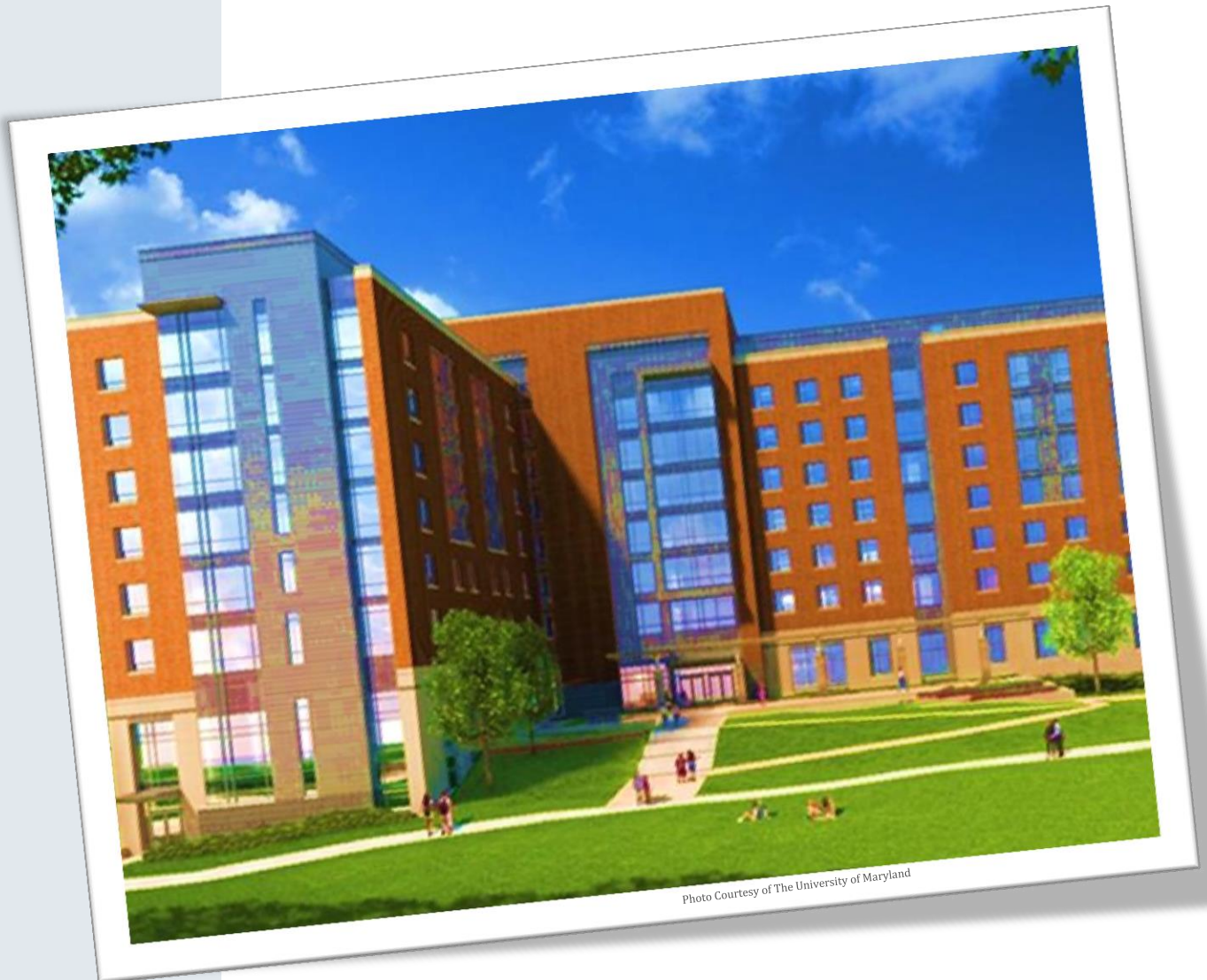


Structural Proposal



Prince Frederick Hall

The University of Maryland

College Park, MD

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AE Senior Thesis- Structural

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Executive Summary

Prince Frederick Hall is a brand new, state of the art, dormitory located on the University of Maryland's campus. Opening for the fall semester of 2014, the new dormitory will house up to 460 students, provide several office spaces and add two grand lecture halls. The building stands at 110 feet tall and is approximately 185,000 gross square feet. The building consists of seven stories, one scub level, two main multipurpose floors, and five dormitory floors. The building's flooring system consists of a cast in place, eight inch thick, two-way slab that connect to concrete columns of varying size. The columns run from floor to floor height, which changes throughout the building. The average floor height, which occurs on the 4th to 7th level, is about 10.67 feet tall. The reinforced gravity columns tie into spread footers at the scub level. There are seven shear walls, which make up the lateral force resistance system.

In the previous four technical reports, the gravity and lateral system were evaluated and determined to be adequate to all minimum industry codes and standards. Alternative gravity systems were designed in technical report three and are designed to meet codes and industry standards.

The purpose of this report is to summarize a rational structural design alternative for Prince Frederick Hall and the proposed method of solution for the design alternative. In the spring semester, Prince Frederick Hall will be relocated from its campus location in College Park, Maryland to a site next to the Arundel Mills Mall in Hanover, Maryland. The building will be redesigned with a change of occupancy from a dormitory building to a hotel. Each floor layout will be redesigned to house hotel guests instead of students. Each dormitory will be designed into five star luxury hotel rooms. The new floor plans will be developed and integrated with the new structural gravity system and lateral system. Composite decking will be used instead of the two way concrete slabs. This will allow for maximum floor to floor height and the use of drop ceilings to hide electrical and mechanical systems. Steel columns will also be integrated into the new design to resist the new calculated gravity loads. Both gravity and lateral loads will be applied to a new structural model of the newly designed systems.

Breadth one will encompass an entirely new structure for the hotel. An architectural breadth will allow for the design of a 45,000 gross square foot attached

indoor water park to the hotel. Strategic park layouts (floor plans), elevations, and water park technology will be explored when adding this addition to the hotel's new layout. All plans and water slide designs will abide by professional industry standards and codes. A steel structural system will be designed to span the open layout to resist gravity and lateral loading. Joist girders from the roofing plan will connect to Prince Fredericks Hall's new composite decking system.

Breadth two will address the humidity of the indoor water park. An HVAC system will be designed to control the humidity and thermal temperature of the indoor water park. Strategic design of the water slides will also allow for a reduction in humidity and will be analyzed. Both humidity and temperature will be monitored to allow for the perfect indoor oasis.

A brief cost analysis will be conducted to compare the original cost to the new proposed building plans. A timeline of the proposed new design is attached at the end of this proposal to ensure the progress of the alternative system is track.

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Introduction/ Background Price Frederick Hall:



Courtesy of UMD

Prince Frederic Hall is a brand new multi-purpose dormitory under construction at The University of Maryland (UMD). The building is expected to open in September of 2014 to undergraduate students. This 185,000 square foot building was expected to achieve LEED Gold rating upon completion but now is going for Platinum rating. Clark Construction was hired by UMD to complete this project as a design-build project with a guaranteed maximum price. The total approximate cost for the building is about 65 million dollars. The brick façade on PFH is similar to the surrounding buildings which allow it to fit in seamlessly with the older architecture of the campus. Figure 1 shows the surrounding buildings - Caroline Hall, Van Munching Hall, and the University Commons - with corresponding facade photographs. Similar façades can be seen on each of the surrounding buildings.



Figure 1: Facade Comparison

Prior to construction, there was a small building on the site which needed to be demolished before any work could be done. The demolition included removal of all existing buildings, footing pads, landscaping, and utility lines. Prior to removal, UMD

received approval from the Maryland Historical Society. Figure 2 shown below highlights the area of construction as well as describes the area in which Prince Frederick Halls is located.

