SSM – St. Clare Health Center: Fenton, Missouri

Proposal

Dr. Linda Hanagan, Advisor

Christopher J Brandmeier, Structural Option

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Executive Summary

SSM St. Clare Health Center is a 420,000 square foot hospital located in a residential area of Fenton, Missouri. The building and parking areas sit on a 54 acre site, which was previously a 9-hole golf course with gently varying topography, large stands of trees, and a 3 acre pond. The hospital program contains a wide variety of medical use spaces, including 158 emergency supported inpatient beds, diagnostic and surgical services, administrative offices, dietary facilities, and pharmaceutical dispensaries. The façade is brick veneer cavity wall and glazed curtain wall depending on the private or public nature of the space behind. Budgeted at $226.8 million, the hospital was constructed with an Integrated Project Delivery method and came in well under budget at $223.5 million.

Structurally, the hospital is a composite steel frame building resting on massive concrete drilled piers connected by grade beams. The structure is broken up into three buildings (bed tower, surgery tower, and interventional care unit) isolated by expansion joints. These individual buildings each contain their own lateral force resisting systems which include special moment frames (SMF), special concentrically braced frames (SCBF), special reinforced concrete shear walls (SRCSW), and ordinary concentrically braced frames (OCBF).

HGA Architects and Engineers served as the primary architects and structural engineers on the project. They worked closely with the MEP engineers, KJWW, and the construction manager, Alberici Construction, through an integrated "Lean" project delivery contract that focused on improving coordination and quality by sharing project risks. The project began construction in September of 2006 and reached completion in March of 2009.

SSM St. Clare Health Center was designed in 2004 and uses the 2003 Edition of the International Building Code and ASCE 7-02 as a reference standard. Design loads were determined based on these codes, additional St. Louis County Codes and Ordinances, and practical engineering judgments.

TABLE OF CONTENTS

1 EXISTING CONDITIONS

1.1 PURPOSE

This report provides a detailed description of the building and the existing structural systems in SSM Health Care Center. The knowledge documented here will serve as a building block for subsequent technical reports, which require more in-depth investigations of systems in particular.

1.2 SCOPE

In addition to a general building description, the major sections of this document discuss framing system elements, load determination, and connection design. The report expands on these major categories with more detailed discussions on individual building elements including typical bays, columns, lateral resisting elements, and secondary structural elements such as canopies. Relevant code requirements are also discussed.

1.3 GENERAL BUILDING DESCRIPTION

SSM St. Clare Health Center is a 6 story, 420,000 square foot hospital surrounded by residential neighborhoods in Fenton, Missouri (part of St. Louis County). The building and parking areas sit on a 54 acre site, which was previously a 9-hole golf course with gently varying topography, large stands of trees, and a 3 acre pond. The hospital program contains a wide variety of medical use spaces, including 158 emergency supported inpatient beds, diagnostic and surgical services, administrative offices, dietary facilities, and pharmaceutical dispensaries. Budgeted at $226.8 million, the hospital was constructed with an Integrated Project Delivery method and came in well under budget at $223.5 million.

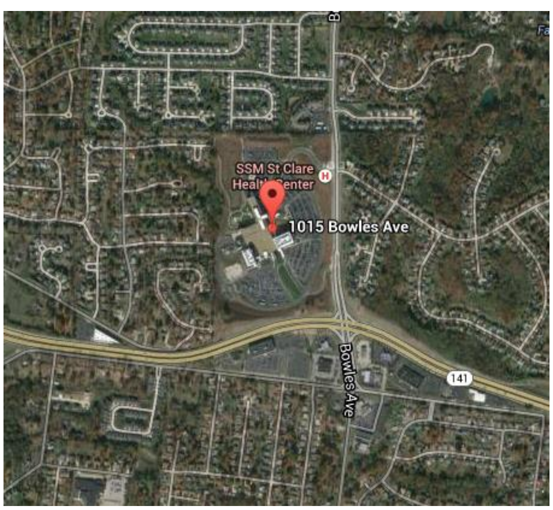


Figure 1: Aerial view courtesy of Google Maps

Figure 2: Aerial view showing proximity to residential areas

HGA Architects and Engineers were the lead architects on the project and worked closely with SSM Health Care to develop a "hospital of the future." The design team used Lean principles traditionally seen in manufacturing facilities to streamline occupant workflows with the goal of reducing errors and saving lives. Patient room mockups were created during the design process so that employees could test layout options for maximum efficiency. Overall, the layout of the building was highly program driven. The building did not receive a LEED certification.

Figure 3 depicts a rendering of the full hospital complex. The office tower on the left of that image was completed in an originally-planned, second-phase expansion.

Figure 3: SSM St. Clare building complex rendering

1.4 Brief Description of Structural Framing System

SSM St. Clare Health Center is predominantly a composite steel frame structure with composite wide flange steel members and composite steel decking. The building foundations are a grid of reinforced concrete grade beams between concrete drilled piers; spread footings run around the perimeter.

Because of its proximity to the New Madrid fault line and poor soil conditions, the site is classified as a seismic category D and seismic loads governed the structural design. From a structural perspective, the size of the hospital and the seismic category of the site made complete building continuity an impossibility, so the building was divided into 3 isolated structures separated by construction joints as shown in Figure 4 The seismic load resisting systems are varied between the different isolated structures, but consist of special moment frames (SMF), special concentrically braced frames (SCBF), special reinforced concrete shear walls (SRCSW), and ordinary concentrically braced frames (OCBF).

This report will discuss the general structural systems of each building segment, and will provide further detail into the various lateral force resisting systems used throughout the complex.

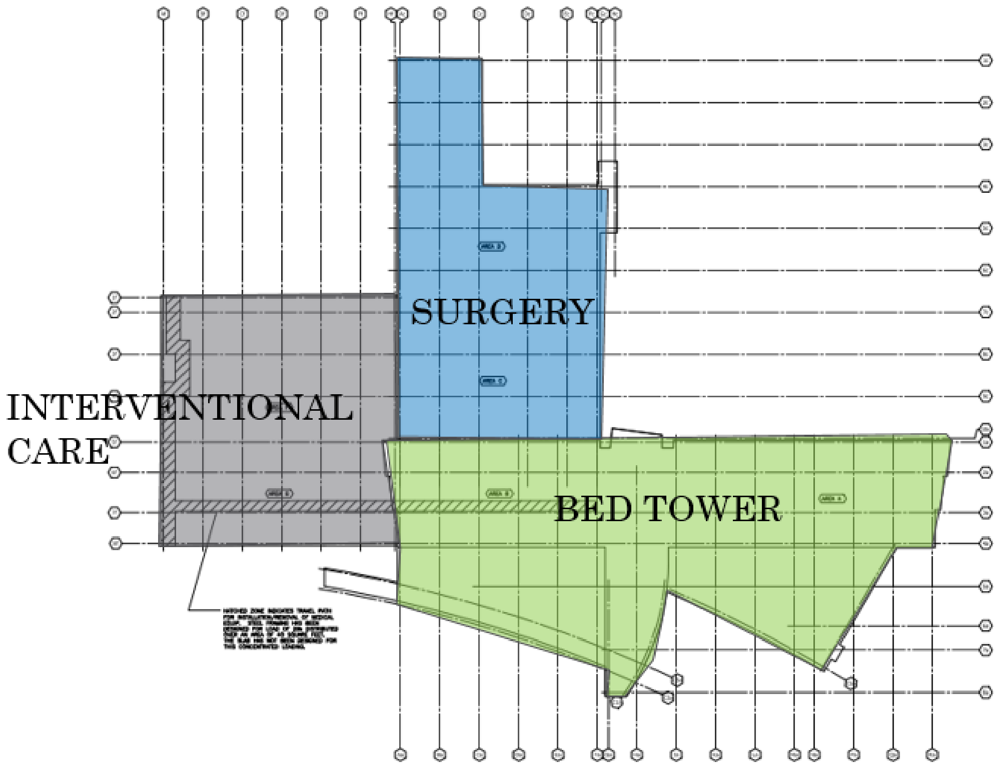


Figure 4: Building segments separated by expansion joints

2 STRUCTURAL FRAMING SYSTEM

This section provides detailed information about structural element types, starting with an overview of typical bays and member design criteria and then examining lateral force systems and load paths. Specific load criteria and governing design codes are covered in Section 3: Loads.

