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Executive Summary

The proposed thesis will include an investigation of a total structural system redesign from the current primarily propriety systems in Building 7 to a steel system. The new structural system will include gravity redesign in either composite steel beams or composite castellated beams based on which will provide more room for MEP systems within the small ceiling cavity. The chosen system will then be modeled in Ram with a new lateral system that is comprised of a determined lateral system that is acceptable for Building 7 in the new region. This proposal hopes to eliminate the overall number of shear walls from the original design while keeping the lateral system within the walls to reduce architectural impacts. Steel was chosen for it seemed to best a good alternative found in technical report 2 for a floor system

Advanced computer modeling techniques will be used to take into consideration more factors, such as shear deformation for example, regarding the lateral system. Along with this, a look and design of the connections in the lateral system will be studied as part of the graduate requirement. In the end a comparison will be made to see if the new system and breath topics are a better overall choice for Building 7.

Since Building 7 is a dorm, it is almost always common to have noise issues, due to the living environment. For this reason a sound isolation study will be looked at for a single room to see the impacts of the structural material change and be designed to meet the requirements if determined to need be. Building 7 is also approaching a LEED Gold rating from its various systems and architectural designs that are incorporated. A green roof with be studied to see if it can contribute to making the building more green water collection and storage from the roof will be looked at also.

Introduction

The University of Maryland College Park Dorm Building 7 (Building 7) is the final stage of the south campus master plan at the University of Maryland. Building 7 is the corner stone of the south campus entrance for all to take part of as they approach the campus. Building 7 is an eight story residential dorm in the shape of an unsymmetrical-U that compliments the adjacent two existing dorm buildings in architectural styles with its shape and material usage.

This eight story-133,000 square feet residential building, houses 370 bedrooms, study lounges, seminar spaces and resident life offices. The average floor to floor height is 10 feet on each floor with an average floor area of 12,000-15,500 square feet per floor, depending on shifts in the vertical plane. The layout of each floor is such that all of the rooms have an exterior view of the surrounding campus with a central corridor running the length of the building. The roof level houses the mechanical equipment along with the elevator and stair towers.

The façade and building envelope is comprised of light gage studs with a brick masonry veneer exterior around the entire building. There is rigid insulation on the exterior of the studs between the veneer with a 1.5 inch air cavity. The walls are filled with batt insulation and covered in drywall.

Figure 1. (Typical Floor Plan)

Structural Systems

Foundation

The foundation system is composed of reinforced concrete grade beams 24”x30” with 3#8’s on the top and bottom with number #4 stirrups placed every 14”. The deep foundation portion is auger cast grout piles 16” in diameter. These piles are to be 65’ below elevation and are to be able to carry at 65 ton allowable load capacity. The pile configurations range from 2-4 piles per cap. The slab on grade for the foundation is 4” thick normal weight concrete reinforced with 6x6-1.4xW1.4 welded wire fabric. All foundation concrete is 4ksi except for the SOG which is 3.5 ksi. Due to the site’s soil conditions it was necessary that the differential settlement over the entire building was limited, because of this the allowable soil bearing capacity was held to 500 psf.

Column and Bearing Wall Systems

The concrete columns support the lower two floors of Building 7. They arranged to form a typical bay of 15’x20’. These columns are gravity bearing only due to the type of lateral system in the building. The typical size of the columns range from 18x14 to 64x14 with the reinforcing ranging in each from 4#9’s to 10#9’s for vertical bars with #4 stirrups spaced at 14” O.C.. The concrete compressive strength for the columns is 6 ksi.

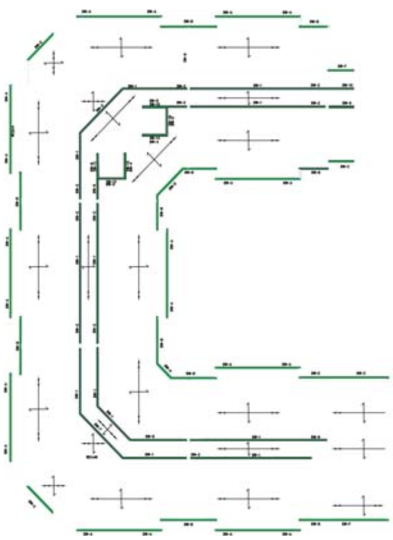
The bearing walls in Building 7 support the upper 6 floors and run along the outside perimeter of the building as well as along the corridors. The typical spans for the floor joists are 20’. Dealing with the concerns that the joists may not line up with the studs causing the header to buckle, this problem was solved by placing a distribution tube across the tops of all bearing walls. These walls are also to be designed by the contractor who is given general criteria to follow along with a loading diagram for all the different bearing walls. The general criteria are: a maximum stud spacing of 16” O.C., a minimum G90 galvanized coating, and have a minimum 16 gage thickness.

