Frank Burke
Structural Option
December 12, 2005
Thesis Advisor – Thomas E. Boothby

Sallie Mae Headquarters
Reston, VA
Proposal

Executive Summary

Sallie Mae HQ is an office building located in Reston, VA. Sallie Mae consists of nine floors of steel tower framing which rests on a five level (mild reinforced concrete) parking garage that is below grade. The lateral resistance for the steel tower is provided by braced frames that are hidden within the stairwell and elevator walls in the central core of the building. The braced frames continue down to the first floor and transfer their loads to shearwalls which extend to the foundation. The area of a typical office floor is approximately 22,000 square feet and consists of structural steel beams with a composite 3¼" lightweight concrete floor slab on 2" deep metal decking (5 ¼" total depth). The tower has three bays along its width (42'-0", 23'-0", 42'-0") and its typical bay in the opposite direction is 28'-0" long. The area of a typical level in the parking garage is approximately 75,000 square feet. The garage is made from a two-way slab system that features drop panels. The drop panels are primarily 3.5" and elevated slab thicknesses vary from 9" to 14". Spans reach 28' and normal column sizes are 30" x 30" concrete columns.

The floor structure must be designed to resist deflection caused by 42' spans. Furthermore, the floor depths must be maintained below 27" to provide an efficient amount of room for mechanical equipment in ceiling envelope. Through my analyses of alternative systems to resist this problem, post-tensioning was the clearly the best alternative. My preliminary design will be as follows; the floor will consist of shallow, wide post-tensioned girders that span the (42'-0", 23'-0", 42'-0") width of the building, and one-way post-tensioned slabs spanning in the opposite direction; the columns will be 24" and 30" square columns; the floor to floor height will remain 14'; the lateral load system will be shear walls at the stairwells and at the elevator shafts in the central core of the building. The design of the one-way slab will be based on the Post Tensioning Manual, Fifth Edition and ACI 318-05. The specific strength and weight will be confirmed after preliminary calculations. The beams spanning the width of the building will be designed as T-beams. A column takedown will be made using rough areas. Preliminary square column sizes will be chosen. Seismic and wind loads on the building will be found using ASCE 7-02. Shearwalls will then be designed. A complete full frame analysis will be made by using the Equivalent Frame Method. The results will be confirmed with the computer program ADAPT.

For my breadth analyses I chose construction management and mechanical due to the following. Construction management is a major issue due to the difficulty of post-tensioning. Scheduling must be carefully implemented, and the design needs to be clear to minimize any possible mistakes in the construction process. Space for the layout of the post-tensioning strands must be planned and the cost must be researched. Mechanical systems and any possible changes in the flow of ductwork will be critical dampened by the use of post-tensioning. Mechanical considerations must be made because post-tensioning doesn't easily allow holes to be made in the floor slab.