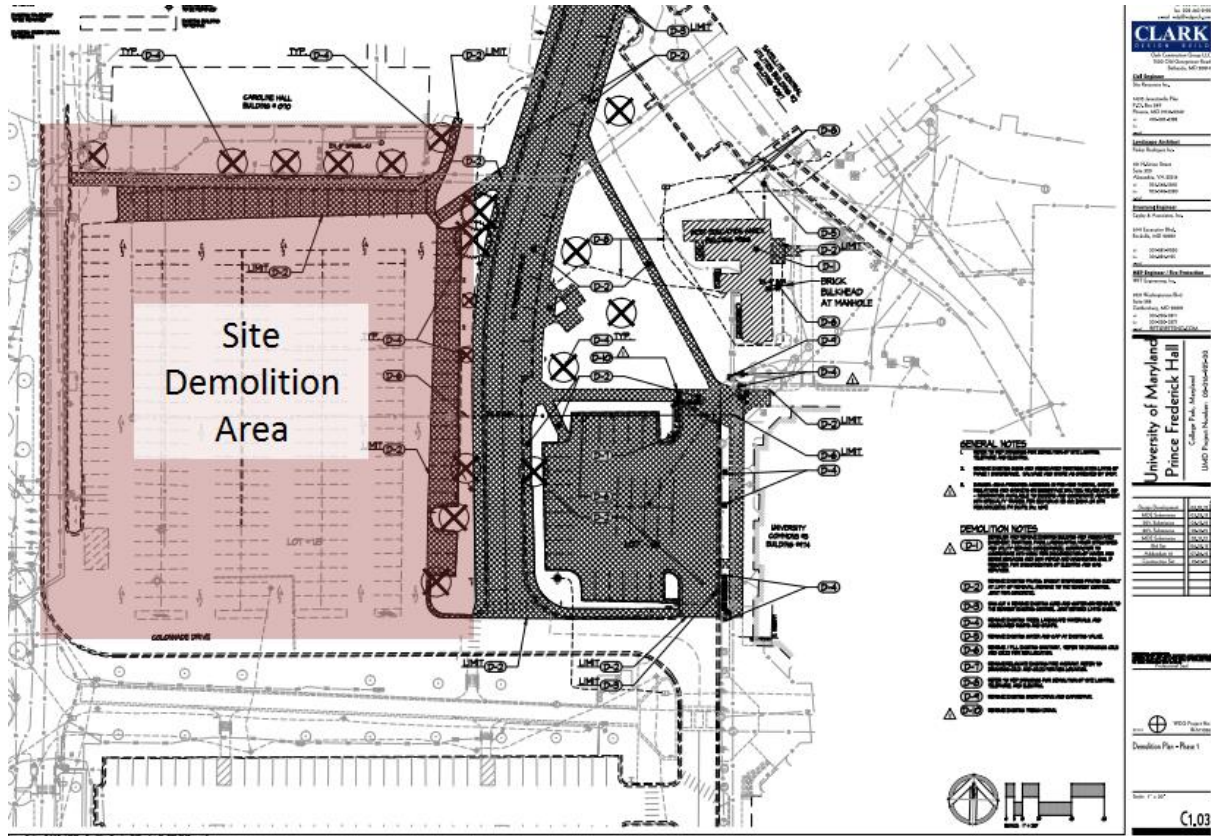


Figure 2: Site Demolition Area

The layout of the interior is designed to have educational space on the first floor and private dormitory space on the upper floors. Roof and scub floors house the mechanical and electrical rooms. The figure 3 is a typical floor plan showing the different occupancies of the third floor. These different occupancies will be discussed later in accordance to the architectural breadth. Also provided is a color code to help show the diversity of the building.

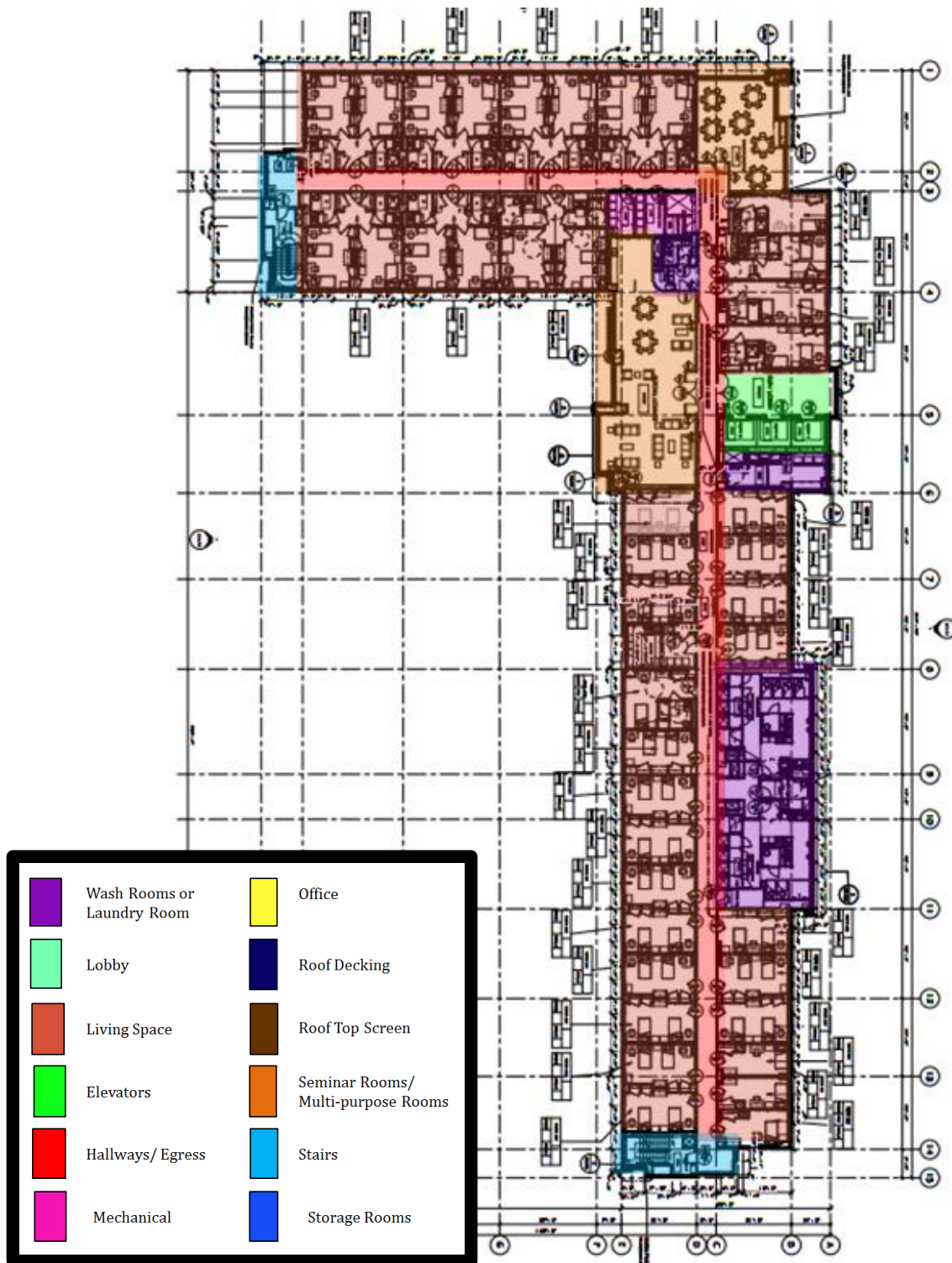


Figure 3: Typical Floor Layout

PFH is designed using cast-in-place concrete with two way slabs and shear walls. Fire safety plays a major role in the design; the building is designed with a fire resistance rating of three hours. The building's occupancy is mixed and includes the following:

- Residential (310) Primary → Group R-2
- Assembly (303) → Group A-3
- Business (304) → Group B
- Storage, Low Hazard (311.3) → Group S-2

PFH's main gravity system consists of 8 inch two way concrete slabs which tie into reinforced concrete columns. The lateral system consists of seven reinforced twelve inch concrete shear walls which resist wind and seismic loads. The exterior is primarily cast stone CMU, glass windows, and glass shear walls located at the two exterior stair wells. Figure 4 through 7 are the elevations of the buildings; notice the façade changes and overall height. This will be discussed later for the redesign.

