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Executive Summary

The intent of the thesis proposal is to shed light on design challenges and opportunities to solve them. Previous analytical calculations done in the technical reports indicate some structural irregularities in the existing Largo Medical Office Building (LMOB). Challenges that these irregularities present, include: soft story and extreme torsion. Soft story is caused by greater height of the first story – when compared with the typical story height. As for torsion, the eccentricity between the center of mass (CM) and center of rigidity (CR) is the underlying cause.

For the re-design, the facility will remain in Largo, Florida. The primary objective will be to address the structural irregularities – mentioned above. Solving these irregularities will permit the owner to expand operations to more seismically active regions, whilst maintaining similar layout and systems – to reduce general logistics, maintenance, and repair costs.

Two potential solutions will be accessed. One is adding additional lateral force resisting elements. The second is eliminating the interior lateral force resisting elements entirely and replacing it with an exterior tilt-up bearing wall system, freeing up the interior for more flexible interior configurations. The tilt-up system will act as both a gravity and lateral force resisting system.

In addition to the structural focus, constructability will be generally explored. Constructability is used to evaluate the competitiveness of the two potential structural solutions with each other. When evaluating constructability, two factors will be implemented – the direct construction costs and site logistics. As site logistics is a broad concept; the breadth of study will only include site access points, construction traffic impact on neighboring buildings and infrastructure, availability of on-site storage and field work areas.

The final topic of general study will be related to building science, more specifically redesigning the building façade. Here the concrete masonry back-up wall will be replaced with light gauge cold formed steel (CFS) studs. Success of the façade redesign will be determined by thermal performance, moisture resistance, acoustical performance, general construction cost, and relative ease of assembly.

In summary, the proposed field of study includes:

1. Lateral Systems (Depth)
2. General Construction Management (Breadth)
3. Building Science (Breath)

Building Overview

Largo Medical Office Building (LMOB) is an expansion of the Largo Medical Center complex. Designed in 2007 and completed in 2009, LMOB is managed and constructed by The Greenfield Group. Overall the project cost $12.6 million, not including the equipment. Located in Largo, Florida (Figure 1.1) the six story facility was designed to house improved and centralized patient check-in area. The facility also houses office space for future tenants, as well as screening and diagnostic equipment.

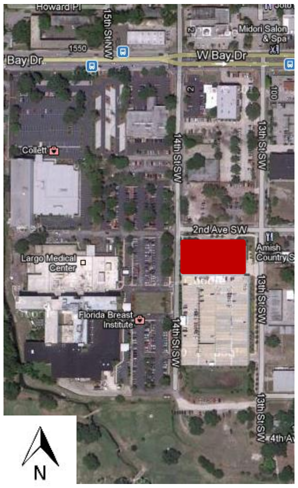
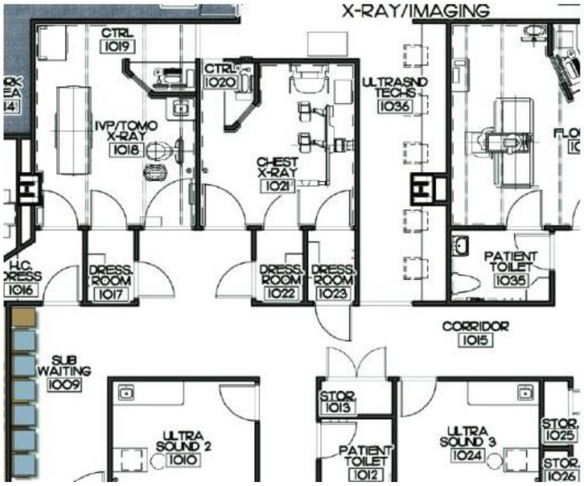


Figure 1.1, Neighborhood
Source: Google Maps



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en, Spina & Partners

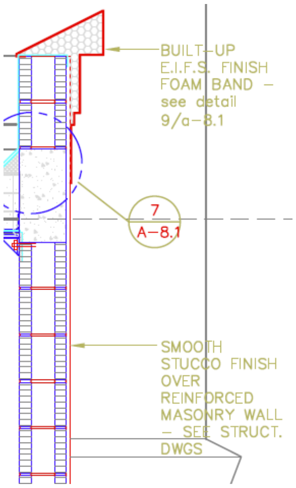


Figure 1.3, Façade Section
Source: Oliver, Glidden, Spina
& Partners

Patient privacy is a major concern for facilities housing medical related activities. Oliver, Glidden, Spina & Partners addressed the concern by clustering the screening and diagnostic spaces close to the dressing areas (Figure 1.2). The architect went a step further, to preserve privacy by compartmentalizing the building's interior.

LMOB is a steel framed facility with ordinary reinforced concrete shear walls to resist gravity and lateral loads, respectively. The shear walls rest on top of spread footings which are at least 27" below grade. Unlike the structural system, the building's façade sit on top of strip footings.

The building's façade primarily consists of stucco finished over a CMU backup wall. All CMUs are grouted and reinforced, to resist hurricane force winds. Likewise, the façade's glazing is impact resistant. To enhance the architecture, LMOB uses an exterior insulation finish system (E.I.F.S.) to create extrusions. The other architectural feature of the building is the overhang over the building's north entrance. Both the stucco finished CMU and E.I.F.S. can be seen in Figure 1.3.

