Handley McDonald

Thesis Proposal (Revised)

Claude Moore Medical Education Building

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Handley McDonald

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EXECUTIVE SUMMARY

The Claude Moore Medical Education center is the newest addition to the University of Virginia's health and medical sciences program. The project itself is meant to push the department, and the school forward into the future with new labs, new techniques, and a new space to learn. The 58,000 square foot building achieves this perfectly by providing state of the art mock labs and outpatient care, as well as appealing architecture that is meant to make the students feel welcome.

After examining the structural system as a whole, examining the flooring systems, and analyzing the lateral resisting system, it is clear that the building was designed exceptionally well, and meets all requirements for a steel frame structure.

This proposal sums up an idea for improving upon the current structure, if possible. It is possible that the ideas presented here do not optimize the structure in any way, but a comparison will still be made, nonetheless. The current mix of moment frame, braced frame, and shear walls will be redesigned into a lateral system comprised of only one type of lateral resisting system. Braced frames and moment frames will be considered for this alternate design, as shear walls are simply too large and heavy to consider making them a primary lateral load carrying system.

Apart from the structural redesign, breadth studies will analyze how these changes will affect the architectural appeal of the building, and how a typical structure could be done faster and cheaper.

BUILDING INFORMATION

Claude Moore Medical Education Building

58,000 sq. ft.

Type B and A-3 mixed occupancy

6 total levels, 4 above grade

OWNER	University Of Virginia | 575 Alderman Rd Charlottesville, VA
ARCHITECT	CO Architects | 5055 Wilshire Blvd Los Angeles, CA
ASSOCIATE ARCH	Train and Partners Architects | 1218 E Market Street Charlottesville, VA
BUILDER	Barton Malow Construction | 100 Tenth Street NE #100 Charlottesville, VA
STRUCTURAL ENG	Nolen Frisa Associates | 103 Homestead Dr Forest, VA
M.E.P. ENG	Bard, Rao& Thomas | 311 Arsenal St Watertown, MA
CIVIL ENG	RMF Engineering | 217 5th St, N.E. #2 Charlottesville, VA
LANDSCAPE ARCH	Dirtworks, PC | 200 Park Avenue South New York, NY
GEOTECH ENG	Schnabel Engineering South | 2020 Avon Court, #15 Charlottesville, VA
AUDIOVISUAL	The Sextant Group | 730 River Avenue #600 Pittsburgh, PA

The Claude Moore Medical Education Building was constructed on the University of Virginia's Health System campus, where they are centralizing all of their medical facilities, both educational and practical. Completed in August of 2010, just in time for classes, the new building was to represent a huge leap forward in medical technologies, and demonstrate the new, hands on teaching facilities of the University.

The third floor Lecture hall can seat 117 students, and provides a traditional learning environment.

This new style of teaching the medical students is represented best in the Learning Center, a large, round room meant to encourage group oriented learning, as opposed to the traditional lecture hall classrooms. Below this learning center, are state of the art mock medical facilities, to provide hands on training in a controlled environment, and with trained "patients." In addition, it will also include a traditional lecture hall, administrative offices, and student lounge.

The Learning Center provides a high-tech and group oriented learning space, where students can collaborate with the teacher, as well as each other.

Exceeding the University's environmental building policy, the Claude Moore building received a LEED silver certification due to a number of environmentally friendly systems. These systems include efficient HVAC equipment, a cool roof design, and several water reduction strategies that help to reduce the amount of runoff from the building.

The entire project cost $40 million, and greatly adds to the effort of condensing the medical facilities of the University.

STRUCTURAL SYSTEM OVERVIEW

The Claude Moore Medical Education Building is a four level structure. The main structure is a composite deck system, composed of steel beams, columns, and a concrete slab on metal floor decking. This system rests on a foundation of drilled concrete piers that continue approximately 25' below grade into bedrock. In several aspects of the design, the large circular section of the building that contains the lecture hall and Learning Center, are distinguished from the typical structural design, and is referred to as the "drum."