2.1 TYPICAL BAY FRAMING AND FLOOR SYSTEM

Typical bays in SSM St. Clare Health Center are approximately 30 ft. square or 30 ft. by 32 ft. (as seen in Figure 5), with some variation at edges and near curved architecture. The structural grid can be seen in Figure 6. Beams are mainly W16x26 or W18x35 wide flange members, the majority of which are cambered between ¾ in. and 2 in. The girders are almost entirely 24 in. deep wide flanges with linear weights varying between 55 lbs. and 94 lbs. depending on span and loading conditions.

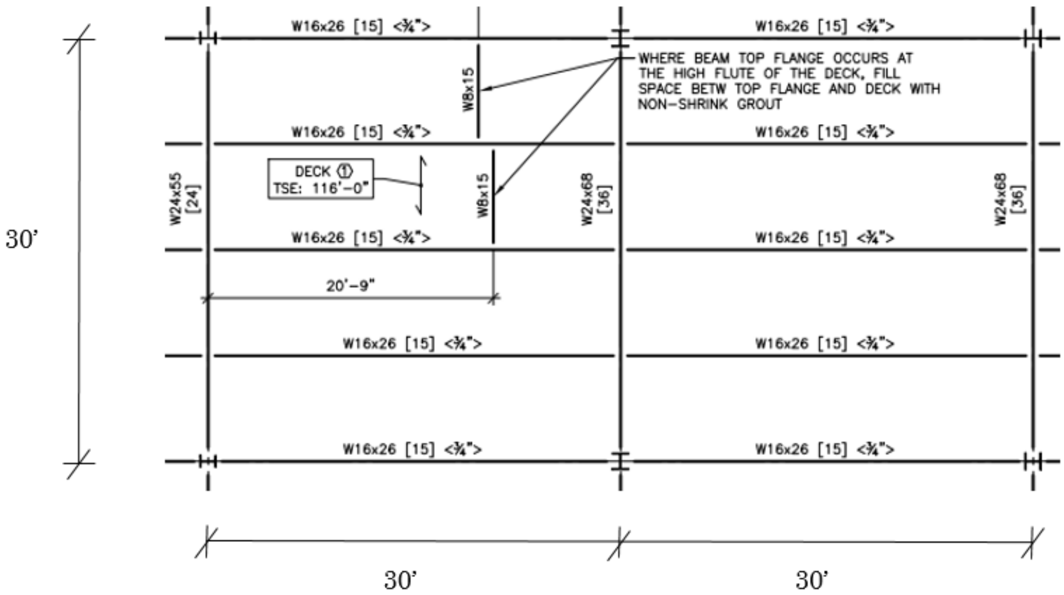


Figure 5: Typical bays from the patient bed tower

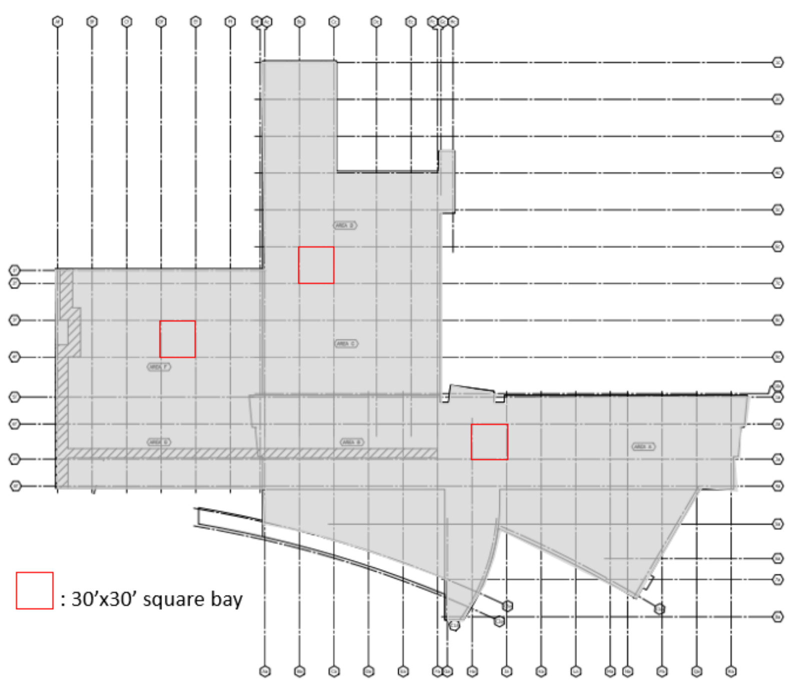


Figure 6: Column grid creating square bays

The typical floor system is 3 inch, 18 gage composite steel deck with a 3 ½ in. lightweight concrete topping that is reinforced with 6x6-W2.1xW2.1 welded wire fabric. Deck is connected to framing members with 5/8 inch diameter puddle welds, and composite action is achieved with ¾ in. diameter, 5 in. long shear studs. Rebar reinforcing is specified at geometric transitions to strengthen the diaphragm collector regions, which are located at the transition between the main tower structure and the outward-jutting tower wing. The roof construction is a 1 ½ inch, 20 gage steel roof deck.

2.2 Foundation System

SSM St. Clare Health Center's foundations consist of a grid of drilled piers connected by grade beams with a strip footing around the perimeter to support exterior walls.

Reinforced concrete drilled piers are required to support any column bearing more than 200 kips of compressive force, thus nearly every column on the project rests on a pier. 26 different pier types are scheduled with diameters ranging from 3 ft. to 8 ft. Each pier is reinforced with spiral reinforcement at 4 in. on center to a depth of three shaft diameters below the lowest grade beam, then with #4 ties at 12 inches on center to the bottom of the pier. Figure 7 shows the approximate depths of the piers under each portion of the building based on the boring report data. The depth of piers varies between 16 ft. and 29 ft. Piers are 3000 psi concrete, have a bearing capacity of 40 ksf, and an assumed skin friction capacity for tension of 2.5 ksf.

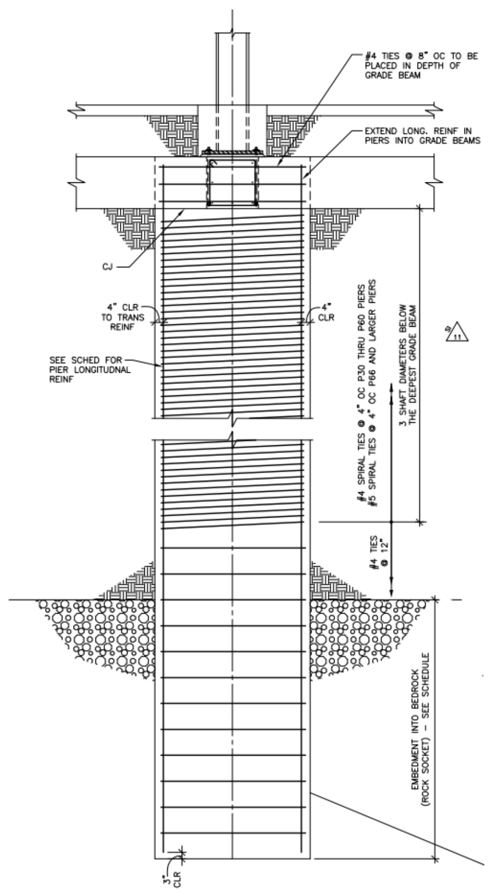


Figure 7: Drilled pier reinforcement detail

Grade beams connect the piers and assist in stabilizing the structure to resist seismic forces. 22 types of grade beams are specified with maximum dimensions of 48 in. by 24 in. and a minimum dimensions of 16 in. by 22 in. Grade beams are 4000 psi concrete. A foundation plan is shown on the next page in Figure 8.

