Thesis Proposal

MICA Gateway Residence

Scott R.
Molongoski

Structural Option ~ Heather Sustersic ~ December 14, 2012

Table of Contents:

Executive Summary:

This Thesis Proposal is a preliminary look into the second half of the AE Senior Thesis course. The MICA Gateway Residence structure will be altered in an attempt to become familiar with the real world design of buildings. The proposal is to change the use of the Gateway from a dormitory to a museum.

Changing the building's use will necessitate a variety of structural modifications. The live loads will increase throughout the building, which will alter the design of both the flat-plate floor slabs and gravity columns. The floor to floor height between several levels will also increase, again changing the gravity column design as well as the lateral forces on the building. An ETABS model will be used to determine the changes in the lateral system due to the building modifications. The foundations of the building will also be analyzed under the new loading conditions.

Two breadth topics will also be studied during the course of the semester. An architecture breadth will be studied to determine the appropriate changes in the building floor plan, as well as a circulation plan and an exterior façade redesign to accommodate museum lighting conditions. A sustainability breadth will also be studied due to the lack of sustainability with the existing structure. This breadth will attempt to bring the Gateway up to LEED certification.

Also included in this proposal are the tasks and tools that will be used throughout the semester to complete the project. This list of necessary steps can be found on Pages 13 and 14. A timetable for the entire semester can be found on Page 15. This timetable features the tasks to be done each week of the semester as well as the milestones to be passed at various dates.

Building Introduction:

The Gateway residence hall at the Maryland Institute College of Arts was designed to be a cornerstone of their campus in downtown Baltimore, Maryland. Gateway is 122' tall, with 9 stories and a mechanical penthouse and has a useable floor area of 108,000 square feet. The building is located on a constricted site near the intersection of several major roads and Interstate 83. Due to its visibility from all directions, the building has a full 360 degree façade. Gateway is primarily circular in plan with a rectangular tower on the side that faces the highway. The circle, or drum component of the building encloses an open-air courtyard that actually begins on the third floor of the structure. This plaza is located directly above a large "black-box" multipurpose room capable of multiple arrangements to fit a variety of functions. This unique condition was explored in Technical Report I. Beyond the multipurpose assembly room, Gateway features 64 student apartments, several art galleries and studios, and a café.

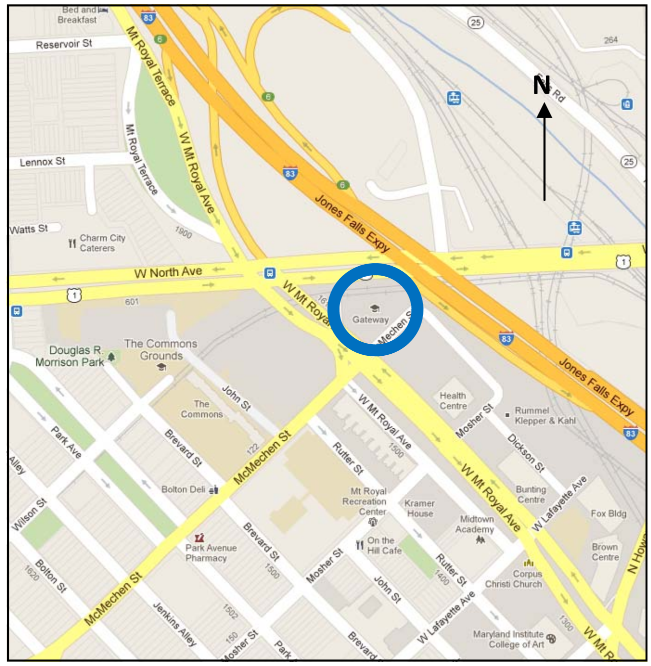

Figure 1: Gateway location in Baltimore. Courtesy of Google

RTKL Associates Inc. were the architects and engineers on the project, with KCW Engineering Technologies as the civil engineer, and Whiting Turner as the general contractor. The project was delivered with the design-bid-build method for an approximate cost of $30 million. The initial design began in 2005, with construction starting in August 2006 and concluding in August 2008. The building was designed using the Baltimore City Code, which at the time was in accordance with IBC 2000. Due to its various functions, the building has the occupancy types R-2, A-3, and B.

