HOWARD COUNTY GENERAL HOSPITAL

PATIENT TOWER ADDITION

COLUMBIA, MD

Thesis Proposal

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Structural Option
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I. EXECUTIVE SUMMARY

The Howard County Hospital Patient Tower was originally designed as a steel beam and composite slab system with moment frames as the lateral resisting elements. Throughout a series of analyses performed in the first three technical assignments, this system was evaluated and compared to other possible framing systems. It was determined that this system meets the strength requirements and is a suitable system for the calculated loads, but fails to meet the desirable drift limit of H/400. Another system could likely achieve the same strength and durability as the composite system but address the drift issue. It has been determined that the most viable solution would be a concrete system, as it could carry the heavy live loads while the increased stiffness could address drift.

This proposal outlines the steps that will be taken in order to determine and design the best alternative floor system. The two systems being considered are a concrete flat slab with drop panels and a concrete flat plate with stud rails. The latter system was not previously analyzed, so some initial analysis will be necessary, which is the first task. Loads will be determined based on ASCE 7-05 and the building plans, then trial sizes will be selected. Using a variety of computer programs including RAM, PCA Slab, and PCA Column, the various aspects of the structural system will be designed. This includes typical slab strips, typical column sizes, and any foundation redesign. A new lateral analysis will be performed based on the new concrete structure, since the weight of the building will affect seismic loads and some of the wind variables will change. It can then be determined if and where shear walls are necessary in addition to the inherent concrete moment frames to resist these loads. Finally, impacts on the building's lateral system due to increased weight will be considered and redesign will be performed where necessary. The two concrete systems can then be compared to determine which system is more suitable for the required loads and building grid.

In addition to the depth topic, two breadth topics will be investigated. The change from steel to concrete will affect all other systems of the building, but construction management and architecture will be further explored. For the construction management breadth, the schedule and detailed cost estimate of the concrete system will be compared to the existing composite system. For the architecture breadth, impacts to the column grid due to the switch from steel to concrete will be investigated so that necessary changes to the layout can be made. The impact on the façade will also be considered so that new elevations and sketches can be produced. At last, it will be determined if the outcome of these two breadth topics verifies the selected concrete system. A calendar is included at the end to be used as a tentative scheduling tool throughout next semester.

II. INTRODUCTION TO BUILDING

Howard County Hospital is a member of Johns Hopkins Medicine located in Columbia, MD. It has been serving the surrounding community for over thirty years and grown significantly in the last decade. The most recent expansion, the 114,261 square foot patient tower, began construction in April 2007. This tower consists of one level partially below grade, four levels above grade, and a generously sized penthouse. The basement level consists mainly of offices for the hospital staff, storage areas, and mechanical/electrical rooms. The first floor is made up of a large gym along with cardio pulmonary and physical therapy areas. Patient rooms comprise the upper three levels, with each of the three floors providing thirty new beds for surgical or other medical patients.

The patient tower addition is part of a larger allover expansion known as the “Campus Development Plan.” It is located on the south west side of the existing south building, close to Cedar Lane. Currently, the site consists of asphalt paved driveways and parking areas as well as a small landscape area. The topography gently slopes towards the west with an overall change in elevation of about 12 feet. The façade was selected to be horizontal bands of precast concrete, glass, and aluminum panels, similar to the existing hospital’s exterior.

This expansion of the hospital was designed with large column bays and a 100 psf live load for flexibility in case of future renovations. Other portions of the hospital are currently undergoing renovations, demonstrating that designing for flexibility is a legitimate issue as the hospital grows and changes. This need for flexibility also contributed to the selection of moment frames as opposed to braced frames or another lateral system.