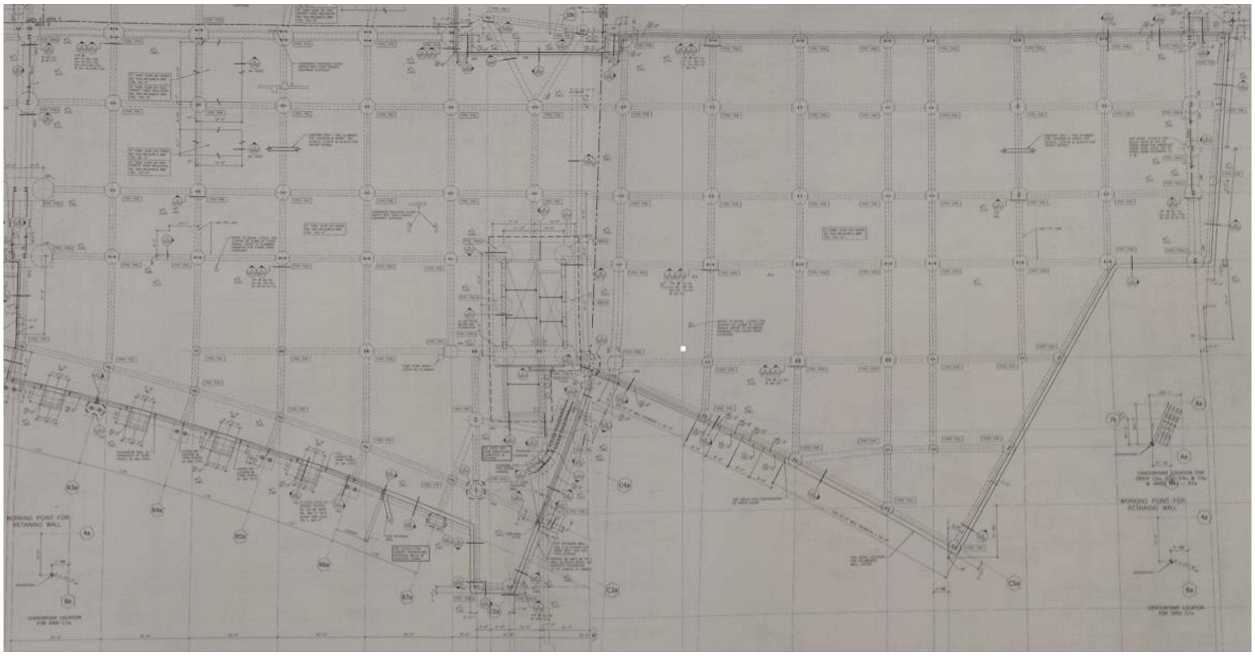


Figure 8: Foundation plan

2.3 Columns

The SSM St. Clare Health Center's columns are W14 steel wide flange members that are spliced at 4 ft. above the second and fourth levels. Figure 9 shows a typical bolted splice detail. The columns range in linear weight between 61 lbs. and 120 lbs. The columns beginning at the penthouse floor (sixth floor) are W8x24 members and are bolted to transfer girders to transfer load to the full-height columns.

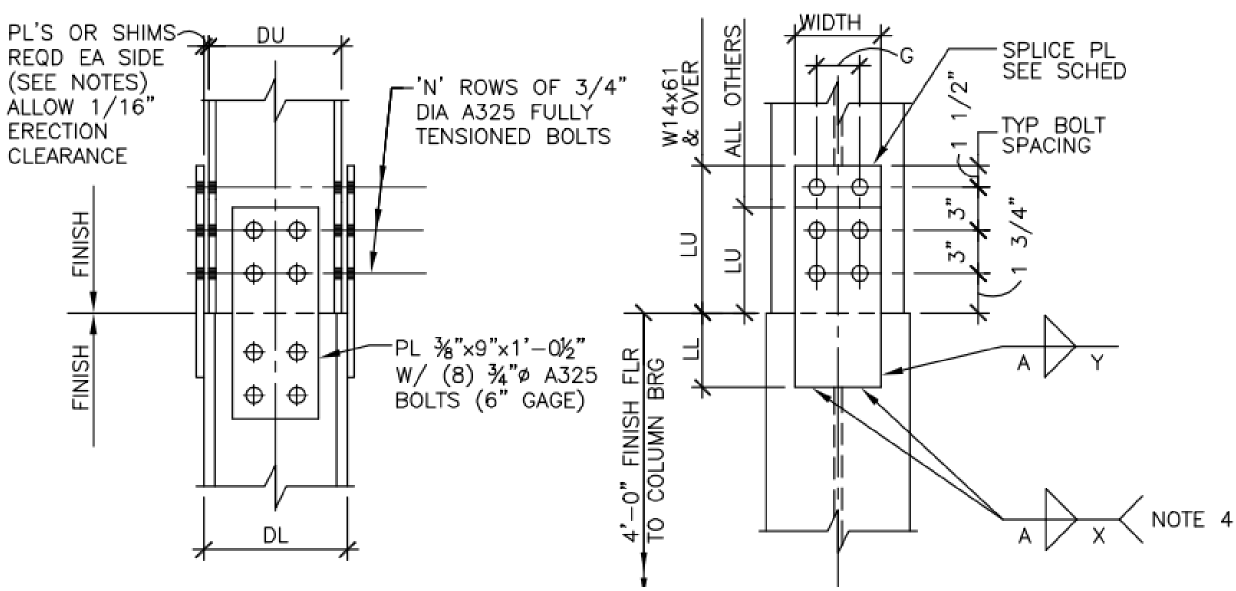


Figure 9: Typical bolted column splice connection

2.4 Lateral Load Resisting Elements

The main lateral force resisting elements in SSM St. Clare Health Center are special moment frames (SMF), special concentrically braced frames (SCBF), special reinforced concrete shear walls (SRCSW), and ordinary concentrically braced frames (OCBF). Figure 10 below shows the location of these lateral resisting elements in the patient bed tower. Lateral elements are located efficiently at the exterior edges of the building to optimally resist torsional irregularities in the building. Note that the stiffer elements (concrete shear walls and braced frames) are oriented along the short axis of the building while the less stiff moment frames are in the long direction. The layout is not only symmetrical in plan, but is also relatively equal in stiffness between the two orthogonal directions.

Figure 10: LFRS element location in bed tower

2.5 Load Paths

Loads on the building fall into two categories: gravity and lateral.

Gravity loads such as live, dead, snow, and rain are resisted from the roof or floor diaphragms, through beams, into girders, then transferred to the foundations through vertical columns. The drilled pier foundations are socketed at least 10 ft. into limestone with a bearing capacity of approximately 40 kips per foot. In the gravity system, the composite deck diaphragms brace beams and girders against torsional buckling and the beams and girders brace the columns against buckling.