North Elevation:

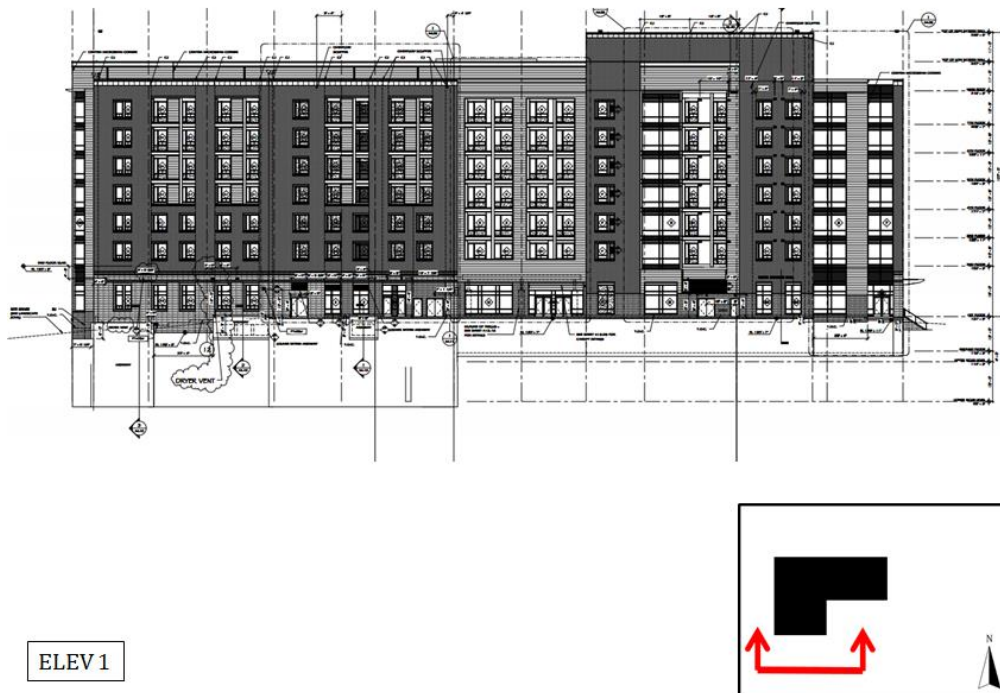


Figure 4: North Elevation

East Elevation:



ELEV 2

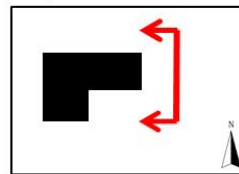
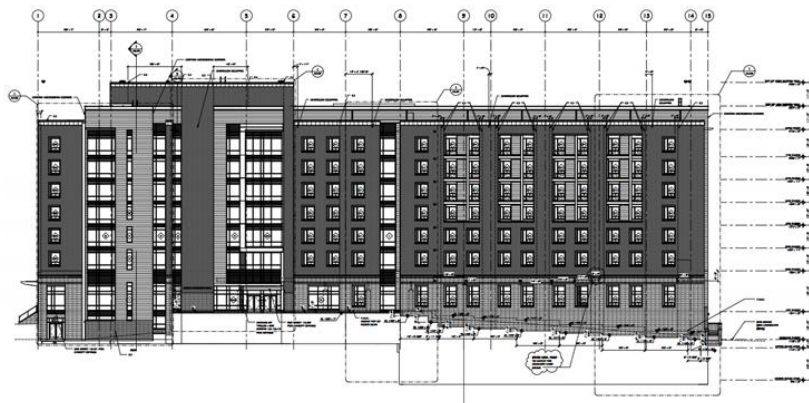


Figure 5: East Elevation

South Elevation:



ELEV 3

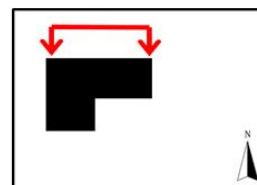
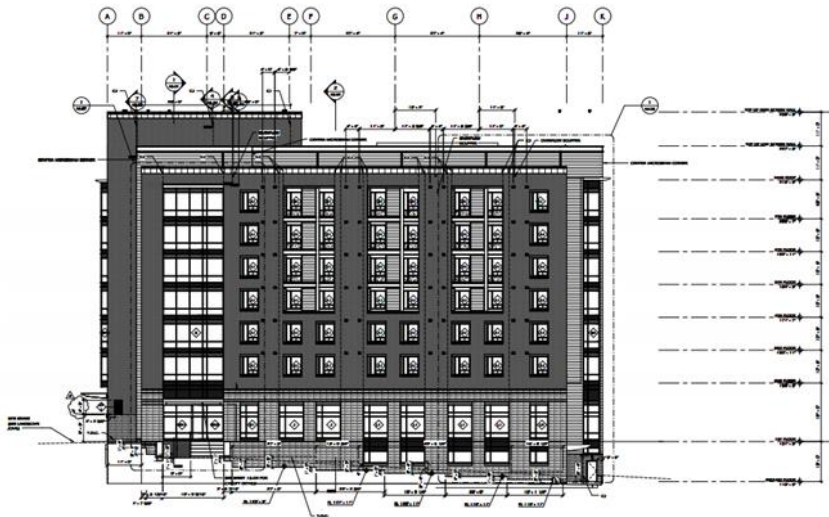


Figure 6: South Elevation

West Elevation:

ELEV 4

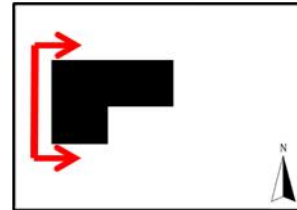


Figure 7: West Elevation

The main gravity system of PFH is a two way slab flat plate with shear caps. In this section, the structural gravity system is described from the first floor to the roof. The gravity system from the third to seventh floor is identical.

Cagley and Associates decided to go with a two way slab system because it is efficient, economical, and is a widely used structural system. A flat slab is essentially a flat plate which is then thickened around columns. These shear caps are used to control the negative moments transferred to the columns. The shear caps also help resist the column punching through the slab, commonly known as punching shear.

The first floor slab is designed to support the loads from several different occupancies which include; washrooms/laundry rooms, lobbies, living space, hallways/egress,

mechanical and storage. On this floor, there are two different slab thicknesses, one is 8 inches thick and the other is 9 inches. Shown in Figure 8, the 9 inch slab comprises the majority of the floor and sits to the west side of the building. The 8 inch slab is located on the East side of the building and has a smaller area.