The building structure is primarily concrete, consisting of two-way flat plate slabs, beams, and columns. There are a few steel framed sections of the building, including the entrance vestibule and lobby. Being a prominent building, Gateway has a full 360 degree façade made almost entirely of glass curtain wall panels. The façade has clear, fritted, and frosted glass panels of white, gray, and mint green. Besides the glass curtain wall the superstructure is exposed in a number of places, such as the vertical cuts through the building and the 40' columns holding up a section of the fourth floor. The edge of each concrete floor slab is also exposed.

Structural Overview:

The Mica Gateway Residence is a predominately concrete structure with some steel members in certain places. Due to the unique circular shape of the building, the designers developed a radial grid with columns located by their X and Y coordinates in the four quadrants of the Cartesian coordinate system. The zero-zero point of the grid is located in the exact center of the courtyard. Thus a column located in the lower left of the plan will have a negative X and Y coordinate while a column in the upper right will have a positive X and Y coordinate. This was done to avoid an unreasonable amount of column lines clustered together at odd intervals.

Foundation:

The geotechnical report was prepared by D.W. Kozera, Inc. They submitted the geotechnical report on February 23, 2005. In their report they found that the site had very dense soil and soft rock, earning a site soil classification of C.

The foundation of the MICA Gateway features drilled caissons that bear directly on bedrock and have a safe bearing capacity of 100 ksf. All columns that start at ground level start at the top of a drilled caisson. Caissons are also located directly under the walls that support the load from the long span beams over the “black box” theater. All caissons are between 3’-0” and 4’-6” in diameter

Where exterior walls meet the foundation, strip footings are incorporated and are a minimum of 30” below the finished grade. For the steel framed entrance vestibule and lobby, steel columns are supported by spread footings with a minimum safe bearing capacity of 1.5 ksf.

Gravity System:

The gravity load system for the Gateway features numerous two-way flat plate slabs as well as several one-way slabs and two-way slabs with drop panels. Below Level 4, there are several one way slabs of 7” thickness that span the areas below the courtyard. They work in conjunction with concrete beams that span very irregular areas. On Level 3, the courtyard spans over the “black-box” theater, to give a column free space for intended use. As such, 48”x48” beams were designed to span over the almost 60’ of the theater and accommodate the large dead and live loads from the plaza and planters in the courtyard above. These beams have (16)#10 bottom reinforcing bars to resist the large moments produced by the load.

On Level 4 there is an area featuring one-way slabs and beams. This area is supported by large exterior columns that rise nearly 40' from grade to the bottom of the slab. Here a transfer beam runs between columns so as to support new columns that rise to support the upper floors. Beams are also used extensively to support the exterior walkways that connect the various parts of the drum.

The rest of Level 4 and all floors above have 8" two-way flat plate slabs between radial column lines as shown in Figure 2 to the right. The dotted lines represent the boundaries between the column and middle strips.

Other unique floor framing conditions include a section of the slab on each floor that frames into a column with a drop panel. This area is located in the northeast quadrant of the plans centered around column 7, as seen in Figure 3 below. The only uses of steel framing in this building are over the entrance and lobby, using mainly W10x15, W10x12, and HSS8x3x3/16.