Lateral loads such as wind are transferred through the façade to the floor and roof diaphragms. In the case of seismic loads, the mass of the building reacting to ground accelerations causes lateral forces. The floor and roof diaphragms transfer shears to collector struts by means of welds and studs as shown in Figure 11 on the following page. These collectors frame into lateral load resisting elements such as concrete shear walls, moment frames, or braced frames (depending on the building segment), which then transfer the loads to the ground by means of angled steel members in tension in the case of braced frames, or shear and flexural forces in the case of moment frames and shear walls. These forces are then transferred through the columns to the foundations and into the ground. Lateral loads create an overturning moment, which can cause uplift on the foundations. This uplift is resisted by skin friction forces in the drilled piers of approximately 2.5 kips per foot.

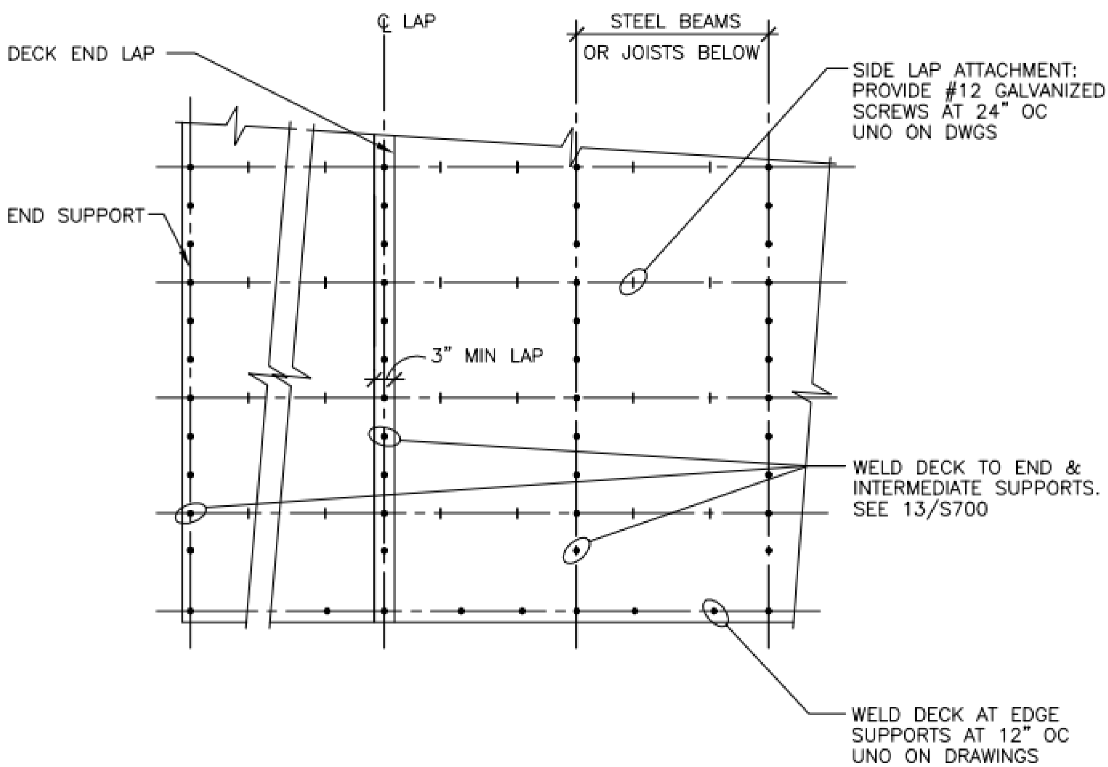


Figure 11: Typical puddle weld steel deck connections

3 LOADS

This section details the national codes and criteria used to determine loading cases on SSM St. Clare Health Center. Included in this section is a description of each building load: its formulation and application. Further load case information can be found in Appendix A.

3.1 NATIONAL CODES

At the time of design in 2004, St. Luis County, Missouri had adopted the 2003 Edition of the International Building code and ASCE 7-02 as a reference standard. Minimum load values are those found in ASCE 7-02 and adjusted to the engineer's judgment. Other applicable codes can be found in Table 2.

Table 2: Applicable Codes

CODE CATEGORY	APPLICABLE CODE
Zoning	St. Louis County Codes and Ordinances
Building Code	International Building Code (IBC) 2003 Edition
Hospital Code	Title 19, Division 30, Chapter 30 for Hospitals and Ambulatory Surgical Centers
	NFPA Life Safety Code (101) 2000 Edition
	AIA Guidelines for Design and Construction of Hospitals and Healthcare Facilities
Fire Code	International Fire Code (IFC) 2003 Edition
Mechanical Code	International Mechanical Code (IMC) 2003 Edition
	International Gas and Fuel Code (IGFC) 2003 Edition
Energy Code	International Energy Conservation Code (IECC) 2003 Edition
Plumbing Code	St. Louis County Codes and Ordinances
Electrical Code	National Electric Code
Elevator Code	ANSI A17.1 Safety Code for Elevators and Escalators, 2000 Edition
State Accessibility Code	Americans with Disabilities Act (ADA)

3.2 LIVE

Live loads were determined from ASCE 7-02 and engineering experience. Table 3 contains a short list of ordinary loads. A full list of Live load design criteria can be found in Appendix A.

Table 1: Typical Live Loads

Live Load	Value (psf)	Code Minimum (psf)
Operating Room	60	60
Offices	50	50
Private Rooms	40	40
Corridors (1st Floor)	100	100
Corridors (other)	80	80
Stairs and Exits	100	100
Equipment Rooms	125	125

3.3 DEAD

Dead loads are determined based on standard material weights, manufacturer data, and engineering experience. A full list of calculations for the values in Table 4 can be found in Appendix A.

Table 2: Typical Floor Dead Loads

Dead Load	Original Design Values (psf)	Thesis Calculated Values (psf)
Hospital Floor	60	64
Hospital Roof	78	70
Power Plant Roof	133	N/A
Penthouse Floor	60	N/A
Penthouse Roof	28	N/A

3.4 WIND

Wind loads are determined from the standard load tables found in ASCE 7-02, and applied based on zones found in the "Wind Loads at Components and Cladding" zone definitions. Uplift forces are considered as part of the zone definitions found in the previously mentioned section of ASCE 7-02. The Occupancy Category and importance factor for the entire structure are IV and 1.15 respectively. The basic wind speed is 90 mph, and the wind exposure category is B.

3.5 SEISMIC

SSM St. Clare Health Center is located near the New Madrid fault line on a soft-soil site. The code-determined design forces are relatively large due to the site acceleration values and a D seismic design category. The SDS spectral response coefficient at short periods is 0.486, and SDI spectral response coefficient at 1 second period is 0.250. Refer to Table 4 for the seismic importance factor (Ie), seismic use group (SUG), seismic design category (SDC), and seismic site class for each of the building segments.

The ordinary concentrically braced frames are used in the penthouse where energy dissipation and ductility are not primary concerns. Special concentrically braced frames are employed in the bed tower and interventional care structure where rigidity is needed beyond standard moment frames but a higher R value was desired to reduce design loads. The building mechanical equipment connections, duct hangers, and natural gas pipe network were all designed with seismic considerations in mind.

Table 4: Seismic Design Criteria

Seismic Design Criteria	Bed Tower	Interventional Care	Surgery	Penthouse
Ie	1.5	1.5	1.5	1.5
SUG	III	III	III	III
Site Class	D	D	D	D
SLRS N-S	SMF	SCBF	SMF	OCBF
SLRS E-W	SCBF + SRCSW	SCBF	SMF	OCBF

3.6 Snow

Snow load values are based on the following snow design criteria per ASCE 7-02. The building occupancy category is IV, snow importance factor is 1.2, exposure factor is 1.0, thermal factor is 1.0, and ground snow load is 20 psf. These factors combined mean that the flat roof snow load for most of the building is 24 psf.