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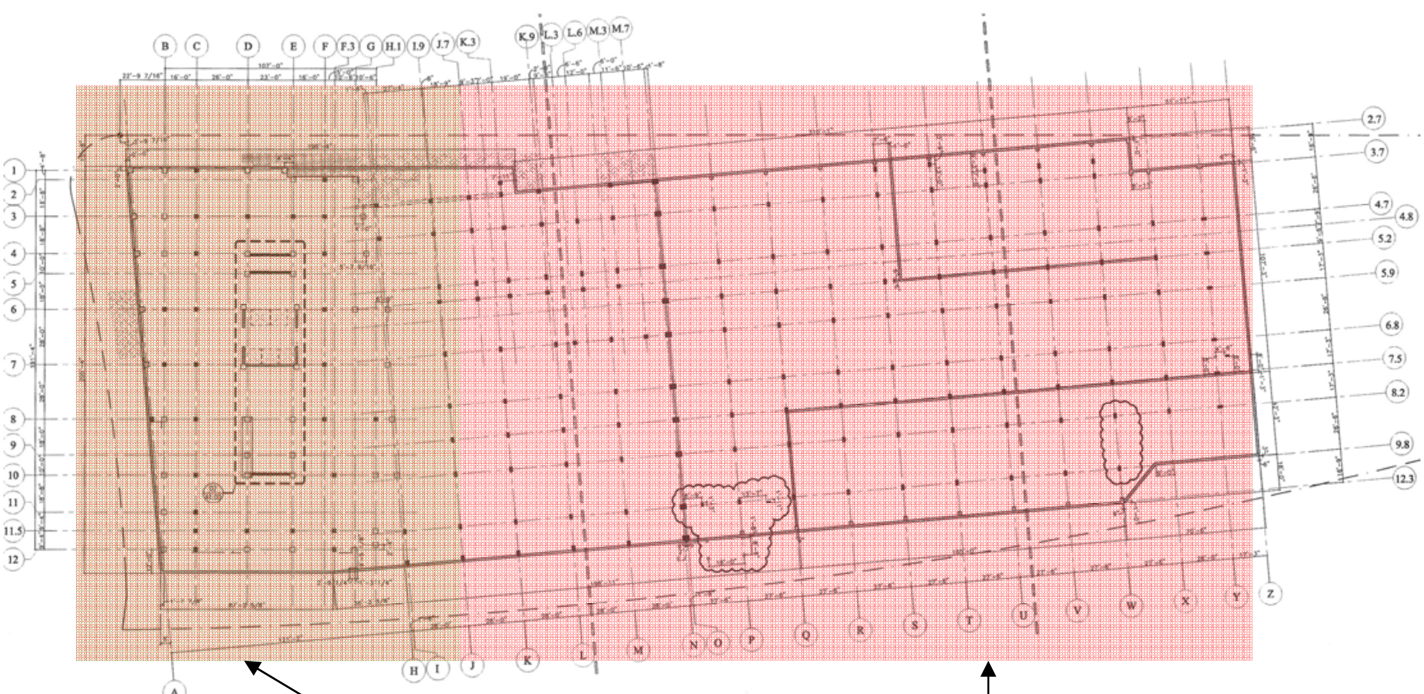
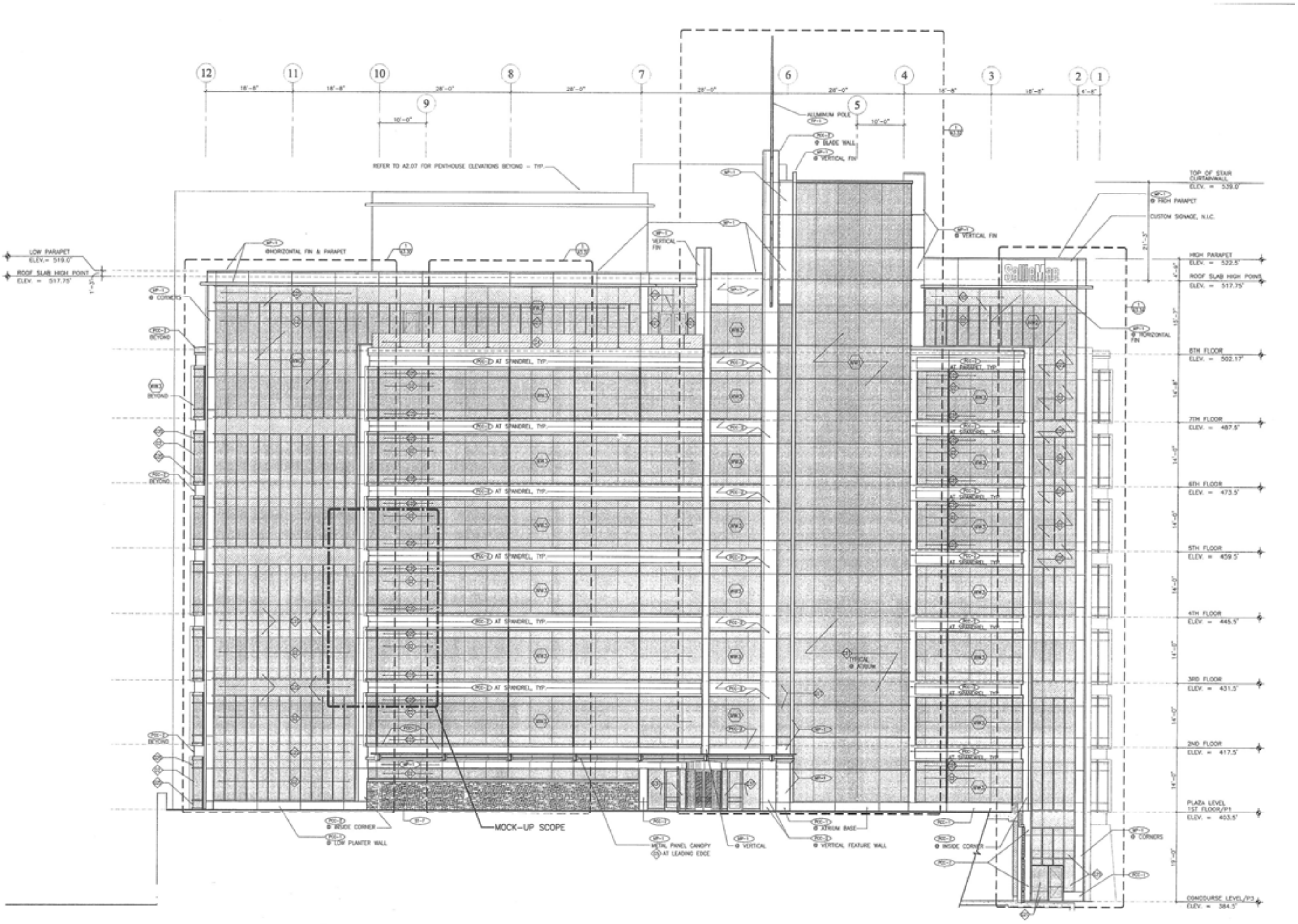
The area of a typical office floor is approximately 22,000 square feet and consists of structural steel beams with a composite 3¼" lightweight concrete floor slab on 2" deep metal decking (5 ¼" total depth). The tower has three bays along its width (42'-0", 23'-0", 42'-0") and its typical bay in the opposite direction is 28'-0" long.