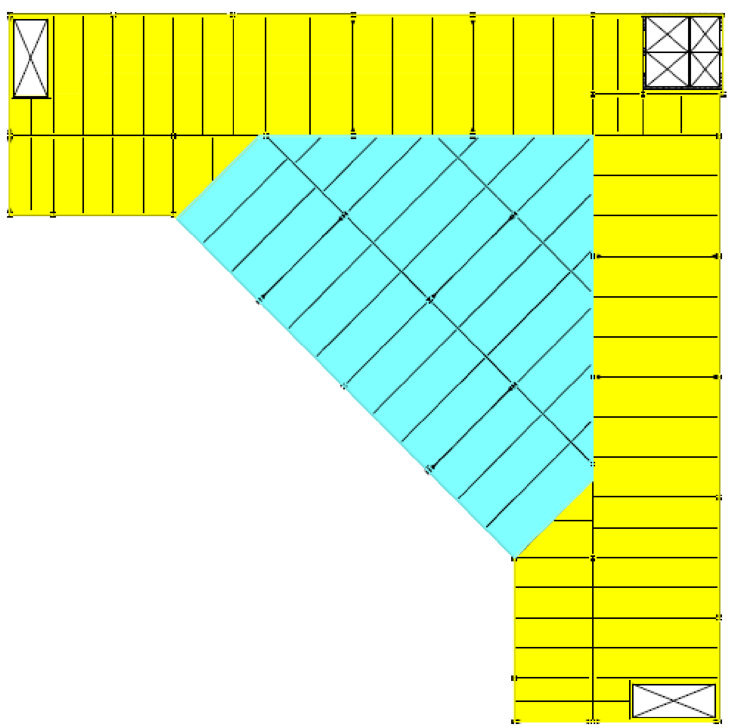
III. EXISTING STRUCTURAL OVERVIEW

Existing Floor System:

The existing typical floor framing system is 3 ¼" lightweight concrete on 2" deep 18 gage composite metal deck for a total depth 5 ¼". Composite action is achieved with ¾" diameter by 4" shear studs evenly spaced along the length of supported beams. This total floor system attains a fire rating of two hours, according to the United Steel Deck catalog. There are three typical infill beam sizes – W12x19, W14x22, and W16x26. These beams vary from 19 feet to 30 ½ feet in length and are usually spaced at 7'-3" or 9'-8". In addition to the standard composite slab, additional reinforcing of 5 foot long #4 top bars are specified at 16" on center over all interior girders.

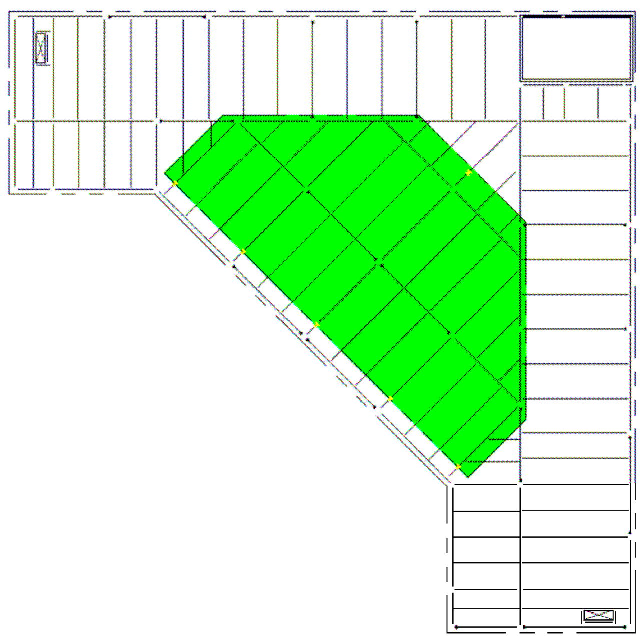
The first floor has a small 1-story extension on the north side of the building that connects to the existing hospital. This area is framed with W10x12 and W14x22 infill beams. The composite slab in this area is the same 5 ¼" thickness as the main addition.

The new addition is a uniquely shaped structure, so the floors are framed in two different directions. As you can see in the figure below, the "center" floor framing (shown in blue) is rotated at a 45 degree angle from the framing along the outer "L" of the building (shown in yellow).



Roof System:

The main roof is also a composite system since a considerable portion of it is occupied for the mechanical penthouse floor. This roof/floor system is composed of the same 3 ¼" lightweight concrete on 2" metal deck as the existing typical floors are. Infill beam sizes and lengths are similar to those mentioned above in the typical floor system. Transfer girders are also required at this level for 6 new columns that extend from the roof/penthouse floor up to the penthouse roof. You can see the portion of this level that is roof, shown in white below, and the portion that is penthouse, shown in green below.



The penthouse roof is the only floor system that varies from the typical system as it is 1 ½" wide rib 20 gage metal roof deck. The infill beams are typically either 24'-9" long W10x19s or 35'-4" long W16x36s. The framing at the penthouse roof is at a forty-five degree angle, the same direction as that in the "center" framing area of the typical floors.

