# The School Without Walls

**Washington, D.C.**

## Senior Thesis Proposal


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**Structural Option**

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# EXECUTIVE SUMMARY

The Grant School has stood in the heart of the George Washington University campus since 1882 and has housed the School Without Walls since 1977. In 2008, a 68,000 square foot addition was added along the south and east face of the building. In addition to the building expansion, the mechanical and electrical systems were replaced and updated.

Currently, the School Without Walls project calls for a floor system calls that requires beams which range from W10 to W30 sections. With the addition of a 5 ¼" decking system, the total floor depth amounts to 30 ¼". A larger clearance between the ceiling and the floor system above would create an easier coordination of the electrical and mechanical systems in the building.

After completing the three technical reports and further investigating the building, a concrete floor system appears to be a viable alternative to the composite steel floor system which is currently in place. The proposed thesis will investigate altering the current floor to a concrete system using post-tensioned beams and a reinforced slab. This proposed floor system will limit the total floor depth and reduce deflections. Concrete columns will be designed as part of this system and replace the current steel columns.

Shear walls will replace the current steel braced frames and will be utilized in order to resist lateral loads. Because of the significant increase in total building weight, the foundations must be investigated.

In addition to the depth structural study, two breadth topics will be researched. The construction management breadth will focus on the effect the change in structural system has on schedule and overall cost. The architectural breadth will study how dropping the ceilings of the existing building will affect the spaces. Lowering the ceiling heights will allow for easier MEP coordination

# INTRODUCTION

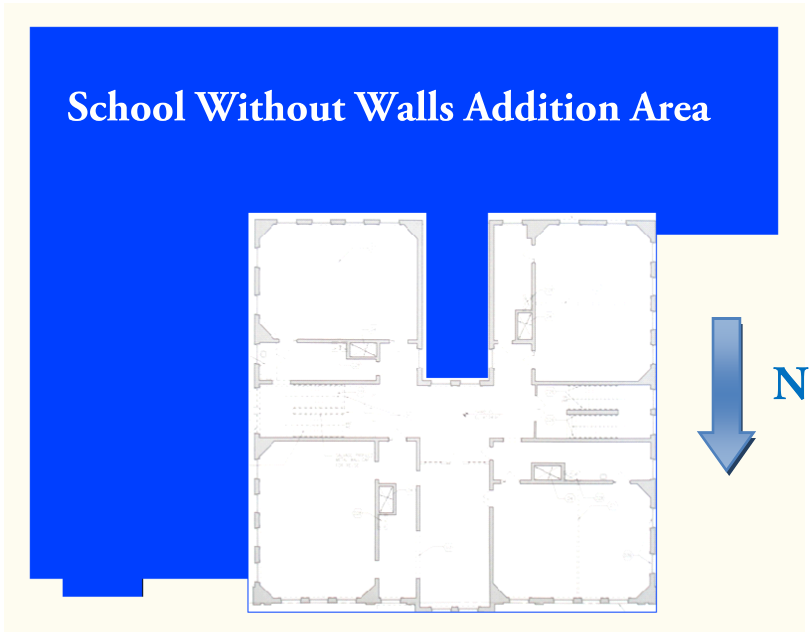
The Grant School has stood in the heart of the George Washington University campus since 1882 and has housed the School Without Walls since 1977. The "School Without Walls" name comes from the encouragement for students to use Washington D.C. as an active classroom, thus not restraining learning to the walls of the school.

The original 32,300 square foot, three story school was in dire need of modernization and expansion due to the increasing number of students and outdated mechanical and electrical equipment. The 68,000 square foot addition and renovation blends the 19th century school with a modern design. This is achieved by combining existing brick patterns with glass, steel and curtain walls as seen in Figure 1.


*Figure 1: Interface of Buildings*

The existing three story school is made up of four large classrooms per floor, one at each corner of the square building. The new addition of the school provides an additional two large classrooms on each floor, an open atrium space, a large student commons, roof terrace area and a library. The basement was also reengineered and redesigned to serve as scientific laboratories for the school.

