Thesis Proposal

CHRIS VANDELOGT | Structural Option

Global Village
Rochester Institute of Technology
The Pennsylvania State University
Faculty Advisor: Dr. Hanagan

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Executive Summary

Thesis Proposal identifies a problem with the structure of Global Village and provides a solution to the problem. Global Village is a European-inspired complex that provides commercial and residential space for the campus at the Rochester Institute of Technology in Rochester, NY. Each location has been designed to incorporate themes and materials that represent different regions from around the world, including marble from Italy and wood siding from Denmark. Global Village is a four-story building that also supports a fifth story dedicated to mechanical equipment; making it rise to an overall height of 62.5 feet.

The building is constructed of steel with metal deck and lightweight concrete at the first, second, and third floors while the other floors have wood framing. The lateral system consists of concentrically braced frames and wood shear walls in both the N-S direction as well as the E-W direction. Considering only the north leg of Global Village, six braced frames are used between the ground and the third floor while shear walls are placed on the third, fourth, and fifth floors.

As a note, the previous technical reports show that the structure of Global Village is adequate and is code-compliant. The stated problem is due to the use of wood framing on the top floors of the building. The use of wood creates many design considerations and additional firms or contractors may be needed. The proposed solution is to alter the wood framed floors and convert them to a steel frame as used in the bottom floors. A new lateral system consisting of concentrically braced frames will also be designed.

In addition to this structural depth, two breadth topics will be studied to compare the existing building to the proposed building. A construction management breadth will analyze the constructability of re-design. This includes general reality checks, improvements in construction methods and safety, and more. An architecture breadth will also be completed to examine any changes that the proposed building creates.

Solution methods and tasks are given in this report to show how the proposed solution will be completed. A schedule detailing these tasks is also given to show how the proposed solution will be accomplished throughout the spring semester.

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Purpose

The purpose of Thesis Proposal is to establish a problem and propose a solution to the problem. It also gives an indication on how the solution will be prepared and completed. A spring semester schedule is given for guidance on completing tasks involved with the proposed solution.

Introduction




Global Village is a mixed-use building that provides commercial and residential space for the campus at RIT. Global Village has achieved LEED Gold certification and has been designed to be community friendly. In total, the Global Village project provides 414 beds for on campus living and 24,000 square feet of commercial and retail space.

The $57.5 million dollar project consists of three independent structures on the campus at RIT. The main four-story Global Village building (Building 400) is 122,000 square feet and the two additional three-story Global Way buildings (Buildings 403 and 404) are 32,000 square feet each. The main project team includes RIT as the owner, Architectural Resources Cambridge as the architect, and The Pike Company as the CM-at-Risk. Eleven other firms were also employed to handle MEP, lighting, acoustics, and so forth.

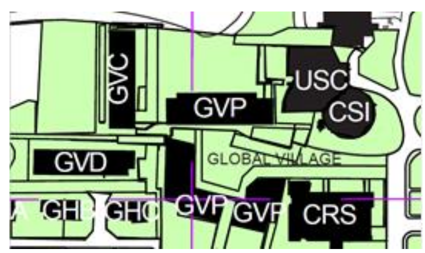


Figure 1: GVP is Building 400 (Global Village Building). GVC and GVD are Buildings 403 and 404 (Global Way Buildings). Courtesy of RIT.

Commercial space is located on the first and second floors, which consist of two dining facilities, a post office, salon, wellness center, sports outfitter, and a convenience store. Campus housing is located on the third and fourth floor which provides room for 210 beds. There is also a fifth floor; however, it is used primarily as a mechanical penthouse. Building 400's unique "U" shape creates a courtyard that features a removable stage, gas fireplace, and a glass fountain. See Figure 1 for a campus map of the Global Village complex. The area also includes outdoor seating with tables equipped with umbrellas. The 28,000 square foot courtyard is also heated to extend its use during the winter and to minimize winter maintenance.

The façade of Building 400 is made up of a cement fiber board rain screen, brick masonry veneer, and flat seamed sheet metal with aluminum clad wood windows, and a coated extruded aluminum storefront.