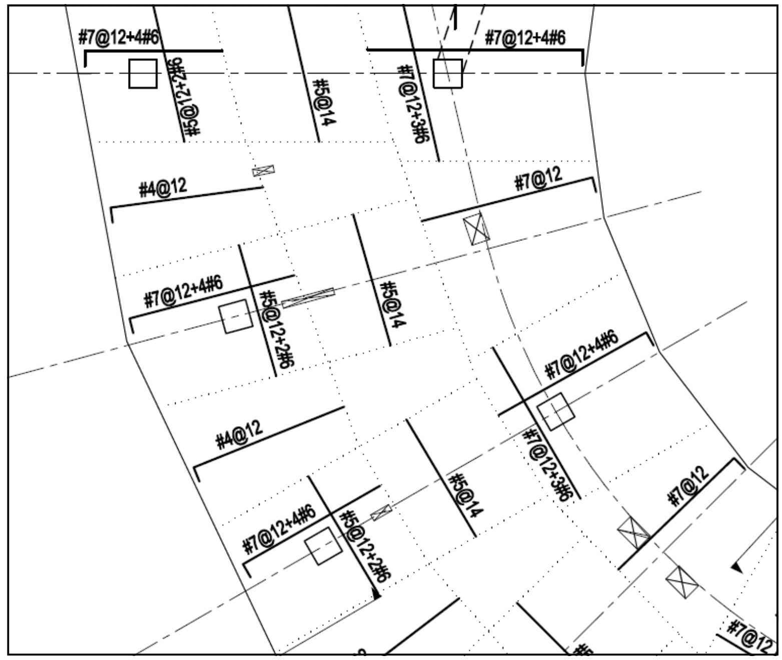

Figure 2: Typical two-way flat plate slab. Courtesy of RTKL

The slabs and beams of the Gateway are all supported by concrete columns that form two concentric circular lines around the drum of the building. In most interior areas and on the upper floors these columns are rectangular, with sizes ranging from 12x12 to 24x24. In other places where the columns are on the exterior of the building, such as the 40' slender columns that support Level 4, the columns are circular with sizes ranging from 24" diameter to 36" diameter.

The roof system of the Gateway is no different from a normal floor. One-way slabs frame into beams that transfer load to the columns. The main difference is the smaller slab thicknesses, between 6"-7" due to the smaller loads on the roof areas.

Lateral Systems:

The lateral system of the Gateway features two concrete shear wall groups located near the stair and elevator cores, one in the tower and the other in the drum. Due to the low seismic risk of the region, it was assumed that the lateral system was primarily ordinary concrete shear walls. Each of the eight shear walls extend from the ground to the highest point in their respective part of the building; 122' in the tower and 103' in the drum. The walls are all 12" thick and from 9' to 24' long. The shear walls are highlighted in Figure 7 below.

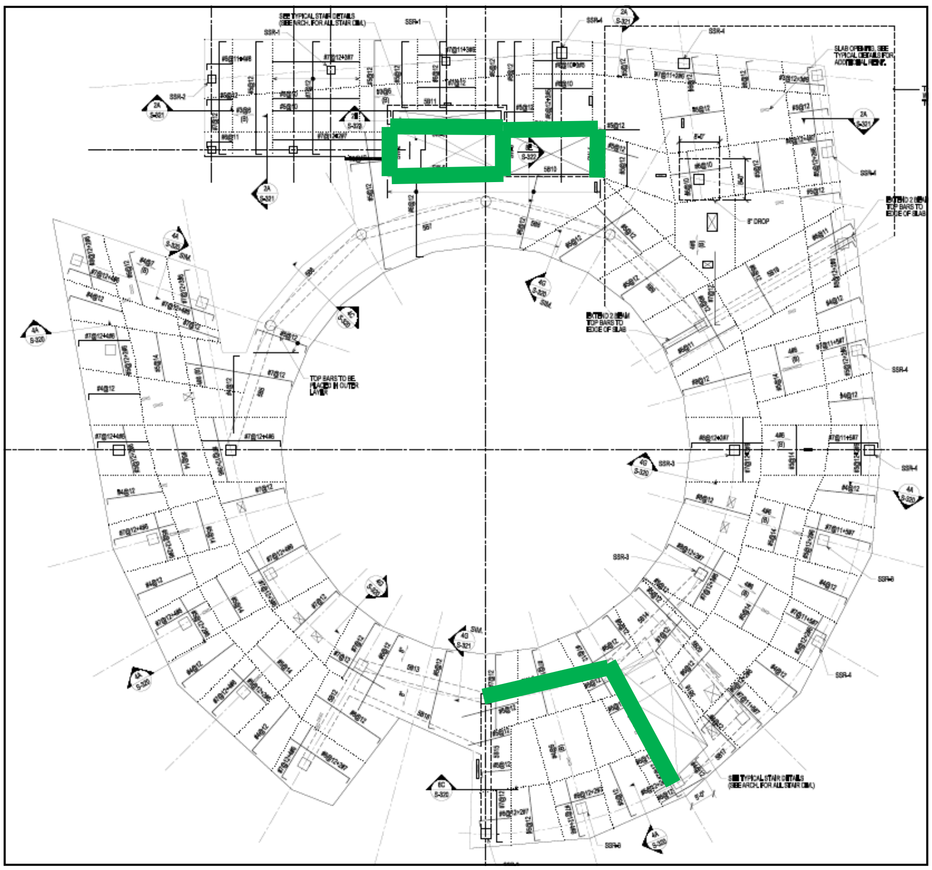

Figure 3: Shear wall locations. Courtesy of RTKL.