Structural System

LMOB is a 105’ tall and 155,000 ft^2 facility which uses ordinary reinforced concrete shear walls and a steel frame. Due to nature of the facility’s function and the owner’s desire; little information about the soil profile, structural details, design codes and structural materials used in LMOB are available. The uncertainty necessitated numerous assumptions during the analysis and upcoming design.

Framing & Lateral System

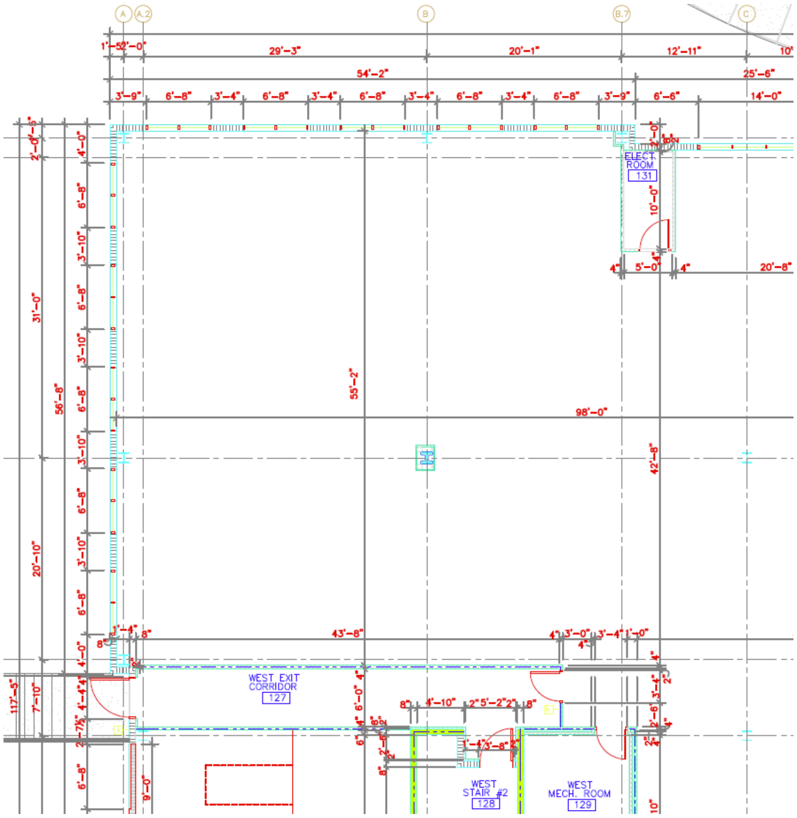


Figure 2.1, Typical Structural Bay

Source: Oliver, Glidden, Spina & Partners

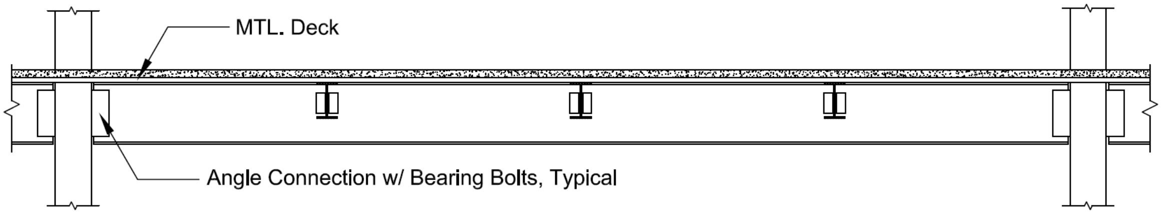


Figure 2.1, Typical Framing

The steel frame is organized in the usual rectilinear pattern. There are only slight variations to the bay sizes, but the most typical is 33’-0” x 33’-0” (Figure 2.1). W12 columns were used throughout the building. Girders are generally W24, like the columns the unit weight of the girder was not provided. It was determined – during previous analysis for the technical reports – that the W24 is likely a W24x76 with shear studs. Girders primarily span in the East/West (longitudinal) direction. A typical structural framing detail can be seen in Figure 2.2. The only locations where girders are orientated differently include: the overhang above the lobby entrance and the loading dock area.

On top of the girders and beams is a 5” composite slab. The composite slab composes of 2” composite steel deck and 3000 psi normal weight concrete. Please see to Appendix A of Technical Report I for typical plans and elevations. It is assumed that the columns, girders, and beams are fastened together by bearing bolts. As a result, the steel frame only carries gravity loads.

To deal with the lateral load, ordinary reinforced shear walls are used. The 86’ shear walls help the facility resist the dominant lateral load – wind – originating from the North/South and East/West directions. Wind loading in the North/South direction dominates in base shear and overturning component. Due to the Florida’s low seismic activity but high hurricane risk it is logical that the facility experience high wind loads when compared to the seismic load.