4 Joint Details and Connections

SSM St. Clare Health Center has a variety of shear, moment, and tension connections in its gravity and lateral systems. Gravity system connections are bolted connections with ¾, 7/8, or 1 inch A325 bolts. Due to the size of the building, an exhaustive description of all connections would be excessive; this section instead presents the typical connections in the building's various lateral force resisting elements. The main lateral force resisting elements are special moment frames (SMF), special concentrically braced frames (SCBF), special reinforced concrete shear walls (SRCSW), and ordinary concentrically braced frames (OCBF)

The "special" design designation requires more advanced member and connection detailing, specifically in the preservation of protected zones as shown in Figure 12. Protected zones in the lateral load resisting system allow for controlled yielding to occur for optimal seismic energy dissipation in a seismic event. Most beams in the lateral force resisting system have "dog bones" within the protected zones as shown in Figure 13. These areas of reduced section help protect the connections from failure and provide a region for the controlled yielding mentioned previously.

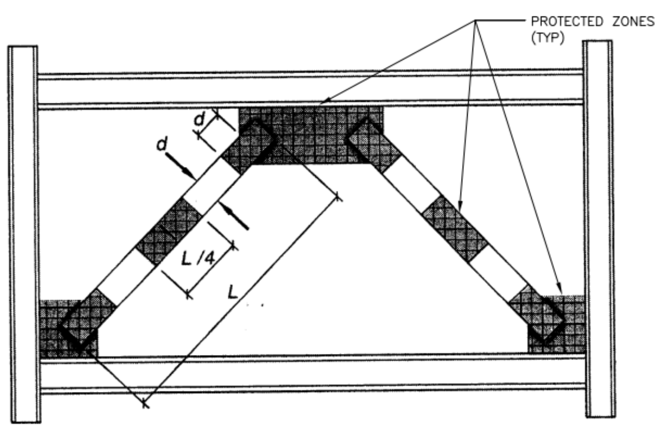


Figure 12: Protected Zones in SCBF

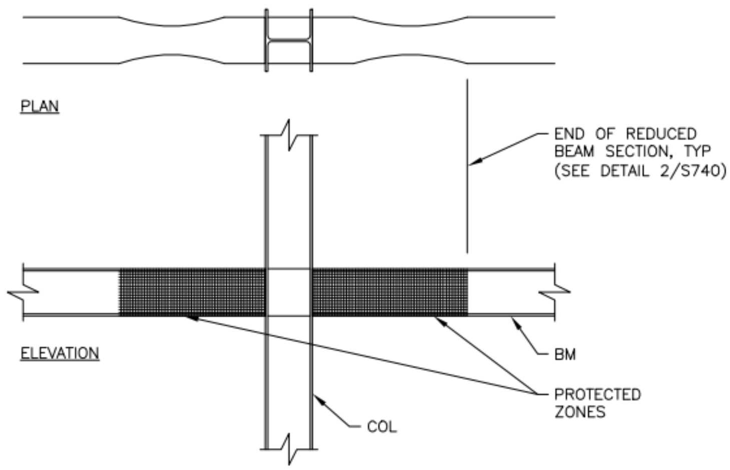


Figure 13: Dog bone section reduction typical of SMF beams

4.1 Special Moment Frames

Special moment frame connections are welded connections with welds connecting the flanges of the beam to the flanges of the column. A continuity plate runs along the web of the column and effectively creates a continuous beam flange through the column as shown in Figure 14.

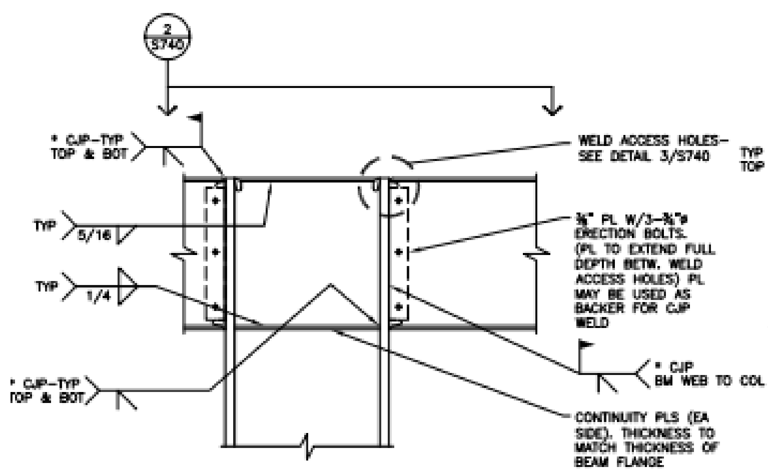


Figure 14: Special Moment Frame welded connection detail

4.2 Special Concentrically Braced Frames

SCBFs are also welded connections. The shear tab plate is held in place with erection bolts, then later welded to the beam. Braces connect to the joints through fillet welds to steel gusset plates. Occasionally the gusset plate is accompanied by a stiffener plate as shown in Figure 15. The “special” designator comes from the connection detailing to create protected zones.

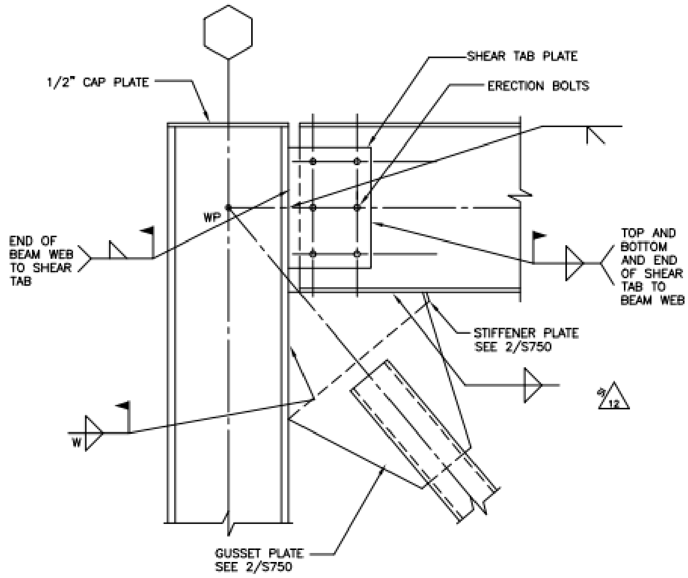


Figure 15: Special Concentrically Braced Frame connection detail

4.3 SPECIAL REINFORCED CONCRETE SHEAR WALLS

The SRCSWs tie directly into the composite floor diaphragm with steel reinforcement bars. A steel angle in the wall supports the steel decking until a second pour of concrete can unify the connection and bond the diaphragm to the wall. The central bar shown in Figure 16 is embedded into a drilled hole in the shear wall with epoxy, while the other bars are continuous from the first concrete pour.