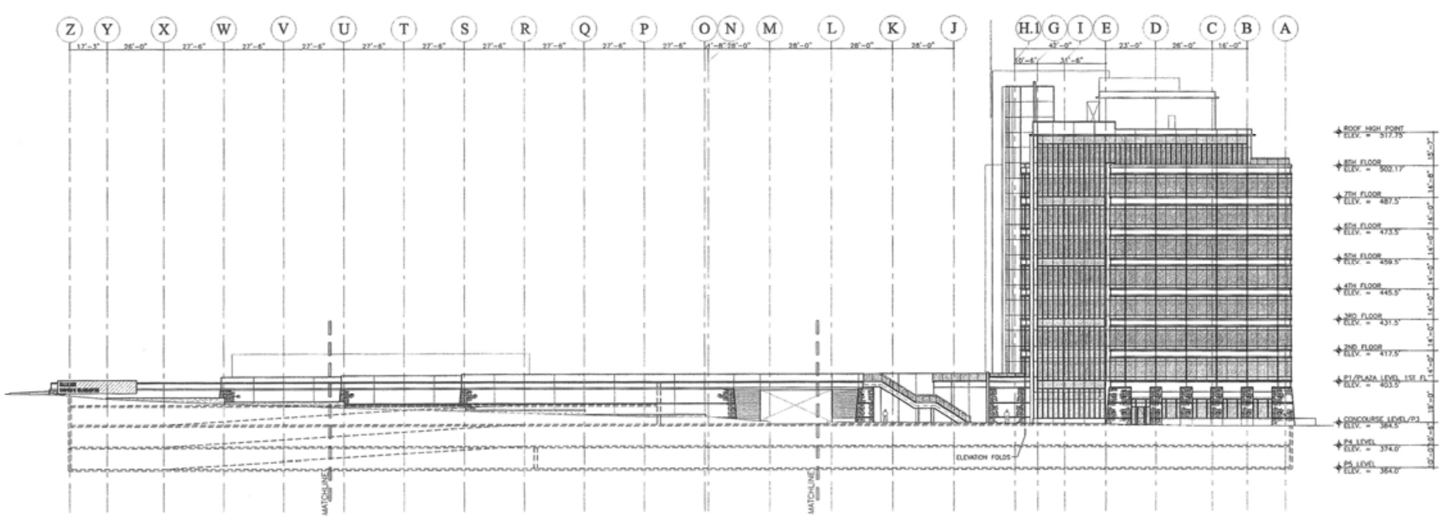
The area of a typical level in the parking garage is approximately 75,000 square feet. The garage is made from a two-way slab system that features drop panels. The drop panels are primarily 3.5" and elevated slab thicknesses vary from 9" to 14". Spans reach 28' and normal column sizes are 30" x 30" concrete columns.