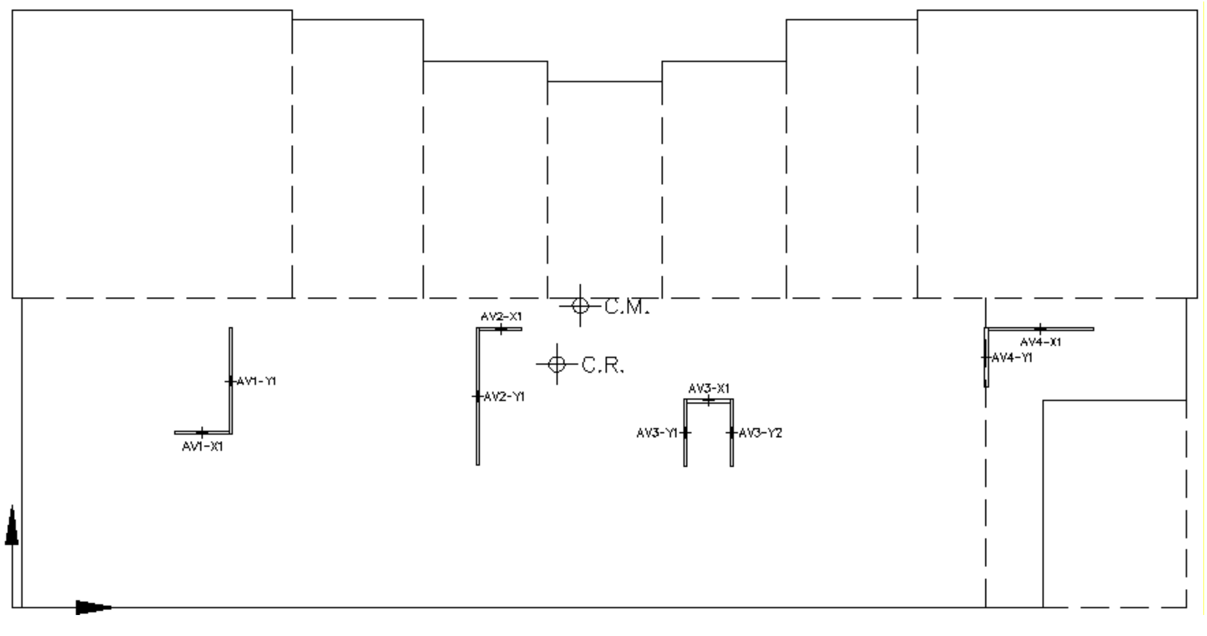


Figure 2.3, Shear Wall Locations

From the drawings it is assumed that the shear walls are positioned around the emergency stairwells and the two elevator cores. Typical shear walls span from the ground floor level to the primary roof (86’ above ground floor level). Shear wall locations and their respective designations are in Figure 2.3. Shear walls are secured to the foundation using dowels. All shear walls are 8” thick. The lateral load path starts at the building’s façade, which then transfers to the floor diaphragm and collector elements. Lateral loads then get transferred to the shear walls and finally to the ground.

Preliminary hand calculations indicate an eccentricity between LMOB’s center of mass and center of rigidity. The eccentricity varies between the first two levels due to the two story lobby. Generally speaking, the eccentricity is 9.28’ in the x-direction, 11.10’ in the y-direction. Torsion resulting from the eccentricity is expected. Using ETABS simulation, it was generally determined that LMOB experiences torsional irregularity defined in ASCE 7-05 Table 12.3-2. The hand calculations also revealed that LMOB experiences soft story irregularity at the first story. Soft first story is caused by the greater floor-to-floor height of the first story height (16’) when compared to the 12’ of the other stories.

Flooring System

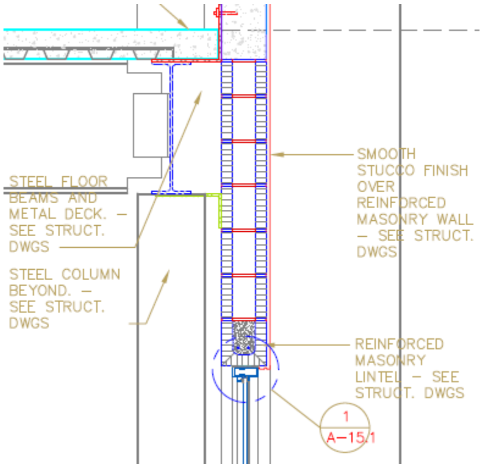


Figure 2.4, Typical Composite Slab

Source: Oliver, Glidden, Spina & Partners

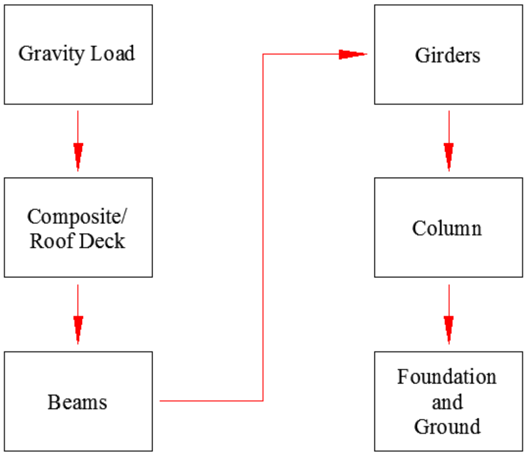


Figure 2.5, Gravity Load Distribution

In general, the structural flooring system is primarily a 5” thick composite slab (Figure 2.4). On all floor levels, except for the ground, the composite slab spans 8.25’ between beams. The structural flooring system uses 2” composite deck with 3” of concrete cover. Shear studs, ¾” diameter, from the girders engage with the slabs. Though the shear stud length is not provided, it was calculated that a shear stud length of 4” is adequate to resist the code defined loads. Composite action results in reduced structural floor depth.