FOUNDATION

The foundation for the Medical Education Building primarily consists of 18" drilled piers. These piers are made of 4000 psi, normal weight concrete, and go 2' into the bedrock underneath the site. This decision was made based on the geotechnical report done by Schnabel Engineering South in 2006. Because of the large column loads, and limited space between this site and the adjacent buildings, a deep foundation had to be used.

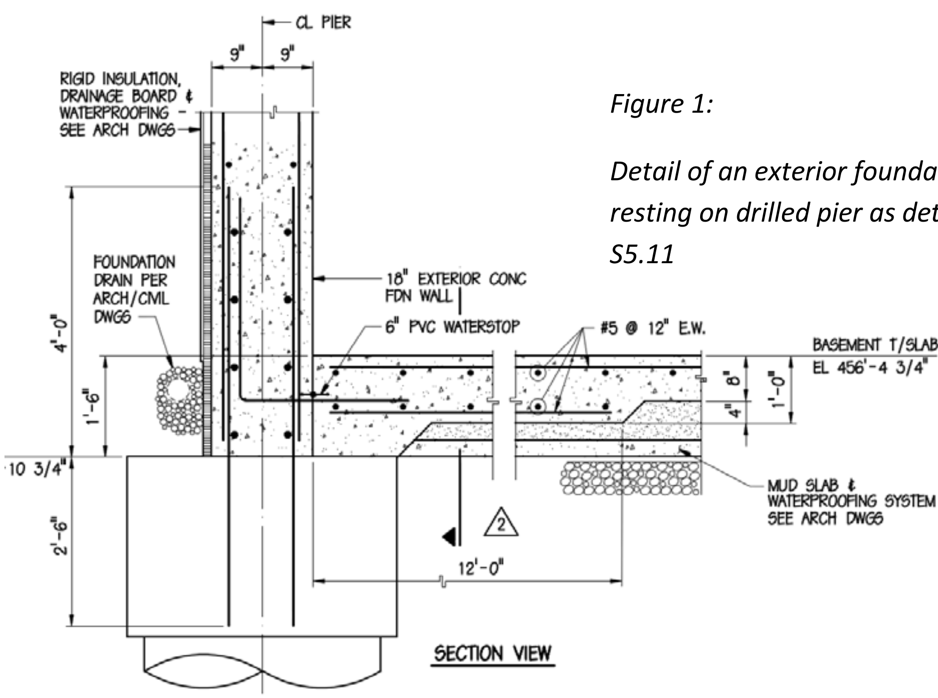


Figure 1:

Detail of an exterior foundation wall resting on drilled pier as detailed in S5.11

The basement level foundation walls are made of 18" thick cast in place concrete, reinforced with both vertical and horizontal reinforcement. These walls rest on the same centerline as the drilled piers below and connect to a 12" thick slab on grade system that includes a mud slab, and waterproofing.

FLOOR SYSTEM

The ground level is made up of an 8" thick concrete slab on grade, with reinforcing in both directions. Below this slab is a mud slab and a waterproofing system, to help stabilize and protect the slab. On each of the floors above, there is a composite metal deck with lightweight concrete, laid in thicknesses of 4.5" and 5.5" (including deck thickness). All metal decking was used in conjunction with composite steel beams, and welded shear studs. All ends were built with a minimum of 1.5" overlay, and end joints lapped at least 2". The beam and girder system here is relatively light, with most wide flanges ranging from W18 to W24, and 10 to 40 pounds per linear foot. Due to the minimal amount of space, and difficulty of the structural system, there is not really any typical bay type; however the rectangular layout fits into the drum section with minimal interruption.