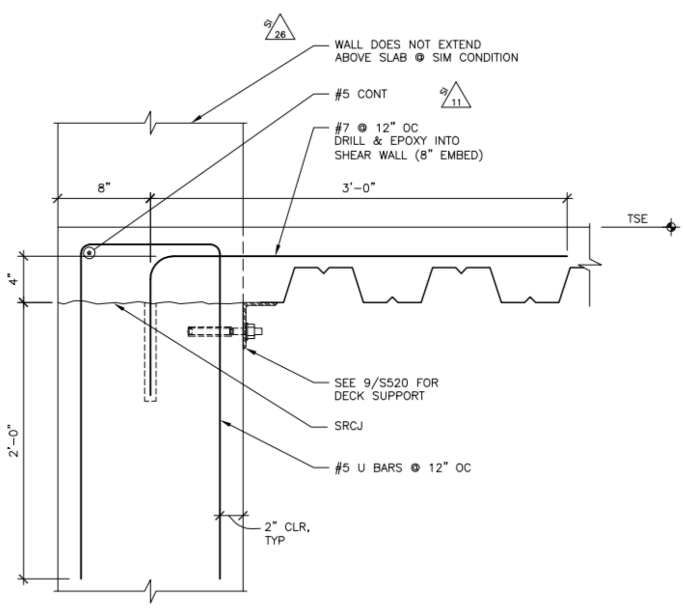


Figure 16: Special Reinforced Concrete Shear Wall connection detail

4.4 Ordinary Concentrically Braced Frames

Like SCBFs, OCBFs are welded connections with braces framing into the connection through a gusset plate as shown in Figure 17. Unlike OCBFs, protected zones are not required. The gusset is stiffened with an angle support on the column rather than a stiffener plate that spans between the beam and column. OCBFs are used in the upper mechanical penthouse where there is no vertical continuity between the penthouse lateral system and the bed tower office lateral system. The penthouse OCBFs resist only a light roof load, and do not require additional expensive seismic detailing to achieve additional ductility or code-based load reductions.

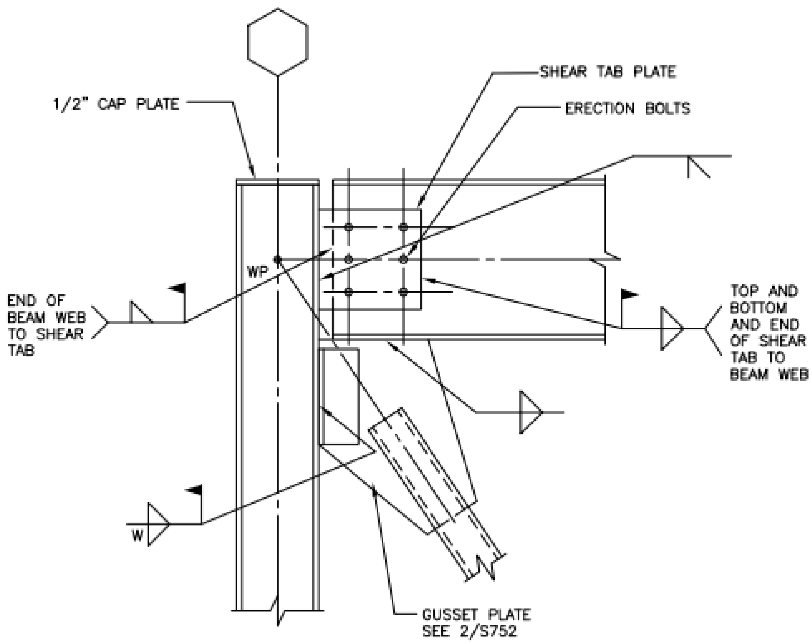


Figure 17: Ordinary Concentrically Braced Frame connection detail

5 Alternative Design

Previous reports have determined that the SSM St. Clare Health Center's current gravity and lateral systems are sufficiently designed to meet strength and serviceability requirements. To further investigate the structure and perform advanced design work, a new scenario has been proposed in which the architect and owner prefer the use of structural concrete rather than composite steel. Since the layout of the architectural floor plans were developed through intensive performance studies, the architect and owner desire the alternative system to create minimal disturbance to the original design.

5.1 Design Proposal

The new concrete structure will utilize the existing 30 foot square bay sizes and column locations. The floor system will be a mild-steel reinforced concrete pan joist system. Pan joists were chosen over flat slab or waffle slab systems for their optimal use of material to resist moments in a 30 foot square bay. The additional cost of pan formwork is hypothetically offset by the reduction in lateral force resisting member sizes due to the overall reduction in floor system weight, which reduces the controlling seismic loads.

The lateral system will utilize the existing specially reinforced concrete shear walls and proposed special concrete moment frames in the East-West direction. Lateral forces in the North-South direction will be resisted entirely with special concrete moment frames.

In the proposed scenario, the owner is also concerned about possible security threats. Progressive collapse analysis procedures will be investigated and an analysis will be conducted for several critical column locations.

5.2 Construction Breadth

The alternate concrete system will have an effect on both the cost and critical path schedule of the project. A cost comparison study will be conducted for the concrete pan joist system and the composite steel system, as well as a critical path comparison. This cost and schedule data will be used to determine the feasibility of the alternate system.

5.3 Architecture/Landscape Architecture Breadth

The building façade will be analyzed for potential blast threats at site-dictated stand-off distances. The project will then be altered to increase threat protection and decrease damage to the building façade. Depending on the analysis results, the façade glazing will be altered to accommodate higher loading or the site landscape will be changed to increase stand-off distances. The analysis will use SBEDS or similar blast pressure software program and reference minimum government antiterrorism standards in UFC 4-010-01.

5.4 MAE Requirements

Redesign of the structural system in reinforced concrete will utilize graduate level coursework from several courses. The gravity and lateral systems will be modelled using three-dimensional techniques learned in AE 530 – "Computer Modeling of Building Structures." The model will primarily be constructed in ETABS and validated with simplified and two-dimensional model data from SAP2000. A seismic modal analysis will be conducted using material covered in AE 538 – "Earthquake Resistant Design of Buildings." A modal analysis is key in reducing code required loads by 15% and will impact the sizing and placement of lateral elements. Reinforcement detailing specifications covered in AE 538 will be used to detail special concrete moment frames and special concrete shear walls for optimal strength and ductility.

The architectural breadth topic will utilize information from AE 542 – "Building Enclosure, Science & Design," which will influence the choice of façade improvements and detailing. AE 542 will be taken concurrently with AE 897G.

5.5 Schreyer Honors College Requirements

The architectural breadth topic will require extensive research into blast analysis and blast design. The research phase includes an investigation of case studies, government standards documents (such as UFC minimum standards), and software techniques. The modeling phase will require interviewing design professionals and experts beyond the academic sphere to model and validate an accurate representation of blast pressures. Such an investigation exceeds the normal academic discussion of applied loads and represents an opportunity for individual learning and professional development.

5.6 Tasks and Tools

1. Research Phase
    a. Identify key characteristics and considerations for pan joist design
    b. Read government UFC minimum protection standards for force protection
    c. Read case studies of façade force protection retrofit
    d. Interview industry experts in blast design and retrofit
    e. Research publically available blast design software
2. Structural Depth: Concrete System Design
    a. Gravity System Design
        i. Design
            1. Estimate new structural loads
            2. Design pan joist system
            3. Design edge beams
            4. Design Columns
        ii. Design Details
            1. Check designs in SP column, slab.
            2. Develop three-dimensional geometric model in Etabs (for later lateral system design process)
    b. Lateral System Design
        i. Design
            1. Calculate new seismic loads from mass change
            2. Conduct modal analysis in Etabs using new seismic loads
            3. Analyze new lateral system configuration
            4. Modify lateral element sections as necessary

5. Design shear wall reinforcement to accommodate new loading
6. Design concrete moment frame reinforcement to accommodate new loading

ii. Design Details
1. Validate Etabs model using supplemental calculations
2. Develop standard detailing for typical lateral system seismic reinforcement