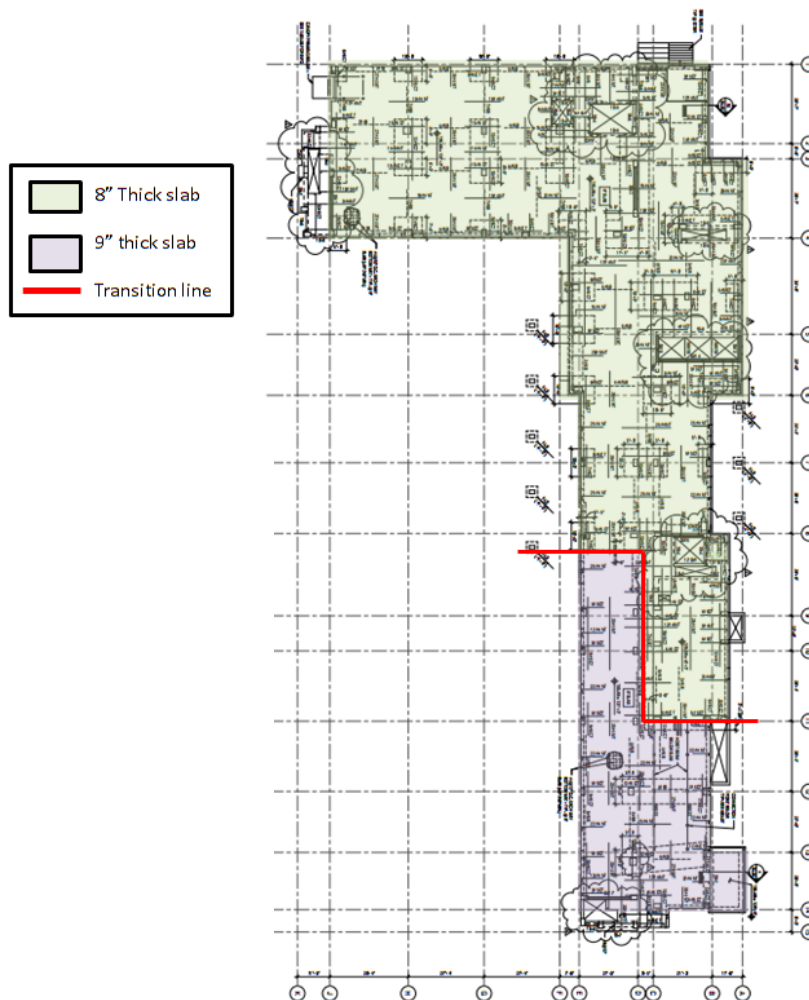


Figure 8: Floor 1 Slab Thickness

The engineer decided to do two different slab thicknesses on this floor because of the difference in spans. It is more economical to design the smaller spans of the two way slab with 8" and the larger spans being 9". The 9" allows for a larger rebar depth (d) in design which will save you on the amount of rebar needed, ultimately reducing the cost. The typical slab reinforcing is #5 bars at 12" on center and #6 bars at 12" on center bottom at column strips and repeat for middle strips.

Along with the two way slabs, there are beams which frame around the floor penetrations.

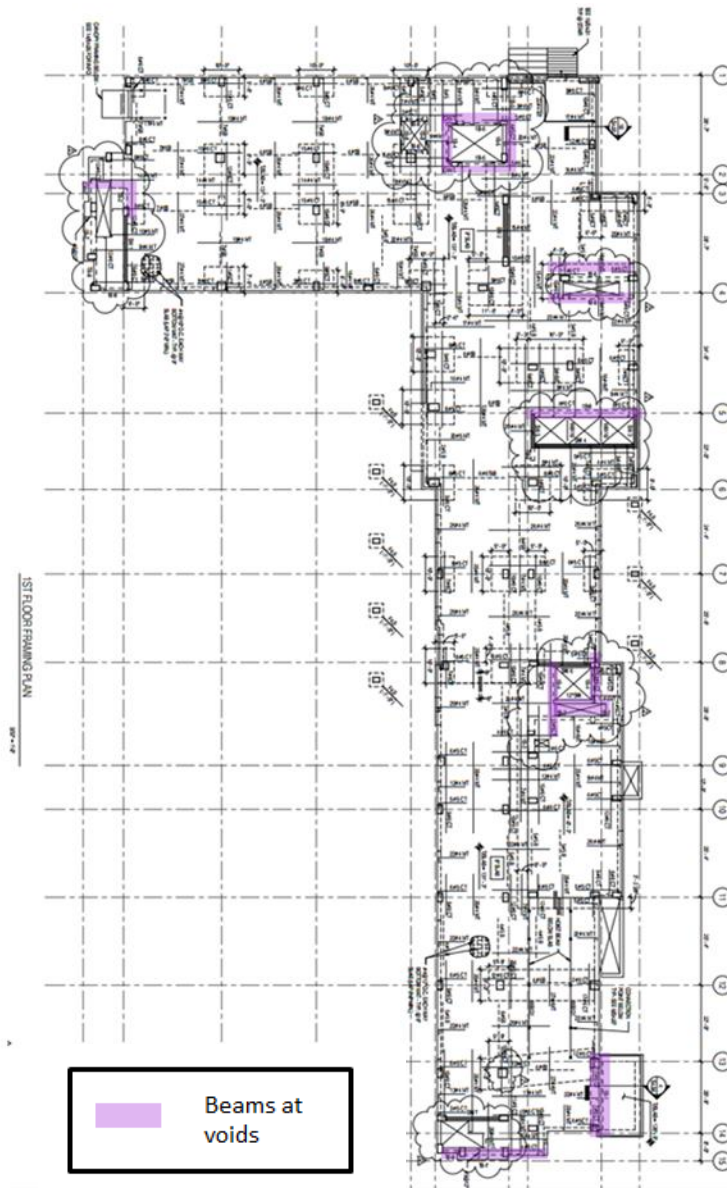


Figure 9: Floor 1 Beams Located at Voids

The second floor slab is slightly different from one; it is 8 inches deep and steps down in designated areas located in Figure 10. The sections of offset slab occur at the washroom

areas, allowing enough space for a flush floor finish. The second floor also has beams at the openings, similar to the first floor. The flooring from the third floor to the seventh has the same slab configuration as floor two; a diagram will not be shown for these.

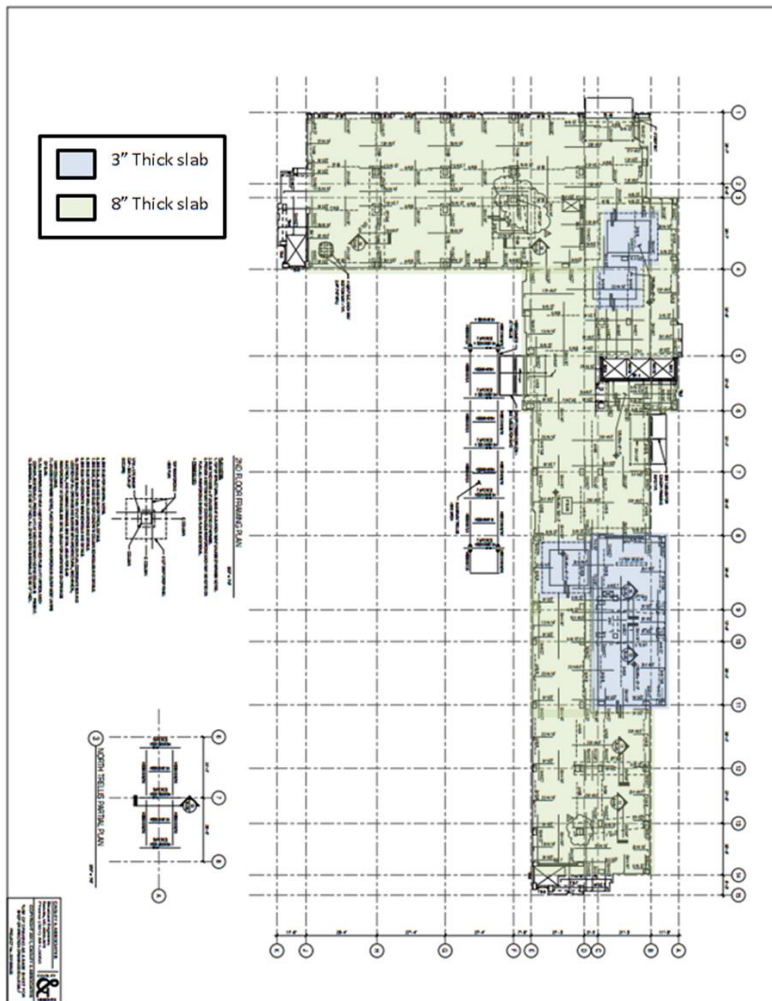


Figure 10: Second Floor Slab

From the slabs, the loads travel in two directions to meet the concrete columns which transfer the loads to the foundation. There are a few typical sizes for the columns: 30x 18, 18x24, 24x30, and 24x36. Each column size is consistent over the height of the building.