Figure 2: Installation of lecture hall structure

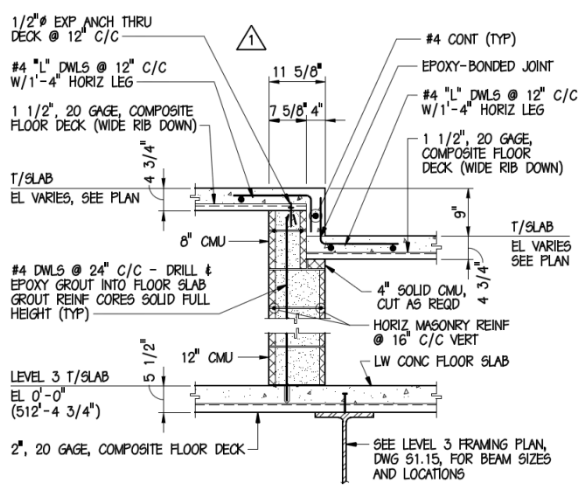


Figure 3: Detail of lecture hall floors, as noted in S5.22

For the lecture hall, 8" grout filled CMU was used to support the stepped composite floor deck. This slab is a 4.75" thick slab, and the circular CMU walls rest on a 5.5" composite floor deck. This part of the building has a much larger substructure of wide flanges, most of which are greater than 150 pounds per linear foot. There is no typical bay type for this section of the floor structure either.

