GOUVERNEUR HEALTHCARE SERVICES

NEW YORK, NY

THESIS PROPOSAL

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Structural

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EXECUTIVE SUMMARY

The Gouverneur Healthcare Project is the expansion and renovation to the Gouverneur Healthcare Facility. The focus of this thesis project is the 75,000 sq. ft. addition to the existing building. The project will create modern ambulatory care center and long term facility in the heart of the Lower East Side of Manhattan.

The current design for the Gouverneur Healthcare Facility is an addition to a concrete building, and employs steel framing for gravity and lateral systems, with members reaching spans greater than 44ft. The long span steel framing allows significant freedom for the architectural design, and saves on foundation costs. However, the lateral system is less efficient and has higher torsional effects than a shorter-span, more regular layout. To accommodate MEP equipment, cellular beams are used for nearly all gravity members due to tight floor height restriction. The design of other systems is further constrained because moment frames divide the floors into individual zones that cannot be changed; assemblies simply cannot pass beyond these frames because there is no clearance between the beams and the ceiling below.

The current design is more than adequate, however, many alternatives exist. For the reasons summarized above, this proposed thesis will include an investigation of the performance and feasibility of a two-way flat plate floor system. Typical construction will comprise of 30ft x 22ft bays with 10" thick floor slabs. Shear walls will be designed to resist lateral loads and attempt will be made to develop a regular scheme to ensure that the center of mass and center of rigidity will coincide.

In order to perform this proposal, both hand methods and computer modeling will be performed. Programs utilized to design structural members will include PCA Slab, PCA Column, and ETABS. Loads will be determined using the provisions of ASCE 7-05, and the concrete structure will be designed to meet the specifications provided by ACI 318-08.

Changing the structural system will have many far-reaching impacts to the overall project. In order to investigate the feasibility of the proposed design change, an architectural and construction breadth will be studied.

INTRODUCTION

The Gouverneur Health Services Modernization Project is an addition to an existing building and a renovation of the 35-year-old healthcare facility. The existing building is a 2-way flat plate floor construction with square and rectangular columns. An existing conditions survey revealed no shear-walls, so it can be assumed that lateral loads are resisting by the continuous frame construction. For the purpose of this technical report, and subsequent thesis project, only the addition will be investigated in further detail. Furthermore, portions of the addition that wrap around the existing building and tie into the existing structure will be neglected for this technical report.

The addition that will be the main focus of this thesis project consists of two distinct portions. The first portion is the 5-story ambulatory care facility. This facility is approximately 115'x175' in plan, and sits on the western side of the site, connected to the existing building. The second portion is an expansion to the floor plan to the existing building in floors 6 through 13. It is roughly square, 50'x60' in plan, and extends upwards from the ambulatory center on the western side of the existing building. The portions may be referred to as lower addition and upper addition, or ambulatory addition and tower addition, respectively. See Figures below.