Steel tower area compared with parking garage area



East Elevation (West is similar)



North Elevation (South is similar)

Statement of the problem

The floor structure must be designed to resist deflection caused by 42’ spans. Furthermore, the floor depths must be maintained below 27” to provide an efficient amount of room for mechanical equipment in the ceiling envelope.

Reasoning

A few alternatives were discussed and seem slightly reasonable, but both of them require deep members that must be prefabricated and brought to site; either a 32” LH-SERIES JOIST or a 32” Double Tee would be sufficient to resist the long spans.

The other alternative other then conventional steel framing is post-tensioning. In examining this alternative I tried to use a flat plate post-tensioning system which spanned the (42’-0”, 23’-0”, 42’-0”) width of the building. This is very uneconomical due to the fact that the slab thickness will need to be approximately 14” to account for these long spans. Another option with the post-tensioning system was to use long span post-tensioned beams along the (42’-0”, 23’-0”, 42’-0”) width of the building, and using one-way post-tensioned slabs in the opposite direction. The slabs will likely be between 5” and 8” due with familiarity with post-tensioning across a 28’ span. So drop panels will likely be needed, or some sort of punching shear resistance depending on the size of the columns.

The makeup of the building with the shearwalls in the center makes it very convenient to use shearwalls. This leads to the fact that the columns don’t have to resist much of the lateral loads and can be designed as square columns throughout the height of the building. Furthermore, if the parking garage is also made with post-tensioned concrete, then the building will be a uniform material and this will aid in the construction efficiency of the building.

Concrete:

Advantages:

- Shorter lead-time required to begin construction.
- Superior vibration and sound-transmission performance.
- Inherent fire resistance rating.
- Shallower overall depth allows for reducing height of building, or provides additional space for mechanical systems.
- One subcontractor to handle entire structure (garage and tower).

Disadvantages:

- Larger foundations
- High formwork costs
- Greater potential for weather-related delays.
- Post-tensioned beams and slabs are difficult to modify for future penetrations. May need to develop a modular layout of tendons to facilitate their location in the future.

Solution

The floor will consist of shallow, wide post-tensioned girders that span the (42'-0", 23'-0", 42'-0") width of the building, and one-way post-tensioned slabs spanning in the opposite direction. The columns will be 24" and 30" square columns. The floor to floor height will remain 14'. The lateral load system will be shear walls at the stairwells and at the elevator shafts in the central core of the building.