# EXISTING STRUCTURAL SYSTEM




**G Street**

*Figure 2: Floor Plan Showing Expansion*

The 68,000 square foot addition to the School Without Walls project is located in blue in Figure 2. Due to expansion joints located at the interface of the addition and the existing building, the structural systems work independently. This expansion joint can be viewed in Figure 3. As stated in the drawing, along the expansion joint along the east side of the existing building is 4", and is 2" along the south side.

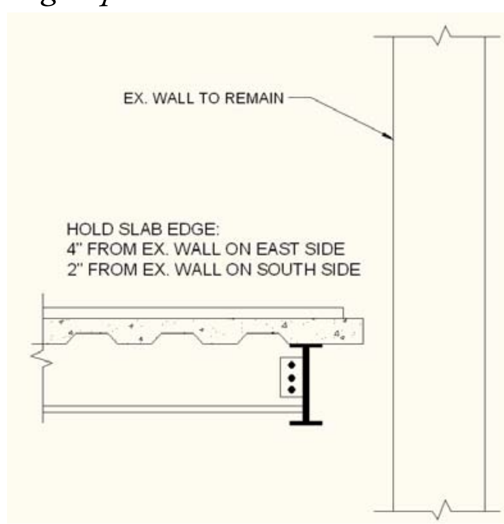



*Figure 3: Expansion Joint Detail*

The new addition to the School Without Wall itself is divided by an expansion joint; therefore creating a total of three self supporting structural systems. This division of the new addition can be viewed in Figures 4 and 5.