Gravity load distribution path can be followed in Figure 2.5. To satisfy the 2-hour fire rating defined by the FBC, it is likely that the floor assembly received a sprayed cementitous fireproofing – based on recommendations by the 2008 Vulcraft Deck Manual. Where an exposed 2” composite deck with 3” of normal weight (NW) topping only has a 1.5-hour rating.

Roof System

LMOB has three roof levels: main roof, east emergency stairwell roof, and the overhang over the main entrance. Each roof level can be seen in Figure 2.6. There is only one roof type for all three roof levels, consisting of a 3-ply bituminous waterproofing applied over the insulated cast-in-place concrete (Figure 2.7). As oppose to the 2” composite metal deck used on the floor slabs, the roof slab utilizes 1.5” non-composite deck. Another difference is the use of joists spaced at 5’-6”, in-lieu of beams. To ensure adequate code defined rainwater drainage, the insulated cast-in-place concrete is sloped ¼” for every 12” horizontal.

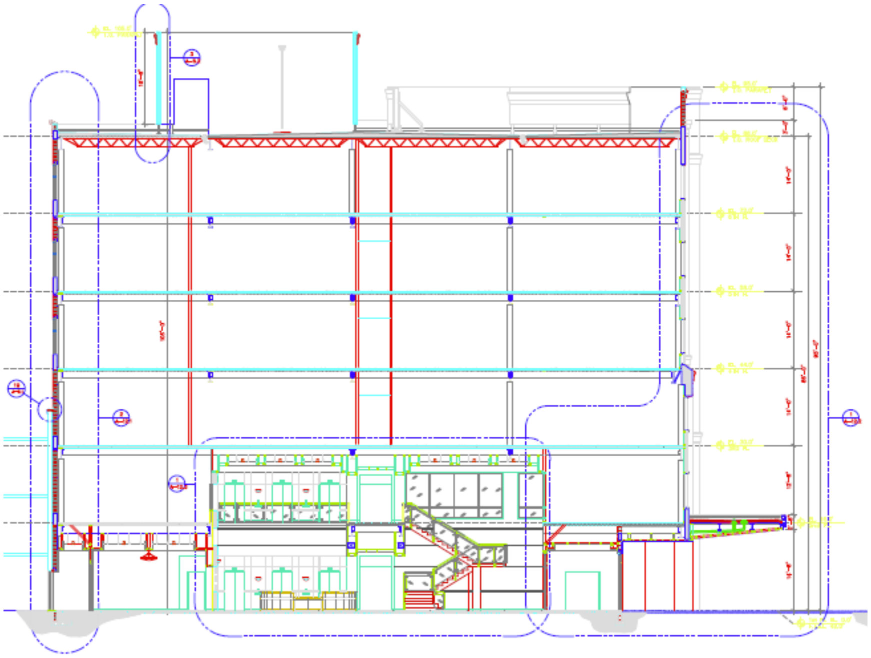


Figure 2.6, Roof Levels

Source: Oliver, Glidden, Spina & Partners

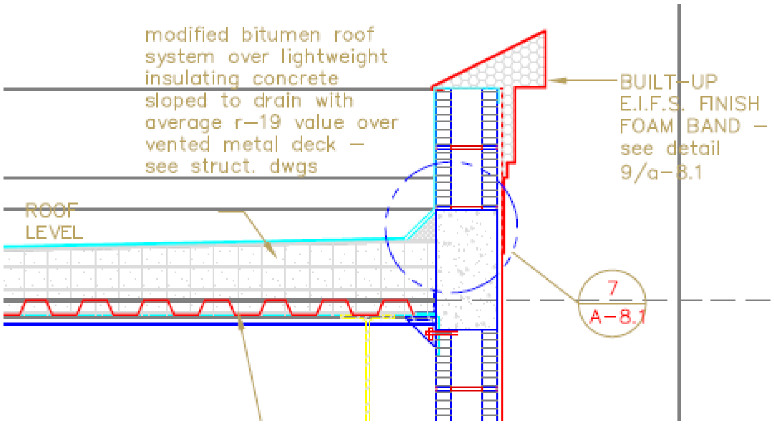


Figure 2.7, Roof Detail

Source: Oliver, Glidden, Spina & Partners

The insulated cast-in-place concrete was used in-lieu of rigid insulation with stone ballast. The insulated concrete has sufficient mass to resist becoming airborne. One reason for the substitution is that the facility is in a hurricane zone – where the potential for loose material to become airborne projectiles and cause damage is significant. An added benefit is the added mass, which counters the uplift component of the dominant wind force.