The lateral system of PFH consists of seven shear walls which act together to resist horizontal lateral forces. The first shear wall (SW1) is located in the far south side of the building apart of the stairwell. Shear wall number 2 (SW2) is located near the main

entrance and it connected to the first floor multipurpose room. Shear walls 3, 4, and 5 wrap around the main elevator system and together create a “C” shape. Shear wall 6 is located in the East wing and touches the main wash rooms on the residential floors. Shear wall 7 (SW7) is located at the far East end and touches the other stairwell. The diagram below shows the location of the shear walls on the first floor plan, these shear walls extend from the ground to the roof.

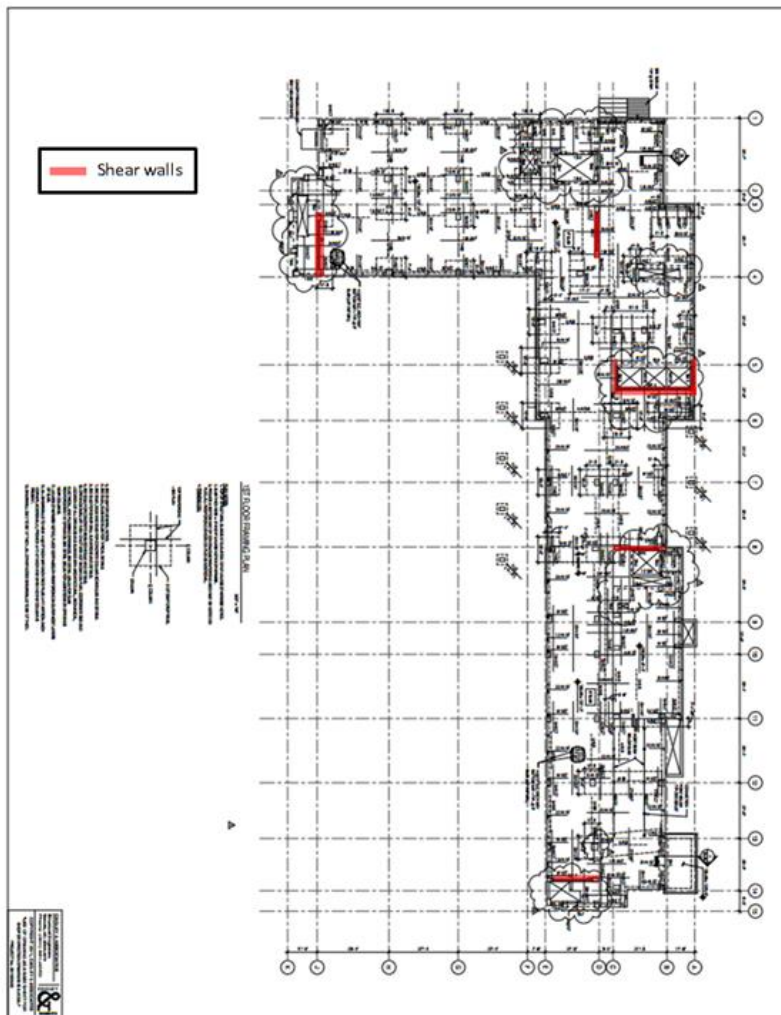


Figure 11: Shear Wall Layout

At the base of the shear walls, standard ninety degree hooks from the foundation connect the two together allowing for a moment connection parallel to the long length. The following detail is the typical layout of the shear walls with openings.

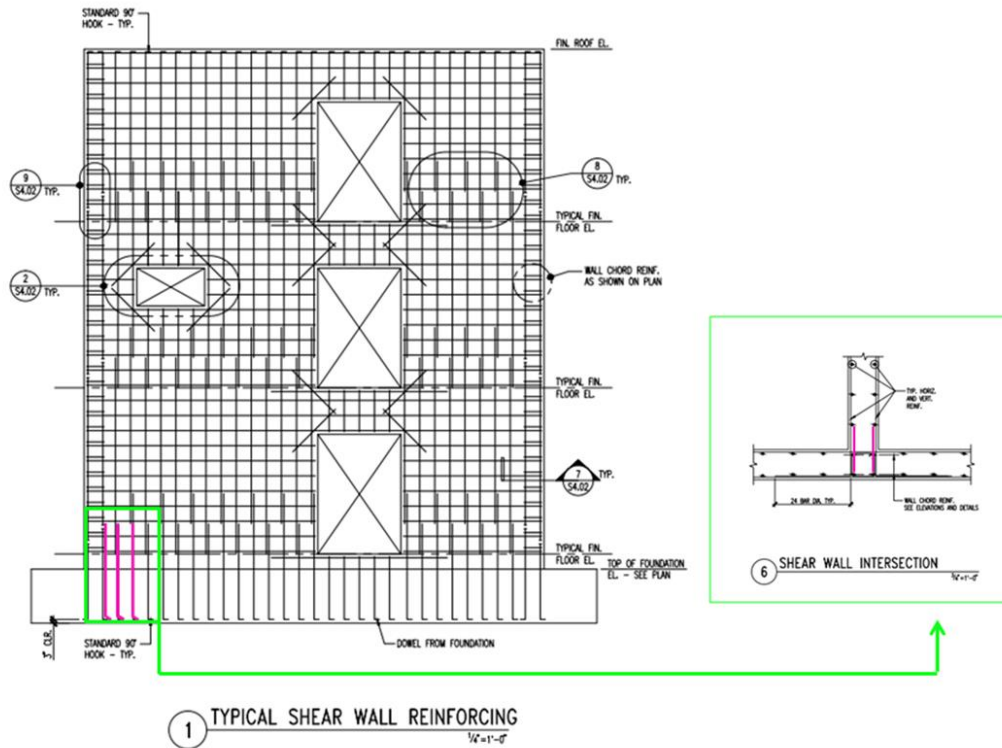


Figure 12: Typical Shear Wall Reinforcement

Building Codes:

This sub-section lists the applicable building codes and design standards associated with PFH.