Global Village Building 400 is a LEED Gold Certified Building. Green aspects include a green roof above the restaurant, daylight sensor lighting, and sensors to shut off mechanical equipment when windows are opened. Global Village is located on a sustainable site that is walk-able and transit oriented, encourages low-emitting vehicles, and reflects solar heat. The building reduces water consumption through water efficient landscaping and technologies such as high-efficiency toilets, faucets, and shower heads. Through the implementation of several energy efficient systems, the building is predicted to use 29.4% less energy. To encourage sustainable energy, seventy percent of the building's electricity consumption is provided from renewable sources (wind) through the engagement in a two-year renewable energy contract. Construction of Global Village included waste management recycling, air quality control, and low emitting materials. Along with regional materials, recycled content were also installed that constitute 20% of the total value of the materials in the project.

Global Village is a part of RIT's campus outreach program. The buildings not only provide student housing and retail space, but were also designed to be community friendly and to provide students with a global living experience. Global Village is LEED Gold certified and the courtyard created promotes outdoor activity.

Structural Overview

The structure of Global Village Building 400 consists of steel framing on a concrete foundation wall along with wood framing used on the upper floors. The first, second, and third floor slabs use a lightweight concrete on metal decking system while the fourth floor, mechanical penthouse, and roof use wood framing. The lateral system between the ground and third floor consists of concentrically braced frames in both directions while shear walls are used on the floors above.

Foundation

In January 2009, Tierney Geotechnical Engineering, PC (TGE) provided a subsurface exploration and geotechnical investigation for Global Village. TGE performed 14 test borings and 2 test pits on the site of Building 400 and recommended foundation types and allowable bearing pressures along with seismic, floor slab, and lateral earth pressure design parameters.

In general, the borings and test pits encountered up to 8 inches of topsoil at the ground surface, or fill. The fill, generally consists of varying amounts of silt, sand, and gravel. At several locations, the fill also contained varying amounts of construction-type debris and deleterious material such as asphalt, topsoil, and wood. The fill was generally encountered to depths of approximately 4 to 8 feet. Below the fill, native soils with a very high compactness were encountered. Overall, most of the structure's foundation is on very compact glacial fill.

From these results, it was determined that the structure may then be supported on a foundation system consisting of isolated spread and continuous strip footings. TGE recommends an allowable bearing pressure of 7,500 psf to be used in the foundation design. It was also recommended by TGE that, due to lateral earth pressure, retaining walls are to be backfilled to a minimum distance of 2 feet behind the walls with an imported structural fill. To prevent storm run-off, permanent drains should also be installed behind all retaining walls.

Floor System

The first floor consists of a 6" concrete on grade slab. For the second and third floors, the floor system is comprised of 3¼" lightweight concrete slab on 3" composite metal (18-gage) decking. Individual steel deck panels are to be continuous over two or more spans except where limited by the structural steel layout. The rest of the floors are made up of wood framing with ¾" plywood sheathing. Shear stud connectors are welded to beams and girders where appropriate. See **Figure 2** below for details.

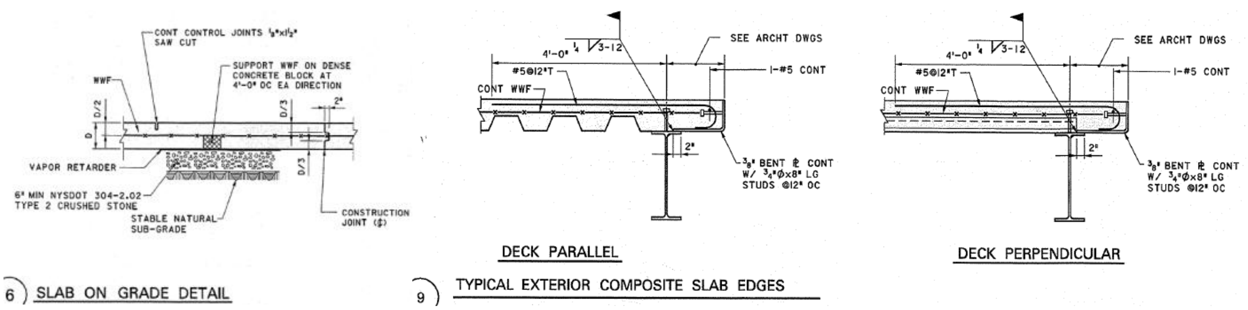


Figure 2: Typical composite slab details. Courtesy of RIT. Drawings not to scale.