Design Codes

Structural engineering consulting firm, McCarthy and Associates, designed the building to comply with the following codes and standards:

1. 2004 Florida Building Code (FBC)
   – Adoption of the 2003 International Building Code (IBC)
2. ACI 318-05
3. 13th Edition AISC Steel Manual
4. Design Manual for Floor and Roof Decks by Steel Deck Institute (SDI)

Codes and standards used for this thesis are as follows:

1. 2009 International Building Code (IBC)
2. ASCE 7-05
3. ACI 318-11
4. 14th Edition AISC Steel Manual
5. American Iron and Steel Institute Standard 100 (AISI 100)
6. 2008 Vulcraft Decking Manual
7. 2007 Vulcraft Steel Joists and Joist Girders Manual

Structural Materials Used

Table 2.1, List of Structural Materials

Steel	
W-Shapes	ASTM A992 Gr. 50
Angles	ASTM A36
Plates	ASTM A36
Reinforcing Bars	ASTM A615
Concrete	
Footings	3000 psi
Slab-on-Grade	3000 psi
Floor Slab	3000 psi

Gravity Loads

Dead, live, rain, and snow loads were calculated for verification of the gravity system. ASCE 7-05 was used to determine the live loads on each floor. However, insufficient information arising from incomplete drawing set and specification prevented direct comparison of code defined loads and loads used to design the existing building.

Dead Loads

Before dead load calculations were performed, quantity takeoffs and research in material weight was implemented. Take-offs were organized by floor level, which allowed ease of future analysis and design of alternate structural systems. The division by floor level has flexibility built in, where changes in materials can be easily tracked without having to decipher the entire building load equation. Items included in the take offs are: slab concrete volume, floor finish areas, areas of roofing layers/components, volume and area of façade components. See Table 3.1 and Table 3.2 for the material weights and total un-factored dead load by floor level.

Table 3.1, Weight of Building Materials

Material	Weight	Reference
Normal-Weight (NW) Concrete	150 lb/ft^3	AISC 14th Edition – Table 17-13
Light-Weight (LW) Concrete	113 lb/ft^3	Arch. Graphics Standards 11 Edition
Vinyl Composition Tile (VCT)	1.33 lb/ft^2	Arch. Graphics Standards 11 Edition
Ceramic/Porcelain Tile	10 lb/ft^2	AISC 14th Edition – Table 17-13
3-Ply Roofing	1 lb/ft^2	AISC 14th Edition – Table 17-13
0.8” Laminated Glass	8.2 lb/ft^2	
MEP	15 lb/ft^2	

Table 3.2, Unfactored Dead Load

Floor Level	Load (kip)
Ground	2425.2
1	3325.7
2	3289.7
3	3289.7
4	3289.7
5	3289.7
Roof	3248.9

Assumptions were made to accelerate and simplify the take-offs and load determination. The assumptions are as follows:

1. Metal deck has equal rib volume
2. All beams are identical to the beam in the typical bay
3. All girders identical to the girder in the typical bay

4. Glazing and concrete are the only façade materials
5. All floors except for the roof use the same type of concrete

Once material quantities and material weight were determined, floor weight was determined. Items not included in the floor weight are the metal decking, joists, and structural steel members. Only after sizing the metal decking, joists, and structural steel members were the items included in the floor weight. A collateral load, of 5 lb/ft^2, was included in the dead load to account for unforeseen gravity loads.

Live Loads

LMOB is classified as a Type B occupancy, by the 2009 IBC. The outcome of the classification is the use of office live loads. The other live load used to analyze the gravity system is associated with emergency egress. Due to the lack of access to the actual live loads used by the structural consultant, the 2003 IBC live loads were compared to the ASCE 7-05 live loads. Comparison of the live loads is on Table 3.3.

Table 3.3, Live Load Comparison

Description	2003 IBC	ASCE 7-05
Stairs	100 lb/ft^2	100 lb/ft^2
Lobby & First Floor Corridor	100 lb/ft^2	100 lb/ft^2
Corridors Above First Floor	80 lb/ft^2	80 lb/ft^2
Ordinary Flat Roofs	N/A	20 lb/ft^2
Partitions	20 lb/ft^2	15 lb/ft^2

The option to use live load reductions was not taken up. Primary reason is that there is a likelihood that the busy hospital will expand its use of facility. Already the hospital occupies 39700 ft^2 of LMOB and has added a parking garage to accommodate additional patients. Another reason, it is likely that the facility will see new equipment, un-foreseen by the designers, in the future.

Table 3.4, Unfactored Live Load

Floor Level	Load (kip)
Ground	2313.6
1	2001.7
2	2103.9
3	2103.9
4	2103.9
5	2103.9
Roof	528.8

Table 3.4, shows the live loads are broken down by floor level.

Rain & Snow Loads

Location of LMOB was the deciding factor in whether rain or snow loads controlled. Being that the facility is in Largo, Florida; Figure 7-1 in ASCE 7-05 indicates that the ground snow load is zero. The result is no snow roof loads. Rain load was determined through the use of ASCE 7-05 and the International Plumbing Code (IPC). A ponding instability investigation was not required by ASCE 7-05, because the roof slope is a 1/4" rise for every 12” horizontal. Thus there was no study of ponding potential on the roof.

The hourly rain rate for Largo, Florida wasn’t in the standards; the closest city’s hourly rain rate was used. Tampa, Florida is the closest city to Largo, Florida. It was determined that the rain load is greater than the live roof load. In many calculations, the rain load (27.89 lb/ft^2) substituted the live roof load (20 lb/ft^2).

Problem Statement

Largo Medical Office Building (LMOB) satisfies strength and serviceability requirements. This was confirmed in Technical Reports I and III. As mentioned earlier, the center of rigidity (CR) and center of mass (CM) don't coincide. Eccentricity between the CR and CM is caused by concentrating the shear walls in the southern half of the building. In the current shear wall arrangement there is likelihood for torsional irregularity.

