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Structural Option
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College of Business Administration
Dec. 12, 2005

Senior Thesis Proposal

Executive Summary

This report is a proposal for a redesign of the College of Business Administration building that is being built on the Northern Arizona University campus. This four story classroom building with mechanical mezzanine is located in Flagstaff Arizona. It is to become the new home for the College of Business Administration (CBA) as well as become the focal point of a growing campus. The CBA has been designed to attract students and faculty with its eye catching architectural features as well as its state of the art technology systems.

This report is intended to serve as a proposal for what is to happen with this project next semester. Included is a description of the College of Business Administration building focusing on the structure. Also clearly explained, are the codes, standards, and the loads that will be used throughout this thesis project.

The focus for this thesis project will be a total redesign of the CBA. The original design of the CBA used precast concrete. This system was proven to be adequate and a good fit for this building. However, it was also shown that there may be other systems that could be as efficient or even more efficient. There were two systems that were chosen to be used in the redesign of the CBA. The first will be a design utilizing structural steel with a floor system of composite steel and concrete. The second will use cast in place concrete with a post-tensioned slab floor system. The alternative designs will be compared to the original to see if which system is the most efficient for the CBA.

Building Introduction

The College of Business Administration is currently under construction in Flagstaff, Arizona and is scheduled to be finished by January1, 2006. This home to the College of Business Administration is made up of four stories as well as an upper mezzanine which houses the mechanical equipment. The CBA will be the new signature building of the growing Northern Arizona University campus. At 110,000 square feet, the CBA will house classrooms, faculty offices, computer labs, and a 200 seat auditorium.

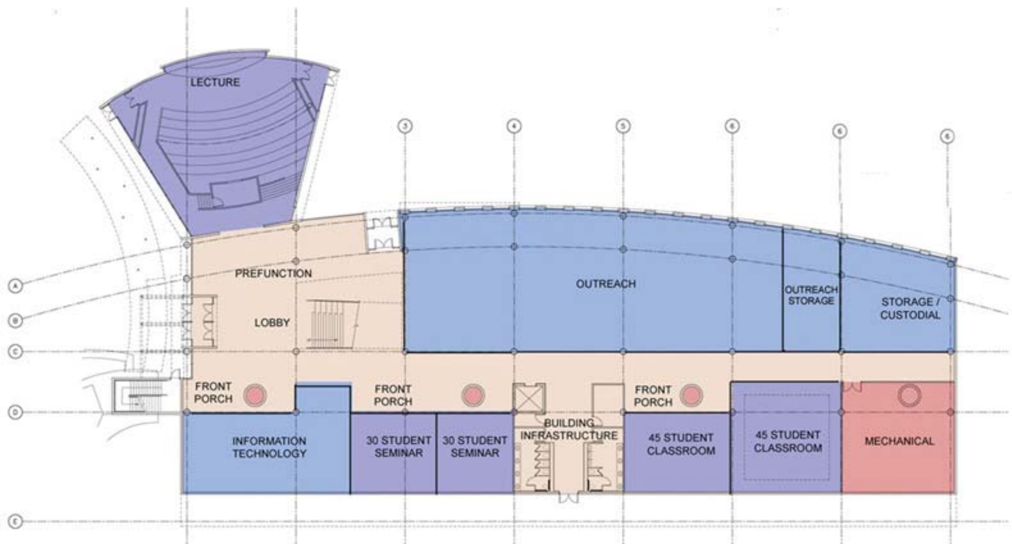
The exterior of the CBA is made of precast concrete architectural panels. There are also a lot of windows to allow the Arizona sunlight into the building. The upper mezzanine of the CBA runs the entire length of the building, but it is only 20 feet wide. The mezzanine is located between column lines C and D. This causes the roof of the structure to be in three different pieces. The middle piece is that above the upper mezzanine and therefore is higher than the other roofs. The lower roofs both slope toward the exterior of the building. This is an architectural feature of the building which makes it very attractive.

