ensure that new design will allow for the current system to work with slight modifications.
    B. Determine if more space is available for mechanical equipment.
    C. Determine if there is a more economical way of routing the ducts with the new system.
    D. Analyze impact and concerns of new system.
7. Finalization
    A. Compile material into final report.
    B. Compile material into final presentation.
    C. Finalize CPEP site.

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.

Activity	Date														
	January			February					March					April	
	16-20	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
Plan Redesign	X														
Lateral Resisting System		X	X												
Preliminary Member sizing					X	X									
Model Building							X	X							
Breadth 1										X		X			
Spring Break											X				
Breadth 2													X	X	
Finalization															X

Conclusion

After exploring multiple structural systems in previous technical assignments, it was decided that a pre-cast hollow core planking system on concrete supports with steel columns 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 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.