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Option: Structural
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Building: The Duncan Center
Location: Dover, DE
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REVISED PROPOSAL

EXECUTIVE SUMMARY

The Duncan Center is a premium office building located in Dover, DE. There are a total of six floors with the building reaching an overall height of 93'-0". Open flex office space is located on the first four floors, a reception and banquet hall on the fifth floor, and a penthouse holding the building management offices on the sixth floor. Small electrical and mechanical rooms are also located on the sixth floor with the larger electrical and mechanical room located in the basement along with storage space. Balconies augment the fourth and fifth floors and the overall structure is crowned with an arched penthouse.

Structural steel frames the building with a composite metal deck floor system and a moment connected frame lateral system. This proposal presents the redesign of the building to a potentially more economical solution of a concrete structural system with a two-way flat plate conventionally reinforced floor system and a concrete shear wall lateral system. After completion of the proposed system redesign, the two systems will be compared to determine which system is more suitable.

In order create a more complete comparison between the two systems; two breadth studies affected by the system change will be performed. The first breadth study will be in acoustics with regards to the performance of the floor systems in sound transmission and reverberation time for the fifth floor banquet hall. The second breadth study will be in construction management to compare the cost and duration of schedule between the existing system and the proposed.

After the proposed work presented is executed next semester, Spring 2008, and the final results will be presented in a final report and formal presentation.



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I. INTRODUCTION

The Duncan Center is a premium office building located in Dover, DE. There are a total of six floors with the building reaching an overall height of 93'-0". Open flex office space is located on the first four floors, a reception and banquet hall on the fifth floor, and a penthouse holding the building management offices on the sixth floor. Small electrical and mechanical rooms are also located on the sixth floor with the larger electrical and mechanical room located in the basement along with storage space. Balconies augment the fourth and fifth floors and the overall structure is crowned with an arched penthouse.

The purpose of this report is to present a proposal for thesis work to be carried out next semester, Spring 2008. Proposals include a complete change of the existing structural system from steel to concrete. Breadth studies on acoustical sound transmission and reverberation and construction cost and scheduling will be performed in order to compare the existing steel system and the proposed concrete system.



II. EXISTING STRUCTURAL SYSTEMS

Foundation System

A deep foundation system comprised of auger cast concrete piles is utilized, as per the recommendation of the geotechnical engineer, John D. Hynes & Associates, Inc. The structural engineer was presented with the choice of several different diameters and depths of piles and a 16" diameter, 40' long pile reinforced with a rebar cage in the top 10' of the pile of 6-#6 bars and #3 ties at 12" o.c. was selected. This pile system affords a bearing capacity of 85 tons per pile.

On top of these piles rest the pile caps of various cross sections with a depth of 3'-1" each. Above the pile caps rest the 24"x24" concrete piers with 8-#8 vertical bars and #3 ties at 12" o.c. The piers are connected by 1' wide by 2' deep grade beams reinforced with 4-#6 bars top and bottom and #3 ties at 12" o.c. Columns rest on top of the piers connected by 18"x18" steel baseplates ranging in thickness from 1" to 2-1/4" with 4-1" diameter A325N bolts.

The basement slab on-grade is a 4" cast-in place concrete slab reinforced with 6x6 W2.9xW2.9 welded wire fabric on 4" of porous fill.

Floor Systems

Typical on all floors is a 5" composite slab including a 2" 20 gage composite metal deck reinforced with 6x6 W2.0xW2.0 welded wire fabric. The deck is spot welded to the composite structural steel members beneath and accompanied by 23-3/4" x 4" long shear studs for girders and 14-3/4" x 4" long shear studs for beams. This provides the overall floor system with a fire rating of 2 hours, including spray-on fire proofing for both the deck and structural members, and forms a rigid diaphragm.

A typical floor bay is 27'-8"x24'-5" with the beams running in the long direction, W16x31 interior and W18x35 between columns. The interior beams rest upon W24x55 girders which transfer the load to the columns; see Figure 1: Second Floor Framing Plan.

Lateral Load Resisting System

Lateral loads are resisted by the Duncan Center's moment connected frames, six-three span frames in the North-South direction and four-five span frames in the East-West direction; see Figure 1: Second Floor Framing Plan for clarification. Each girder and beam between columns is moment connected by shear tabs with full penetration welds to the columns. Columns range from W12x45 to W12x136 and are spliced at the third and the fifth floor.