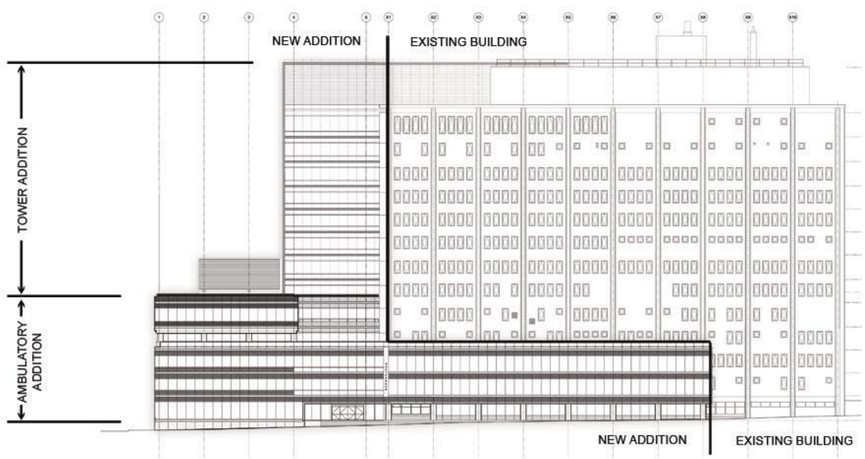

Fig 1. Gouverneur Layout Schematic

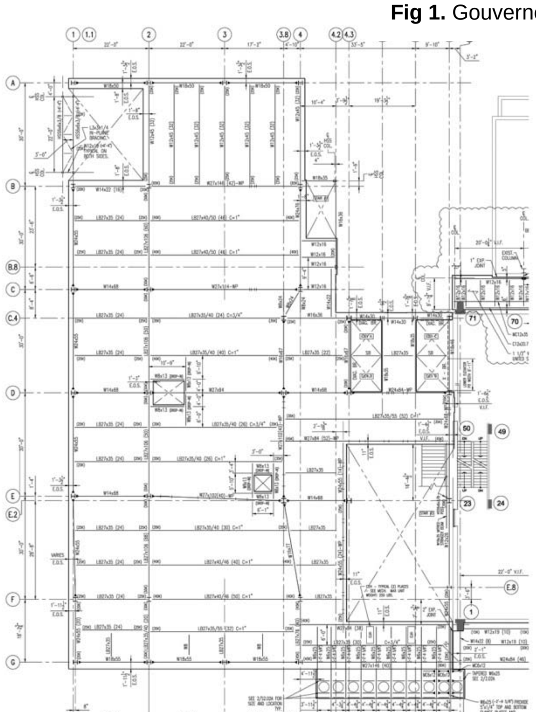

Fig 2. Typical Ambulatory Center Framing Plan

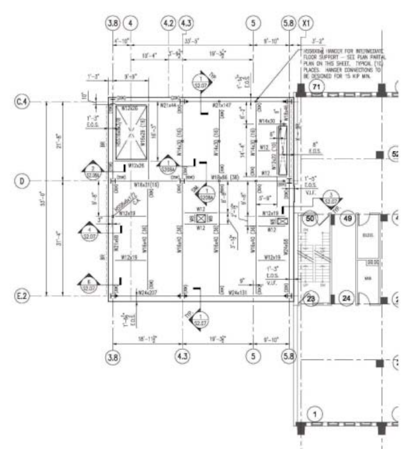

Fig 3. Typical Tower Addition Framing Plan

STRUCTURAL SYSTEM

Foundation

The Gouverneur Healthcare Facility bears on a pile foundation system, with 60-ton capacity, 12” piles. Pile caps vary from 35” to 54” thick with the number of piles ranging from 2 to 16 piles per cap. The footprint for the cellar is smaller than the extents of the overall building so the depths of the pile caps vary. The depths of the caps are either 4’-6” below datum if the columns terminate in the cellar, or 16’-9” above datum if the columns terminate on the first floor.

The piles support grade beams that span between 15’ and 40’. Their sizes range from 4’-0” to 8’-3” deep with reinforcing bars from #8 to #12 bars. A structural, one-way slab-on-grade spans between grade beams to make up the cellar floor.

Floor System

The floor system for Gouverneur Healthcare Services is a composite system that utilizes cellular beams for all gravity beams in the ambulatory addition. A 4 ¼” slab rests on a 2” LOK floor composite deck, and is tied to the beam with 5” long, ¾” diameter shear studs. Typical bays are 30’-0” by 44’-0” and almost all beams are nominally 27” deep to accommodate mechanical systems. The tower addition uses traditional W-shapes in a composite floor system. Beams are W16’s in areas where clearance for mechanical equipment is not an issue, and W14’s where clearance is an issue.

Columns

Almost all columns in the Gouverneur Healthcare Services Building are W14 columns, regardless if it is a part of the lateral system or just a gravity column. Sizes range from W14x43 to W14x257, and are continuous from the foundation to the roof, with only column bearing on a transfer girder on the seventh floor. Columns are spliced on every other floor starting on the third floor. Base plates are typically 22” x 22” with bolts ranging in size from ¾” to 2”.

Lateral System

Due to the vast use of glass curtain walls and irregular plan between floors, most of the lateral system in the Gouverneur Healthcare Services Building is moment resisting frames. For the interior moment frames, sizes are either W27’s for long span beams or W14’s for the shorter spans. Most beams in exterior moment frames are W18’s and W24’s. In the tower portion of the building, lateral loads are resisted by exterior moment frames in the East-West direction, and braced frames in the North-South direction, both concentric and eccentric. Most braced frames are continuous from the roof to the column termination at the foundation. But at the interface of the upper addition and the lower addition, where one frame is discontinuous, loads transfer into columns in the floor below, and redistribute through the structure.