For the scenario; the facility will remain in its current location (Largo, Florida). When considering that the LMOB's owner owns multiple medical facilities and general ever increasing percentage of the U.S. population over 65 years of age, it is likely that additional medical facilities will be built. In the generally realistic scenario, LMOB's owners will aggressively expand their operations beyond Florida to more seismically active regions of the U.S. in the future. With foresight the owners plan to minimize general logistics, maintenance, and repair costs through using similar building layout and systems. In order to use a similar layout, LMOB's structure will need to be revised to eliminate ASCE 7-05 code defined torsional irregularity and soft story irregularity. Both which create significant structural weakness when the building is exposed to significant seismic loads.

As evident in recent hurricanes, preservation of the building envelope's integrity is equally important. The envelope serves to preserve a building's internal environment by minimizing the effects of the external environment. Compromised building envelopes allows water and moisture infiltration.

Short term consequences of a compromised envelope are as follows:

1. Electrical fires due to shorting the circuits
2. Damage to interior finishes
3. Increased internal humidity and latent load, causing the HVAC system to wear-out prematurely
4. Mold growth

Though the existing building façade is generally code compliant and performs adequately, it is heavy. The façade's weight is detrimental if a similar facility is built in a more seismically active region due to increase strengthening of lateral force resisting elements – either through more expensive high strength materials or increase dimensions. Reducing the façade's weight is paramount along with preserving moisture resistance and acoustical performance, whilst reducing general construction cost, and improving relative ease of assembly.

Problem Solution

Two design solutions will be considered to eliminate torsional irregularity and soft story irregularity. These solutions focus on increasing resistance to torsion and reinforce the soft first story of LMOB. Success of the solutions will not only rest upon performance but also upon the structural solution’s constructability.

The first design is a general revision of the current lateral structural system. In Technical Report III, it was discovered that LMOB experiences soft story and extreme torsional irregularity. As a result, the lateral force resisting elements will be strategically placed to minimize eccentricity between the CM and CR. All lateral force systems will be designed either by hand or with the help of ETABS.

A second design solution is the tilt-up exterior bearing wall system. The tilt-up walls will serve as a lateral load resisting system and be the same height as the original lateral load resisting system – 86’. 86’ tall tilt-up walls will push close to the maximum feasible height for monolithically cast walls. Currently, the tallest panel feasibly cast monolithically and tilted into place is approximately 92’ – for a commercial building in Hollywood, FL (TCA, 2014). The current limits to taller and heavier tilt-up walls are cost, lifting technology, and temporary bracing (Griffin, 2014). Internal lateral resisting elements will only be added, if it is determined that the tilt-up exterior walls are insufficient – however this is not expected. Due to the nature of tilt-up construction, the system’s stability must be studied when under the various phases of construction. The purpose of the study is to ensure adequate temporary bracing and prevent failure during construction.

In terms of the façade redesign, a light gauge cold formed steel (CFS) stud back-up wall will be used. What can be said is that the façade redesign strives to maintain – if not reduce – the general construction cost, and improve relative ease of assembly. Whether it has similar performance levels as the concrete masonry back-up wall remains to be determined.

Breadth Topics

Construction Management

Changing LMOB's structure will directly influence both the cost and site logistics. It is to be determined whether the two potential solutions – adding additional lateral force resisting elements or using a tilt-up bearing wall system – are economical. The ability to construct the facility efficiently is an important matter in determining the project's cost and progression.

Constructability criteria which will be studied are:

1. Direct construction cost
2. Studying the influence of the facility's access points on maximum member size
3. Maintaining uncongested or reduce construction impact on the access road to the Largo Medical Complex
4. Adequacy of site area to contain field work and/or material storage

Replacing the concrete masonry back-up wall with one made of light gauge CFS studs is of interest, because the building weight could potentially be reduced. The reduction stems from the greater strength to weight ratio of CFS. A benefit of reducing weight is greater productivity, whereby the laborers would not tired out as quickly and the construction can be accelerated. The potential downsides of using CFS stud back-up walls are the numerous connections required to join significantly more back-up wall components. When considering the mentioned downside with the potential of insufficient laborers with knowledge of CFS stud back-up walls in Florida, any weight reduction could be offset by potentially greater cost.

Building Science

Using CFS stud back-up in lieu of one made of concrete masonry has significant impact on thermal, moisture, and acoustical performance of the façade. Understanding that CFS studs have less thermal mass than concrete masonry, thermal insulation must be added to prevent significant energy loss and high building operational cost – utilities. The position and type of thermal insulation will be determined in the study.

To determine whether the redesign is successful, the existing façade and the redesign will be assessed by a set criterion, and are as follows:

1. General thermal performance
2. Vapor profile
3. Acoustical privacy
4. General construction cost
5. Ease of assembly

Understanding the vapor profile of the redesign will permit the determination of the condensation plane. The significance of the condensation plane is that this is the location where water vapor turns to liquid water, the surface which this occurs should direct the liquid water to the exterior – preventing long term moisture damage in the wall assembly. Long term moisture damage include but not limited to mildew, material degradation, and health hazards like mold.

Acoustical privacy depends multiple factors; some are controllable, others are not. The upcoming study will focus on the façade assembly’s ability to block out audible sound. To determine the mentioned metric, the acoustical characteristics of the wall components will be determined from available literature.