Typical Floor Framing Plan

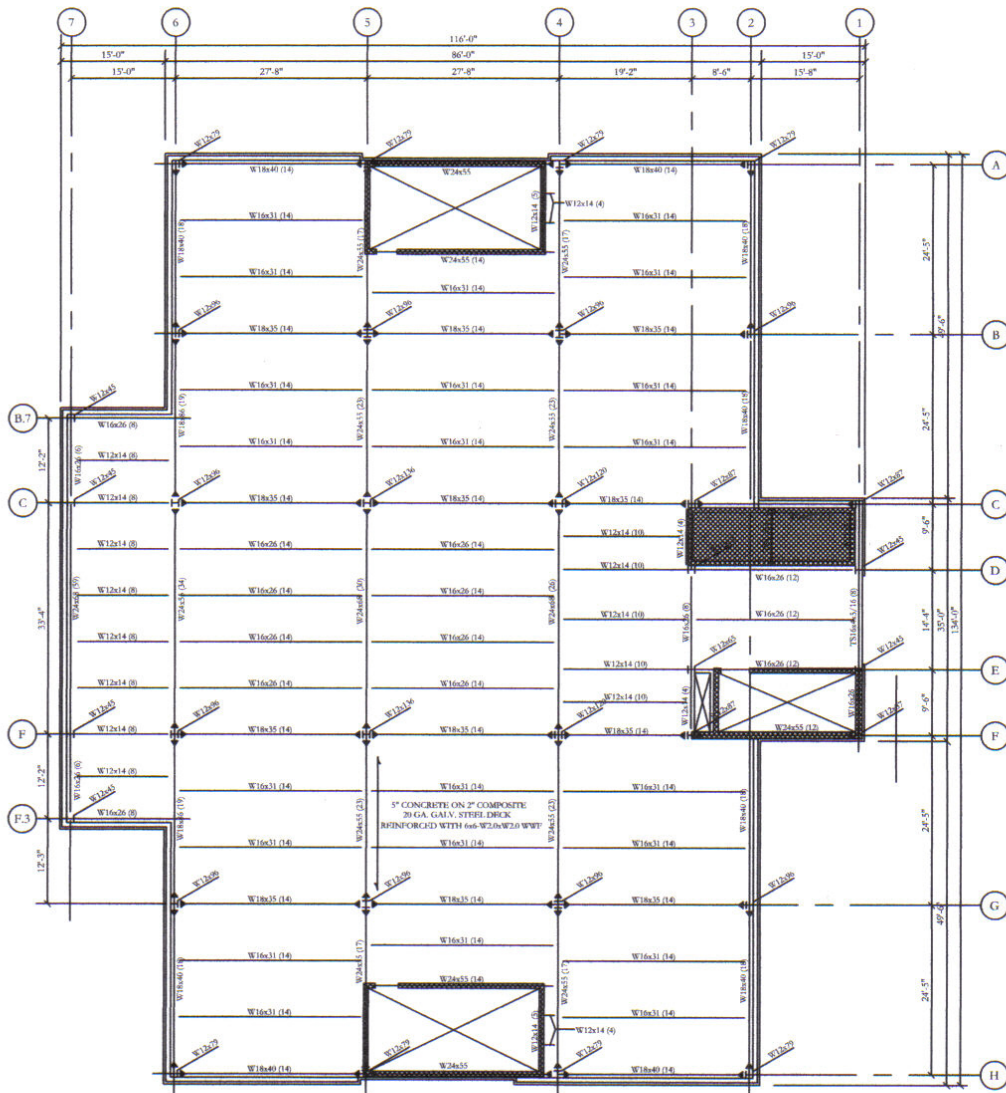


Figure 1: Second Floor Framing Plan

III. DEPTH TOPIC

Problem Statement

When the Duncan Center was originally designed, it was decided to use a lateral load resisting system of a steel moment frame. The key advantage of using moment connected frames is that there is freedom of architectural constraints of the façade and interior space. Comparatively, braced frames and shear walls provide such constraints to the placement of doors, windows, and walls, which may play a significant contributing factor to the overall architecture of the building. Other potential deciding factors may have been the duration of construction and overall weight of the building, as steel may be erected more quickly and is typically a lighter system than one of concrete.