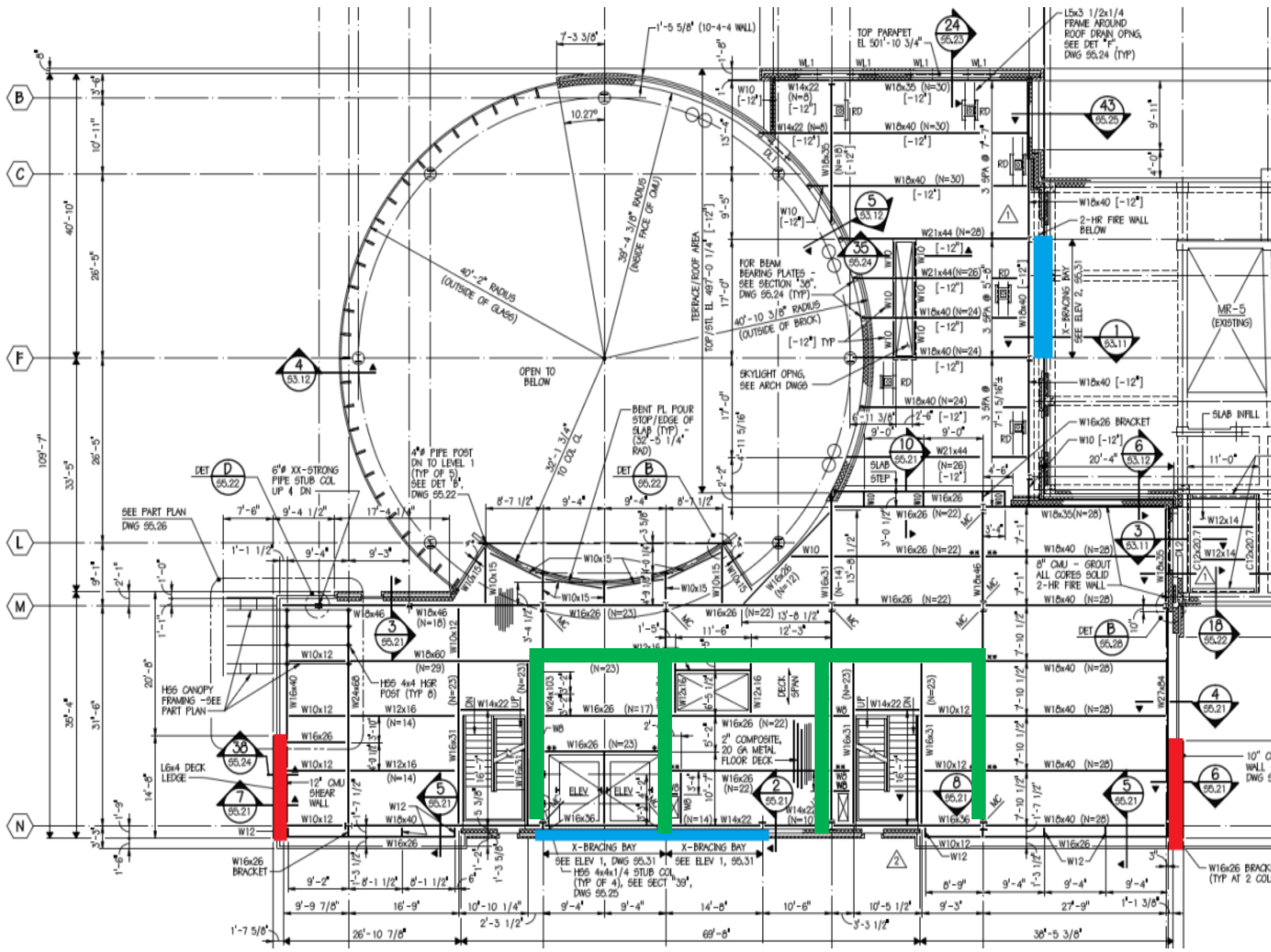
FRAMING SYSTEM

All of the framing for the Claude Moore Building was done with steel wide flanges. The beams, as previously mentioned, unfortunately do not follow much of a typical plan for size or spacing, but one should note that very minimal deviations were made as far as fitting the structure of the drum area into the rectangular structure of the rest of the building. A framing plan for reference is located in Appendix D. The columns are mostly W12 to W24 wide flanges; however the weights and spacings vary greatly within that. Because of the irregularity in the framing system, several transfer girders were necessary to allow for the change in structure from floor to floor. Most of these transfers happen below the first floor, and allow for the load to move from the main structure to the structure below grade.

LATERAL RESISTING SYSTEM

The lateral resisting system for this project is mostly made up of moment frames. Originally, the intent was to use only moment frames, with limited X-bracing to react with the curtain wall system. Changes were made, however, when the owner and architect modified the design, and limited the space available such that other options had to be considered. As a result, the system is a hybrid of moment frames, X-bracing, and shear walls.

The bays that include X-bracing are shown below in blue. The east wall braces are made of HSS 4x4x3/16 sections, and the south wall employs the same type of section, ranging from HSS 7x5x1/4 to HSS 9x5x1/2. The loads applied to these systems are transferred to the cast in place concrete foundation wall below, using a bolted base plate connection. In addition to these braced frames, two 14' long 12" CMU shear walls (red) were added at the plan southwest and southeast corners of the building. These walls help for shear in the north-south direction, and transfer their loads directly to the basement foundation below. The moment frames are given in green, and generally fill out the middle of the structure. These frames are also steel wide flanges, with bolted and welded connections to transfer lateral load directly to the foundation below.


B
C
F
L
M
N
OPEN TO BELOW
40'-2" RADIUS (OUTSIDE OF GLASS)
38'-4 3/8" RADIUS (INSIDE FACE OF CMU)
TERRACE/ROOF AREA
FOR BEAM BEARING PLATES - SEE SECTION "36", DWG S5.24 (TYP)
SKYLIGHT OPNG, SEE ARCH DWGS
BENT PL POUR STOP/EDGE OF SLAB (TYP)
2-HR FIRE WALL BELOW
X-BRACING BAY SEE ELEV 2, S5.31
MR-5 (EXISTING)
SLAB INFILL
W16x26 BRACKET
8" CMU - GROUT ALL CORES SOLID 2-HR FIRE WALL
SEE PART PLAN DWG S5.26
HSS CANOPY FRAMING - SEE PART PLAN
L6x4 DECK LEDGE
12" CMU SHEAR WALL
W16x26 BRACKET
ELEV
ELEV
2" COMPOSITE, 20 GA METAL FLOOR DECK
X-BRACING BAY SEE ELEV 1, DWG S5.31
X-BRACING BAY SEE ELEV 1, S5.31
HSS 4x4x1/4 STUB COL (TYP OF 4), SEE SECT "39", DWG S5.25
TOP PARAPET EL 501'-10 3/4"
109'-7"
68'-8"
26'-10 7/8"
38'-5 3/8"