The lateral load path is as follows: wind pressure bears on the building cladding, which is supported by the edge slab. From here the slab transfers the load into shear walls either directly or through beams. The shear walls then direct the load into the foundation. Shear walls prevent unwanted torsion and large displacements of the building from occurring in the event of an earthquake or a severe storm with high winds.

Problem Statement:

The Maryland Institute College of Arts is a prestigious visual art school known for innovative curriculum and well-equipped campus. Though there are a number of art galleries located in many buildings on the campus, there is no one building dedicated as an art museum. As such the MICA Gateway Residence will be designed as if it was an art museum. Changing the building's use creates a number of problems with the current structure.

Currently the live load for the residence floors of the Gateway is 40 psf, which is too low for the circulation space live load a museum would have. The floor to floor height of the structure is 10 feet between floors 4-9, which would be too low a space for a museum gallery. Also, the current all glass façade of the building would be very difficult to control the amount of light entering the gallery spaces, an important factor when viewing art in a museum.

There are also a variety of architectural concerns that need to be addressed when changing the buildings use. This aspect of the redesign will be covered in the Breadth Topic Section. The current Gateway Residence was not designed with any regard to sustainability. Lacking any sustainable measures is not only bad for the environment but also for MICA's reputation and yearly expenses. The sustainable problem will be covered more in depth in the Breadth Topic Section.

Proposed Solution:

The entire Gateway structure above level 3 will be redesigned to accommodate a live load of 100psf, the live load for a circulation space in a museum. The slabs will still be designed as flat plates but will likely experience changes in thickness and reinforcement. As a museum is unlikely to have 10 foot floor to floor heights, the distance between the floors will be extended to 15 feet and floors 8, 9, and 10 will be taken out of the building to maintain the same overall building height, as shown in Figure 4 below. The increased floor to floor height will necessitate a redesign of the gravity columns throughout the building.