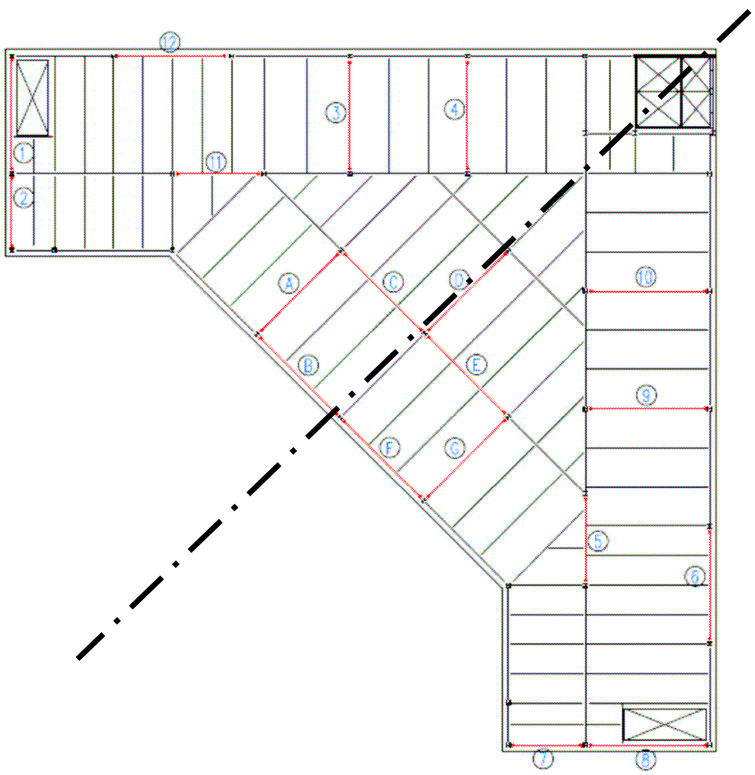
Exterior:

The exterior of the building is typically precast, metal and glass panels. The precast panels are 8" thick. At the first floor on the east side of the building, a curtain wall system is used similar to the curtain wall used on the existing hospital. The only variation to the precast, metal, and glass striping pattern is that the 39.5' true south and true north walls are made up of almost exclusively precast with a few punched out windows.

The walls that extend from the penthouse floor to the penthouse roof are composed of 6" metal studs at 16" on center with insulation. These walls have an exterior finish of "dryvit" on them for protection and aesthetics.

Lateral Load Resisting System:

In the existing system, steel moment frames were used at each level to resist lateral loads. Each floor contains 19 moment frames, 8 of which are along the perimeter of the building and 11 are interior beams. The moment frames are symmetrical about the same diagonal axis that the building is. These lateral force-resisting beams are highlighted in red in the diagram below with the axis of symmetry shown as a dashed line.



Moment frames were used to allow for floor plan flexibility. With the hospital constantly growing and the changing demands various branches (i.e. surgery, physical therapy, rehabilitation, etc.), the space initially designed for patient rooms could have an alternate use sometime down the road. If trusses or braced frames were used, the location of these braces would reduce the flexibility of the space.

Foundation System:

Five soil test borings were taken at the site of the new patient tower. They were drilled to a depth of about 30 feet each according to ASTM D 1586 standards. It was found that the top layer of soil was fill soil consisting of sand and silt, but the basement floor elevation should generally fall below this layer of soil. Therefore, a new allowable bearing pressure of 6,000 psf was used to design the foundations.

The footing sizes of the main addition vary from 8 foot by 8 foot to 11 foot by 11 foot square footings along with a few rectangular footings. Smaller 4 and 5 foot square footings occur at columns located in the one-story extension to the north of the main tower. Along the north wall of the building, there is an existing retaining wall footing. This footing is to be field verified and any portions that interfere with the new footings are to be removed.

A 14" thick concrete foundation wall surrounds that building at the basement level. The wall is reinforced with #4 bars at 12" vertical on each face and #5 bars at 12" horizontal. Concrete piers protrude from the wall at the location of exterior columns from which steel columns extend from the first floor up.