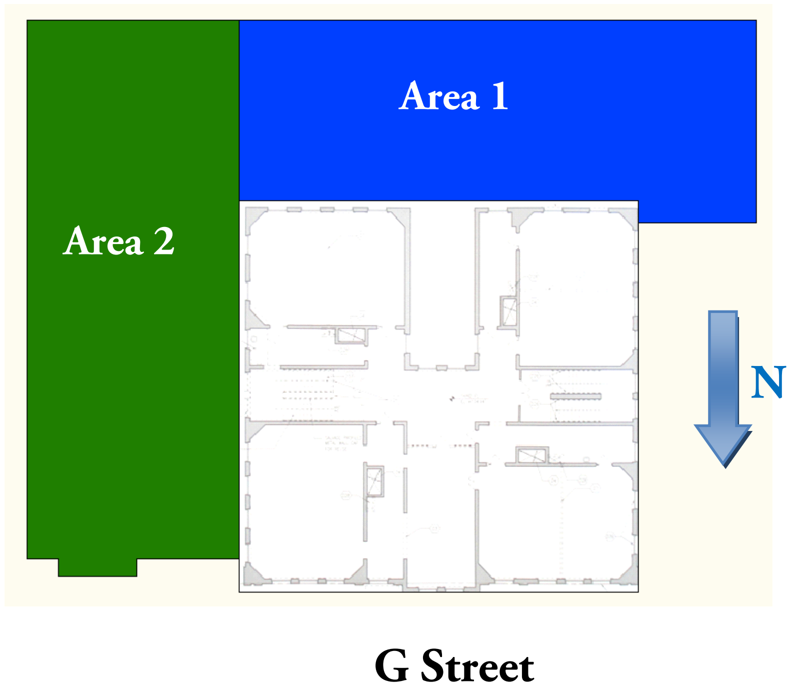



*Figure 4: Floor Plan Showing Building Separation*

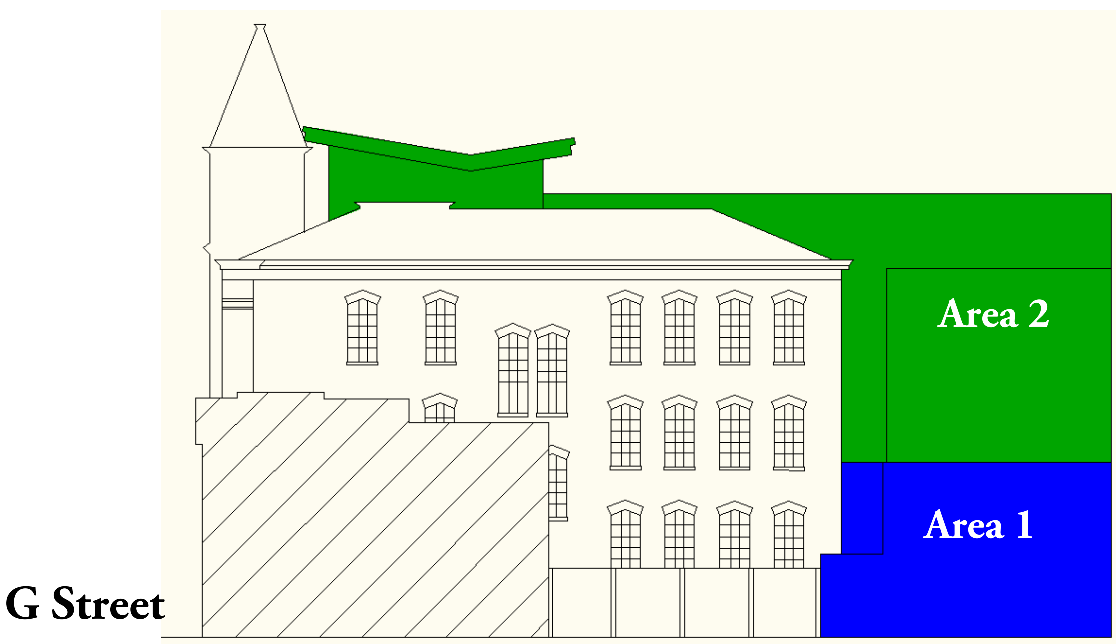



*Figure 5: West Elevation*

**Foundation**

The geotechnical engineering study was performed by Thomas L. Brown Associates, P.C. on January 28, 2007. After performing a series of in-situ tests, considering the lab test results, anticipated loads, and settlement analyses, a shallow foundation consisting of reinforced cast-in-place spread footings and grade beams was deemed appropriate. Based on the testing and analysis, the footings should be designed for an allowable bearing capacity of 3.0 ksf. Typical footings of the addition are 2' 6" wide by 2'0" deep and rest on compacted earth 3'0" below the top of the slab-on-grade. Grade beams are also used in the foundation of the new addition. The beams measure 30"x30" along the east side and 30"x24" along the south side of the building.

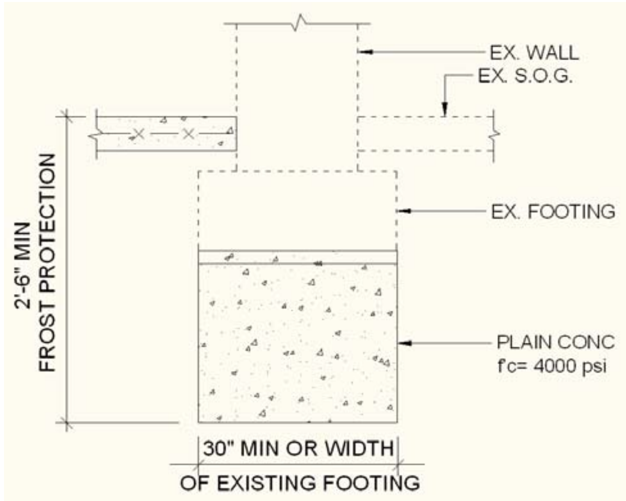



*Figure 6: Underpinning Detail*

Due to the increased load and the disruption of earth, underpinning the existing footings of the school became necessary. An underpinning detail is located in Figure 6. The underpinning sequence will be performed in sections no larger than 4 feet wide, approximately spaced 12-15 feet apart.

**Lateral System**

The lateral system of the School Without Walls works as three different systems due to expansion joints as stated before and shown in Figures 4 and 5. The two story structure supporting the outside roof terrace (Area 1), the four story structure supporting the library (Area 2) and the existing building all act independently from one another.

Area 1 utilizes lateral braced frame for lateral support, comprised of HSS6x6x3/8 sections. Area 2 uses a combination of an HSS braced frame, ranging from the ground to the roof level, and shear walls around both the elevator core and the stair core. The stairwell creates a 12" concrete shear wall core, and the elevator shaft creates an 8" concrete shear wall core labeled as "5" and "6" respectively in Figure 7. The lateral braced frame locations are located in blue in Figure 7.