Roof System

The roof system is made of the same Hambro Composite Floor System bearing on light gage walls. This Hambro Composite Floor System is also to be designed by the contractor instead of the Engineer just as the other floors are to be designed. Here are the criteria for the roof: overall depth of the members is 16” deep typically throughout except in the corridors which it drops to 8”deep with a 3” thick concrete slab reinforced with 6x6-2.9xW2.9 welded wire fabric. The mechanical unit weights are listed and are placed close to the corridors for they are formed by the bearing walls. The elevator towers and stair towers are made of the same light gage studs.

Floor Systems

Lower 2 Floors

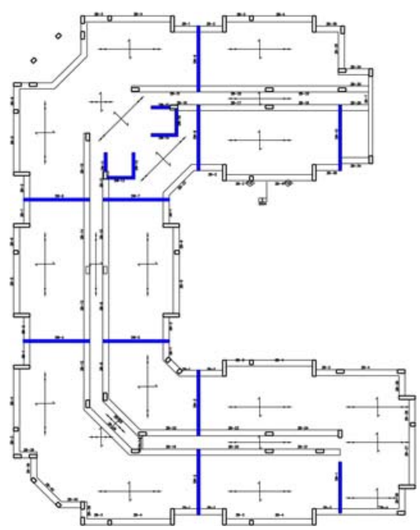


The lower two floors are made of reinforced concrete beams spanning between the columns. The intermediate members between these beams are made up of the Hambro Composite Floor System, which includes the steel joists and the slab system. The concrete beams range from 16x36 to 18x18 to 24x36 with the reinforcing ranging in each from 3#5's to 6#10's for longitudinal bars with #4 stirrups spaced from 8" to 16" O.C.

The floor system is made of the same Hambro Floor System but instead of them bearing on concrete girders they bear on light-gage stud bearing walls. This Hambro Floor System is also to be designed by the contractor instead of the Engineer. Here are the criteria for these 7 stories: overall depth of the members is 16" deep typically throughout except in the corridors which it drops to 8"deep with a 3" thick concrete slab reinforced with 6x6-2.9xW2.9 welded wire fabric.

Lateral Systems

The primary lateral system for Building 7 is shear walls. On each floor there are 16 shear walls spanning both directions of the building, 9 in the north-south direction and 7 in the east-west direction. The lower two stories shear walls are 10" thick reinforced concrete with 10#5's on each end for flexure and for shear reinforcement there is #5@12" each way, each face. All concrete shear walls are 6 ksi normal weight concrete. The upper floors shear walls are to be light gage studs with maximum stud spacing of 16" O.C. they are also have a minimum G90 galvanized coating and have a minimum gage of 16 for the studs while the tracks are permitted to have a 20 gage minimum. Since these are light gage it was determined that steel strapping was needed and is being provided in an X pattern connecting to the farthest opposite ends.



Problem Statement

The present design of Building 7 utilizes primarily propriety systems for the structure for as much as the materials will allow. These systems, while they may be cheaper require long lead times while also the general contractor to is required to design them. The propriety systems used involve many miscellaneous metal supports for the lack of strength in the light-gage studs. From investigating these systems in the past technical reports noise, vibration, and fire proofing issues arise that makes these system less desirable. These systems prevent the multiple floors from being build before the inner walls are placed (due to so many bearing walls). This issue increases the construction time. The low floor to floor heights (10’ with an 8’ ceiling) are an issue for placing the structural elements and along with the MEP systems within the floor cavity. Finally the current system as 16 shear walls due to light-gage cannot take a large amount of shear.

Being that Building 7 is a dorm it is almost always common to have noise issues, due to the living environment along with the cuts in advanced sound isolation materials and techniques that could be utilized. Building 7 is also approaching a LEED Gold rating from its various systems and architectural designs that are incorporated. It seems that a simple and effective green issue has been overlooked, a green roof. A green roof can be used to collect water and recycle it throughout the building thus giving more LEED points.

Proposed Solution

In an effort to address the issues stated above a redesign of the structural system is being proposed in steel. This redesign will include both a gravity system and a lateral system. The gravity system will take a look at two systems composite steel and composite castellated beams. An initial study will be made to see which is best when looking at the thin ceiling cavity to allow for more space for the MEP systems. After the better choice has been determined that system will be further developed and used throughout the rest of the structural redesign. All steel gravity framing will be designed to conform to AISC Manual of Steel Construction, 13th Edition.

The lateral system will be redesigned after initial research to see which lateral systems are acceptable and function best in a nigh seismic region. The best choice will be redesigned and an optimum layout with hopefully fewer shear walls can be resolved. It should also be noted that since the material has been changed to steel and that the soil has a poor bearing capacity that the foundations may need to be addressed but will not be looked at in detail due to the complexity of the current foundation.

Solution Methods

Structural Analysis and Design

The new gravity system of Building 7 will be looked at first within the redesign. To lower the impact on the architecture a new bay layout will be planned such that the new columns do not interfere with the floor plan, mainly by trying to keep the columns within then walls or at intersections where they can be hid more easily. From here two different gravity models will be produced using composite steel and composite castellated beams. RAM Structural System will be used to design all gravity members with the loads given by ASCE 7-05. This includes, but is not limited to, the new floor's beams, girders, and columns. Once both have been looked at in their early stages, the one with the best ratio for MEP systems in the ceiling cavity will be chosen and fully developed.