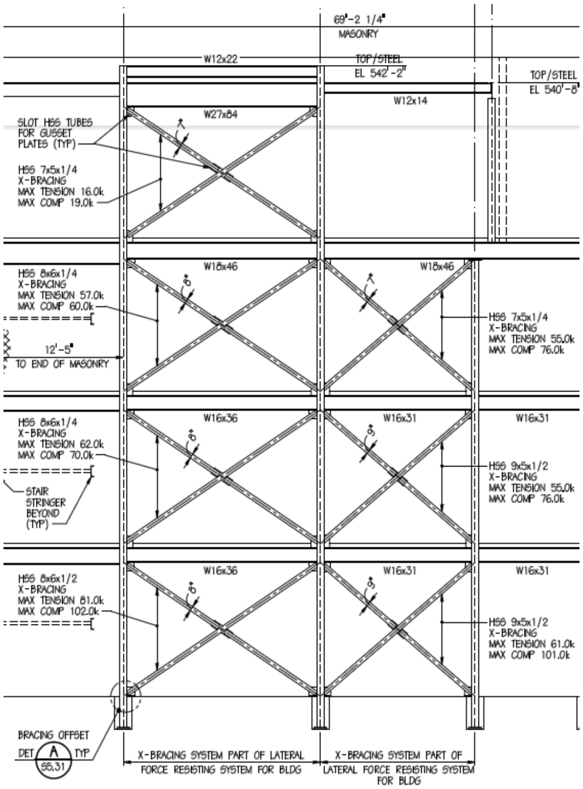
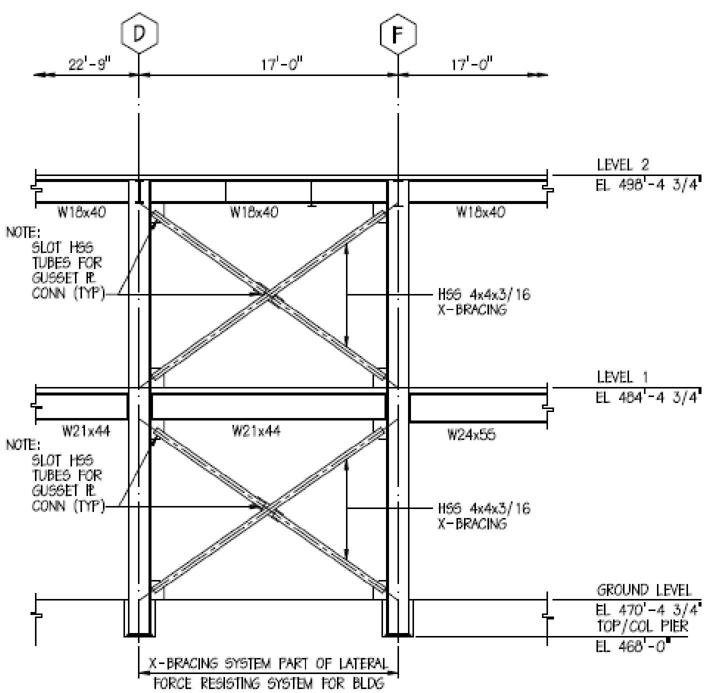


Figure 4 (above): Framing plan including highlights of non moment-frame lateral resisting elements. Detailed in S1.14.

Figure 5 (left): Elevation of X-bracing between column lines 3 and 5.9 as detailed in S5.31.

Figure 6 (below): Elevation of X-bracing between column lines D and F, as detailed in S5.31



DESIGN CODES

According to sheets S0.11 and A0.02, the following major code regulations were applied to this project:

- IBC 2003 with VA amendments (Virginia Uniform Statewide Building Code)
- IFC 2003 with VA amendments (Virginia Statewide Fire Prevention Code)
- IMC 2003 International Mechanical Code
- IPC 2001 International Plumbing Code
- ANSI/ASME A17.1 Safety Code for Elevators and Escalators
- Local ordinances and amendments to all of the above codes
- ACI 318-02 Structural Concrete Building Code
- AISC Manual of Steel Construction, 9th edition
- ASCE 5-02, 6-02 Code Requirements and Specifications for Masonry Structures
- ASCE 7-02 Minimum Design Loads for Buildings

These code standards vary from the ones used in this report, and from the ones that will be used in future reports. These differences will result in variations between the report results, and the results used in the building design.