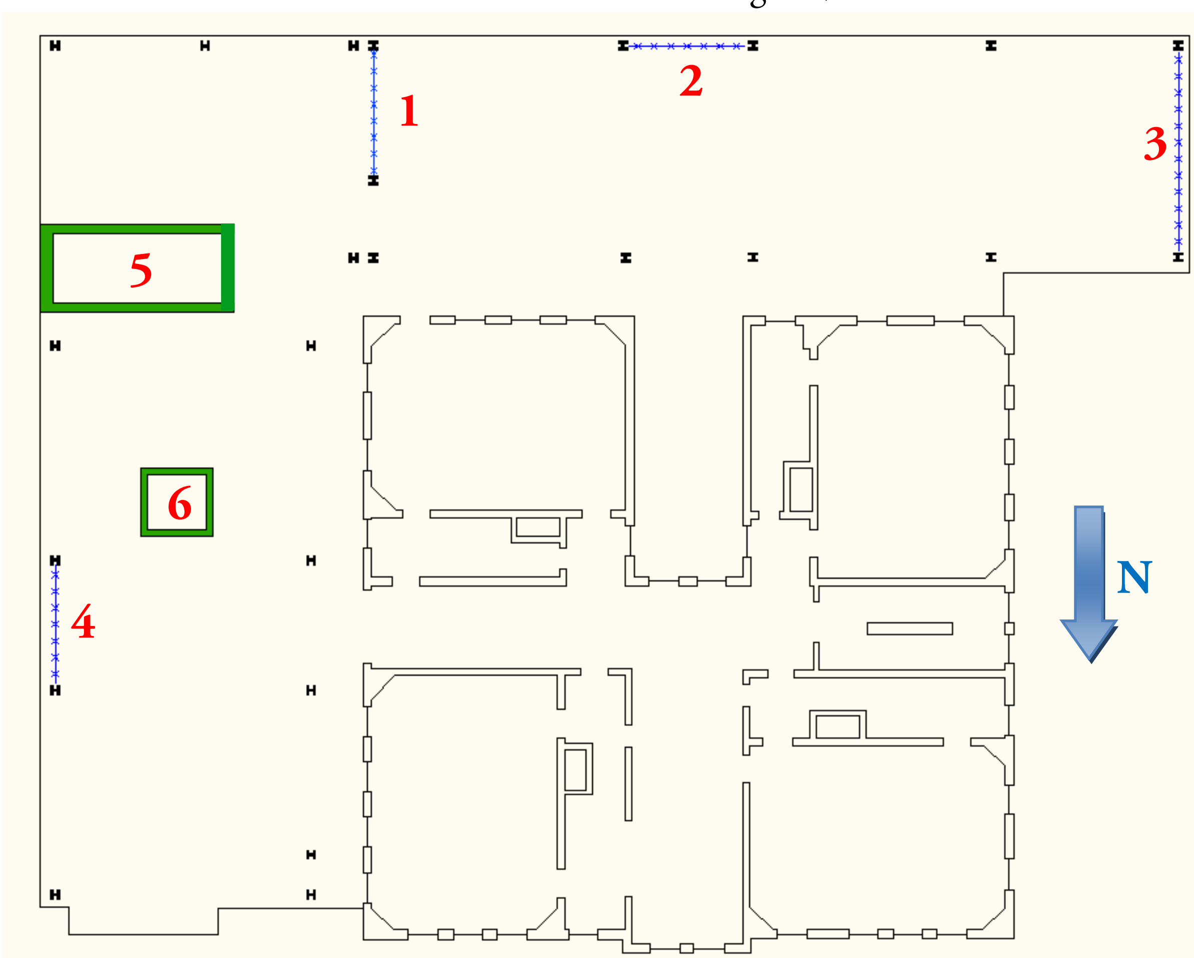



*Figure 7: Summary of Lateral Systems*

## Existing Floor System

The floor system of School Without Walls is a composite steel system. The floor slab of the new addition is 3 ¼" LWC topping over a 2" 20 GA LOK composite steel floor decking, bringing the total floor slab to 5 ¼" thick. Along the top flange of the beam, ¾"x4" long headed shear studs are used for composite action. A section of this floor system is shown above in Figure 8.