Solution Method

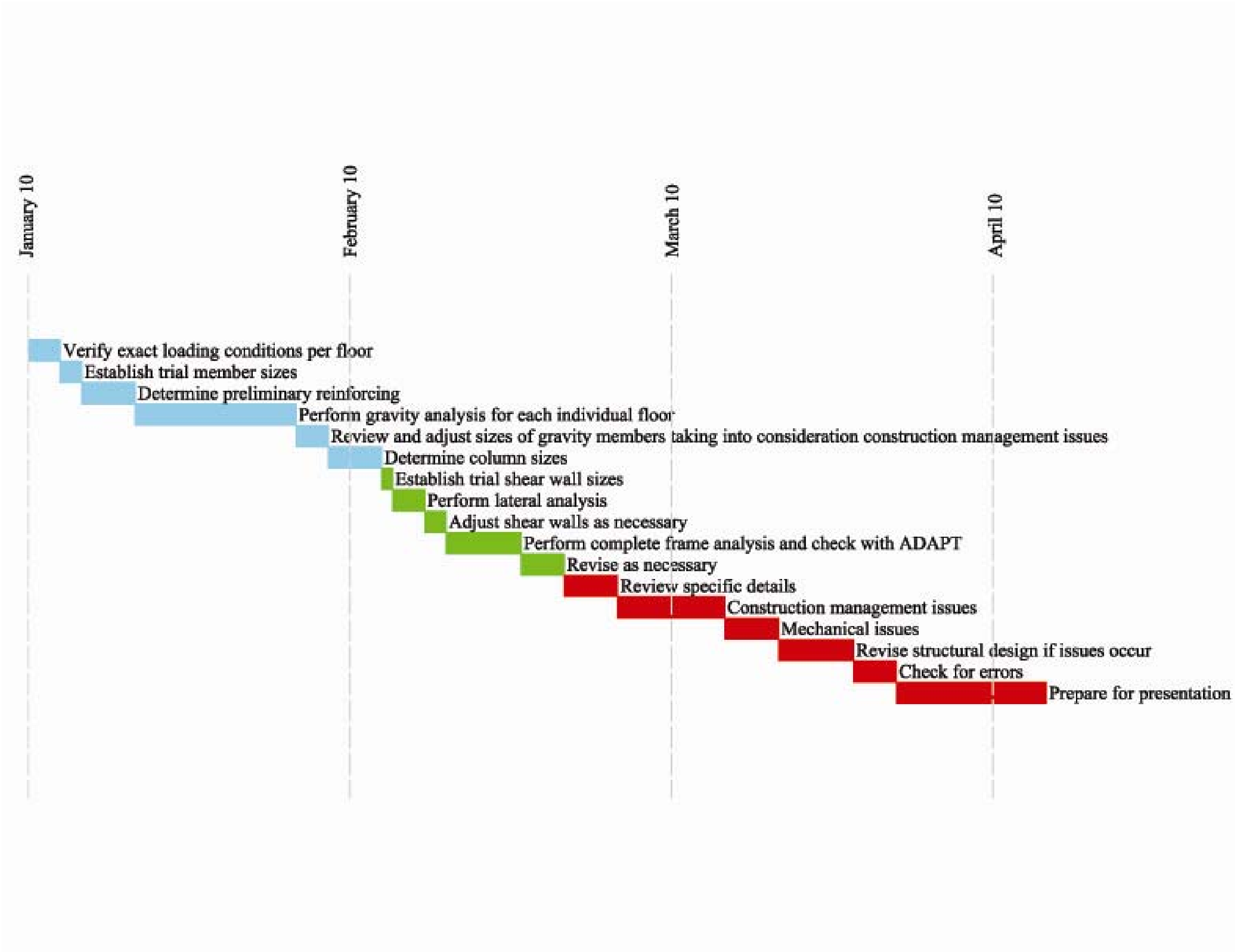
The design of the one-way slab will be based on the Post Tensioning Manual, Fifth Edition and ACI 318-05. The specific strength and weight will be confirmed after preliminary calculations. The beams spanning the width of the building will be designed as T-beams. A column takedown will be made using rough areas. Preliminary square column sizes will be chosen. Seismic and wind loads on the building will be found using ASCE 7-02. Shearwalls then will be designed. Complete full frame analysis by using the Equivalent Frame Method. Confirm the results with the computer program ADAPT. Specific connection details will be analyzed and designed. Verify design loads with IBC 2003 and the Virginia Uniform Statewide Building Code – 2003.

Tasks and Tools

Codes

Existing Design	New Design
BOCA 1996	IBC 2003
ASD Manual, Ninth Edition, 1989, AISC	LRFD Manual, Third Edition, 2001, AISC
Virginia Uniform Statewide Building Code – 2000	Virginia Uniform Statewide Building Code – 2003
ASCE 7-98	ASCE 7-02
ACI 318-99	ACI 318-05
Post Tensioning Manual, Fifth Edition, 1990, PTI	Post Tensioning Manual, Fifth Edition, 1990, PTI

Course of action	# of Days
Call contacts and try to retrieve construction management information	Over Break
Gravity	
Verify exact loading conditions per floor	3
Establish trial member sizes	2
Determine preliminary reinforcing	5
Perform gravity analysis for each indivdual floor	15
Review and adjust sizes of gravity members taking into consideration construction management issues	3
Determine column sizes	5
Lateral	
Establish trial shear wall sizes	1
Perform lateral analysis	3
Adjust shear walls as necessary	2
Perform complete frame analysis and check with ADAPT	7
Revise as necessary	4
Final Details	
Review specific details	5
Contruction management issues	10
Mechanical issues	5
Revise structural design if issues occur	7
Check for errors	4
Prepare for presention	14
Total amount of days	95



Breadth Issues:

Construction management

Construction management is a major issue due to the difficulty of post-tensioning. Scheduling must be carefully implemented, and the design needs to be clear to minimize any possible mistakes. Space for the layout of the post-tensioning strands must be planned and the cost must be researched.

Mechanical

Mechanical systems and any possible changes in the flow of ductwork will be critical dampened by the use of post-tensioning. Mechanical considerations must be made because post-tensioning doesn't easily allow holes to be made in the floor slab.