# The Forensic Medical Center


Image courtesy of Gaudreau, Inc.

Thesis Proposal
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Keenan Yohe
Structural Option

Dr. Memari – Faculty Advisor

# Executive Summary

The Forensic Medical Center is a five-story, 105-foot tall building, with 121,000 square feet of office, classroom, and laboratory space. The structural system as designed is an 11”-thick two-way flat-plate concrete slab, with 24”x24” concrete columns, and a dual lateral system consisting of concrete moment frames and 12”-thick concrete shearwalls.

Because of the high-tech laboratory equipment inside, vibration issues are very important in the design of the structural system. Concrete is a logical choice, but there are few design guidelines for vibrations in concrete. The proposed thesis will include an investigation of a composite steel floor system that can be more easily designed for vibrations, along with steel columns and a steel braced frame lateral system.

As with almost any construction project, budget and schedule are crucial to The Forensic Medical Center. As part of a breadth study, the proposed thesis will analyze the effects of a steel structural system on the overall cost, schedule, and constructability of the project, compared to the existing concrete system.

An early project idea was the inclusion of a temporary triage unit in the ground floor parking area of The Forensic Medical Center in the case of a local catastrophic event. The idea was cut because of budget constraints. The proposed thesis will research the lighting, electrical, mechanical, and architectural requirements of such a triage unit, and include a cost estimate and feasibility study for the inclusion of the unit into the building.

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## BUILDING DESCRIPTION

*Columns*

All of the columns in the building are normal weight concrete with a strength of 5000 psi. Typically, the columns are 24” by 24”, except for ten 34” diameter circular columns in the parking garage area. Exterior columns are reinforced with eight #8 bars and #4 ties at 12” on center. Interior columns are reinforced with eight #10 bars and #4 ties at 12” on center.

*Slabs*

The ground floor parking garage level of the Forensic Medical Center is a 6” thick, normal weight concrete slab-on-grade, concrete strength is 3500 psi. At the edges of this slab are concrete grade beams that are 30”-36” deep, with concrete strength of 3000 psi.

The floor systems of levels two through five are typically 11” thick, two-way, flat-plate, normal weight concrete slabs with 26” wide by 36” deep concrete perimeter beams. Slab reinforcement is typically #5 bars at 15” on center, each way, top and bottom at mid-span, with heavier reinforcement at the columns. Typical slab spans range from 22’-6” to 30’-0”.

Variations on the typical floor slab include large recessed slab areas for body storage coolers and freezers on level two. The finished floor elevation of these slabs is 10” lower than the typical finished floor elevation. These slabs are 11” thick, one-way slabs, and are supported by monolithically-poured concrete beams with sizes ranging from 18” to 40” wide by 11” to 26” deep. On level three, there are two 9” thick, two-way slab sections that serve as low roofs. Also, a high-density file storage area requires two 24”x18” concrete beams under the mid-span of the slabs, between grid lines 3 and 4.

The Penthouse level floor slab consists of two areas. The roof areas are an 8” thick, two-way, flat-plate, normal weight concrete slab with #5 bars, typically spaced at 16”, each way, top and bottom for reinforcement. The slab under the mechanical equipment is increased to 15” thick, with #5 bars at 11” each way, top and bottom, for typical reinforcement.

A steel-framed mechanical penthouse sits on the top of the Penthouse level. The HSS 14”x14”x½” columns are cantilevered from the concrete floor slab and extend 20’ to the roof.

*Lateral System*

The lateral force resisting system of the Forensic Medical Center is a dual-system, consisting of four ordinary reinforced concrete shearwalls with an ordinary reinforced concrete moment frame.

Shearwalls 1 and 4 are oriented east-west, and are tied to an exterior column. On the interior side of these walls is a 4’-6” boundary element containing 12 #9 bars for vertical reinforcement, with #4 ties at 12” on center. The webs of these walls contain the minimum amount of reinforcement for $\rho = 0.0025$, which is #5 bars at 18” on center each way, in each face.

Shearwalls 2 and 3 are oriented north-south. At both ends of these walls are 6'-0" boundary elements with 14 #9 bars for vertical reinforcement and #4 ties at 12" on center. The webs of these walls also contain the minimum amount of reinforcement, #5 bars at 18" on center each way, in each face.