Proposed Schedule & Implementation

Thesis Depth

Task I: System with additional lateral force resisting elements

A. Determine the locations for the additional lateral force resisting elements
B. Generally size the lateral force resisting elements to eliminate LMOB’s torsional irregularity
C. Design the flexural, shear, and axial reinforcement for the lateral force resisting elements added
D. Model the lateral system, in ETABS, to determine confirm whether torsional irregularity has been eliminated
E. If torsional irregularity is not eliminated then revisit steps A to D
F. Resize base lateral force resisting elements to eliminate soft story irregularity
G. Model the lateral system, in ETABS, to determine confirm whether soft story irregularity has been eliminated
H. If soft story irregularity is not eliminated then revisit steps F to G
I. Acquire the interstory drift and fundamental period of the redesigned structure – from ETABS simulation – for later comparison with the other structural systems

Task II: Design Tilt-Up Load Bearing Wall System

A. Subtract shear wall loads from load calculations in Technical Report I
B. Size the tilt-up walls for gravity loads
C. Design the flexural, shear, and axial reinforcement to resist gravity loads
D. Determine locations of lateral force resisting tilt-up walls
E. Design the flexural, shear, and axial reinforcement to resist lateral loads
F. Model the lateral system, in ETABS, to determine confirm whether torsional and soft story irregularities exists
G. If torsional and/or soft story irregularity is not eliminated then revisit steps D to F
H. Acquire the interstory drift and fundamental period of the redesigned structure – from ETABS simulation – for comparison with the other structural systems
I. Determine loads acting on temporary bracing
J. Size members for temporary bracing

Construction Management Breadth

Task I: Site Logistics

A. Locate the site access points and determine the available turning radius to limit the maximum building component size.
B. Evaluate the additional traffic, caused by construction, on access roads to neighboring facilities

C. If construction traffic significantly affects neighboring buildings then formulate a solution (such as expanding existing infrastructure)
D. Generally organize the site for on-site material storage and field work during different construction phases

Task II: Quantity Take-Offs

A. Determine material quantities for the original structural system
B. Determine material quantities for adding additional lateral force resisting elements
C. Determine material quantities for the tilt-up wall system
D. Determine material quantities for the original façade system
E. Determine material quantities for the redesigned facade

Task III: Cost Analysis

A. Use R.S. Means to determine the cost of original structural system
B. Use R.S. means to determine the cost of adding additional lateral force resisting elements
C. Use R.S. Means to determine the cost of tilt-up wall system
D. Use R.S. Means to determine the cost of original façade system
E. Use R.S. Means to determine the cost of redesigned facade