MATERIALS USED

The following is a breakdown of the structural materials used throughout the building as taken from S0.11

STEEL		
Use	**Class**	**Strength**
W Sections	ASTM A992 GR 50	50000 psi
Channels, Angles, & Plates	ASTM A36	36000 psi
Hollow Structural Sections	ASTM A500 GR B	46000 psi
Steel Pipe Section	ASTM A53 GR B Type E or S	35000 psi
Structural Bolts	ASTM A325 and A490	n/s
Welding Electrodes	--	E70xx
Anchor Bolts	ASTM F1554 GR 36	36000 psi
Headed Shear Studs for Composite Beams	ASTM A108	60000 psi Designed for 11.4k per stud

CONCRETE		
Use	**Class**	**Strength**
Slab on grade, cast in place walls & foundations	Normal Weight (Assume 150 lb/ft^{3})	4000 psi
Elevated Floor Slabs	Light Weight (Assume 100 lb/ft^{3})	4000 psi
Reinforcing Steel	ASTM A615 GR 60	Fy=60000 psi
Welded Wire Fabric	ASTM A185	Fy=60000 psi

MASONRY		
Use	**Class**	**Strength**
Lightweight CMU	ASTM C90 GR N-1	f'm=1500 psi
Mortar for CMU	ASTM C270 Type S	f'c=1800 psi
Structural Grout	ASTM C476	f'c=2500 psi
Vertical Reinforcement	ASTM A615 GR 60	fy=60000 psi
Horizontal Joint Reinforcement	ASTM A82 w/ galvanizing per ASTM A 153 class B-2	n/s

	SOILS
Use	**Strength**
Bearing Capacity	3000 psf standard bearing case
Bedrock Bearing	50 ksf for drilled piers
Disintegrated Rock Bearing	25 ksf for drilled piers
Side Friction	2 ksf for elevation below 450' above sea level

GRAVITY LOADS

As an exercise in structural analysis, this report includes a basic spot check of a composite beam in as much a typical bay is found in this frame. Also in this section are estimates of dead loads for the building materials, and live loads that were used in the design, per Sheet S0.11

DEAD AND LIVE LOADS

The following is a list of the loads used in the calculations, and as specified in S0.11.

Dead Loads: Actual weights of materials were used for the design of the building. Calculations used estimates of building material weights.

Live Loads:

USE	LOAD
Roof live load	30psf unreduced
Assembly and large lecture halls	100psf
Terrace level roof at 2nd level	100psf
Stairs, corridors, lobbies, and exitways	100psf
Classrooms and training rooms	100psf*
Offices and conference rooms	100psf*
File storage	250psf
Mechanical equipment room (penthouse)	150psf or equipment weight
Slab on grade at basement level	200psf
All other floor areas	100psf*

*Indicates areas designed for greater load than code minimum. These greater loads allow for flexibility in future use of the space.

PROBLEM STATEMENT

After analyzing the structure from several different angles, it is clear that it has been designed quite well. It meets all code, serviceability, and safety requirements. This hybrid system of moment frames, shear walls, and braced frames work together quite well to resist lateral loads, and as discussed in the second report, the current flooring system is the most efficient type of system that could be used. No adjustment was required. However, the third tech report came out unclear as to the state of the lateral resisting system.

The current framing system is steel wide flange columns and composite beams, however due to the awkward nature of the architectural plan, many transfer girders were used and a typical bay size could not be established. This also reflected on the lateral system design, and forced the engineers to pursue several different avenues as far as resisting lateral loads.

While the lateral system is clearly acceptable, it was very complex to analyze, and according to the engineer, a very complex design problem as well. The plan is to unify the entire structural system into one type of lateral resisting element, for potential simplification purposes. Altering the structural system in this manner will have a large impact on construction cost and scheduling, which will need to be analyzed in making a final decision on which system would be more ideal. Second, the architectural design of the building will need to modify in some areas as well. Whether this be exterior details such as window placement, or interior walls that need to be thickened, these results will also be taken into consideration in the final report.

