North Mountain IMS Medical Office Building

Phoenix, Arizona

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Thesis Proposal

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AE 481W-Senior Thesis

The Pennsylvania State University

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Table Of Contents

Executive Summary

Building Overview: North Mountain IMS Office Building is a 123,400 square feet precast concrete office building located in Phoenix, Arizona. This $10 million design-build project started construction in June of 2007 and is expected to be completed February 2008. It features a state-of-the-art outpatient diagnostic imaging center and ambulatory surgery center on the ground floor. The remaining floors feature over 92,000 square feet of open, rentable office space. The total building height is 60 feet, with a mechanical parapet wall that reaches 70 feet above ground level.

Structural Depth Problem Statement: North Mountain's precast concrete structure provides adequate resistance to lateral and gravity loads as well as performing well for service criteria. However, the heavy concrete structure raises the required seismic load to more than five times the wind load. Although seismic forces are suspected to control the lateral resisting system design, it is desirable to reduce these loads to a minimum. Reducing the lateral loads will allow for more design flexibility and a more efficient use of materials.

Structural Depth Proposed Solution: To limit weight, steel framing will be substituted for the precast double tees and inverted tee girders. Reducing the weight will reduce the seismic load which may decrease the requirements for the lateral load resisting system. The exterior shear walls will be kept to resist the seismic forces. Changing to light weight concrete and evaluating different materials throughout the building will also reduce weight.

Sustainable Architecture Breadth: Every building in the United States could be more environmentally friendly, and North Mountain is no exception. The sustainable architecture breadth will include the study of green roofing technologies, alternative precast concrete facades and material selection. The goal of reevaluating these aspects of the building is to achieve LEED certification.

Mechanical System Breadth: The mechanical breadth will comprise calculating the change in heating and cooling loads of the building due to the sustainable architecture technologies and designing a solar hot water heating system. Even though the Phoenix climate does not require a high demand for heating, the goal is to eliminate the use of a boiler to provide hot water.

Building Background

Floor Framing System:

North Mountain IMS Office Building floor framing consists of 24” deep, 10’ wide double tees with a minimum of 3-1/4” concrete topping. The tees are normal-weight concrete and have a 28-day compressive strength of 6,000 psi. The minimum prestress release strength is 4,200 psi. The prestressing strand is 7 wire, ½” diameter 270 ksi low relaxation strand. Each strand is pulled to 72.5% capacity, which results in a 30 kip force. The strand is held down at one point in the middle of the tee. Depressed strand provides greater flexural strength while reducing the stresses in the concrete during prestress release. Typical spans are 44’, 48’, and 54’.

The 24” deep double tees bear on 24” deep by 32” wide inverted tee girders. 28-day strength is 7,500 psi and minimum release strength is 3,750 psi. Typical inverted tee girders use 22 ½” diameter stand for tensile reinforcement. Span length for a 30’ bay is 28’ due to the columns on each end. Dapped ends on the double tees allow the top of the tee to line flush with the top of the girder. The topping is then poured over the tee and the girder at the same time, interlocking them. This construction technique is known as emulation. Emulation design creates construction that is either monolithic at critical joints, or provides connections that act as if they are monolithic at those locations. This is a great way to connect precast pieces in high seismic zones.

Columns:

Interior spans of inverted tee girders bear on 24” x 24” columns. Concrete strength is 6,000 psi. There is no need for prestressing strand in columns, because there is no large tensile zone. Any tension in the columns is addressed with traditional reinforcing bars. These columns are 56’ tall and arrive on site in one piece. These columns are a great showcase of precast concrete’s advantages over other structural systems. The columns only need one connection, to the foundation. This ease of construction makes North Mountain’s erection duration much shorter compared to other systems. However, long lead times may be an issue due to cure time and storage at the precast fabrication plant. A typical interior elevation is shown below to demonstrate the bearing conditions for inverted tee girders and columns.

Lateral Load Resisting System:

The exterior walls for North Mountain IMS Office Building fulfill many different structural requirements. First, and most importantly, they provide the building enclosure. Second, they support gravity load from double tees. Third, the walls are detailed to provide a pleasant architectural aesthetic. Last, but also extremely important, they resist the lateral forces due to wind and earthquakes. These walls give the structure its rigidity and structural integrity. Without shear walls, a moment-resisting frame system would have to be used. This structure utilizes interior and exterior shear walls. The interior shear walls are located in the center of the building around the elevator shaft and a stair tower.

Foundation:

Interior column foundations are 6’-0” diameter piers drilled to a minimum depth of 30’-0”. Vertical reinforcing consists of (13) #11 bars and #4 ties at 18” on center. The exterior shear walls are supported by grade beams which span 15’-0”. Typical grade beams are 18” wide by 40” deep and contain (8) #9 bars in the top and (8) #10 bars in the bottom. These grade beams rest on drilled piers which have diameters ranging from 4’-0” to 5’-0”.