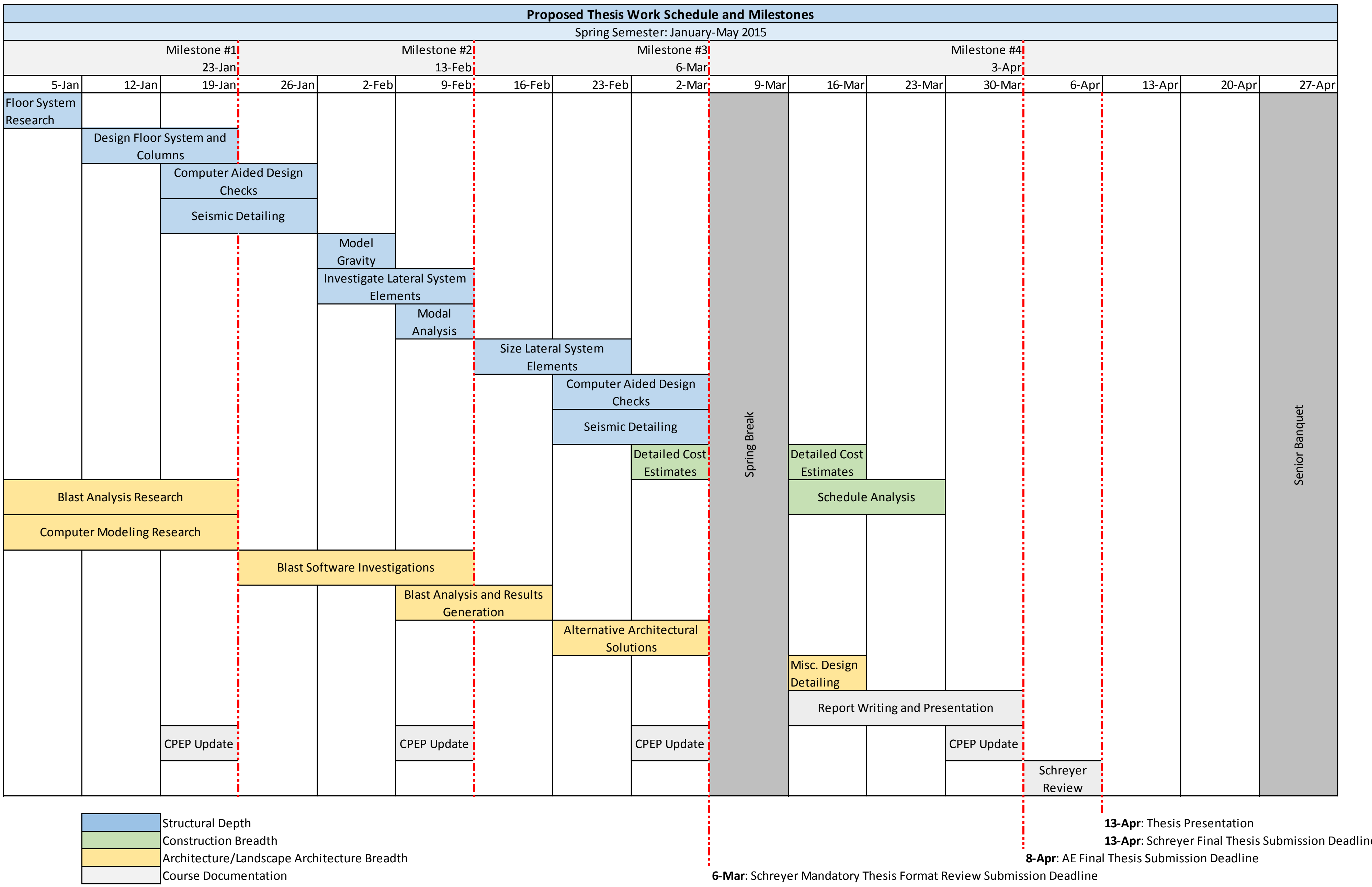
3. Construction Breadth:
   a. Cost Analysis
      i. Complete detailed cost analysis of concrete system using RS means data.
      ii. Compare cost with existing composite system data.
   b. Schedule Analysis
      i. Adjust schedule activities for concrete construction timeline
      ii. Compare critical path timelines for new and existing systems.
4. Architecture/Landscape Architecture Breadth:
   a. Investigate blast pressure software capabilities
   b. Blast model
      i. Create simplified SDOF model of building façade and UFC specified blast threat
      ii. Determine pressures at given stand-off distances
   c. Compare results to UFC minimum requirements
   d. Make adjustments to façade or landscape to accommodate UFC specified blast threat
5. Course Documentation
   a. Create final report outline
   b. Create presentation outline
   c. Finalize report and presentation
   d. Submit documentation for Schreyer review
   e. Regularly update CPEP website

5.7 Work Schedule

The work schedule on the following page is a visual timeline containing the task list presented in the previous section. Milestone completion goals are shown in Table xxx below.

Table 5: Milestone Completion Goals

Milestone #1		
Structural Depth	33%	Research and gravity system design complete
Construction Breadth	0%	N/A
Arch/Larch Breadth	33%	Research complete
Course Documentation	N/A	CPEP site updated
Milestone #2		
Structural Depth	50%	Computer modeling complete
Construction Breadth	0%	N/A
Arch/Larch Breadth	66%	Computer modeling complete
Course Documentation	N/A	CPEP site updated
Milestone #3		
Structural Depth	100%	Lateral system design complete, including seismic detailing
Construction Breadth	33%	Cost estimates in progress
Arch/Larch Breadth	90%	Alternative solutions complete
Course Documentation	N/A	CPEP site updated
Milestone #4		
Structural Depth	100%	Misc. activities completed
Construction Breadth	100%	Cost and Schedule analysese completed
Arch/Larch Breadth	100%	Misc. design work completed
Course Documentation	N/A	Report and presentation completed and submitted to Schreyer


Proposed Thesis Work Schedule and Milestones
Spring Semester: January-May 2015
Milestone #1 23-Jan
Milestone #2 13-Feb
Milestone #3 6-Mar
Milestone #4 3-Apr
5-Jan
12-Jan
19-Jan
26-Jan
2-Feb
9-Feb
16-Feb
23-Feb
2-Mar
9-Mar
16-Mar
23-Mar
30-Mar
6-Apr
13-Apr
20-Apr
27-Apr
Floor System Research
Design Floor System and Columns
Computer Aided Design Checks
Seismic Detailing
Model Gravity
Investigate Lateral System Elements
Modal Analysis
Size Lateral System Elements
Computer Aided Design Checks
Seismic Detailing
Detailed Cost Estimates
Spring Break
Detailed Cost Estimates
Schedule Analysis
Senior Banquet
Blast Analysis Research
Computer Modeling Research
Blast Software Investigations
Blast Analysis and Results Generation
Alternative Architectural Solutions
Misc. Design Detailing
Report Writing and Presentation
CPEP Update
CPEP Update
CPEP Update
CPEP Update
Schreyer Review
Structural Depth
Construction Breadth
Architecture/Landscape Architecture Breadth
Course Documentation
13-Apr: Thesis Presentation
13-Apr: Schreyer Final Thesis Submission Deadline
8-Apr: AE Final Thesis Submission Deadline
6-Mar: Schreyer Mandatory Thesis Format Review Submission Deadline

6 SUMMARY AND CONCLUSIONS

SSM St. Clare Health Center is a 6 story, 420,000 square foot composite steel structure resting on a seismic category D site. Its structure is broken up into 3 distinct building segments that are isolated by expansion joints. These segments have different occupancies, loadings, and geometries and require unique solutions for load resistance, particularly for lateral force resistance. Each independent structure has its own lateral force resisting system.

An alternate design scenario has been proposed in which the architect and owner prefer reinforced concrete as the primary structural material. The structure will be redesigned with seismically detailed reinforced concrete, using a pan joist floor system. The lateral system will consist of specially reinforced concrete shear walls and special moment frames.

The cost and schedule implications of the material change will be evaluated and a comparison study will be presented for the architect and owner's consideration. In addition, security threats to the building façade will be analyzed and the facade and site will be improved to meet minimum government force protection standards if the design is not already sufficient.