The new lateral system will be looked at next for the redesign. An optimization of where to place the newly selected framing system will be performed to try and reduce their quantity throughout the building. All proper codes, AISC Seismic design manual, will be will be used in the design. A computer model created with RAM Structural Steel will be utilized to control the design and obtain the forces so that the drift of the building is satisfactory to what ASCE 7-05 allows. A comparison of the old system to the new system will be performed in limited detail to show the overall benefits and the negative impacts of the system to see if this new proposed steel system is better for Building 7.

Graduate Course Integration

When looking at the lateral system in RAM advanced modeling techniques will be used to gain more accurate results and also the use of permitted analytical procedures of the applicable building codes. The models either use rigid or semi-rigid diaphragms. The steel plate shear walls will be modeled with area elements. All area and line elements shall account for flexural, shear, and axial deformations along with stiffness property modifiers defined in the steel code and ASCE 7 code. The contribution of panel zone deformations to overall story drift will be checked. Finally the lateral force analysis will consider inherent torsion, accidental torsion, and P-Delta effects.

Steel Connections will also be addressed in the redesign. The primary focus will be on the chosen lateral system connections which are typical in its layout. While investigating the gravity system beam and girder sizes will be chosen such that simple and constructible connections are able to be used.

Breadth Topics

Following the main structural depth study, a minimum of two breadth studies will also be performed for this proposal. These studies are chosen for they have a correlation to the structural depth change and also towards the goal of making Building 7 a LEED rated building, a gold rating preferred by the owner.

The first breath topic will look at a green roof added to the top of Building 7 this was one LEED/green design option the owner and architect avoided due to cost reasons. Green roofs have benefits with being able to recycle the water runoff and be used throughout the building. For this proposal different green roof will be looked and the best choice will be picked. Waterproofing issues, weight issues, and the collection tanks with the piping will be designed for this breath.

The second breath topic will be to look at a single apartment/dorm room and will study the impact of the change in structural material to steel to see if sound isolation is an issue. If sound isolation is a problem then the walls and floors will be designed to prevent as much of the noise as possible from being transmitted from one area to another. If sound isolation is not an issue a higher standard from the minimal will be used/designed since the building is a dorm and the noise environment tends to be quite loud at times. This can be looked at mechanical duct isolators, resilient channels on the walls, etc.

Tasks and Tools

Listed below is a list of tasks to be completed in the investigation of the proposals above as well as the required tools.

1. Gravity System
    * Check ASCE 7-05 for dead, live, load changes
    * Determine layout of flooring for both columns and beams
    * Determine preliminary slab and member sizes with AISC Steel Manual 13^{th} edition.
    * Determine which system is better then continue through steps below with selected gravity system
    * Creation of a RAM model to check and optimize the design.

2. Lateral System
    * Check ASCE 7-05 for wind and seismic load changes
    * Research and determine the best lateral system for the building in a high seismic zone
    * Design the layout of the lateral members
    * Determine load distribution to the members.
    * Determine member sizes based AISC 341 and 13^{th} edition
    * Model the lateral system in while checking the design for strength and serviceability
    * Design the connections of a represented frame

3. Green Roof Architecture Study
    * Research types of green roofs and requirements
    * Layout green roof
    * Design/investigate waterproofing
    * Determine water collection and location for holding tanks to recycle water.

4. Acoustics
    * Research noise criteria requirements for dorms
    * Determine materials needed for proper sound isolation
    * Determine placements and resulting effects of materials
    * Determine architectural limitations

Schedule Outline

	Week 1 (1/11-1/17)	Week 2 (1/18-1/24)	Week 3 (1/25-1/31)	Week 4 (2/1-2/7)	Week 5 (2/8-2/14)	Week 6 (2/15-2/21)	Week 7 (2/22-2/28)	Week 8 (3/1-3/7)	Week 9 (3/8-3/14)	Week 10 (3/15-3/21)	Week 11 (3/22-3/28)	Week 12 (3/29-4/4)	Week 13 (4/5-4/11)	Week 14 (4/12-4/18)	Week 15 (4/19-4/25)
Gravity System															
Gravity Loads															
Bay Layout															
Size gravity members															
RAM Model Optimization															
Lateral System															
Lateral loads															
Layout of Lateral System															
Load Distrubtion															
Size Lateral frames															
Model Itterations															
Drift and Strength Checking															
lateral Connections															
Green Roof									Spring Break					Presentations	
research roof types															
Roof Loads															
Roof Layout/Design															
Water Storage Design/Location															
Acoustics															
Noise Criteria Research															
Verify Sound Isolation															
Modify Design															
Write Report															
Create Presentation															
ABET AND CPEP UPDATE															