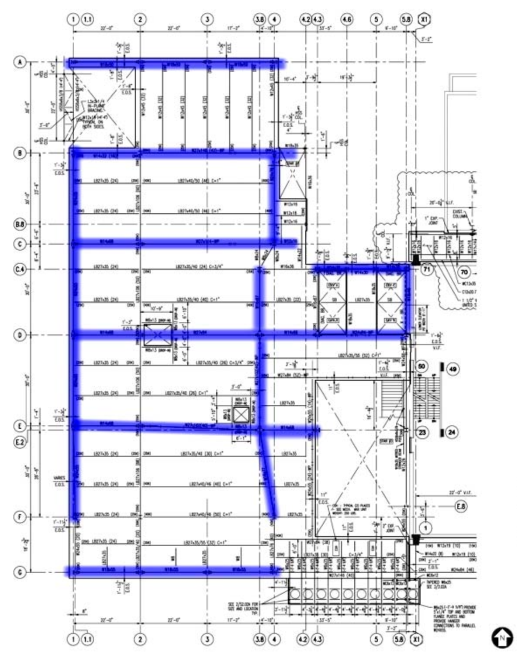

Fig 4. Typical Framing Plan Showing Moment Frames

Wind loads transfer from curtain wall system to floor diaphragm. The floor diaphragm is rigid compared to structure so loads transfer to lateral frames based off of relative stiffness. Loads then transfer to foundations in the form of shear and axial load (tension and compression) in braced frames, and transfer to the foundation through moment frames.

