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Option: Structural
AE Faculty Consultant: Kevin Parfitt
Building: The Duncan Center
Location: Dover, DE
December 18, 2007

# 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. The second breadth study will be in construction management to compare the cost of the two systems and duration of schedule.

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*

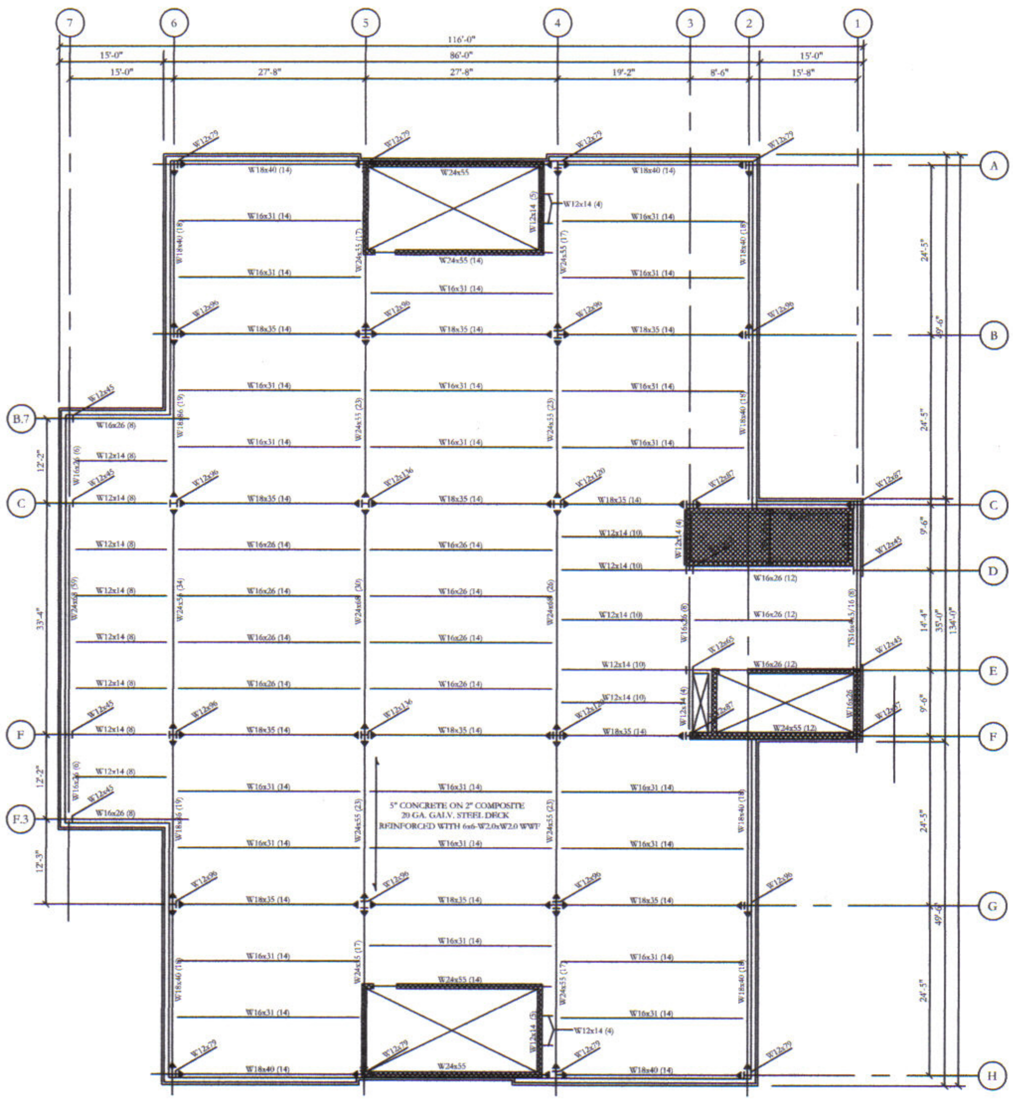


Figure 1: Second Floor Framing Plan

## 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. By using a concrete flat plate system, a steel framing system is no longer logical and a concrete one shall be put in its place.

By changing the framing system to concrete versus steel, this also drives a change in the lateral system from the existing. The alternative 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 and reverberation study will be performed to see which floor system performs the best in these respects. Contribution of the results of this study will be utilized to determine which floor system performs best under the given conditions.

*Construction Management*

As the primary reason for selecting a different floor and lateral system is mainly cost driven, a comprehensible cost analysis between the two systems will be performed. Also, duration of schedule will most likely vary between the two systems. A construction schedule comparison between the existing structure and the proposed will also be analyzed 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 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 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. Analysis of the foundations will be aided by the recommendations per the geotechnical engineer on the load capacity of given for several different pile configurations.

As for the breadth studies, acoustical transmission and reverberation studies will be performed according to methods presented in the text <u>Architectural Acoustics</u> by David Egan. Cost and schedule information will be obtained from the latest edition of RS Means. 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 by Equivalent Frame Method and 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 with aid of ETABS 3-d Model with regard to Strength, Deflection, Drift, and Torsion according to ACI 318-05
    b. Spot Check Slab, Column, and Shear Walls with Hand Calculation according to ACI 318-05
    c. Resize Foundation Spread Footings and Pile Configurations according to Recommendations by John D. Hynes & Associates
    d. Draft Depth Portion of Final Report
5. System Comparison
    a. Compare Existing System and Proposed System
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
    b. Perform Take-off and Calculate Cost of Proposed System with aid of RS Means
    c. Create Schedule of Existing System with aid of RS Means
    d. Enter Schedule of Existing System into Primavera
    e. Create Schedule of Proposed System with aid of RS Means
    f. Enter Schedule of Proposed System into Primavera
    g. Compare Existing System and Proposed System
    h. Draft Construction Management Breadth of Final Report
8. Finalize Report
    a. Compile Final Report
    b. Revise Final Report

c. Post Report on CPEP
d. Print Report Copies and Bind

9. Presentation
    a. Finalize PowerPoint Presentation
    b. Post PowerPoint Presentation on CPEP
    c. Practice
    d. Present PowerPoint Presentation to Faculty
10. Reflections
    a. CPEP Final Update
    b. ABET Evaluation
    c. Reflections

## 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 |
| Design Loads | | | | | | |
| 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| Preliminary Sizing of Framing System | | | | | | |
| 27 | 28 | 29 | 30 | 31 | | |
| Preliminary Sizing of Lateral System | | | | | | |

### February 2008

| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| | | | | | 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 | | | | | | |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Final Sizing | | | | | | |
| 24 | 25 | 26 | 27 | 28 | 29 | |
| Final Sizing | | | | | | |

## March 2008

| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 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 |
| Construction Management Breadth: Cost | | | | | | |
| 30 | 31 | | | | | |
| Construction Management Breadth: Schedule | | | | | | |

## April 2008

| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| | | Construction Management Breadth: Schedule | | | | |
| 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Finalize Report | | | | | | |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| Presentation | | | | | | |
| 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.