Framing System

The framing grid that Global Village possesses is very unique and very complicated. Steel framing is used between the ground and third floor while wood framing is used on the floors above. The bay sizes on each floor of the steel frame vary dramatically and the beams don't line up on each side of the transfer girders. The steel framing is also not consistent between floors. There is no simple consistent grid except for a couple areas highlighted in Figure 3. In these highlighted areas, the beams vary from W18x35 to W16x31 while the transfer girders vary from W14x22 to W21x44. Column sizes also vary significantly throughout the structure where the majority is in between W10x54 to W12x106.

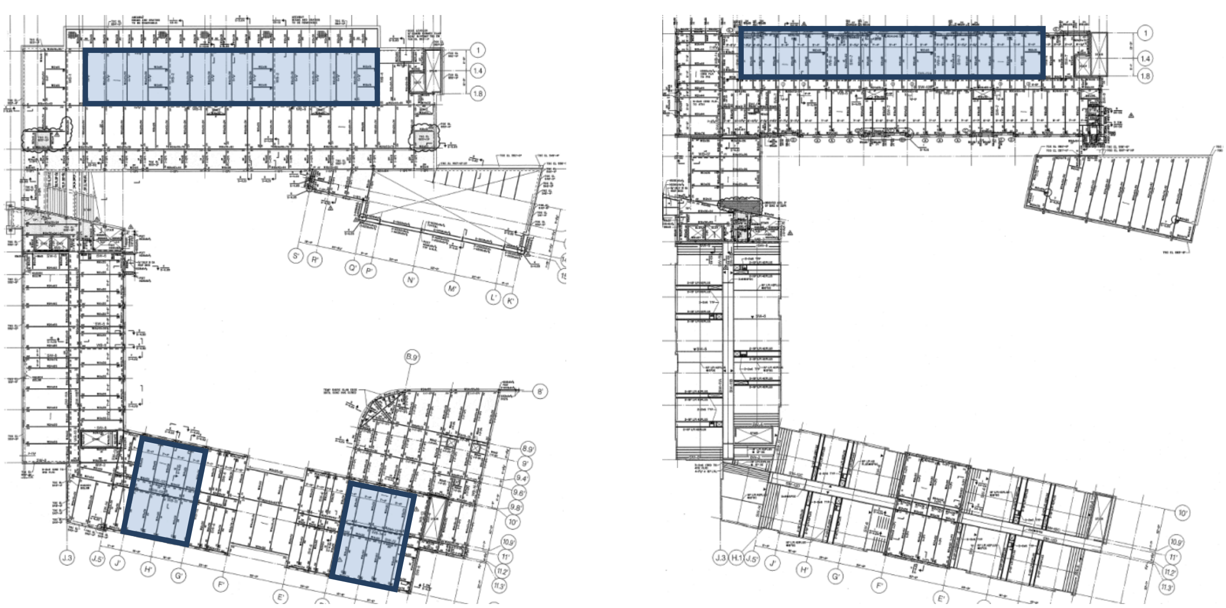


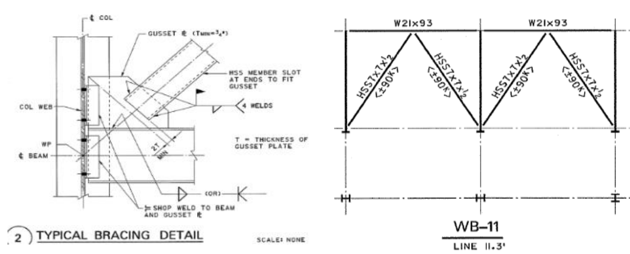
Figure 3: 2nd Floor (left) and 3rd Floor (right) framing plans. Typical bays on each level highlighted. Courtesy of RIT. Drawings not to scale.

Lateral System

The lateral load resisting system consists of concentrically braced frames and wood shear walls, each acting on separate floors. Braced frames are used between the ground and the third floor while shear walls are placed on the third, fourth, and fifth (penthouse) floors.