Problem Statements

Structural Depth Problem:

North Mountain's precast concrete structure provides a safe environment for all occupants. However, the heavy concrete structure raises the required seismic load to more than five times the wind load. Considering the building's dimensions, wind load should not control the lateral load resisting system in this region of the United States. The only way to reduce the seismic load is to reduce the weight of the structure. Precast concrete systems are very heavy structures which may decrease the requirements for the lateral load resisting system. Choosing different materials throughout the building may also lead to a lighter weight.

Sustainable Architecture Breadth Problem:

Every building in the United States could be more environmentally friendly, and North Mountain is no exception. Investigating "green" technologies early in the design process is a very important step in any new construction project. Reducing electricity use and limiting green house gases will help to create a more sustainable Earth.

Mechanical System Breadth Problem:

In conjunction with sustainable architecture, the means and methods of providing heating and cooling for a building must also be investigated. Using solar panels for hot water generation will greatly reduce electrical demand in heating for the building. Also, reduced heating and cooling loads must be calculated to due to the added insulation from the vegetative roof.

Proposed Solutions

Structural Depth Solution:

In general, there are two ways to reduce the seismic load on a building. The first is to change the lateral load resisting system itself. Different systems have different Response Modification Factors, R, which is a multiplier used to determine the seismic loads. A larger value will result in a smaller seismic load. The other way to reduce the seismic load is to reduce the weight. This can be accomplished by choosing different materials for the floor framing and lateral load resisting system.

From these two different conditions, it is more feasible to change the weight of the building by changing the internal framing to steel. Employing an open web steel joist system could potential reduce the floor dead load to half the double tee weight. A different façade could also be used to reduce weight, but this may drastically alter the exterior appearance of the building. So, the exterior precast concrete shear walls will remain to provide the lateral force resisting system and keep the overall aesthetic of the building. The only alteration to the shear walls would be a reduction in thickness due to the lower seismic loads and to use light-weight concrete.

Sustainable Architecture Breadth Solution:

A sustainable building incorporates many different green technologies throughout all aspects of construction. However, for this breadth, a few main components will be investigated to produce a more environmentally friendly building. Such components will include a vegetative roof and insulation techniques for precast concrete wall panels. Also, the effects of changing the framing system from concrete to steel will be discussed. The goal of reevaluating these aspects of the building is to achieve LEED certification.

Mechanical System Breadth Solution:

With the addition of a green roof and increased exterior insulation, new heating and cooling loads will have to be calculated. Also, by utilizing Phoenix's 200 plus days of full sunshine a year, energy to generate hot water can be greatly reduced. A system of solar panels on the roof will provide hot water for the building's heating demand. Even though the Phoenix climate does not require a high demand for heating, the goal is to eliminate the use of a boiler to provide hot water.

Solution Methods and Tasks

Structural Depth Solution Methods and Tasks:

A1. Select steel floor framing system referencing Technical Assignment 2
A2. Select column grid spacing to produce economical steel sections
A3. Design slab and beams for new floor system using a RAM Structural System
A4. Design columns to support new floor system and vegetative roof
A5. Calculate new seismic base shear due to reduced weight
A6. Design shear walls with insulation to withstand new lateral loads
A7. Design and detail steel to precast connections
A8. Design new foundation requirements for steel columns

Sustainable Architecture Breadth Solution Methods and Tasks:

B1. Discuss sustainable features of steel versus concrete
B2. Detail vegetative roof system
B3. Select insulation for concrete wall panels

Mechanical System Solution Methods and Tasks:

C1. Calculate new heating and cooling loads
C2. Determine size of solar panel system

Miscellaneous Tasks:

D1. Finish final written report
D2. Prepare presentation
D3. Post all files and finalize website

Task Schedule

	January						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1	14	15	16 A1	17	18 A2	19	20
Week 2	21	22	23	24	25 A3	26	27
Week 3	28	29	30	31			

	February						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 3			B1		1 B2	2	3
Week 4	4	5	6 A4	7	8 A5	9	10
Week 5	11	12	13	14	15 B3	16	17
Week 6	18	19	20	21	22 A6	23	24
Week 7	25	26	27	28	29 A7		

	March						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 7						1	2
Week 8	3	4	5	6	7 A8	8	9
Week 9	10	11	12	13	14	15	16
	Spring Break						
Week 10	17	18	19	20	21 C1	22	23
Week 11	24	25	26	27	28 C2	29	30
Week 12	31						

	April						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 12		1	2	3	4 D1	5	6
Week 13	7	8	9 D2	10	11 D3	12	13
Week 14	14	15	16	17	18	19	20
	Faculty Jury						
Week 15	21	22	23	24	25	26	27
Week 16	28	29	30				

	May						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 16				1	2 Awards Jury	3	4
Week 17	5	6	7	8	9	10	11
	Final Exams						