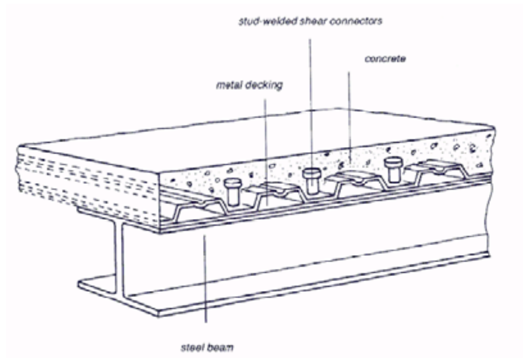



*Figure 8: Typical Composite Steel Construction (www.epitech.com)*

The columns which run along the perimeter of the existing building are set back from the structure, creating a cantilever. Moment connections are utilized at these columns in order to carry the load which is being cantilevered. A typical bay showing the cantilevered slab and moment connections is located below in Figure 9.

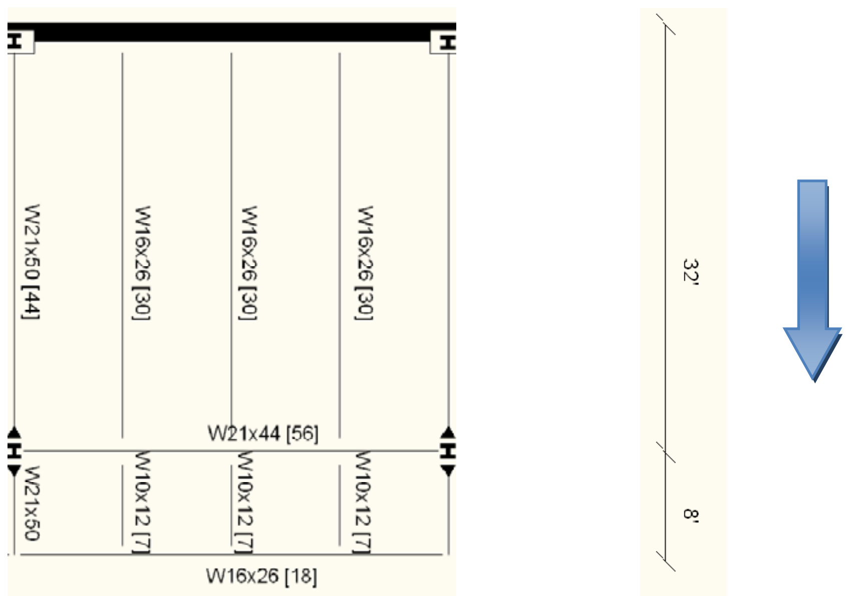



*Figure 9: Typical Bay Showing Moment Connections and Cantilever*

# DEPTH STUDY

## Problem Statement

Currently, the School Without Walls project it was found that the current floor system calls for beams which range from W10 to W30 sections. With the addition of a 5 ¼" decking system, the total floor depth amounts to 30 ¼". A larger clearance between the ceiling and the floor system above would create an easier coordination of the electrical and mechanical systems in the building.

## Solution

To limit the total depth of the floor system, the gravity resisting system will be altered from the current steel composite system to a concrete system. From Technical Report 2 it is clear to see that the floor depth of both the two way flat plate and one way system is significantly smaller than the existing floor system. Also, using a concrete system allows column lines to remain in their current position, therefore effectively meeting the layout which was required by the architect.

After further review of the floor systems researched in Technical Report 2, and considering alternative systems, a post-tensioned concrete is also very applicable to this project because of the relatively large spans the building layout requires and the desire for minimal floor deflection. Post-tensioning of the beams will allow for the desired cantilever along the face of the existing building and reduce deflections. A one way reinforced slab will be designed to bridge the span between the post-tensioned beams. Concrete columns will also be designed as part of this concrete system and replace the current steel columns. A preliminary sketch of the proposed post-tensioned beam system can be found in Figure 10.