- The International Building Code – 2009, International Code Council
- Minimum Design Loads for Buildings and Other Structures (ASCE 7) American Society of Civil Engineers
- Building Code Requirements for Structural Concrete, ACI 318, American Concrete Institute
- ACI Manual of Concrete Practice, Concrete Reinforcing Steel Institute
- Post Tensioning Manual, Post Tensioning Institute
- Steel Construction Manual, 13th edition, 2005, American Institute of Steel Construction Including ANSI/AISC 360-05 Specifications for Structural Steel Buildings, Specification for Structural Joints Using ASTM A325 or A490 Bolts and AISC 303-05 Code of Standard Practice for Steel Buildings and Bridges

- Manual of Steel Construction, Volume 2 Connections, ASD Ninth edition/LRFD First Edition, American Institute of Steel Construction
- Detailing For Structural Construction, American Institute of Steel Construction
- Structural Welding Code ANSI/AWS D1.1 American Welding Society
- Standard Specifications for Long span Steel Joists, LH Series and Deep Long span Steel Joists, DHL-Series, Steel Joint Institute
- Design Manual for Floor Decks and Roof Decks, Steel Deck Institute

Materials:

- ASTM C150; Type 1 or 3
- ASTM C595, Type is (limit to 35% max of cementitious content by weight)
- ASTM C33 (normal weight)
- Air entraining admixtures ASTM C260
- Chemical Admixtures ASTM C494
- *Compressive strengths after 28 day
- Footings 3000psi
- Foundation Walls 4000psi
- Shear walls 4000psi
- Columns Shown in schedule
- Slab-On-Grade 3500 psi
- Reinforcing Slabs 5000 psi
- Reinforcing Beams 5000psi
- P.T. Concrete 5000psi
- Topping 3500psi
- Deformed Reinforcing Bars : ASTM A615, Grade 60
- Welded Wire Reinforcement: ASTM A185
- Seven Wired Stress Relieved Pre-stressing Strands: ASTM A416, Grade 270
- Wide Flange Shapes and Tees: ASTM A992
- Square or Rectangular Hollow Structural Shapes: ASTM A500, Grade B, FY=46ksi
- Base Plates and Rigid Frame Continuity Plates: ASTM A527, Grade 50
- Other Structural Shapes and Plates: ASTM A36
- High Strength Bolts: ASTM A325-N or ASTM F1852
- Anchor Rods: ASTM F1554, Grade 36
- Galvanized Steel Roof Deck: ASTM A653 SS. Grade 33, G-90

Proposal:

With the ever increasing demand for entertainment, Arundel Mills Mall in Hanover, Maryland is in need for a new hotel proposal. Arundel Mills is Maryland's largest outlet, retail shopping, dining and entertainment complex with over 200 shops. Along with shopping there are interactive dining facilities such as Medieval Times and Dave and Busters. With the addition of Maryland Live! a twenty-four hour casino introduced in 2012, there is great demand for a new family friendly resort that could be used year round. This proposed thesis will address the need for a new interactive family hotel that could be used year round by providing a hotel with an attached indoor water park. The following proposal will describe the steps in which the new hotel will be converted from Prince Frederick Hall dormitory.

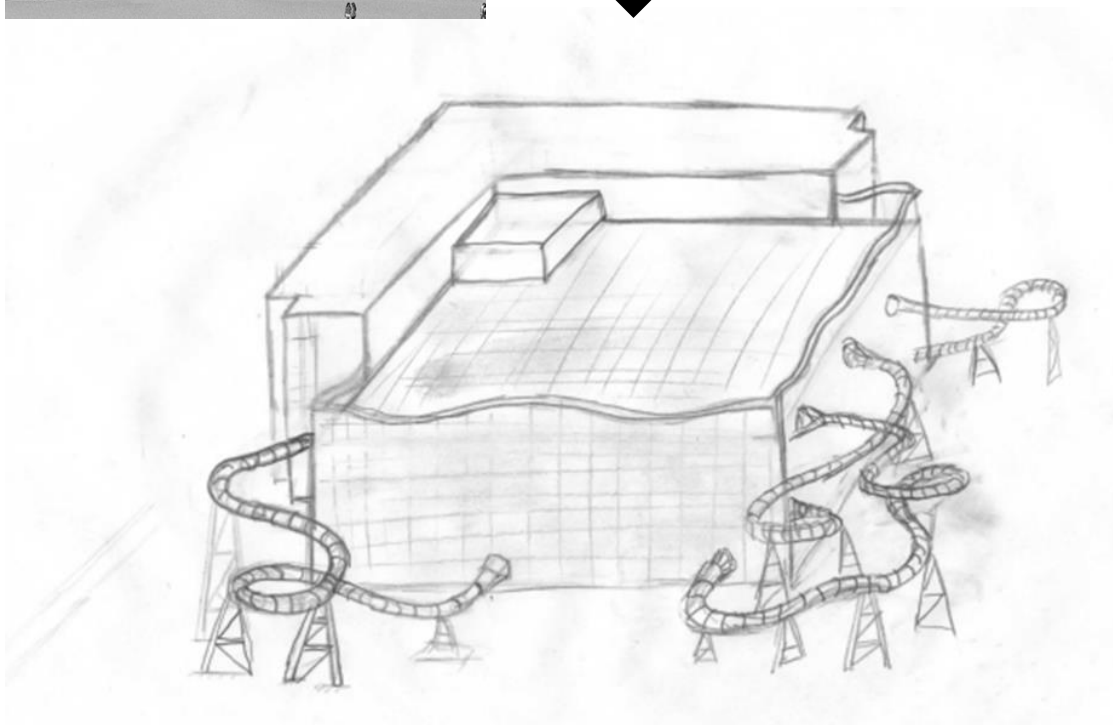


Figure 13: Hand Drawing of Proposed New Hotel

Figure 13 is a hand rendering of what the hotel will look like after it is converted from a dormitory and an indoor water park is added to the building. Figure 14 is a basic flow chart of how this proposal will be completed.

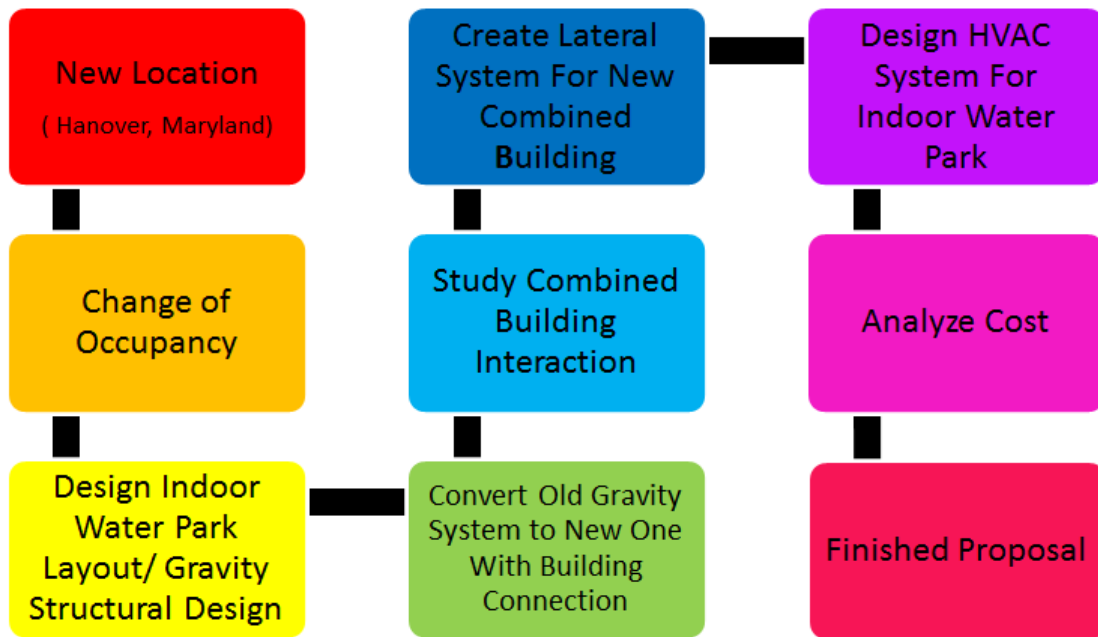


Figure 14: Proposal Flow Chart

Breadth One; Architectural Design:

The architectural breadth will be considered before the main structural depth. The new site location in Hanover, Maryland must be strategically selected to provide enough land, accessibility, and minimal environmental impact. The site will be investigated based on those properties to provide smooth transition of the building. Figure 15 shows the potential new site for Prince Frederick Hall and labels the surrounding attractions.