Steel moment frames, however, are known to not always be the most cost effective lateral system that could be selected for a particular building. This is primarily due to the expense incurred by the moment connections themselves, which often incorporate multiple welds in the shop and also in the field. Thus, the current lateral system in the Duncan Center may or may not be the most economical and a different lateral system will be investigated to determine if steel moment frames are indeed the optimal solution.

Proposed Solution

From the preliminary study performed in the Technical Assignment #2 it was found that compared to the existing composite system, a concrete two-way flat plate conventionally reinforced system may be more cost effective and allow increased floor to floor heights or increased cavity area for MEP ductwork and equipment. In order to account for the weight of the façade, as not part of the study performed for Technical Assignment #2, exterior beams will also be utilized to aid in the distribution of the wall loads.

By using a concrete flat plate system, a steel framing and lateral system is no longer logical and a concrete framing and lateral system shall be put in its place. The alternative lateral system to be investigated will be concrete shear walls, the optimal location of which will be decided upon preliminary analyses to be performed at a later date. The shear walls will be positioned within the building to create as little obstruction to the architecture as possible, taking into account the existing façade and typical tenant floorplan.

Due to the significant change in weight present between the two floor systems, the foundation system will also need to be reanalyzed.

IV. BREADTH TOPICS

Acoustics

The fifth floor of the Duncan Center houses The Outlook Center, an elaborate reception and ballroom space available for rent to the public. As the ballroom is positioned directly above office space available for rent, an acoustical sound transmission of the floor system and a reverberation study will be performed between the two systems. The reverberation study will be performed accounting for change in the floor system and dimension changes to the spaces based on column and moveable partition locations. Contribution of the results of this study will be utilized to determine which system performs the best acoustically under the given conditions.

Construction Management

As the primary reason for selecting a different floor and lateral system is mainly cost and schedule driven, a comprehensible analysis of both will be performed and compared for the two systems. The cost analysis will include costs related to schedule, labor, equipment, and materials. A construction schedule comparison between the existing structure and the proposed will also be analyzed from time of the beginning of the steel fabrication process or the start of foundation construction, whichever comes first. After the cost and schedule analyses are complete, the two systems will be compared to determine which system is most advisable.

V. SOLUTION METHOD

To perform the proposed system change from steel to concrete, 3-d modeling in ETABS will be utilized to aid in preliminary analyses of the shear walls and overall design of the system. Initial sizes for columns will be obtained from the CRSI Handbook and sizing for the slab and beams by utilizing Equivalent Frame Method and PCA Slab. Spot checks will also be performed by hand calculation to check the validity of results obtained from ETABS and PCA Slab. The concrete system will be designed and analyzed with respect to strength, deflection, drift, and torsion according to ACI 318-05. Analysis of the foundations will be aided by the recommendations per the geotechnical engineer on the load capacity given for several different pile configurations specified for the given site conditions.

As for the breadth studies, acoustical transmission and reverberation studies will be performed according to methods presented in the text Architectural Acoustics by David Egan. Cost and schedule information will be obtained from the latest edition of RS Means and aid from professionals participating in the CPEP Discussion Board. Construction schedules of the existing system compared to the proposed system will be compared by using Primavera software.