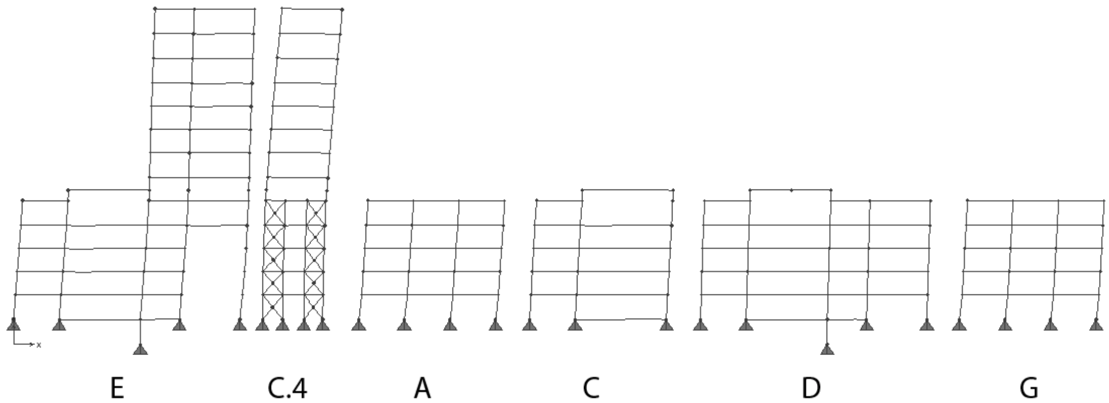

Fig 5. Lateral Frames in the East-West Direction

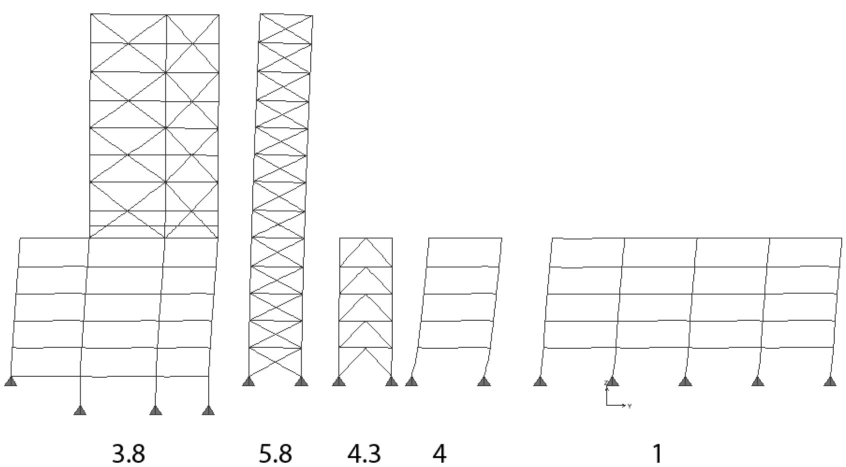

Fig 6. Lateral Frames in the North-South Direction

MATERIALS

Concrete	ASTM	Min Strength
Structural slab-on-grade	-	3000 psi
Pile cap	-	4000 psi
Retaining walls	-	4000 psi
Interior Slabs	-	4000 psi
Reinforcing Steel	A615	60 ksi
Structural Steel		
Structural Tubing	A500	46 ksi
Steel Pipe	A53	35 ksi
Rolled Shapes	A992	50 ksi
Other Rolled Plates	A36	36 ksi
Connection Bolts	A325	90 ksi
Anchor Bolts	A307	45 ksi

APPLICABLE CODES AND DESIGN REQUIREMENTS

Codes and References

The City of New York Building and Administrative Code
New York Electrical Code
All Applicable NFPA Codes
New York State Energy Code
AIA Guidelines for Design and Construction of Hospital and Health Care Facilities

Deflection Criteria

Floor Deflection	L/240 Total and L/360 Live
Lateral Deflection	
Total Drift	3 ½” (due to expansion joint between addition and existing building)
Story Drift	H/400
	$0.10h_{sx}$ (Table 12.21-1 ASCE7-05) for seismic

DESIGN LOADS

Dead Load (psf)	
Floor Load	
3 1/4" LW concrete fill on 3" LOK-Floor	60
Ceiling	2
Floor Finish	2
Mech/Elect	10
Partitions	12
Steel Framing	13
TOTAL	99
	(psf)

Wall assemblies	
1. Metal Panel	25
2. Glass Curtainwall	15
GFRC	40
	(psf)

Dead Load (psf)	
Penthouse Roof	
Steel	8
Deck/Insulation	8
Mechanical	10
Membrane	2
Fire Proofing	2
TOTAL	30
	(psf)

Main Roof	
3 1/4" LW concrete fill on 3" LOK-Floor	60
Ceiling	3
Mech/Elect	14
Roofing/Insulation	9
TOTAL	86
	(psf)

Live Load (psf)		
Live Load	As Designed	As per ASCE7
Dormatory Floors	40	40
Lobby	100	100
Lounge	100	100
Corridor 1st Floor	100	100
Corridor above 1st	80	80
Stairs	100	100
Mechanical Rooms	150	-
Main Roof (Mech)	150	-

Fig 7. Design Load Tables

PROBLEM STATEMENT

Designers chose to utilize steel framing for the structure of the Gouverneur Healthcare Facility, with moment frames comprising the majority of the lateral system. Because the current design is an addition to an existing concrete building, many constraints were imposed on the design of the addition, causing difficulties for all trades. The tight, 11ft floor-to-floor height of the existing building constricts the usable space between the ceiling and structural system. In order to accommodate MEP systems, while remaining cost-effective, deep long-span cellular beams were employed for gravity members.

Moment frames used to resist lateral loads had bays that spanned these long distances, averaging 44ft. This long-span condition means that the moment frames are not as efficient as possible and the stiffness of the overall building is reduced. The added weight that is a result of long span lateral members may offset the cost benefits associated with utilizing this design. Specifically, long span members were utilized to save money on foundation costs, although the inefficient lateral system may negate these benefits. Furthermore, numerous web penetrations in the moment frames also cause more intensive fabrication.

Further complicating the structural design is the interaction between the tower addition, the ambulatory center, and the central atrium. The performance of the building is greatly impacted due to the placement of the tower directly above the atrium, and the dissimilar column grids between the tower and lower portion. These conditions created irregular braced-frames and moment-frames throughout the building, all leading to a significant amount of torsion under lateral loads.

PROPOSED SOLUTION

Depth Study

In order to improve the coordination of systems a two way flat-plate floor system is proposed for implementation in the Gouverneur Healthcare Facility. Replacing the current design with concrete construction will match the existing portion of the building and will allow adequate space for all systems within the floor height constraints. In order to ensure reasonable slab thickness and resistance of gravity loads, spans will be reduced from 44ft to 22ft. This will allow 10” slabs and create a typical 30ft x 22ft bay for the lower portion of the Gouverneur building. The structure will be designed according to the provisions specified in ACI 318-08 and a full three-dimensional E-TABS model will be used for lateral design.