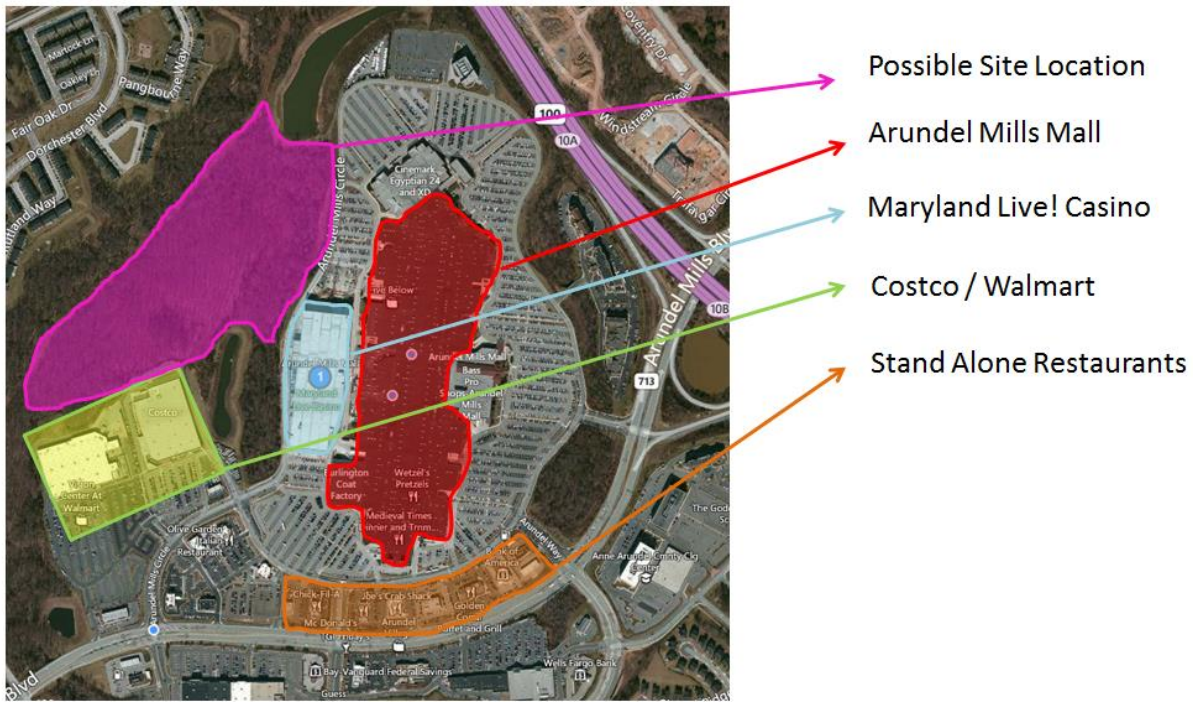


Figure 15: Potential New Site

The occupancy change will be the next step investigated. New floor plans will be designed to convert the interior of the building to a luxury hotel complete with a reception desk, gift shop, and an interactive arcade. The scub floors will be redesigned as maintenance floors with a full service laundry rooms and employee break rooms. The main floor will contain a check-in desk, offices, a gift shop, bar and an interactive game room. It will also be the main entrance to the indoor water park. Figure 16 shows the proposed flow from the exterior parking lot to the indoor water park.



Figure 16: Main Floor Building Flow

The second floor will contain meeting spaces that can be rented out and a couple up scaled hotel rooms. The 3rd floor to the 7th floor will be similar in layout consisting of single and double hotel rooms.

Next the layout of the 45,000 square foot waterpark will be designed by industry code and standards. Park layout, guest flow, and ride design will all be considered when planned. Existing water park layouts will be studied to help aid in the design. Column location will also be considered before the structure is designed. Guest flow charts will be created to show the attractions provided and how a guest will flow throughout the park. Figure 17 below shows the estimated dimensions layout for the addition.

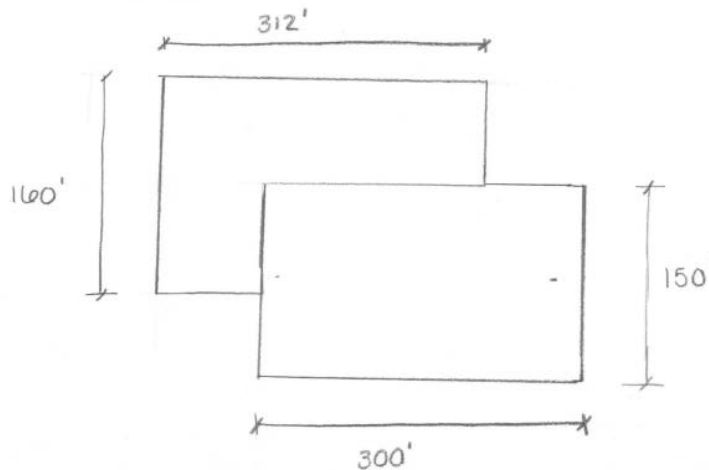


Figure 17: Estimated New Dimensions

Façade and roofing will be selected based from an architectural aesthetics and an engineering stand point. Sky lights will be used on the roofing structure to allow light inside of the space to incorporate the feeling of being outdoors while completely enclosed.

Structural Depth:

Proposed structural plans will be designed to the most recent codes and industry standards.

The water park's gravity and lateral system will both be designed using steel. Steel joist girders will span across the water parks short span minimizing the amount of columns inside of the structure. This allows for an open floor plan for the indoor water park and allows for future layout changes. Below is an image of an existing water park in Erie PA, notice the minimal column design and open floor plan; this is the concept behind Prince Frederick Halls new water park addition.



Picture 1: Splash Lagoon Erie PA (Image Courtesy of Marriot Hotel)

The joist girders will tie into steel beams which will distribute the loads to steel columns on the exterior side of the building. The transferring roof loads will be distributed to the foundation system. The roofing system of the water park will connect to the gravity system on the 6th floor. The columns where there hotel building and water park meet will be designed to carry loading from the roof of the indoor water park as well as the loads on its floor. These columns will be much larger than the other columns and will need to be considered when designing the architectural floor plans. The lateral force resisting system (LRFS) will be designed and will interact with the original concrete shear walls of the hotel to resist seismic and wind.

The hotel's two way concrete slabs will be redesigned with a composite steel decking system. A concrete system was sensible design material for Prince Frederick Hall due to its location on campus, occupancy, and fire rating. A steel design is an adequate choice because it allows for long spans with small depths. The indoor waterpark additive would not be feasible economically or architecturally constructed with concrete. Using steel for the whole design increases ease of constructability on site and shorter constructions periods. The new steel composite decking could be more economical than the existing 2-way slabs; cost analysis will be done to determine if this is possible.

New gravity loads will be calculated based off of the new architectural floor plans and occupancies. Vulcraft composite decking tables will be used to determine the appropriate decking size based off of span and allowable pounds per square foot. New column locations will be determined based off of the architectural plans and designed using the AISC steel manual. The existing lateral system from Prince Frederick Hall will be used and combined with the new lateral system for the expansion. Both will be modeled in a structural analysis program to determine adequate strength of the overall LRFS system.

The figure below is a conceptual idea of the new gravity system. This figure shows the special relationship of the existing mass and additive mass.