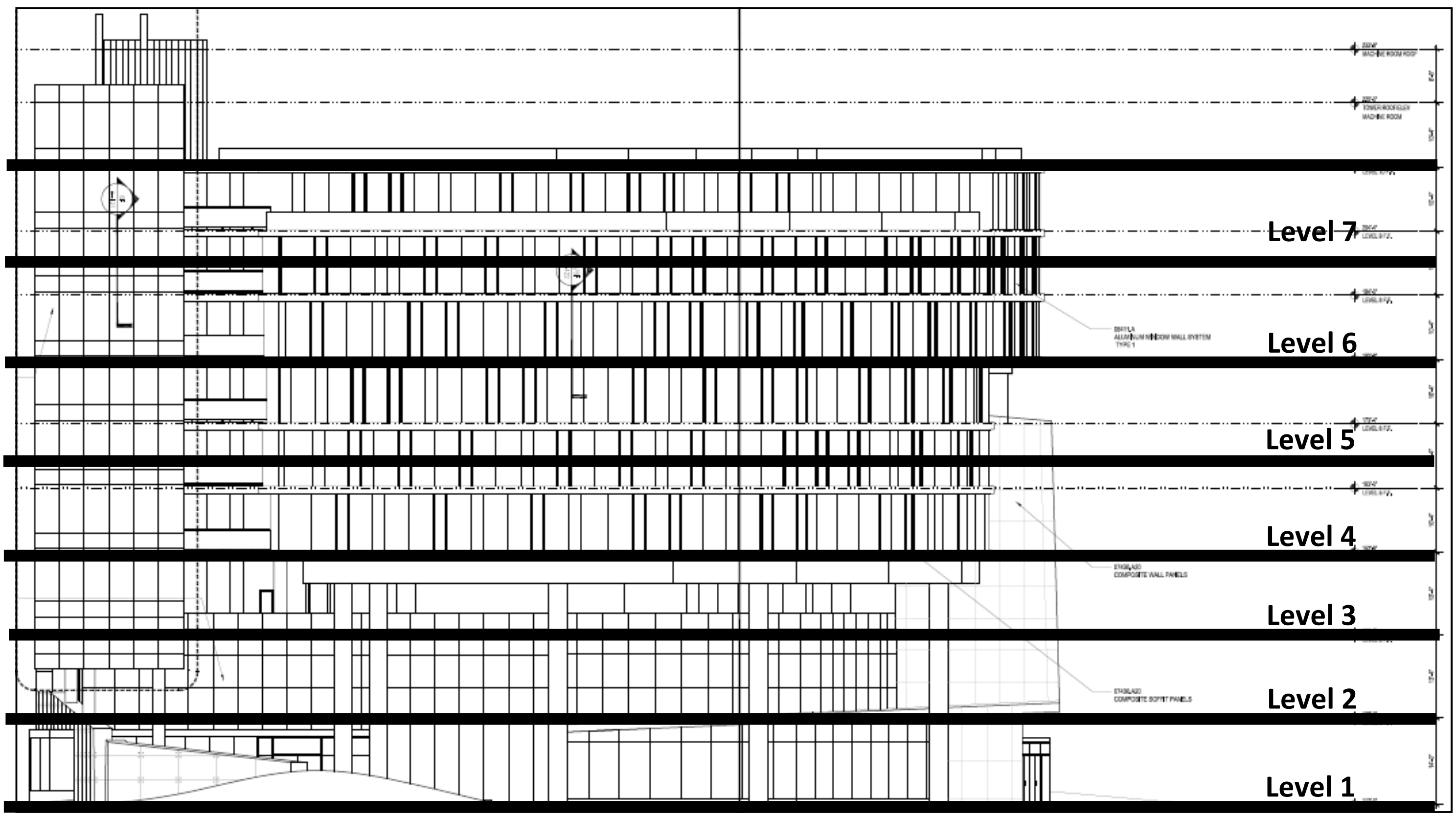

Figure 4: New level locations imposed on a building elevation. Courtesy of RTKL.

Changing the gravity system of the building will have direct impacts on the Gateway lateral system. Taking out several floors will decrease the overall building weight, but the increased floor to floor height will change the story shear at each level. The building will need to be re-analyzed for wind and seismic forces and the lateral shear walls will likely need to be redesigned. The foundations of the building will also need to be considered to see if any changes are necessary.

Solution Methods:

The design of the gravity system will follow ACI 318-11, Chapter 13, using the equivalent frame method. The equivalent frame method must be used due to the irregular geometry of the Gateway floor slabs. Typical flat plate slabs, beams, and columns within the Gateway structure will be redesigned through hand calculations. The foundations will also be checked by hand calculation to determine if any changes are necessary.

New lateral loading based on new story forces will be determined similar to the procedure used in Technical Report 1. ASCE 7-10 will be used to determine the new wind and seismic story forces. An ETABS model will then be used to analyze the new structure. This procedure will parallel Technical Report 3 and will check the drift, overturning moments, and torsion on the building. The shear walls will also be spot checked by hand to determine their adequacy in the new structural system.

Breadth Topics:

An architectural breadth will be studied due to the changes in floor plan and floor to floor heights associated with changing the building's use. All of the apartments in the building will be taken out and replaced with museum galleries. The circulation of people through the museum will also be an important aspect of the architectural breadth. The last part of this breadth will be a redesign of the building façade to more appropriately fit a museum. The amount of glass will be diminished to limit the amount of direct sunlight penetrating the building into the museum spaces. This will be done in an aesthetically pleasing way so as to maintain the architectural significance of the Gateway.

A sustainability breadth will also be studied due to the complete lack of sustainable features on the existing building. The United States Green Building Council's LEED program will be the basis for the sustainability breadth, with the goal of making the Gateway at least LEED Certified. Based on the LEED scorecard, shown in Figure 5 on the following page, a total of 40 points are needed for LEED Certification. For this breadth the points will be drawn heavily from the Sustainable Sites, Water Efficiency, and Materials and Resources sections. Due to time constraints the Indoor Environmental Quality and Energy and Atmosphere sections will be neglected, though in an actual building design they would be considered.