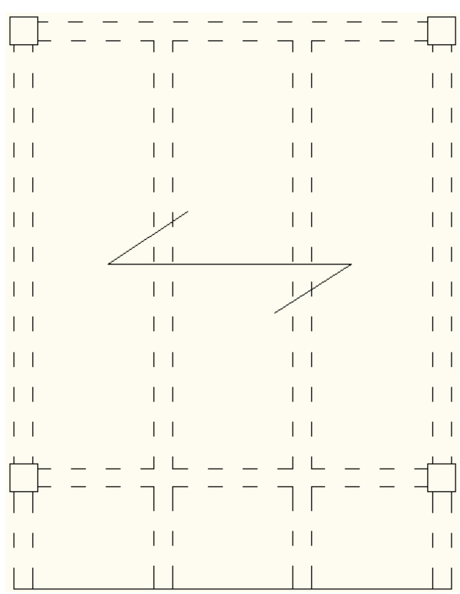


*Figure 10: Typical Bay Showing Post Tensioned Beam Layout*

Changing the steel building to concrete will increase the overall weight of the building, therefore effecting foundation system. An investigation must be conducted to determine if the current foundation system is adequate for this altered design.

The lateral system will be redesigned using shear walls, thus removing the braced frames which currently resist lateral loads. The expansion joints which separates the School Without Walls into three different zones will remain, therefore, creating three different lateral systems.

## Solution Method

ACI 318-05 will be reference throughout in the design of the concrete system. PCA slab and column will be utilized to aid in the structural design. ADAPT will be used to assist in the design of the post tensioned beams. An ETABS model will be built in order to effectively analyze the lateral system of the building. Hand calculations will be performed to confirm and verify the accuracy of the computer programs.

# BREADTH STUDIES

## Breadth Study 1: Construction Management

Because the building is being altered from a primarily steel structure to a concrete building, the cost and schedule will be greatly affected. A cost and schedule comparison to the existing structure will be made to determine the effectiveness and feasibility of the change made from steel to concrete. The cost estimating computer program ICE and RS Means will be used to aid in determining the cost of the altered structure. Microsoft project will be used to create and display the altered schedule.

## Breadth Study 2: Architecture Breadth

After speaking with the construction manager on the School Without Walls project, he mentioned that when updating the mechanical system in the existing portion of the school, problems occurred because the ceiling was attached to the wood joists above. This architectural breadth will involve dropping the ceiling to allow for more MEP clearance. The effect of this to the classrooms will be analyzed and modeled in REVIT. If this architectural change proves not to affect the overall appearance to the room, the constructability of the MEP system could be greatly simplified.

# TASKS

## Part 1: Depth Study

Task 1: Determine Loading of Spaces
Task 2: Design Reinforced Slab
Task 3: Design Post Tension Beams
Task 4: Determine Concrete Columns
Task 5: Calculate Building Weight
Task 6: Calculate Lateral Loads
Task 7: Model Shear Walls
Task 8: Model and Analyze Lateral System
Task 9: Determine Impact on the Foundation

## Part 2: Breadth Study

Task 10: Construction Management Breadth

- Obtain cost and schedule for the current system
- Calculate cost of proposed concrete system
- Determine schedule of proposed structural system
- Compare cost and schedule of the proposed and current system