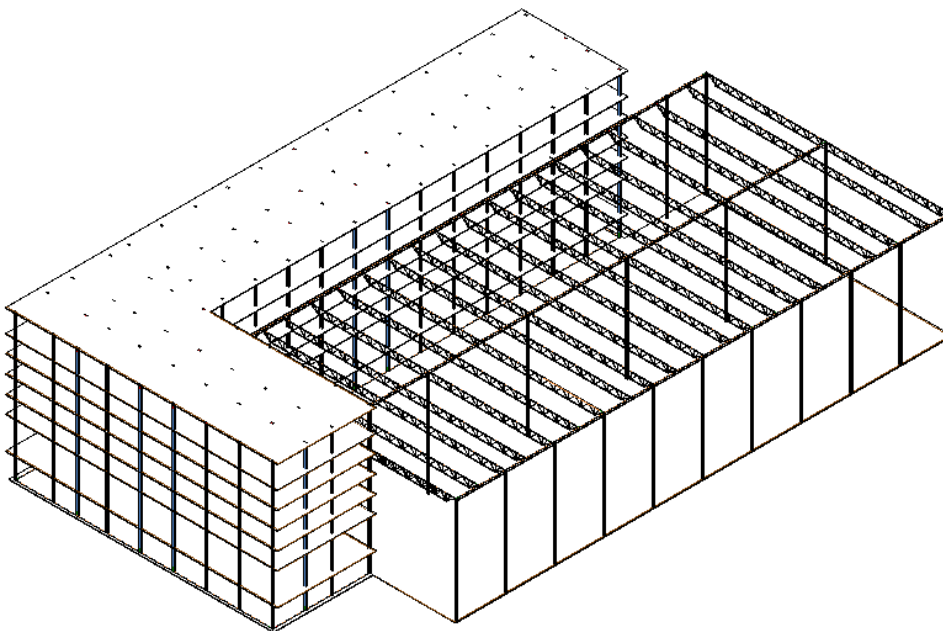


Figure 18: Conceptual Idea of Gravity System

Breadth Two; Mechanical:

Indoor water parks demand a comfortable climate. In order for humans to be comfortable in an environment, the loss of body heat should be kept minimal and the surrounding environment should be kept at a constant temperature. For the indoor water park, a HVAC system will be designed to maintain a constant temperature and minimize humidity. A 100% outside air system will be selected because the air inside is filled with humidity and odor from the pool water treatment chemicals which cannot be reused. A basic design understanding that 30-40 inch diameter HVAC ducts will be used inside of the building.

Tasks and Tools:

Task 1: Move Site Location [breadth 1]

- Look at surroundings
- Accessibility
- Building orientation

Task 2: Occupancy Change [breadth 1]

- Create new floor plans

Task 3: Design Indoor Water Park Layout [breadth 1]

- Design layout of interior spaces
- Conduct research in order to include all necessary spaces
- Choose water slide types and pool sizes

Task 4: Design Structure for Water Park [depth]

- Calculate loads on roofing structure
- Investigate interaction of water slides on structure
- Design water slide structure (RISA)
- Design joist girders and check deflection limits
- Design columns and check potential limit states.

Task 5: Design New Gravity System [depth]

- Calculate new dead and live loads
- Develop new spans based off of new architectural plans
- Design composite decking: check for minimum strength and deflection
- Investigate connection of joist girders to the composite decking system
- Design columns and check potential limit states

Task 6: Lateral System [depth]

- Study overall building interaction
- Determine where a new lateral resistive member should be located
- Design new lateral resistive member
- Model using a structural analysis program. (Potentially adding to ETABS model from tech 4)

Task 7: Design HVAC system for water park [breadth 2]

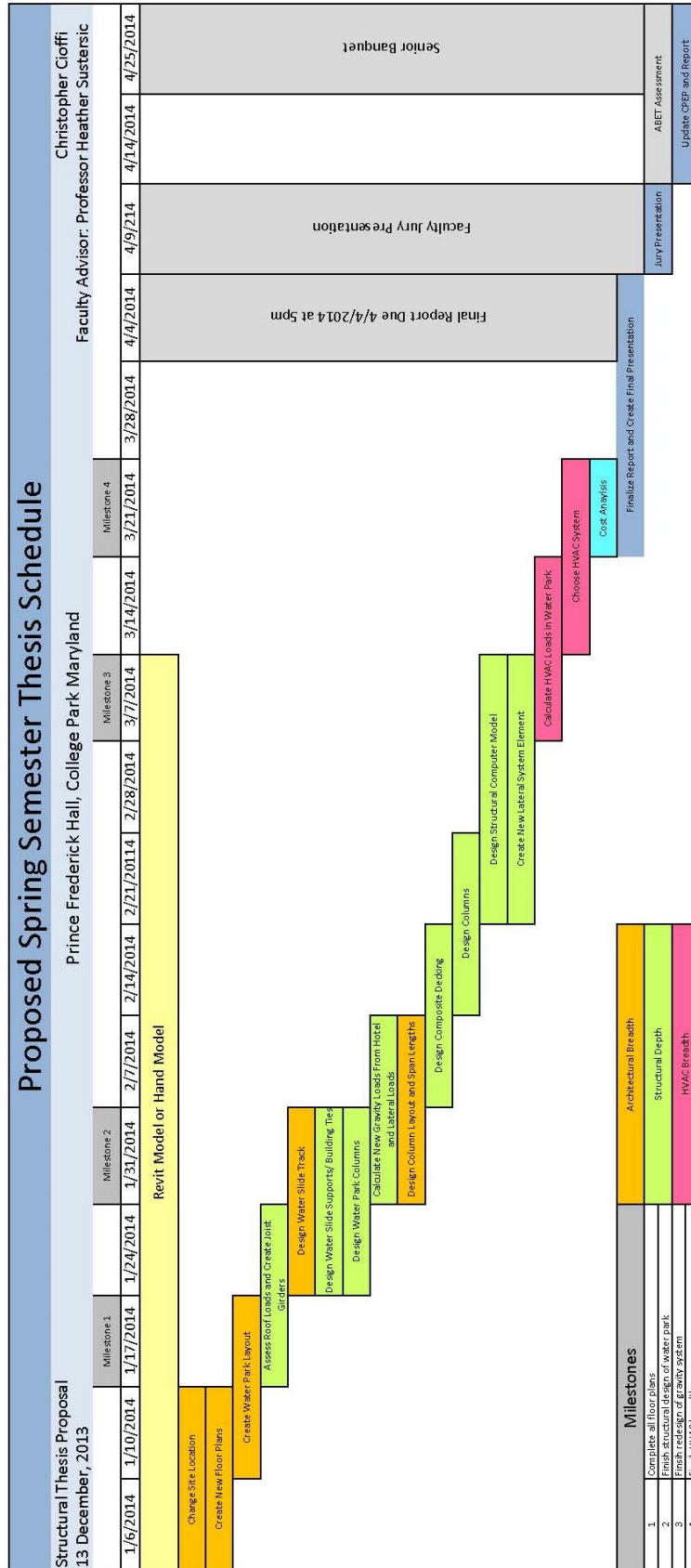
- Determine desired conditions
- Use Trane Trace to calculate loads
- Explore and choose system
- Address the impact of new system

Task 8: Cost Analysis

- Explore cost of overall building
- Use RS Means to compare existing structure to new structure

Task 8: Create Revit Model/ hand model

- Create model for renders



Conclusion:

This report has provided an overview of the proposed depth and breadths for the spring semester senior thesis work. The proposal explains the transition of Prince Frederick Hall; from a dormitory to a luxury interactive resort using architectural, structural and mechanical knowledge. First the building will undergo major layout redesign to change occupancies from a dormitory to a hotel. Next the layout and structural design of the indoor water park will be designed and analyzed. The existing gravity system will be restructured using composite decking and a new lateral system will be designed for the water park. A structural model will be completed to analyze the redesigned building under lateral loading. An HVAC system will be designed to control the temperature and humidity within the waterpark. Finally a cost analysis will determine if this new expansion is feasible.