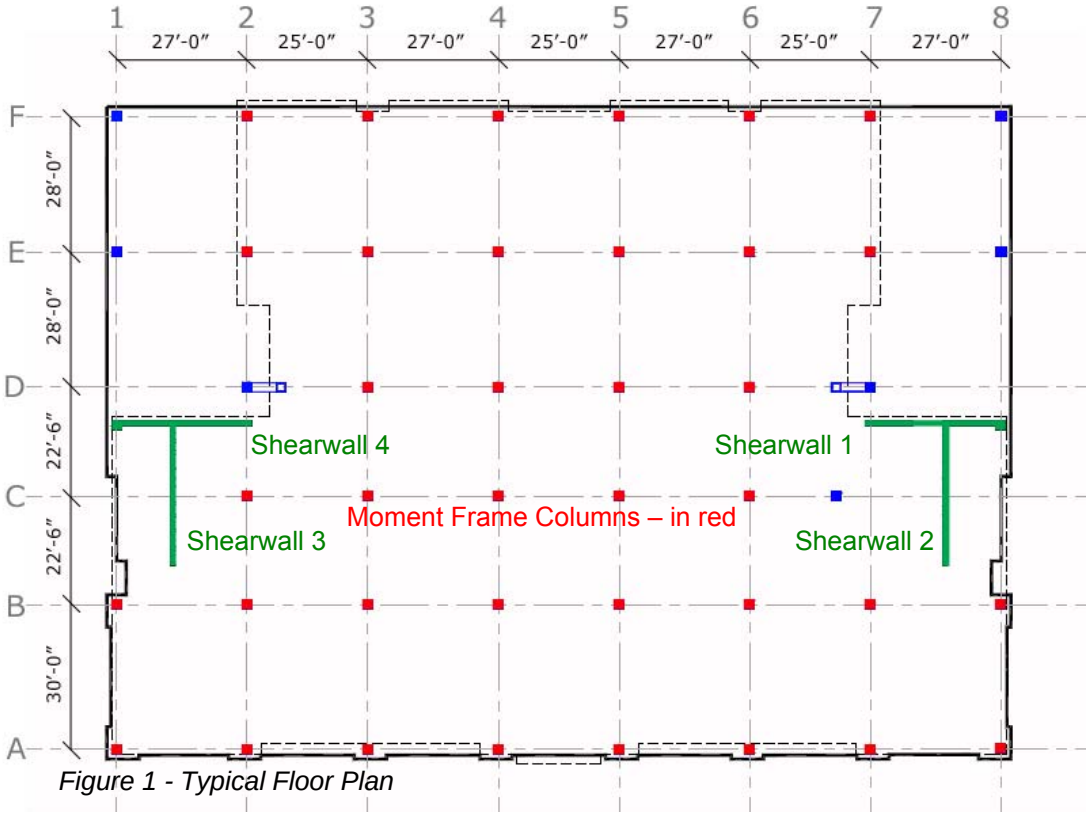



*Figure 1 - Typical Floor Plan*

## PROBLEM STATEMENT

Because The Forensic Medical Center will be home to a modern, high-tech laboratory, with equipment that is very sensitive to motion, vibration concerns are critical to the structural system design. While a concrete structural system is generally a good choice to resist vibration problems, there are few guidelines for designing a concrete system for vibration. Typically, it is difficult to tell whether a concrete system will meet vibration criteria until the structure is already built. On the other hand, design guides have been published for vibrations in composite steel systems.

The budget of the building is also a concern. Any changes to the existing building structural design need to be of similar or lower cost. Based on previous Technical Reports, some parts of the concrete structural system appear to be larger than required. A steel system could be more efficient, reducing the amount of material used and thus reducing seismic loads as well, leading to a lighter lateral system.

## PROPOSED SOLUTION

A composite steel structural floor system with steel columns is proposed, to be designed for vibration criteria. The concrete shearwalls will be replaced with steel braced frames. These changes can be done with little effect on the floor layout and architecture of the building, while making certain that vibration criteria are met.

According to Technical Report 2, typical beam and girder depths will be in the 16”-18” range, with a slab-on-deck thickness of 4”. This is a considerably thicker floor system than the 11” existing concrete slab, but The Forensic Medical Center is well within height restrictions. The new steel system may be more efficient than the existing concrete one, creating a lighter and possibly more cost-effective design.

To implement these changes, a computer model of the new gravity system will be constructed and tested in RAM. Since the new system will result in changes to the height, weight, and lateral system of the building, lateral loads will be recalculated and applied to a new lateral system model.

## BREADTH TOPICS

*Cost and Schedule*

A Construction Management breadth study will be done on the new composite steel system. The cost, schedule, and constructability of the new system will be compared to the existing concrete system to determine feasibility, given the budget and time constraints of the project. Primavera and MC2 will be used for this part of the analysis.