VI. TASKS AND METHODS

1. Design Loads
 - a. Dead Loads per ASCE 7-05
 - b. Live Loads per ASCE 7-05
 - c. Snow Loads per ASCE 7-05
 - d. Wind Loads per ASCE 7-05
 - e. Seismic Loads per ASCE 7-05
2. Preliminary Sizing of Framing System
 - a. Preliminary Slab Thickness and Beam Sizing by PCA Slab
 - b. Preliminary Column Sizing by CRSI Handbook
3. Preliminary Sizing of Lateral System
 - a. Preliminary Shear Wall Locations with aid of ETABS 3-d Model
 - b. Preliminary Shear Wall Sizing with aid of ETABS 3-d Model
4. Final Sizing
 - a. Confirm Sizing of Slab, Beams, Columns, and Shear Walls with aid of ETABS 3-d Model with regard to Strength, Deflection, Drift, and Torsion according to ACI 318-05
 - b. Spot Check Slab, Beams, Columns, and Shear Walls with Hand Calculation according to ACI 318-05
 - c. Resize Foundation Spread Footings and Pile Configurations with aid of ETABS 3-d Model according to Recommendations by John D. Hynes & Associates
 - d. Draft Plans, Sections, Elevations, and Details using AutoCAD 2008
 - e. Draft Depth Portion of Final Report
5. System Comparison
 - a. Compare Existing System and Proposed System
 - b. Preliminary Braced Frame Sizing with aid of ETABS 3-d Model (as time permits)
6. Acoustical Breadth
 - a. Calculate Reverberation Time of Existing System according to Architectural Acoustics by David Egan
 - b. Calculate Sound Transmission Class (STC) of Existing System according to Architectural Acoustics by David Egan
 - c. Calculate Reverberation Time of Proposed System according to Architectural Acoustics by David Egan
 - d. Calculate Sound Transmission Class (STC) of Proposed System according to Architectural Acoustics by David Egan
 - e. Compare Existing System and Proposed System
 - f. Draft Acoustical Breadth Portion of Final Report
7. Construction Management Breadth
 - a. Perform Take-off and Calculate Cost of Existing System with aid of RS Means and Discussion Board
 - b. Create Schedule of Existing System with aid of RS Means and Discussion Board
 - c. Enter Schedule of Existing System into Primavera
 - d. Perform Take-off and Calculate Cost of Proposed System with aid of RS Means and Discussion Board
 - e. Create Schedule of Proposed System with aid of RS Means and Discussion Board
 - f. Enter Schedule of Proposed System into Primavera

- g. Compare Existing System and Proposed System
- h. Draft Construction Management Breadth Portion of Final Report
- 8. Finalize Report
 - a. Compile Final Report
 - b. Revise and Edit Final Report
 - c. Create PDF Version of Final Report
 - d. Post Report on CPEP
 - e. Print Report Copies and Bind
- 9. Presentation
 - a. Create PowerPoint Presentation
 - b. Revise and Edit PowerPoint Presentation
 - c. Post PowerPoint Presentation on CPEP
 - d. Practice, Practice, Practice!
 - e. Present PowerPoint Presentation to Faculty
- 10. Reflections
 - a. ABET Evaluation
 - b. Post Reflections on CPEP
 - c. CPEP Final Update

VII. SCHEDULE

January 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
		1	2	3	4	5	
		Winter Break					
6	7	8	9	10	11	12	
Winter Break							
13	14	15	16	17	18	19	
Revise Proposal							
20	21	22	23	24	25	26	
Design Loads							
Preliminary Sizing of Framing System							
27	28	29	30	31			
Preliminary Sizing of Framing System							
Preliminary Sizing of Lateral System							

February 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1	2
				Preliminary Sizing of Framing System	Preliminary Sizing of Lateral System	
3	4	5	6	7	8	9
Preliminary Sizing of Lateral System						
10	11	12	13	14	15	16
Final Sizing						
Construction Management Breadth						
17	18	19	20	21	22	23
Final Sizing						
Construction Management Breadth						
24	25	26	27	28	29	
Final Sizing						
Construction Management Breadth						

March 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1
2	3	4	5	6	7	8
Construction Management Breadth						
System Comparison						
9	10	11	12	13	14	15
Spring Break						
16	17	18	19	20	21	22
Acoustical Breadth						
23	24	25	26	27	28	29
Finalize Report						
Presentation						
30	31					
Finalize Report						
Presentation						

April 2008

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1	2	3	4	5
Finalize Report						
Presentation						
6	7	8	9	10	11	12
Presentation						
13	14	15	16	17	18	19
Faculty Presentations						
20	21	22	23	24	25	26
Reflections						
27	28	29	30			
Spring Semester Continues						

VIII. CONCLUSION

The proposal presented here shall provide ample in depth study to constitute a complete thesis by changing the structural system from steel to concrete. Also by investigating a concrete system, increased knowledge of two-way flat plate systems and shear walls will also be attained.

After comparing the strength and serviceability of the two systems, along with the two breadth studies of acoustics and construction management, it will be decided which system is most suited to the building's function and use.