The slab on grade is 5" thick reinforced with 6x6" WWF on a vapor retarder over a minimum 4" layer of clean, well graded gravel or crushed stone. There is a small area, approximately 20 by 40 feet, where the top of slab elevation is depressed one foot.

IV. PROBLEM STATEMENT

The existing composite steel system adequately performs as the building's structural system, proving to be a suitable design for the 100 psf live load and relatively large 29 by 29 foot column bays. However, a few issues were identified in the three completed technical assignments, which suggest that another structural system could be equally if not more appropriate.

Most notably, an in-depth lateral analysis proved wind drift to be an issue. Both total building drift and story drift greatly exceeded the industry standard of H/400. Although this is not a strength requirement and is not addressed in the code, it is still an issue that requires some improvement per engineering judgment and industry standards. Either increasing steel member sizes or switching to a heavier structural system, such as concrete, could address this issue.

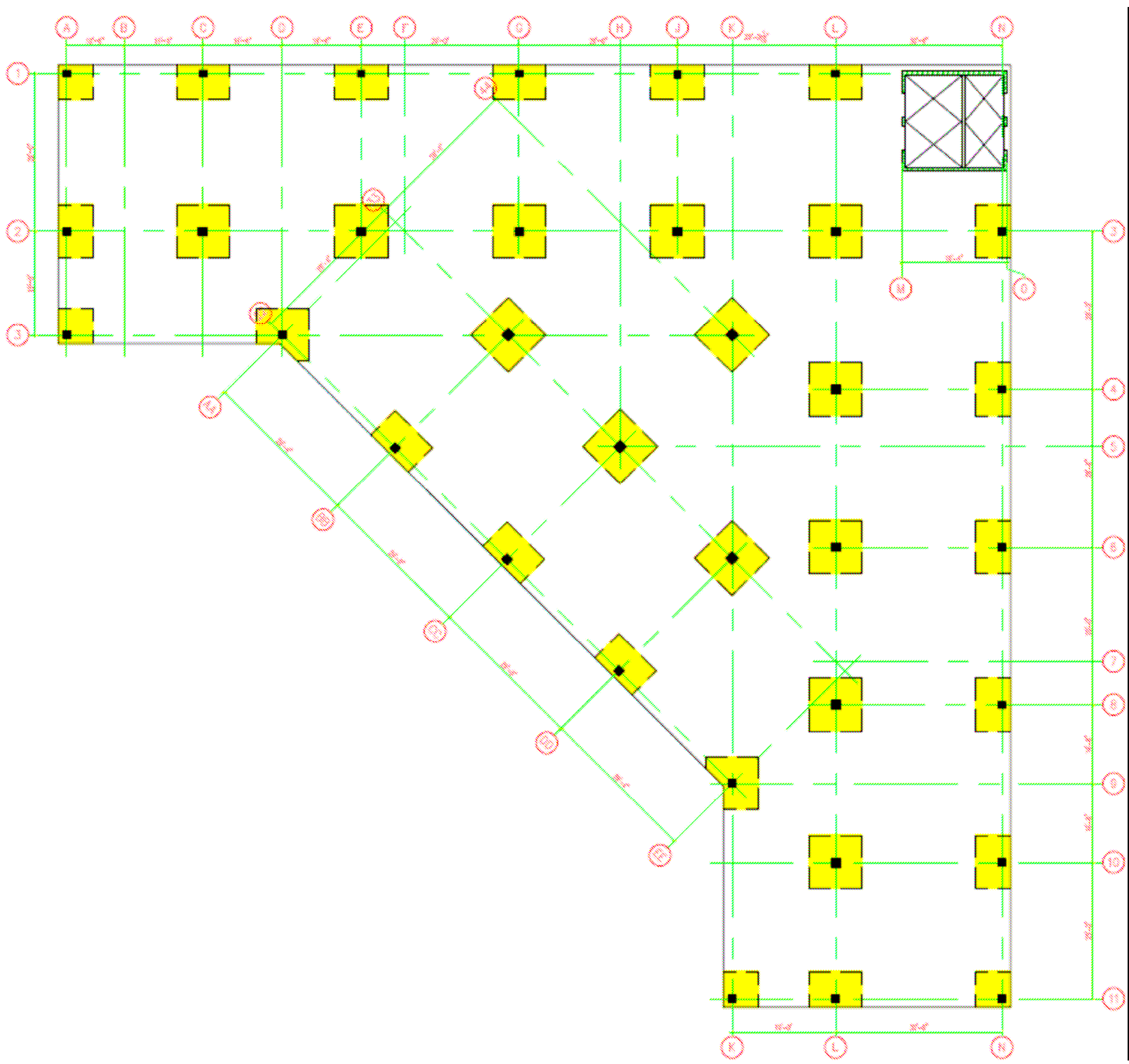
The existing lateral system resists all lateral loads with steel moment frames. Nineteen frames occur at each level and require substantially sized steel sections. This was desirable because of floor plan flexibility. However, moment connections are expensive to produce, so another lateral system could greatly decrease the total building costs, especially in terms of labor. Architectural layout would have to be considered if a lateral system redesign is to occur.