The lateral HSS bracing ranges in size where the majority is HSS7x7x½. See **Figure 4** for details and placements of the braced framing used on the second floor. The shear walls are made of wood blocking, consisting of 2x4's, and sheathing. These wood shear walls are used due to the use of wood structuring above the third floor. For placements and details, see **Figure 5**.

For the purposes of this report, only the north leg of Global Village will be analyzed. Reasoning behind this decision was due to greater wind and seismic loadings which will be explained further later on. The rest of this report will also explain the lateral system in more detail; including load paths and distribution, torsion, drift, and overturning moments. An ETABS model was also produced to compute results and compare them to hand calculations.



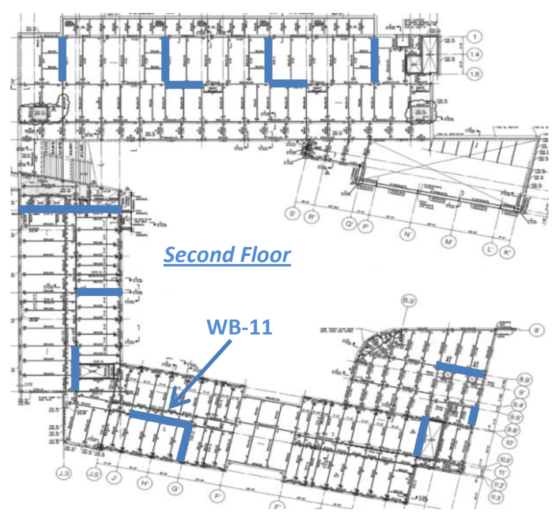
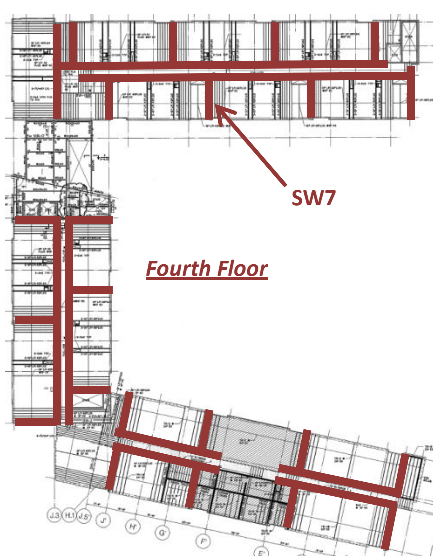


Figure 4: Typical bracing details and placement of bracing on 2nd Floor. Courtesy of RIT. Drawings not to scale.



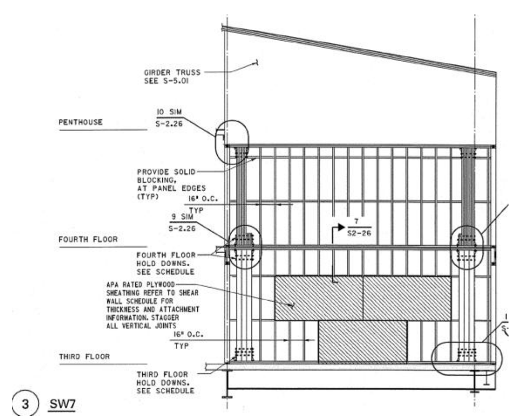


Figure 5: Typical shear wall details and placements used on the 4th Floor. Courtesy of RIT. Drawings not to scale.

Problem Statement

As mentioned above, Global Village consists of two different structural systems. A steel frame is used between the ground and third floor while wood framing is used on the third and fourth floor, mechanical penthouse, and roof. The use of different structural materials within the building is very complex and is very complicated to design. Not only does the designer have to have an extensive knowledge of both wood and steel design, the designer must also consider the connection between the steel and wood. An outside firm may have to be contacted to design or analyze the connections, which in turn requires more communication, time, and money.

Using different structural materials also has an impact on how the lateral system is designed. In order to accommodate the lateral loads, this building has two types of lateral systems. Concentrically braced frames are used on the bottom floors where steel is used. These braced frames rise to the third floor where wood shear walls are then used on the floors above. The wood shear walls are made up of 2x4's similar to shear walls used in residential structures.

