

## I PRO 335 – Architectural Capstone Design Abstract

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### **Objective**

This project concerns design of a two-story building plus a basement to be constructed on a 60 feet wide by 120 feet long lot. The structure is located in Carbondale, Illinois subject to moderate-high seismic activities. The structure will serve as a museum of contemporary art. Our client is especially interested in having a design that would protect museum artifacts during a potential seismic activity. The suggested method is to use a base isolation system for the building. As a minimum, the following tasks are required: overall design layout for the building, architectural design of the building, structural design of the building, electrical and lighting, plumbing, fire protection and HVAC design, and addressing any serviceability issues.

### **Tasks Accomplished**

#### Architecture Group

The goal of the architectural group was to be in charge of the functionality, design and layout of the building. Case study research was performed to define what an art gallery entails, other accomplishments included programming, and drawings included plans, elevations and perspectives. Additionally the architecture group worked with electrical and architectural engineers on lighting designs.

#### Structural Group (Base Isolation)

The first Structural Group had to utilize the concept of base isolation – an alternative approach for designing structures in seismic-prone areas. The goal of the design is to protect the structure against lateral forces from seismic ground motion, preserving its functionality and its precious contents. The project was divided into individual and cooperative tasks. Accomplishments included: load calculations, SAP analysis, girder design, column design, slab and the intermediate monolithic system design.

#### Structural Group (Seismic Design)

Our part of this I PRO was to use traditional methods to design effective concrete members, for this museum, under seismic conditions. This traditional design incorporates using significant amounts of steel reinforcement throughout the building. Our final member sizes were similar to those of base isolation design, but our design incorporated a significantly larger amount of steel reinforcement and Moment Resisting Frames.

#### HVAC/Envelope design/Acoustics

The envelope design of the general building was simple. It was decided to incorporate a Greenroof to the building increase thermal resistance and aesthetics and decreasing noise pollution and maintenance. The HVAC system chosen is a highly efficient and quiet hybrid system of radiant heat through the floors and air circulation. Acoustics was a consideration in the design process of the envelope and the HVAC. General calculations of the public spaces found the noise control to be adequate for the building.

#### Plumbing/ Fire Protection/Security/Lighting Group

Part of the design reserved for the architectural engineers was the plumbing, fire protection, security, and lighting systems. The job at hand was to analyze and research into what ways work best to provide for the plumbing fixtures, in the building, protect a museum from fire and theft as well as the proper way to light the interior. An independent clean agent system was used for the fire suppression in the building since it is non-toxic and will not damage the artwork like water would. The system works off of its own pressure and requires no outside power. For security, a wireless system was installed to protect the artwork and includes a range of detectors including fire and door sensors. Three different kinds of lights were used to illuminate the interior: fluorescent, can, and track lighting. Only incandescent bulbs were designed for the gallery spaces to prevent deterioration of the art. Smart lighting and dimmers were also installed to adjust inside level with the amount of sunlight received from the windows on the south side.

The plumbing was designed and sized using the ANSI A-40 and International Plumbing code. Drawings and isometrics were used to properly show the placement and size of the pipes and fixtures.

### Electrical Group

Our primary task was to calculate the total electrical load for the museum and then design the electrical system to supply that load. The load consisted of the lighting design, the power needs of all the major motors, and the total receptacles in the museum. The next step was choosing the main voltage, determining the local utility supply voltage, and sizing the transformers and panels to feed the voltage to all loads. We proposed a variable speed motor for the heating/air conditioning system; this uses less energy and, thereby, increases the efficiency of our design.

### Elevator Group

The elevators needed to be both environmentally friendly and conscientious of the design of the building. A glass enclosed elevator was selected in order to match the building design. A special telescoping hydraulic elevator was chosen to be both practical and environmentally friendly. In order to protect against earthquakes, the elevator is equipped with sensors that cut the power during an earthquake. A backup battery lowers the cab to the nearest floor when the power is cut.

## **Critical Barriers and Obstacles**

### Architecture Group

Some challenges have included completing drawings at a short amount of time and making sure that those drawings are close to the final plan. Finding out what an art museum requires and incorporating that knowledge on the floor plans for a small site.

### Structural Groups

Problems Encountered: At the beginning of our design our biggest obstacle was determining the seismic loading on the building. Once this obstacle was overcome the only obstacle was the constant redesign of the building by the Architect, the rest of the design was laborious work. Additional obstacles included learning all the aspects of the Base Isolation system and how to implement it in our structure.

### HVAC/Envelope design/Acoustics

This designer had little experience with HVAC design; therefore the learning process of designing the HVAC was difficult and long, which did cause things to fall behind schedule.

### Plumbing/ Fire Protection Group

Because of the potential size of the project, work was limited to basic designs. With more time, green building design considerations and detailed cost estimates could be made.

### Electrical Group

The lighting design was a difficult task because of the special lighting requirements for a museum and the sensitivity of the artwork to light. The other major obstacle was not being familiar with electrical design procedure for a building nor the specific elements that comprise it, such as the panels, circuiting, etc.

## **Recommendations/ Next Steps**

We also would like to explore more ways to decrease energy consumption in the museum and, along with that, explore the possibility of using alternative energy sources, such as solar energy. More accurate and in-depth code checks, as well as considerations for green building design and a cost estimate. For electrical, a full data network would have been sized and placed, and a more comprehensive load calculation would be done. For structural, we would further refine our design – use smaller beam/column sections and perform in depth modal analysis of seismic loading on the structure. Concerning the elevators, it would be wise to complete detailed calculations of the stresses the elevator would undergo. Due to time constraints, not all the tasks could be accomplished. Also, more time should be used in research for understanding how an elevator reacts during an earthquake. If more time was available it would be desirable to do a thorough foundation design for this building.