Further study and design will require the use of advanced modeling techniques, in-depth research, professional development, and application of graduate level course material.

7 APPENDIX A: LOAD CRITERIA

This appendix contains the structural design engineers' documented design loads. The values are referenced for comparison purposes.

Design Criteria (Live Loads)

Hospitals

Operating rooms, labs	60 PSF *
Private rooms	40 PSF *
Wards	40 PSF *
Corridors (above 1st floor)	80 PSF *

* Design for uniform load indicated or 1000# concentrated load over 2.5 feet square, whichever produces the greater load effect.

Offices

Offices	50 PSF **
Lobbies & 1st floor corridors	100 PSF **
Corridors (above 1st floor)	80 PSF **

** Design for uniform load indicated or 2000# concentrated load over 2.5 feet square whichever produces the greater load effect.

Misc. Live Loads

Corridors, except as otherwise indicated	100 PSF
Stairs and Exits	100 PSF ***
Dining Rooms and Restaurants	100 PSF
Retail Stores (first floor)	100 PSF
Mechanical rooms	125 PSF (Includes allowance for equipment pads)
Storage – Light	125 PSF

*** Design for uniform load indicated or 300# concentrated load over 4 inches square whichever produces the greater load effect

Partition loads 20 PSF
(Offices & locations where partitions are subject to change)

Design Floor Live Loads (Typical unless noted otherwise in calculations)
Typical floors: 80 PSF (60 PSF + 20 PSF Partitions) or (80 PSF Corridors)
First floor (typical): 100 PSF (60 PSF + 20 PSF Partitions) or (100 PSF Corridors)
First floor (equip): 120 PSF (60 PSF + 20 PSF Partitions + 40 PSF Equipment)
Mechanical Rooms: 125 PSF
Elevator Machine Rooms: 500 PSF
Interstitial Level: 25 PSF
Roof Top Mechanical Unit Support: 50 PSF (Live Load + Snow Load)

Other Live Loads

Handrails and guards	50 PLF or 200# concentrated load @ top rail
Components	50# over 1 foot square

Grab bars, shower seats, dressing rm. seats250# load in any direction at any point

Impact Loads
Elevator loads shall be increased by 100 percent for impact
Machinery weight shall be increased to allow for impact
Elevator machinery: 100 percent
Light machinery, shaft or motor driven: 20 percent
Reciprocating machinery or power driven units: 50 percent
Hangers for floors or balconies: 33 percent

Live Load Reduction
Live loads to columns will be reduced in accordance with IBC Section 1607.9.1. Live loads that exceed 100 PSF and roof live loads will not be reduced.

Distribution of Floor Loads
Uniform floor live loads shall be patterned to produce the greatest effect on continuous framing.

Roof Loads
Uniform roof live loads shall be patterned to produce the greatest effect on continuous framing.
Minimum roof load will be less than snow load
See section 1607.11 for other roof loads (roof gardens, landscaped roofs, canopies)

Interior Walls and Partitions
Interior Partitions 5 PSF horizontal pressure
Medical Equipment
MRI Equipment (four pt loads) 29000 lb/4 = 7250 lb
MRI Equip minus equip allowance 7250 lb – (40 PSF)*(25 ft2) = 6250 lb

Design Criteria (Dead Loads)

Hospital Floor (Composite slab, 2 Hour)	
3" Deck + 3 1/2" LW Conc	48 PSF
Beams/Girders/Columns	Self Wt (Assume = 9 PSF)
Ceiling/Mechanical/Misc	12 PSF
	60 PSF (Mass DL = 69 PSF + 10 PSF for Partition Mass)
Hospital Roof (Future Floor) (Composite slab, 2 Hour)	
3" Deck + 3 1/2" LW Conc	48 PSF
Beams/Girders/Columns	Self Wt (Assume = 9 PSF)
Ceiling/Mechanical/Misc	12 PSF
Roofing/Insulation/Ballast	18 PSF
	78 PSF (Mass DL = 87 PSF)
Hospital Roof (No future floors) (Composite slab, 2 Hour)	
3" Deck + 3 1/2" LW Conc	48 PSF
Beams/Girders/Columns	Self Wt (Assume 9 PSF)
Ceiling/Mechanical/Misc	12 PSF
Roofing/Insulation/Ballast	18 PSF
	78 PSF (Mass DL = 87 PSF)
Power Plant Roof (No future floors) (Composite slab, 2 Hour)	
3" Deck + 3 1/2" LW Conc	48 PSF
Beams/Girders/Columns	Self Wt (Assume 9 PSF)
Ceiling/Misc	7 PSF
Mechanical Piping	60 PSF
Roofing/Insulation/Ballast	18 PSF
	133 PSF (Mass DL = 142 PSF)
Penthouse Floor (Composite slab, 2 Hour)	
3" Deck + 3 ½" LW Conc	48 PSF
Beams/Girders/Columns	Self Wt (Assume = 9 PSF)
Mechanical/Misc	12 PSF
	60 PSF (Mass DL = 69 PSF + 10 PSF for Partition Mass)
Penthouse Roof (Steel Roof Deck)	
Steel Deck	3 PSF
Beams/Girders/Columns	Self Wt (Assume = 7 PSF)
Mechanical/Misc	7 PSF
Roofing/Insulation/Ballast	18 PSF
	28 PSF (Mass DL = 35 PSF)
Roof Top Mechanical Unit Support	
Beams/Girders/Columns	Self Wt (Assume = 7 PSF)
Mechanical Unit	60 PSF
Miscellaneous Pipes & Ducts 15 PSF	
	75 PSF (Mass DL = 82 PSF)
Hospital Floor – Piping Zone (Composite slab, 2 Hour)	
3" Deck + 3 1/2" LW Conc	48 PSF
Beams/Girders/Columns	Self Wt (Assume = 9 PSF)
Mechanical Piping	60 PSF
Ceiling/Misc	7 PSF
	115PSF (Mass DL = 94 PSF + 10 PSF for Partition Mass)
Hospital Floor/Power Plant (Composite slab, 2 Hour)	

3" Deck + 3 1/2" LW Conc	48 PSF
Beams/Girders/Columns	Self Wt (Assume = 9 PSF)
Mechanical Piping	60 PSF
Ceiling/Misc	7 PSF
	115PSF (Mass DL = 94 PSF + 10 PSF for Partition Mass)
Hospital Floor – MRI Zone (Composite slab, 2 Hour)	
3" Deck + 3 1/2" LW Conc	48 PSF
Beams/Girders/Columns	Self Wt (Assume = 9 PSF)
2" Concrete Topping	18 PSF
Mass for Permanent Equip	(15 PSF Mass DL)
Ceiling/Mechanical/Misc	12 PSF
	78 PSF (Mass DL = 102 PSF + 10 PSF for Partition Mass)
Hospital Floor – Piping Zone plus MRI Zone (Composite slab, 2 Hour)	
3" Deck + 3 1/2" LW Conc	48 PSF
Beams/Girders/Columns	Self Wt (Assume = 9 PSF)
2" Concrete Topping	18 PSF
Mass for Permanent Equip	(15 PSF Mass DL)
Mechanical	30 PSF
Ceiling/Misc	7 PSF
	103 PSF (Mass DL = 127 PSF + 10 PSF for Partition Mass)
MOB Floor (Non-Composite slab, 0 Hour)	
1 ½" Deck + 2" LW Conc	29 PSF
Beams/Girders/Columns	Self Wt (Assume 9 PSF)
Ceiling/Mechanical/Misc	7 PSF
	36 PSF (Mass DL = 45 PSF + 10 PSF for Partition M ass)