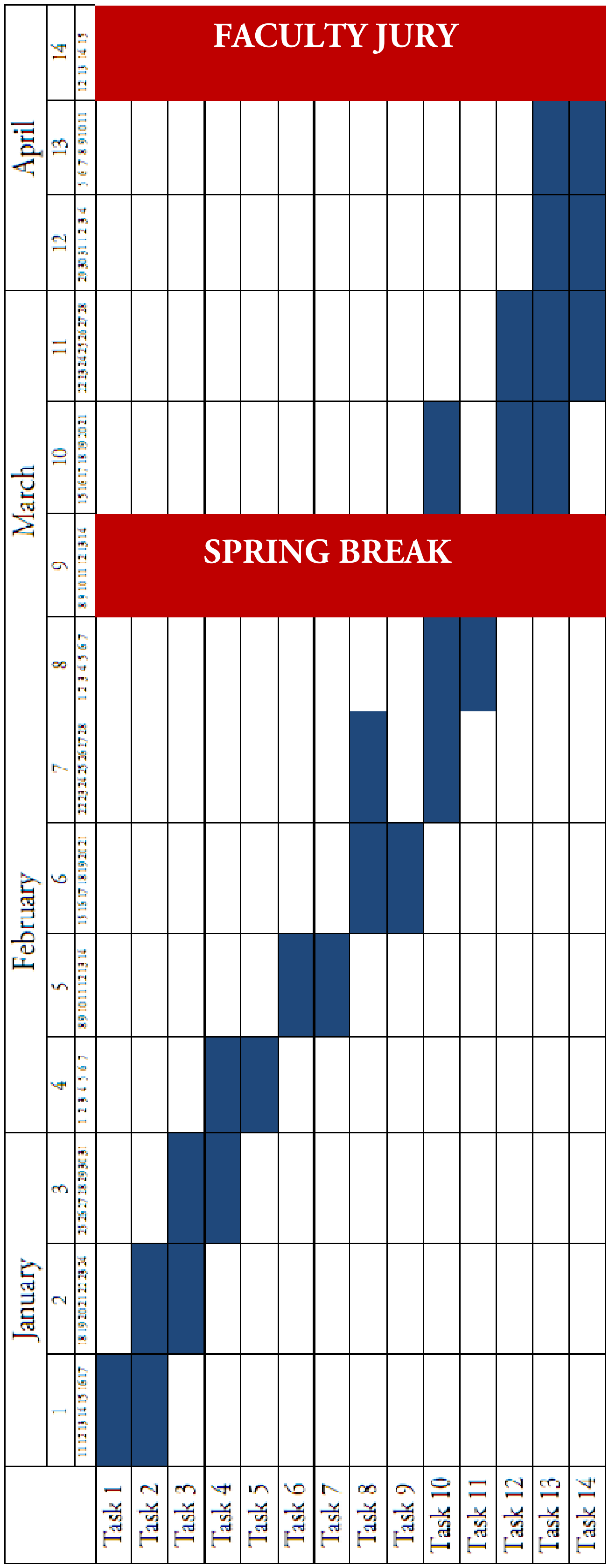
Task 11: Architectural Breadth

- Model existing classrooms in REVIT
- Create interior renderings
- Create REVIT model of proposed classrooms
- Create renderings and compare to existing classroom

## Part 3: Miscellaneous Tasks

Task 12: Develop Comparisons and Conclusions
Task 13: Finalize Report
Task 14: Prepare Presentation

# SCHEDULE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SPRING BREAK
FACULTY JURY

# CONCLUSION

The School Without Walls project calls for a floor system calls that requires beams which range from W10 to W30 sections. With the addition of a 5 ¼" decking system, the total floor depth amounts to 30 ¼". A larger clearance between the ceiling and the floor system above would create an easier coordination of the electrical and mechanical systems in the building.

The proposed thesis will investigate altering the current floor to a concrete system using post-tensioned beams and a reinforced slab. This proposed floor system will limit the total floor depth and reduce deflections. Concrete columns will be designed as part of this system and replace the current steel columns.

The lateral system must be altered as well and exclusively use shear walls in order to resist lateral loads. Because of the significant increase in total building weight, the foundation must be investigated.

Computer programs such as ETABS, ADAPT, PCA slab and column will be utilized to aid in the structural design. ADAPT will be used to assist in the design of the post tensioned beams. An ETABS model will be built in order to effectively analyze the lateral system of the building. Hand calculations will be performed to confirm and verify the accuracy of the computer programs.

Two breadth topics will also be researched as part of this senior thesis project. The construction management breadth will focus on the effect the change in structural system has on schedule and overall cost. The architectural breadth will study how dropping the ceilings of the existing building will affect the spaces. Lowering the ceiling heights will allow for easier MEP coordination