Finally, for the composite system, each individual slab depression for the stall-less showers had to be framed out in steel members. Considering there are 30 rooms on each typical floor, each room including a shower, this is a very costly, time consuming, and inconvenient task. This could be resolved by using concrete, as slab depressions are easily formed.

It has been demonstrated that an alternate structural system could prove to be more effective for this building. Ideally, the optimal system would address all of the above issues while maintaining the positive impacts of the composite system.

V. PROPOSED SOLUTION

As demonstrated in the problem statement, it is possible that another structural system could be more efficient for this design. Switching from a steel to concrete structure seems to be a viable alternative that would address most or all of the issues outlined in the problem statement. It was previously determined in technical assignment 2 that a possible concrete floor system for this building would be a two-way concrete flat slab system with drop panels. Preliminary sizes for the columns, drops, and slab were determined using the CRSI Handbook. This system is illustrated below.



Initially in technical assignment 2, a concrete flat plate was ruled out because of the large column sizes required to resist punching shear. However, upon a number of discussions, it was discovered that using a flat plate system with stud rails could be another viable alternative. Because this system was not analyzed in technical assignment 2, additional research and investigation will be required at the beginning of next semester.

Based on the preliminary analysis of a flat slab with drops performed in technical assignment 2, this floor system has many advantages, some of which are inherent to concrete. Concrete is more readily available and requires less lead-time than steel. The concrete slab provides the required 2-hour fire rating and the increase in mass and stiffness relieves the building of any vibratory or acoustical issues. Most importantly, concrete will address the drift problem previously mentioned.

The same advantages identified for the flat slab that are inherent to a concrete frame apply to the flat plate system. For the flat plate, although stud rails are fairly expensive, formwork will be reduced as no drop panels are required.

According to preliminary sizes obtained in technical report 2 per the CRSI Handbook, the existing typical 29 by 29 foot column bays can essentially be maintained with a 10" slab, 8 ½" drop panels, and 16" to 19" square columns. Some slight changes to the architectural layout and/or column grid may be necessary. The overall structural floor thickness of the building will decrease, reducing the total building height while maintaining the typical 18 foot stories.

Because the flat plate with stud rails was not previously investigated in technical report 2, there was less time to research the system. However, it is estimated that the required slab thickness would be approximately 11-12". With the use of stud rails, this system would require similarly sized columns as those used for the flat slab system. By eliminating the drop panels, even with the increased slab thickness, the total floor thickness will be reduced even more.

For both systems, the concrete columns and slabs will be poured together, inherently forming concrete moment frames to resist lateral loads. However, it is possible that concrete shear walls will also be required to provide additional resistance against lateral loads. The need for shear walls will be assessed during the redesign process, at which, if required, optimal locations will be determined per the building plans.

By switching from steel to concrete, the building weight will greatly increase. This could have a negative effect on the foundation sizes and seismic loading. The existing spread footings will need to be evaluated and changes in size and/or reinforcing due to the increase dead load will most likely be necessary. Seismic forces will be thoroughly reevaluated.

It must be recognized that a redesign of the building structure will affect all other building systems. Two of these aspects will be addressed in the breadth study. Efforts will be made to remain cognizant of this issue and briefly address any considerable impacts due to the change in structural system throughout the report.

VI. SOLUTION METHOD

Depth: Design a New Concrete Structural System

This project will begin with research on the flat plate with stud rail system, as I am not very familiar with the use of stud rails. Between internet research and conversation with practicing engineers, I hope to gain insight into how the stud rails compare to a flat slab system along with any advantages and disadvantages. Once it is determined whether this floor system is a viable alternative, design will begin.