The CBA is the beginning a major program to rebuild the Northern Arizona University campus. The university has made a commitment to being a leader in sustainable design and green buildings, which can be seen in the new CBA building. NAU set out to build the most sustainable building possible. It was decided at the outset of the project to seek LEED (Leadership in Energy and Environmental Design) certification from the U.S. Green Building Council.

Building Structure

The CBA utilizes precast concrete as the main structural system for the building. The super-structure of the CBA rests on a foundation system consisting of caissons, grade beams and continuous footings. The caissons, located under the columns, bear at least 2'-0" into decomposed bedrock with a minimum 5'-0" shaft length. All lateral resisting caissons must be a minimum of 15'-0" below the bottom of the concrete grade beam.

The ground floor is composed of a 4" slab on grade on top of 4" of aggregate base course fill. The 2^{nd}, 3^{rd}, and 4^{th} floors are composed of 10" hollow core planks spanning 36 feet with a 3" concrete topping. In the upper floors, the hollow core planks will bear on precast concrete beams. The beams span in the north-south direction and are inverted t-beams in interior bays and l-shaped around the perimeter. There are also rectangular beams that span in the east-west direction along column line C. These rectangular beams are part of braced frames. All of the columns throughout the building are 24" square precast columns. Plan with column lines is shown below.



The roof of the CBA is constructed using structural steel. The lower roofs are made of open web steel joists which are covered with painted steel decking. The upper roof is made of W shaped members which are covered acoustical steel deck.

The lateral load resisting system of the CBA is a combination of shear walls, braced frames, and moment frames. The shear walls are 8" precast walls. There are four shear walls in the North-South direction and one in the East West direction. Due to the architecture, shear walls could not be placed throughout the building so moment and braced frames were incorporated in the lateral design. There are three braced frames that are all the same and located along column line C. These frames are made up of the 24" square concrete columns, 24"x 26" precast beams at the floor levels, a W24x 68 at the roof level and 8in steel pipes as braces. Also used for lateral support, are moment frames along column lines A, B, 4 and 5. These moment frames are 24" precast concrete columns with W shaped steel at the roof level.

Design Codes and Standards

Building Code:
- 2000 Edition of the International Building Code*
- Will update to IBC 2003 for Thesis work

Design Specifications and Standards:
- Loads:
  - ASCE 7-02
- Concrete:
  - ACI 318 (Latest Version)
  - PCI Design Handbook (Latest Version)
- Steel:
  - AISC Handbook and Specification (Latest Version)
  - SJI Specifications and Standards (Latest Version)

Loads

Gravity:
- Roof:
  - Live Load: 31.5 PSF (Based on 45 PSF Ground Snow Load)
  - Dead Load: 20 PSF
- Floor:
  - Live Load: 100 PSF (reducible)
  - Dead Load: 138 PSF
    - Structural Members: 128 PSF
    - MEP: 5 PSF
    - Miscellaneous: 5 PSF

Lateral:

The lateral loads are determined based on ASCE 7-02 and will be based on the following:
- 3 Second Wind Gust: 90 MPH
- Exposure C, Soil Site Class C
- S_S: 0.46
- S_1: 0.13

Problem Statement

The College of Business Administration was designed expertly and intelligently. The firms involved in the design and construction are well known and distinguished. After completing my three technical assignments, it was shown that the design which is now being constructed was one that worked very well for this building. Ideas for a change in design have been hard to come by due to this fact.

Based on the results of my second technical assignment, I feel the problem facing the CBA is that there are other structural systems that may be as efficient as the one that was used. It is possible for many types of systems to be viable options for the same building. While the system chosen is adequate, it may not be the most efficient. The choice of a floor system is not always based on efficiency. The owner or architect may have wanted a certain feel for the building.

Part of this problem has to do with the building getting LEED certification. The structural system used had to follow strict guidelines in order for the building to gain this certification. Any different system must be looked at in this light. This can limit types of systems used and must be considered with detail.