*Triage Area*

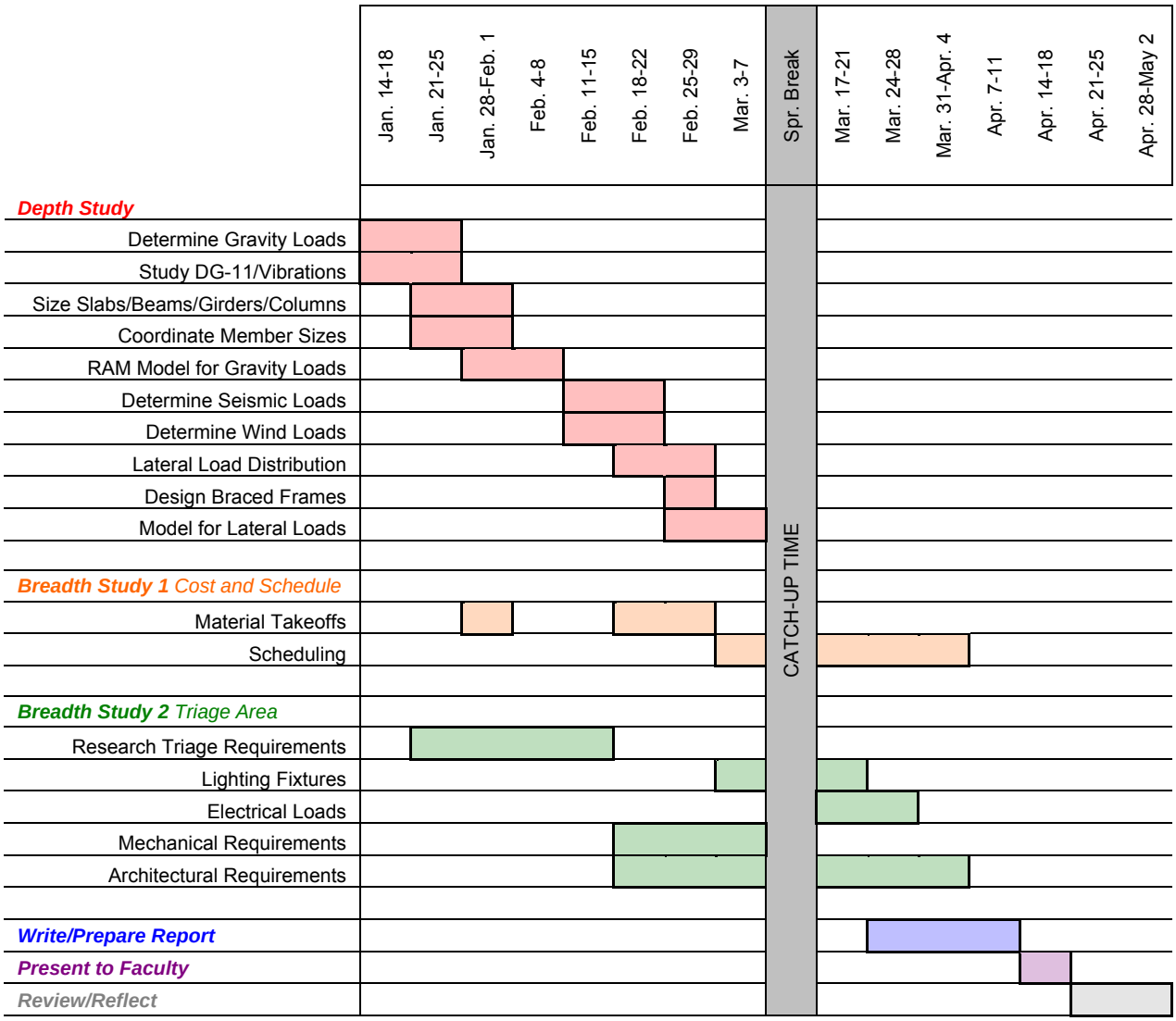
An original idea for The Forensic Medical Center was to include a temporary triage area in the ground floor parking lot, in case of a catastrophic event. The idea was shelved due to budget concerns. A main requirement for the triage area is adequate lighting. Also required are electrical outlets, mechanical elements, plumbing, and some temporary architectural elements that can be set up and removed quickly and easily. Research will be done on the specific requirements for a triage area, and the cost of implementing this idea will be investigated, as well as the feasibility.

## TASKS AND TOOLS

A list of tasks to be completed in the investigation of these proposals, as well as the tools required, is included below. In addition, a tentative schedule is included showing the estimated time to complete each task.

1. Gravity System
    - ASCE 7-05 for dead, live, snow loads
    - AISC Design Guide 11 for vibration design
    - Determine preliminary slab and member sizes
    - RAM model check of composite steel floor system
2. Lateral System
    - ASCE 7-05 for wind and seismic loads
    - Determine load distribution to steel braced frames
    - Determine member sizes for steel braced frames
    - Lateral system model – check strength and serviceability
3. Cost and Schedule
4. Triage Area
    - Research triage requirements
    - Determine size/type/quantity of lighting fixtures/electrical outlets
    - Determine new electrical load
    - Determine architectural requirements

## SCHEDULE


Jan. 14-18
Jan. 21-25
Jan. 28-Feb. 1
Feb. 4-8
Feb. 11-15
Feb. 18-22
Feb. 25-29
Mar. 3-7
Spr. Break
Mar. 17-21
Mar. 24-28
Mar. 31-Apr. 4
Apr. 7-11
Apr. 14-18
Apr. 21-25
Apr. 28-May 2
CATCH-UP TIME
Depth Study
Determine Gravity Loads
Study DG-11/Vibrations
Size Slabs/Beams/Girders/Columns
Coordinate Member Sizes
RAM Model for Gravity Loads
Determine Seismic Loads
Determine Wind Loads
Lateral Load Distribution
Design Braced Frames
Model for Lateral Loads
Breadth Study 1 Cost and Schedule
Material Takeoffs
Scheduling
Breadth Study 2 Triage Area
Research Triage Requirements
Lighting Fixtures
Electrical Loads
Mechanical Requirements
Architectural Requirements
Write/Prepare Report
Present to Faculty
Review/Reflect