Concrete shear walls are proposed to resist lateral loads. A more regular lateral design will be implemented in order to reduce the torsional effects present in the current design. An attempt will be made to design the lateral system in such a way that the center of mass and the center of rigidity coincide. The use of shearwalls will be more restrictive to the floorplan of the building than the moment frames currently employed, however, penetrations can be made at doorways and other openings. Despite this drawback, the inherent stiffness of shearwalls means fewer elements are needed to resist lateral loads, and will not negatively affect the function of the building.

Methods

In order to redesign the structure, hand calculations will first be used to create trial sizes. Slab thickness will be determined using table 9.5c from ACI 318-08. New gravity loads will then be used to determine trial column sections. Hand calculations using revised lateral loads will be used to determine trial shear walls.

Once these initial sizes are chosen, lateral loads and gravity loads will be recalculated and used in the computer analysis to finalize the design in accordance with ACI 318-08. ETABS will be utilized for lateral analysis, and a three-dimensional model will be created to determine drift and lateral forces. PCA Slab will be used to model the two-way flat plate system and design the floor system for gravity loads. PCA Column will be used to finalize the design by checking interaction diagrams for both the columns and shearwalls. Spot checks of selected members will be performed to verify the results of computer modeling.

Breadth Studies

Changing structural systems from steel to concrete may greatly impact the architectural design of the Gouverneur Healthcare Facility, making an architecture breadth a logical area of investigation. In order to accommodate the change in design of 44ft bays to 22ft bays, an extra row of columns will be needed. The use of shearwalls will also affect the architecture of the building as it will somewhat restrict the open plan that the original moment frame affords. The impact of these columns and walls on the floor layouts will be investigated, and rearranging of spaces will be performed as necessary, while still meeting IBC and ADA requirements.

It may also be of interest to investigate the architectural impact of the new structural system on key spaces such as the atrium. It will be important to ensure that shearwalls and concrete frames do not interfere with the atrium. If this impact is unavoidable, it may be possible to incorporate the structure into the design of this space.

Along with the architecture, the change in systems from steel to concrete will influence the construction process considerably. It will be necessary to investigate these impacts as a second breadth study to determine if the proposed changes to the structural system are feasible. Schedules and cost estimates will be evaluated for both the current design and the proposed design Special attention will be given to the investigation of the critical path. Findings will be compared in order to understand the benefits and drawbacks of both systems.

TASKS

Determine Loads

Task 1. Determine design live loads as per specificied in ASCE 7-05

Task 2. Calculate dead load using minimum slab thickness per Table 9.5c from ACI 318-08

Task 3. Determine preliminary lateral loads

- Wind loads using MWFRS Method 2 from ASCE 7-05
- Seismic loads using Equivalent Lateral Force Procedure from ASCE 7-05
- Revise loads as necessary as structural changes affect the building

Layout Proposed Lateral System

Task 4. Analyze architectural floorplan to determine optimum shearwall locations

Task 5. Use preliminary loads to determine trial shearwall sizes

- Layout openings to coordinate with floorplan

Design Two-Way Flat Plate Gravity System

Task 6. Model floor system using PCA Slab and size reinforcing per ACI 318-08 provisions

Task 7. Calculate final loads on columns and use PCA Column to design section and reinforcing

Task 8. Spot check critical members using hand calculations

Lateral System Redesign

Task 9. Model structure three dimensionally using ETABS

Task 10. Finalize shearwalls, designing for drift considerations according to ASCE 7-05

- Obtain wall forces and use PCA Column to design reinforcing and check interaction

Architectural Breadth

Task 11. Determine impact of additional column line and proposed lateral system

Task 12. Research applicable codes to understand design requirements

Task 13. Redesign affected spaces, as necessary

- Integrate lateral system into the design of the atrium space, if required

Construction Breadth

Task 14. Perform preliminary study of potential impact of proposed design on other systems

- Including foundations and mechanical systems

Task 15. Develop schedule for schedule for existing structural design and proposed design with consultation from design engineer

Task 16. Develop structural cost estimation for existing and proposed design

Task 17. Create pro/con study including cost, schedule and impact on the design and performance of other systems

Presentation/Paper

Task 18. Write Final Paper

Task 19. Develop Final Presentation

PROPOSED SCHEDULE

CONCLUSION

The choice to design the Gouverneur Healthcare Facility as a steel-framed addition to an existing concrete structure creates many design challenges and constraints. The long span steel framing allows significant freedom for the architectural design, and saves on foundation costs. However, the lateral system is less efficient and has higher torsional effects than a shorter-span, more regular layout. Furthermore, the use of steel also limits the design of MEP systems due to tight floor-to-floor limitations.