Problem Solution

The results of my study on alternative floor systems showed that there are additional systems that could be viable to use in the design of the CBA. A cast in place concrete system featuring a post-tensioned slab was shown to be a system that could use further investigation. Also, a steel system with composite steel and concrete floor proved worthy of a closer look. My solution to the problem stated above will be to use these two systems in two separate redesigns of the CBA. I will reevaluate the designs done in my second technical assignment and expand them. In the event one of the redesigns proved to be inadequate, I will discontinue it and concentrate on the other. The alternative designs will be compared to the original based on factors such as efficiency, cost, construction time.

Each of these systems must be investigated with the LEED guidelines in mind. Since the building utilizes a passive cooling system in which concrete is used to help with the movement of air, a steel system must be designed such that there is enough concrete to allow this to occur. Other LEED requirements must be considered such as; construction waste management, resource reuse specifications, regional materials section, and building reuse section. These are some sections of the LEED ratings that must be well thought-out when redesigning the CBA to achieve LEED accreditation.

Solution Method

In order to perform the redesigns of the CBA, a 3D model will be made using RAM. RAM was chosen to model the steel system because it is a relatively easy program to use. Preliminary sizes will be imputed into the program and analyzed. The steel system shall utilized braced frames for its lateral system. Moment frames will also be used if necessary. The lateral system will be designed in a way as to allow the floor plan to remain the same as in the original design.

For the post-tensioned slab I will do hand calculations or use a post-tensioned slab program if it becomes available. The lateral system to accompany the cast-in-place concrete system will employ shear walls. Since there were shear walls used in the original design, those locations of shear walls will be used in this design as well. A few walls will need to be added in order to eliminate the frames used in the original design. The placement of these shear walls will be such that the floor plan does not need to change.

The new structural systems will be designed for both the gravity and lateral loads laid out in this report. The analysis will be based on the Load and Resistance Factor Design method which is outlined in the AISC Design Handbook.

Tasks and Tools

The first task that must be completed is the verification of the loads presented earlier in this report. After that is finished it is possible to start the redesign process. The tasks for each system will be laid out separately even though the tasks may not be completed in that order. Both systems will be worked on at the same time and will be checked against each other as progress is made in order to determine if one of the systems will not be suitable to complete. If it is found that one system should be discarded, the other will be focused on for the duration of the project.

A RAM 3D model will be constructed in order to design the composite steel and concrete system. A preliminary design will focus on the gravity loads in order to estimate sizes of members. The lateral loads will be verified and the initial lateral system will be designed. Drift calculations, with complete frame analyses, will be made by hand. The members will be resized and checked again. The original foundation will be checked to see if it is still adequate. This will complete the structural portion of the steel system redesign.

The post-tensioned floor system analysis which was completed in the second technical assignment will be the basis for the redesign. The equivalent frame method will be used to distribute design moments in the slab. These moments will be used to refine the floor design. Hand calculations will be done to find tendon layouts in all sections of the floor. Column load takedowns will be completed in order to size the columns. The preliminary lateral system will be designed and column loads adjusted as necessary. Drift calculations will be done by hand with resizing of members done where necessary. The foundation system from the original design will be checked.

When the redesigns are complete, a comparison of the three systems will be done. This comparison will be based on factors such as efficiency, cost, and construction time.

Breadth Studies

Two breadth studies will be carried out as part of this thesis project. The first will be a construction management study which will include detailed cost comparison of the alternative designs and the original. In addition, the study will include a comparison of schedules of each of the designs. The cost comparison will include short and long term costs of the structure.

The second breadth study will concentrate on the mechanical systems. Since the current design allows the building to operate using either natural ventilation or mechanical cooling, any change to the structural system will impact the ability for the cooling system to act this way. This ability for passive cooling is critical for the sustainability points in the LEED system. This study will show the impact the new structural system has on the mechanical system and adapt it as necessary.

Timetable

	WEEK															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Research									!!!							
Verify Loads									S							
RAM 3D Model									P							
Prelim. Gravity Designs									R							
Prelim. Lateral Designs									I							
Final Designs									N							
Foundation Checks									G							
Mech. Breadth Analysis																
System Comparisons									B							
Const. Breadth Analysis									R							
Catch-up									E							
Presentation Preparation									A							
Thesis Presentations									K							
Review/Assessment									!!!							