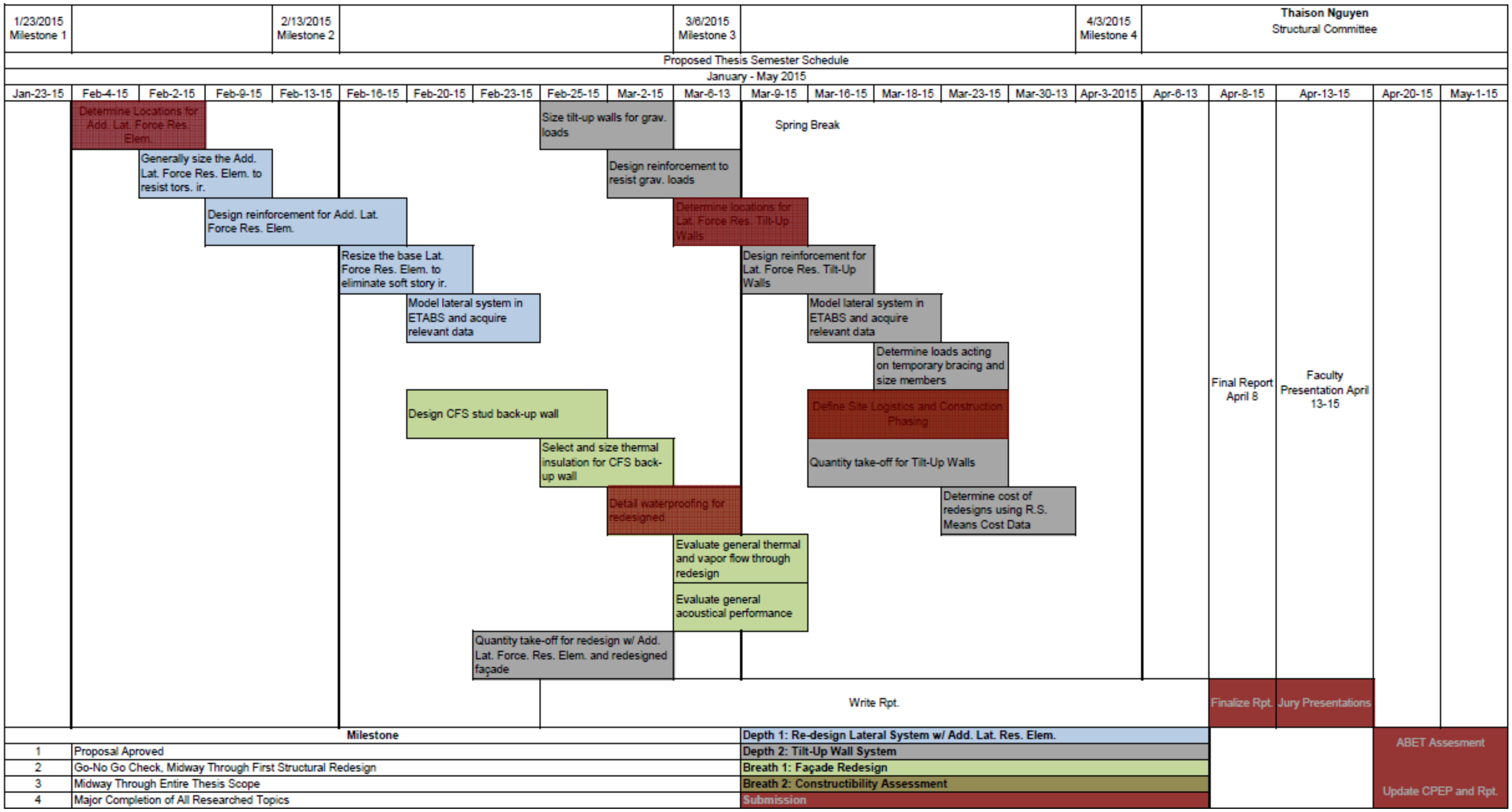
Building Science Breadth

Task I: Discovery

A. Determine the waterproofing, acoustical performance, and detailing used on the existing façade system
B. Define interior and exterior temperature and humidity, for use in analysis
C. Literature review of waterproofing methods
D. Determine thermal and vapor flow through the original system
E. Read through AISI 100
F. Determine the out-of-plane lateral load acting on the building's facade

Task II: Redesign Façade

A. Design CFS stud back-up wall
B. Detail waterproofing for redesigned façade
C. Evaluate general thermal and vapor flow through the redesign
D. Evaluate the general acoustical performance of the redesign
E. Compare the original and redesign façade – to determine if redesign is worth it


1/23/2015
Milestone 1
2/13/2015
Milestone 2
3/6/2015
Milestone 3
4/3/2015
Milestone 4
Thaison Nguyen
Structural Committee
Proposed Thesis Semester Schedule
January - May 2015
Jan-23-15
Feb-4-15
Feb-2-15
Feb-9-15
Feb-13-15
Feb-16-15
Feb-20-15
Feb-23-15
Feb-25-15
Mar-2-15
Mar-6-13
Mar-9-15
Mar-16-15
Mar-18-15
Mar-23-15
Mar-30-13
Apr-3-2015
Apr-6-13
Apr-8-15
Apr-13-15
Apr-20-15
May-1-15
Determine Locations for Add. Lat. Force Res. Elem.
Generally size the Add. Lat. Force Res. Elem. to resist tors. ir.
Design reinforcement for Add. Lat. Force Res. Elem.
Resize the base Lat. Force Res. Elem. to eliminate soft story ir.
Model lateral system in ETABS and acquire relevant data
Design CFS stud back-up wall
Select and size thermal insulation for CFS back-up wall
Detail waterproofing for redesigned
Evaluate general thermal and vapor flow through redesign
Evaluate general acoustical performance
Quantity take-off for redesign w/ Add. Lat. Force. Res. Elem. and redesigned façade
Size tilt-up walls for grav. loads
Design reinforcement to resist grav. loads
Determine locations for Lat. Force Res. Tilt-Up Walls
Design reinforcement for Lat. Force Res. Tilt-Up Walls
Model lateral system in ETABS and acquire relevant data
Determine loads acting on temporary bracing and size members
Define Site Logistics and Construction Phasing
Quantity take-off for Tilt-Up Walls
Determine cost of redesigns using R.S. Means Cost Data
Spring Break
Final Report April 8
Faculty Presentation April 13-15
Write Rpt.
Finalize Rpt.
Jury Presentations
ABET Assesment
Update CPEP and Rpt.
Milestone
1 Proposal Aproved
2 Go-No Go Check, Midway Through First Structural Redesign
3 Midway Through Entire Thesis Scope
4 Major Completion of All Researched Topics
Depth 1: Re-design Lateral System w/ Add. Lat. Res. Elem.
Depth 2: Tilt-Up Wall System
Breath 1: Façade Redesign
Breath 2: Constructibility Assessment
Submission

Conclusion

The purpose of this thesis proposal is to engage in the evaluation of various structural and façade solutions for the Largo Medical Office Building (LMOB). Each of the potential solutions aim to prepare the building components and structure for the owner to expand operations to more seismically active regions of the U.S. whilst using similar building layout and systems.

Successful structural solution will rely on the elimination of torsional irregularity and soft story irregularity, as well as constructability. Reducing the façade's weight through using a lightweight back-up wall is paramount in reducing the seismic load impact on lateral force resisting elements. However it is not the only criterion for a success; other criterion include: thermal performance, moisture resistance, acoustical performance, and also constructability.

Both potential structural solutions and façade redesign strive to satisfy constructability. Yet constructability is a broad topic, to maintain focus only a few aspects will be addressed. The constructability aspects examined will be ease assembly without significant site infrastructure and labor force, minimize the impact to the neighborhood, as well as reducing the owner's financial burden.

Works Cited

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