MAE Requirements:

Two MAE classes will be used to meet the requirements of the integrated degree. The knowledge gained in AE 597A– Computer Modeling of Buildings will be incorporated into the thesis project with the construction and analysis of an ETABS model. The knowledge from AE 597A will be essential in accurately building the model in ETABS and interpreting the results of the analysis. AE 542– Building Enclosure Science and Design will also be incorporated into the redesign of the Gateway. This course studies the design and analysis of building facades which will be relevant to both the architecture and sustainability breadths.

LEED for New Construction and Major Renovations (v2009)

SUSTAINABLE SITES		POSSIBLE: 26
SSp1	Construction activity pollution prevention	REQUIRED
SSc1	Site selection	1
SSc2	Development density and community connectivity	5
SSc3	Brownfield redevelopment	1
SSc4.1	Alternative transportation - public transportation access	6
SSc4.2	Alternative transportation - bicycle storage and changing rooms	1
SSc4.3	Alternative transportation - low-emitting and fuel-efficient vehicles	3
SSc4.4	Alternative transportation - parking capacity	2
SSc5.1	Site development - protect or restore habitat	1
SSc5.2	Site development - maximize open space	1
SSc6.1	Stormwater design - quantity control	1
SSc6.2	Stormwater design - quality control	1
SSc7.1	Heat island effect - nonroof	1
SSc7.2	Heat island effect - roof	1
SSc8	Light pollution reduction	1

WATER EFFICIENCY		POSSIBLE: 10
WEp1	Water use reduction	REQUIRED
WEc1	Water efficient landscaping	4
WEc2	Innovative wastewater technologies	2
WEc3	Water use reduction	4

ENERGY & ATMOSPHERE		POSSIBLE: 35
EAp1	Fundamental commissioning of building energy systems	REQUIRED
EAp2	Minimum energy performance	REQUIRED
EAp3	Fundamental refrigerant Mgmt	REQUIRED
EAc1	Optimize energy performance	19
EAc2	On-site renewable energy	7
EAc3	Enhanced commissioning	2
EAc4	Enhanced refrigerant Mgmt	2
EAc5	Measurement and verification	3
EAc6	Green power	2

MATERIAL & RESOURCES		POSSIBLE: 14
MRp1	Storage and collection of recyclables	REQUIRED
MRc1.1	Building reuse - maintain existing walls, floors and roof	3
MRc1.2	Building reuse - maintain interior nonstructural elements	1
MRc2	Construction waste Mgmt	2
MRc3	Materials reuse	2
MRc4	Recycled content	2

MATERIAL & RESOURCES		CONTINUED
MRc5	Regional materials	2
MRc6	Rapidly renewable materials	1
MRc7	Certified wood	1

INDOOR ENVIRONMENTAL QUALITY		POSSIBLE: 15
EQp1	Minimum IAQ performance	REQUIRED
EQp2	Environmental Tobacco Smoke (ETS) control	REQUIRED
EQc1	Outdoor air delivery monitoring	1
EQc2	Increased ventilation	1
EQc3.1	Construction IAQ Mgmt plan - during construction	1
EQc3.2	Construction IAQ Mgmt plan - before occupancy	1
EQc4.1	Low-emitting materials - adhesives and sealants	1
EQc4.2	Low-emitting materials - paints and coatings	1
EQc4.3	Low-emitting materials - flooring systems	1
EQc4.4	Low-emitting materials - composite wood and agrifiber products	1
EQc5	Indoor chemical and pollutant source control	1
EQc6.1	Controllability of systems - lighting	1
EQc6.2	Controllability of systems - thermal comfort	1
EQc7.1	Thermal comfort - design	1
EQc7.2	Thermal comfort - verification	1
EQc8.1	Daylight and views - daylight	1
EQc8.2	Daylight and views - views	1

INNOVATION		POSSIBLE: 6
IDc1	Innovation in design	5
IDc2	LEED Accredited Professional	1

REGIONAL PRIORITY		POSSIBLE: 4
RPc1	Regional priority	4

TOTAL 110

40-49 Points	50-59 Points	60-79 Points	80+ Points
CERTIFIED	SILVER	GOLD	PLATINUM

Figure 5: LEED Scorecard for new construction. Courtesy of USGBC.