In terms of construction, different materials require more coordination from the construction manager. Additional contractors may also have to be hired for their knowledge of structural wood construction. Figure 6 shows the complexity of typical wood sections. This impacts the schedule and cost of the project which are significant for university buildings.

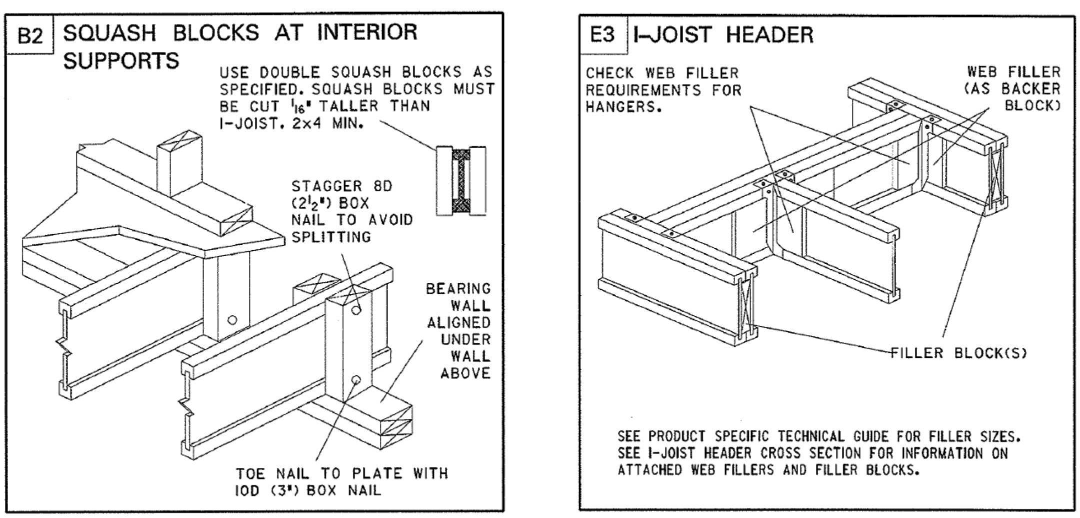


Figure 6: Typical wood sections and details. Courtesy of RIT.

Proposed Solution

To speed up the design and construction process, it is proposed to use steel framing throughout the entire structure. Replacing the structural wood framing with a steel frame will minimize extra considerations that wood creates. Therefore, outside firms and contractors that specialize in wood structures can be eliminated which saves time and improves communication throughout the entire project.

To structure the proposed building, composite floor decking will be applied as used in the second and third floors of the existing building. The floors will be then supported by steel beams, girders, and columns. The roof will also be composed of steel through steel joists supporting a steel deck. To accommodate lateral loads, a concentrically braced frame system will be designed and assessed in ETABS. Breadth topics will then be completed to compare the existing to the proposed building.

Breadth Topics

Breadth topics are used to compare the existing building to the proposed building. A construction management breath will examine the constructability of re-design. An architecture breadth will also be completed to analyze any changes that the proposed building will create.

Construction Management

The purpose of the construction management breadth is to assess the constructability of re-design. This entails general reality checks and examining any improvements in construction methods, safety, or use of recycled materials. A reduction of construction waste and field labor will also be checked for the proposed building.

Architecture

Designing the proposed building could have several impacts on the architecture of the building. The use of wood creates a more flexible floor plan than steel. This is due to wood frames using load bearing walls instead of columns used in steel frames. In a steel frame, the column placement affects the bay size which in turn affects the floor plan. Columns may also create an aesthetically unpleasing effect if not appropriately incorporated into the theme of the space. Therefore, the column layout will need to consider the current floor plan and appearance of the space.

The floor plan of the existing building will also need to be considered when designing the lateral system due to diagonal bracing conflicting with openings or other features. Some adjustments may be needed which may affect the floor plan or the appearance.

Solution Methods

In order to design the gravity system of the proposed structure, live loads will be taken from ASCE 7-10 and the dead loads previously found in Technical Report 1 will be used. Column placements and typical bays will be determined based on the layout and architecture of the existing building. These bays will then be designed by hand through the use of the AISC 2010 Steel Manual and procedures again found in Technical Report 1. These preliminary sizes will be input into ETABS to verify that the design is adequate.