Assuming the flat plate system proves to be a suitable solution, the design of the new two-way systems will utilize the Equivalent Frame Method from Chapter 13 of ACI 318-05. The slab will be designed utilizing PCA Slab, which directly references the Equivalent Frame Method outlined in ACI. To begin, trial slab, column, and drop sizes (for the flat slab) previously obtained from the CRSI Handbook will be input into PCA Slab. The program will design the slab based on self weight, superimposed dead load as prescribed, and patterned live loading. Once run, the output will identify the necessary reinforcement in each column and middle strip. This program gets run for each slab strip in each direction.

Once the slab has been designed, RAM Structural System will be used to determine column gravity and lateral loads. First, the model will be built using column grids and locations as identified in the building plans. Once dead and live loads are specified, the gravity analysis of the building will be performed. It is important to note that the gravity analysis includes a calculation of slab self weight, so that will not be included in the dead load. This analysis will provide the user with gravity loads in each of the columns. Next, in RAM Frame, lateral load criteria will be specified. This includes Wind Speed, Importance Factors, and Seismic Coefficients, along with some other criteria. The Analysis will be performed for a variety of wind and seismic cases, with loading in various directions, to determine the design base shear. In “Member Results”, the axial load and moment in each column due to lateral loading can be obtained. Finally, a drift analysis for each wind and seismic case will provide the user with drift values at either a specified point of the center of mass.

After obtaining all of the necessary loads for each column from RAM, PCA Column will be used to check the column sizes and determine the required amount of reinforcing. The version of PCA column on the AE computers references ACI 318-02. PCA Column allows the dimensions of the column, material properties such as f’c and w_{conc}, and reinforcement to be entered. Then, the loads can be input for each load case. PCA applies the load combinations, from which interaction diagrams of the column can be viewed. This will be done for several representative columns to determine the optimum reinforcement.

Foundations will not be fully redesigned, but in an attempt to estimate additional concrete and reinforcement costs, hand calculations will be performed to obtain a "percent increase" in foundation sizes. The column loads calculated using PCA column will be used to size the foundations based on f = P/A + M/S. The allowable bearing pressure is available in the geotechnical report previously obtained.

Finally, the flat plate and flat slab systems will be compared on the basis of structural performance, cost estimates, and constructability. Cost estimates for materials and labor will be taken from RS Means 2006 based on the amount of concrete and reinforcing calculated throughout all tasks for all structural elements. Other costs such as formwork will also be evaluated. It will also be important to consider any effects that the structural systems have on other building systems. Once this comparison is made, the best concrete system of the two will be chosen.

Breadth #1: Construction Management

As mentioned above, changes to the structural system will affect all of the other building systems. One of the most important issues will be construction management, since switching to concrete will result in a completely different cost estimate and schedule than the existing composite steel system.

First, any available information on the actual building cost for the existing composite system will be obtained from the Construction Manager. This data will be used in conjunction with RS Means 2006 to estimate the overall building cost, including materials and labor, for the existing composite system. Some of the major costs for the composite system will include, steel framing, shear studs, lightweight concrete, and moment connections. Also, any scheduling information available for the existing composite system will be requested. This will allow a mock schedule to be produced based on the provided schedule and/or knowledge of steel fabrication, lead time, etc.

Next, RS Means will be used to evaluate the cost of the new concrete system chosen – either the flat plate with stud rails or flat slab with drops. Concrete, formwork, and reinforcing will be some of the major expenses for this system. A mock schedule for the new concrete system will be produced, considering issues such as concrete curing time. It will be helpful to have contacts in the construction industry for additional scheduling insight.

The total cost and schedule of the two structural systems will be compared to determine if one of the systems has advantages in terms of construction. This decision will mainly be based on cost and schedule. Some research will be performed to determine if the costs and scheduling for each of the two systems seem reasonable.

Breadth #2: Architecture

It is almost certain that there will be some changes to the column grid and column locations when switching from the steel to concrete system. Also, the typical W12 and W14 girders will become larger concrete columns, which could impede on the existing room layout. These changes will be evaluated so that a typical floor plan can be redesigned where necessary.