PROPOSED SOLUTION

The current system employs a hybrid of moment frames, braced frames, and shear walls to resist lateral load. While this system resists the lateral loads, the complexity of it leaves something to be desired.

The ultimate goal will be to only use one type of framing system, and compare it to the current system to decide which is more efficient. For this research, braced frames will be pursued, and two different configurations will be proposed, to compare not only to the structure as is, but compare both configurations to each other.

First, the structural capacity of the system will be analyzed. Based on the assumption that the strength capacity is acceptable, other considerations will be taken into account. The architectural details may be altered, and if the changes were to be put into place, those changes must so miniscule that no one will notice. As a point of measurable data, the redesign will attempt to keep the architectural features as unchanged as possible, and any failure to do so will count negatively towards the proposed design. The main issue with this approach will be the exterior openings. If the current placement of braced frames does not allow enough capacity, other wall segments will be included in the resisting system.

Construction concerns will also be weighed during this project. If a construction crew can erect the same typical structure several times, they can do it faster, and cheaper. Any redesign will be made with that fact in mind, and will attempt to make the structure simpler. Finally cost will be estimated for the current project and the redesigns. Materials, labor, and time of construction will be combined and examined to see if any one solution is drastically better.

BREADTH STUDY I

Since the architect was the main catalyst in altering the design of the lateral system, then architectural considerations certainly will be looked at when attempting to simplify the lateral structure. When redesigning the lateral system to be only braced frames, exterior openings will be the first concern. If additional walls are made to resist lateral load, openings may need to be relocated, or removed. In addition to analyzing any effects made by the structural system, a brief adjustment will be made to attempt to unify the two areas of the building, in particular, the exterior. While the materials and functionality match the surrounding areas, I get the impression that the building itself is made up of two buildings that were thrown together. Exterior details, landscaping, façade materials, and interior flow will be looked at, and modified as needed to tie together the circular "drum" with the rectilinear portions of the building.

Figure 7: Picture of front façade of building, with lines to accent the lines of the building. Red shows the very horizontal and flowing nature of the drum. Blue shows the verticality of the rectilinear areas. Black outlines what appears to be a very abrupt division line between the two. Attempts will be made to blur this line.