Tasks and Tools:

I. Redesign Gravity System

1. Calculate floor loads
   - A. Calculate self weight of the floor system
   - B. Determined superimposed dead loads from Gateway structural plans
   - C. Determine live loads based on IBC 2006
2. Design flat plate slab
   - A. Simplify geometry of the floor slab
   - B. Use ACI 318-11 to determine slab thickness
   - C. Use equivalent frame method to determine moments on slab
   - D. Design reinforcement for flexure and shear, as well as development length and hooks
3. Design gravity column
   - A. Calculate the loads taken by a typical column
   - B. Calculate interaction diagram
   - C. Determine appropriate reinforcement

II. Develop and Check ETABS Model

1. Calculate new design loads
   - A. Determine wind loads from ASCE 7-10
   - B. Calculate total building weight
   - C. Determine seismic loads from ASCE 7-10
2. Update existing ETABS model
   - A. Eliminate floors 8 and 9 and increase floor to floor height to 15 feet
   - B. Update model with new slabs and columns
   - C. Update building mass
3. Run analysis and interpret data
   - A. Run analysis
   - B. Check drift, overturning moment and torsional effects
   - C. Spot check shear walls

Tasks and Tools:

III. Check Foundation Impact

1. Spot check foundations
    - A. Redesign caisson foundation for new building weight
    - B. Compare to existing foundation design

IV. Architectural Study

1. Redesign interior spaces
    - A. Redesign floor plans for a museum
    - B. Determine an appropriate circulation plan for people to view the art
    - C. Model a sample interior space using Revit
2. Redesign exterior façade
    - A. Determine how much glass to eliminate from the façade
    - B. Determine what type of glass is appropriate in a museum for art
    - C. Model new façade using Revit

V. Sustainability Study

1. Determine potential LEED credits
    - A. Check Sustainable Site credits
    - B. Check Water Efficiency credits
    - C. Check Material and Resource credits
2. Develop cost saving data for LEED conversion

Timetable:

Scott Molongoski	Structural Option	Heather Sustersic	MICA Gateway Residence				
Projected Thesis Semester Schedule							
January 2013-April 2013							
		1/25/2013 Milestone 1			2/15/2013 Milestone 2		3/1/2013 Milestone 3
1/7/13- 1/11/13	1/14/13- 1/18/13	1/21/13- 1/25/13	1/28/13- 2/1/13	2/4/13- 2/8/13	2/11/13- 2/15/13	2/18/13- 2/22/13	2/25/13- 3/1/13
Building Stat II and proposal revisions							
	Design flat plate slabs and gravity columns under new load conditions						
			Calculate new lateral design loads, update ETABS model Run analysis and interpret data				
						Check foundation impact	
Spring Break			3/25/2013 Milestone 4	4/3/2013 Final Report Due	Presentations		
3/4/13- 3/8/13	3/11/13- 3/15/13	3/18/13- 3/22/13	3/25/13- 3/29/13	4/1/13- 4/5/13	4/8/13- 4/12/13	4/15/13- 4/19/13	4/22/13- 4/26/13
	Architectural redesign						
		Sustainability Analysis					
			Compile final report and prepare final presentation				
						ABET evaluation and CPEP update	

Milestones:
1. Gravity system design complete
2. Lateral system design complete
3. Depth complete
4. Breadths complete

Blue	Structural Depth Tasks
Yellow	Architecture Breadth Tasks
Green	Sustainability Breadth Tasks

Figure 6: Proposed Semester Schedule

Conclusion:

The MICA Gateway Residence will be redesigned as a museum. This will change the loading requirements throughout the building, necessitating a redesign of the gravity and lateral systems. The flat plate slabs and gravity columns will be designed by hand and the overall lateral resisting system will be analyzed with an ETABS model. The foundations of the structure will also be checked and redesigned if necessary. The change in building use from dormitory to museum will create a variety of architectural changes in the Gateway. A breadth study in architecture will analyze the new floor plans, circulation plan, and exterior facades. Since the existing structure is not considered sustainable, the breadth study will attempt to bring the Gateway up to LEED certification. Continuing research and analysis of the Gateway will determine if changing the building's use will create a drastic change in the building's structure.