It is important that any changes to the floor plans maintain the current spatial relationships. Once it is identified where the alterations will occur, it may be necessary to use bubble diagrams and/or other space/relation exercises to reconfigure the floor plans. After the floor plan is rearranged, a new typical floor will be drawn in AutoCAD to be included in the final report.

The floor plan is not the only architectural aspect affected by the structural changes. Currently, the façade consists of precast and metal panels with lots of glass. The new, larger concrete columns are likely to require changes to the façade. Also, the overall floor thickness will decrease, further changing the “striping” of the façade. Sketches of possible new façade options will be produced, taking the new concrete framing into consideration.

VII. TASKS AND TOOLS

A. Research Flat Plate with Stud Rails System

Task 1: Learn More About Stud Rails

a. Research stud rails on the internet to become familiar with what they do and how they work.
b. Look into similar projects that did or did not use stud rails to resist punching shear and discuss advantages and disadvantages with the practicing engineers.
c. Collect preliminary cost estimates in terms of materials and construction.

Task 2: Determine if Flat Plate with Stud Rails is a Viable Alternative

a. Use information gathered in task 1 to determine if this alternative will provide suitable member sizes for the required 29 by 29 foot column bays
b. Compare cost estimates to those obtained for the concrete flat slab system.

B. Design Flat Slab and Flat Plate Systems with Columns (Same Steps Required for Both):

Task 1: Determine Trial Member Sizes

d. Determine minimum slab thickness requirement for a 29 by 29 foot bay per ACI 318-05 and CRSI Handbook.
e. Establish minimum interior and exterior column sizes per CRSI Handbook.
f. For flat slab system, determine required drop panel size for given columns and bay sizes per CRSI Handbook and ACI 318-05.

Task 2: Determine New Design Loads

a. Calculate new self weight of both floor systems based on trial member sizes obtained in Task 1.
b. Add superimposed dead loads specified in building plans to calculate the total dead load.
c. Determine live loads from building plan general notes.

Task 3: Design Two-Way Slab in PCA Slab

a. Choose representative slab strips to model from the building plans.
b. Input slab thickness, column sizes (and drop sizes) per task 1 for individual strip.
c. Run PCA Slab and check capacity of slab, deflection, and required reinforcement for each strip.
d. Make any necessary changes to trial member sizes that may increase efficiency of slab. Rerun PCA Slab with adjusted sizes if required.

e. Perform a simplified direct design hand analysis for each floor system to spot check PCA Slab's output.

Task 4: Build Model in RAM and Obtain Gravity and Lateral Loads

a. Set up building grids according to designer's plans.
b. Add columns at locations identified on building plans.
c. Save two separate files, "Flat Plate" and "Flat Slab"
d. Input column sizes and slab (and drop) geometry for each floor system per task 1, unless any changes were made in task 3.
e. Apply dead and live loads to each model as calculated in task 2.
f. Run gravity analysis for each model in order to determine column loads.
g. Perform a load takedown by hand for 2 or 3 columns to check the validity of RAM's gravity load output.
h. Input lateral analysis criteria for wind and seismic load cases. This should be the same for both systems.
i. Run lateral analysis in both files to determine column lateral loads.
j. Check drift values from wind and seismic loading and compare to industry standards.
k. Perform wind pressure calculations by hand and compare to RAM to verify results.

Task 5: Design Columns in PCA Column

a. Based on gravity and lateral load analysis, choose representative interior and exterior columns to size.
b. Input column size into PCA Column.
c. Determine trial reinforcement based on column size and loads. Input into program.
d. Enter gravity and lateral loads obtained in task 4.
e. Run program and check interaction diagram. Make any necessary changes to reinforcement for column optimization. Run program again if required.
f. Repeat for each of the selected representative columns from both floor systems.
g. Check PCA's output with hand calculations for one column in each floor system to verify required reinforcement and other results.

Task 6: Consider Foundation Re-design Based on New Loading

a. Choose common footing sizes from building plans and compare old column loads to new column loads.
b. Obtain soil bearing pressure information from geotechnical report.
c. Perform hand calculations using $f = P/A + M/S$ to determine new required footing size for the given bearing pressure.
d. Determine the standard "percent increase" of footings as a result of switching from a steel to concrete system.