ETABS will also be used to design the concentrically braced lateral system. The wind and seismic loads found by following ASCE 7-10 and completed in Technical Report 1 will be checked for changes. The worst case will then be applied to the building and the lateral system will be analyzed as in Technical Report 3.

To analyze the constructability of re-design, information taught in AE 372 will be used along with textbooks and other resources. If addition information is needed, an experienced professional will be contacted.

Tasks and Tools

Structural Depth

Task 1: Design Steel Gravity Frame
- Research design criteria and determine appropriate dead and live loads
- Determine composite deck size using Vulcraft catalogs
- Size beams, girders, and columns in typical bays by hand using the AISC Steel Manual
- Design roof joists and steel decking using Vulcraft catalogs
- Model gravity system in ETABS and check adequacy
- Adjust members as needed

Task 2: Design Lateral System
- Check and adjust wind and seismic loads based on procedures outlined in ASCE 7-10
- Determine controlling loads and design concentrically braced frames
- Model system in ETABS and check adequacy
- Adjust lateral system as needed

Breadth 1: Construction

Task 1: General Reality Checks

Task 2: Reduction of Field Labor and Improvements in Construction Methods and Safety
- Analyze and research or contact experienced professional

Task 3: Use of Recycled Materials and Reduction of Construction Waste
- Analyze and research or contact experienced professional

Breadth 2: Architecture

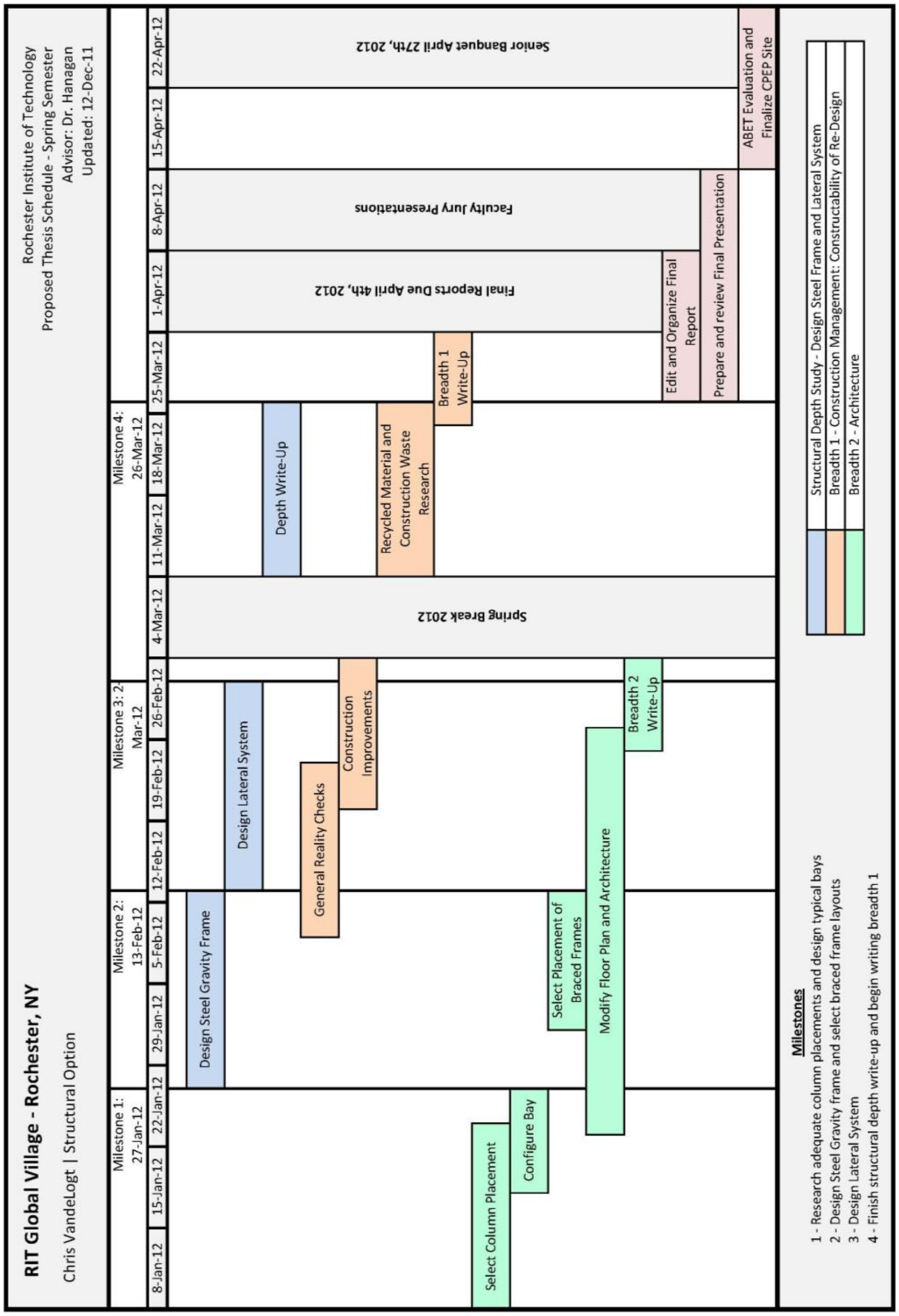
Task 1: Select Placement of Columns
- Research floor plan and architecture of each floor
- Place columns to avoid altering the floor plan or architecture of each space