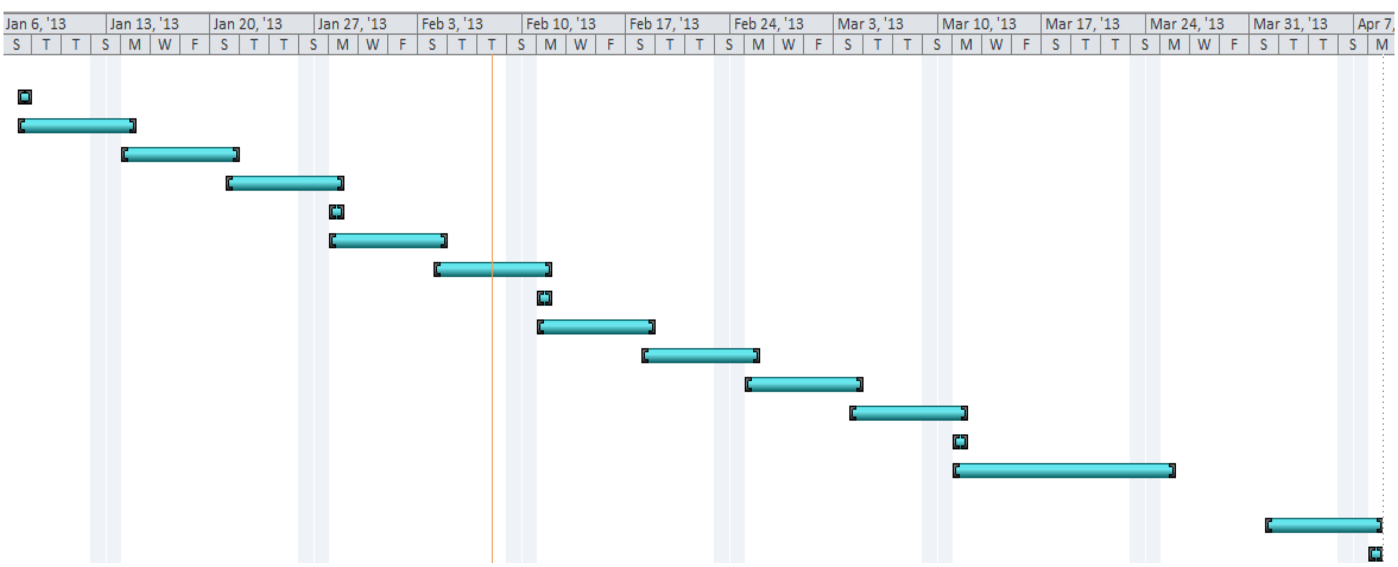
BREADTH STUDY II

This will be the final consideration, as it is dependent upon what decisions are made with the previous design considerations. A typical braced frame will reduce the need for specialized welding, and therefore decrease cost and time needed to complete the lateral system. A single type of frame may also be pursued to reduce the varying types of sections needed on site. However, the architectural implications of adding features to tie the building appearance together will add both time and cost, and the question only remains as to how much. A comprehensive analysis will be made to account for cost impact, scheduling impact, and ease of construction, as compared to the original design, and to the other proposed design.

TASKS AND TOOLS

I. Fix current 3d ETABS model
   a) re run all data tests that failed in tech 3
   b) summarize them
II. Identify potential problem areas
   a) Transfer girders
   b) Large spans
   c) Serviceability issues
III. Redesign lateral system using braced frames
   a) Locate where structure can be hidden, yet effective
   a) Design steel braced frames per AISC steel design manual
   b) Attempt to redesign floor structure as well, for more efficient spans
IV. Redesign lateral system using moment frames
   a) Design steel moment frames per AISC steel design manual
   b) Attempt to redesign the floor structure as well, for more efficient spans
V. Analyze results and compare
   a) Structural performance
   b) Appearance changes
   c) Usable space gained or lost
   d) Cost
   e) Scheduling
   f) Ease of construction and efficiency
VI. Choose the most suitable design, even if it is the current one
VII. Prepare for presentation

		Task Mode	Task Name	Duration	Start	Finish
1						
2			MILESTONE 1	1 day	Mon 1/7/13	Mon 1/7/13
3			Revise Proposal	6 days	Mon 1/7/13	Mon 1/14/13
4			Fix Current Model	6 days	Mon 1/14/13	Mon 1/21/13
5			Identify Problem areas	6 days	Mon 1/21/13	Mon 1/28/13
6			MILESTONE 2`	1 day	Mon 1/28/13	Mon 1/28/13
7			Redesign 1	6 days	Mon 1/28/13	Mon 2/4/13
8			Redesign 2	6 days	Mon 2/4/13	Mon 2/11/13
9			MILESTONE 3	1 day	Mon 2/11/13	Mon 2/11/13
10			Redesign Arch	6 days	Mon 2/11/13	Mon 2/18/13
11			Analyze Arch	6 days	Mon 2/18/13	Mon 2/25/13
12			Analyze Cost/Schedule	6 days	Mon 2/25/13	Mon 3/4/13
13			SPRING BREAK	6 days	Mon 3/4/13	Mon 3/11/13
14			MILESTONE 4	1 day	Mon 3/11/13	Mon 3/11/13
15			Prepare for final presentation	11 days	Mon 3/11/13	Mon 3/25/13
16			Final-April 3rd	6 days	Mon 4/1/13	Mon 4/8/13
17			JURY PRESENTATION	1 day	Mon 4/8/13	Mon 4/8/13



CONCLUSION

The design proposal for the Claude Moore Medical Education Building focuses on simplifying a complex structure that may not need to be so intricate after all. The design is expected to alter many of the design decisions, but strict comparisons will be made between designs as to how they impact the architect and the construction manager.

An architectural breadth study will be done focusing on two things: how much did the structural system alter the appearance? And how do both parts of the building tie into each other? After these questions are answered, a breadth analysis will be done looking at how much it would cost to build the alternate systems, and compare those costs to the original. Scheduling impact and ease of construction will be compared as well.