A proposal is suggested to redesign the steel framing as a two-way flat plate system, with shear walls being utilized to resist lateral forces. An attempt will be made to allow for improved coordination of all systems while still remaining a cost effective design solution. Any impacts on the architectural plan, foundations, or construction will be investigated and any conflicts will be addressed. A comparison between the existing system and the proposed design will be provided.

APPENDIX A LIST OF FIGURES

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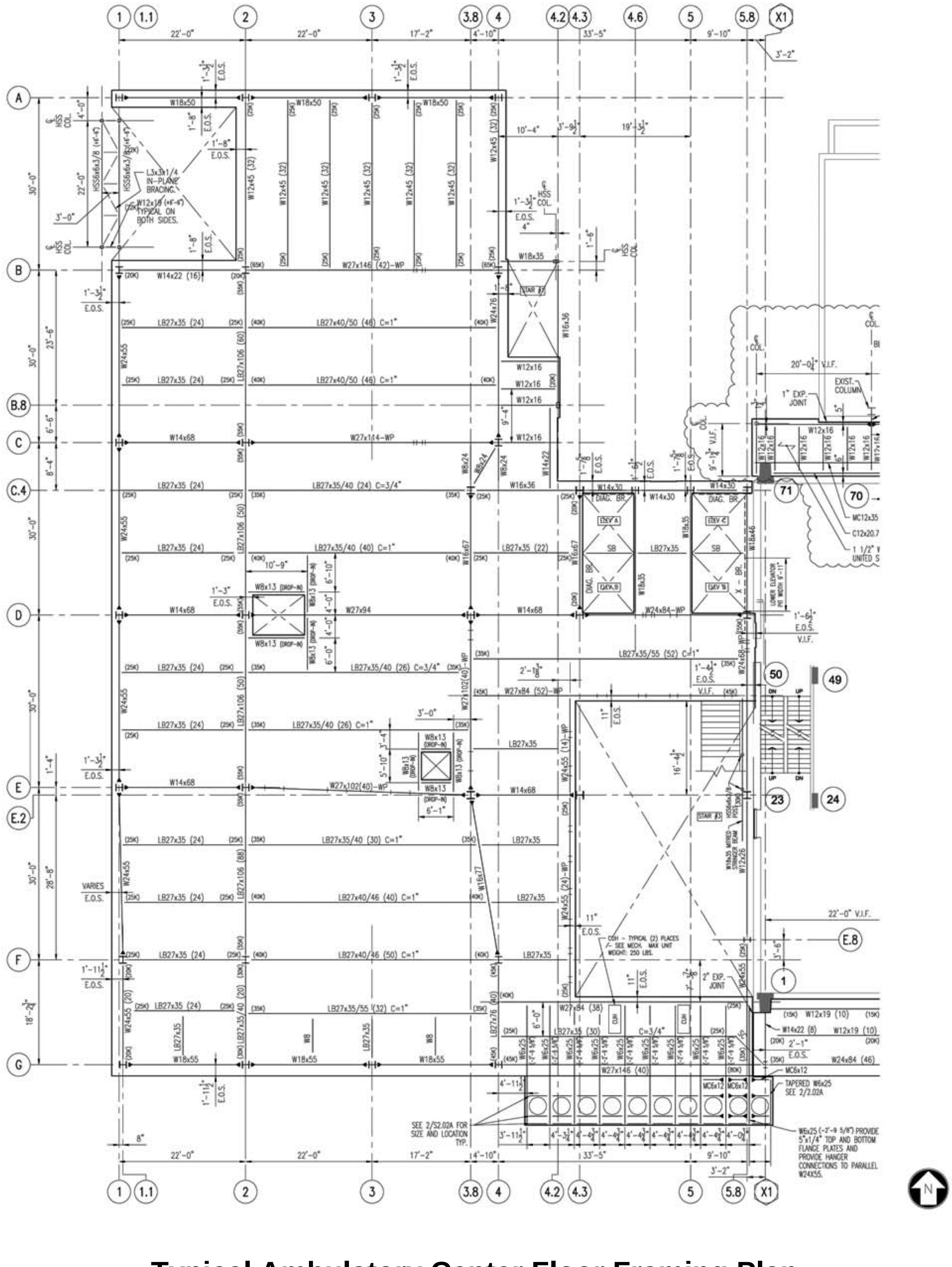
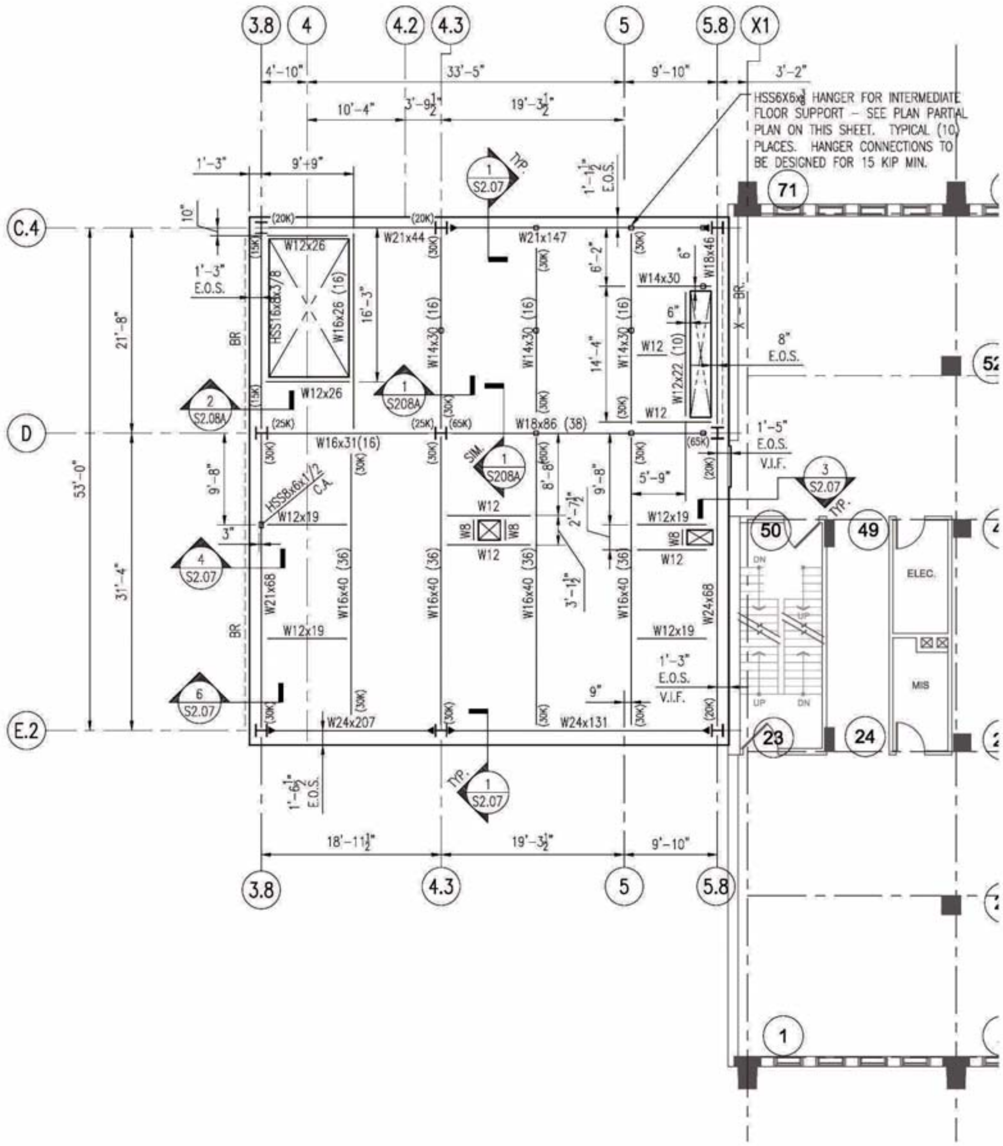


Typical Ambulatory Center Floor Framing Plan



Typical Tower Addition Floor Framing Plan

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