C. Compare Framing Systems and Select the Best Alternative:

Task 1: Collect Cost Information on Both Systems and Compare

e. Sum the required amount of concrete and required amount of reinforcing for each system, including slabs and columns.
f. Using RS Means, obtain cost information on each of the systems based on the quantities calculated.
g. Consider additional costs for the two systems such as formwork.
h. Compare costs, member sizes, and any other varying factors between the two systems.

Task 2: Select the Optimal New Framing System:

a. Based on above comparison, choose which system is the best alternative for this building.
b. Draw typical framing plans to graphically demonstrate the new system

D. Breadth Topic #1: Construction Management

Task 1: Determine the Cost and Schedule of the Existing Composite System:

a. Inquire to the CM about any actual cost data or scheduling information that may be available.
b. Using RS Means and Cost Works, estimate any costs that were not available including material and labor expenses.
c. Based on any scheduling information provided by the CM and knowledge as to steel fabrication, lead time, erection time, etc., create a mock schedule of construction.

Task 2: Determine the Cost and Schedule of the New Concrete System:

a. Based on the selection of a new concrete framing system, use RS Means and Cost Works to estimate material and labor expenses.
b. If possible, obtain cost information for a building of similar size and function to verify the estimate made in part a.
c. Based on knowledge of concrete availability, curing requirements, etc., create a mock schedule of construction.

Task 3: Comparison of Steel vs. Concrete Systems

a. Compare detailed cost estimates obtained in tasks 1 and 2. Determine any significant savings provided by one system or the other.
b. Compare schedules and total time of construction obtained in tasks 1 and 2. Determine any significant scheduling advantages or disadvantages for one system or the other.

c. Make a decision as to whether one system is significantly advantageous in terms of construction management.

E. Breadth Topic #2: Architecture

Task 1: Identify Necessary Floor Plan Adjustments:

a. Identify changes in column grid or column locations required by new concrete floor system.
b. Using trace paper, overlay new column locations as identified in part a to existing floor plans. Make note of rooms that will require relocation or new layouts.
c. Redraw columns as square/rectangular concrete columns rather than steel w-shapes. Note where the new column sizes pose a layout issue. Realize that the steel columns were hidden and concrete columns may be exposed.

Task 2: Make Changes to Floor Plan:

a. Based on the issues identified in task 1, perform bubble diagram and space planning exercises to rearrange the necessary spaces.
b. While maintaining general spatial relationships and room sizes, reconfigure a typical floor plan.
c. Draw the new floor plan in AutoCAD.

Task 3: Consider Façade Alterations

a. Identify the location of exterior concrete columns.
b. Using the elevations provided by the architect, determine where the increased column sizes require changes to the façade.
c. Considering the decreased structural floor thickness in the new concrete system, determine if any positive changes to the façade could be made.
d. Sketch ideas for new façade based on parts a-c. Realize that the same overall look of precast, glass, and aluminum striping is to be maintained, as it mimics the façade of the existing hospital.

VIII. TIMELINE

JANUARY

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1 WINTER BREAK →	2	3	4	5
6 →	7	8	9	10	11	12
13 →	14 Research Flat Plate with Stud Rails System: Tasks 1-2 →	15	16	17	18	19
20 Design Flat Plate and Flat Slab System: Tasks 1-2 →	21	22	23	24	25	26
27 Design Flat Plate and Flat Slab System: Task 3 →	28	29	30	31		

FEBRUARY

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1 Design Flat Plate and Flat Slab System: Task 4	2
3 →	4	5	6	7	8	9
10 →	11	12	13	14 Design Flat Plate and Flat Slab System: Tasks 5-6 →	15	16
17 →	18	19	20	21	22	23
24 Compare Framing Systems and Select the Best Alternative: Tasks 1-2 →	25	26	27	28 Construction Management Breadth #1: Tasks 1-2	29	

MARCH

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1 →
2 →	3 →	4 →	5 →	6 →	7 →	8
9	10 SPRING BREAK: Visit Site to See Construction Progress	11	12	13	14	15
16	17 →	18	19 Construction Management Breadth #1: Task 3	20	21	22 →
23 Architecture Breadth #2: Tasks 1-2	24	25 →	26 →	27 →	28 →	29 →
30 Architecture Breadth #2: Task 3	31					

APRIL

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