Task 2: Configure a Typical Bay
- Create typical column lines and adjust columns where allowed
- Place beams based on the span of each bay

Task 3: Select Placement of Braced Frames
- Research floor plans and architecture for each floor
- Place braced frames where allowed

Task 4: Modify Floor Plan and Architecture
- Analyze changes produced by column placements or braced frames
- Design spaces to include alterations that coincide with the existing architecture (if required)

Schedule


RIT Global Village - Rochester, NY
Chris VandeLogt | Structural Option
Rochester Institute of Technology
Proposed Thesis Schedule - Spring Semester
Advisor: Dr. Hanagan
Updated: 12-Dec-11
Milestone 1: 27-Jan-12
Milestone 2: 13-Feb-12
Milestone 3: 2 Mar-12
Milestone 4: 26-Mar-12
8-Jan-12
15-Jan-12
22-Jan-12
29-Jan-12
5-Feb-12
12-Feb-12
19-Feb-12
26-Feb-12
4-Mar-12
11-Mar-12
18-Mar-12
25-Mar-12
1-Apr-12
8-Apr-12
15-Apr-12
22-Apr-12
Select Column Placement
Configure Bay
Design Steel Gravity Frame
Select Placement of Braced Frames
Modify Floor Plan and Architecture
Design Lateral System
General Reality Checks
Construction Improvements
Breadth 2 Write-Up
Spring Break 2012
Depth Write-Up
Recycled Material and Construction Waste Research
Breadth 1 Write-Up
Edit and Organize Final Report
Prepare and review Final Presentation
Final Reports Due April 4th, 2012
Faculty Jury Presentations
ABET Evaluation and Finalize CPEP Site
Senior Banquet April 27th, 2012
Milestones
1 - Research adequate column placements and design typical bays
2 - Design Steel Gravity frame and select braced frame layouts
3 - Design Lateral System
4 - Finish structural depth write-up and begin writing breadth 1
Structural Depth Study - Design Steel Frame and Lateral System
Breadth 1 - Construction Management: Constructability of Re-Design
Breadth 2 - Architecture

Conclusion

The proposed solution is to modify the wood framed floors and convert them to a steel frame as used between the ground and the third floor. A concentrically braced frame lateral system will also be designed in place of the wood shear walls used in the existing building. This will reduce the number of design considerations that connecting a wood frame to a steel frame would entail. Therefore, additional firms or contractors that may be needed for their knowledge of wood design and construction can be excluded. This improves communication throughout the project team and time and money may also be saved which are very important for university buildings.

A construction management breadth will be completed to test the constructability of re-design. This includes general reality checks and examines any improvements in construction methods, safety, or use of recycled materials. A reduction of construction waste and field labor will also be researched for the proposed building.

A second breadth will consider the changes in architecture that arise due to the steel frame. Since wood provides a more flexible floor plan through the use of load bearing walls, column placements will need to be considered. This may drastically affect the floor plan and architecture of the space. Therefore, some spaces may need to be redesigned to incorporate columns into the existing theme of the space.