**Blackstone Valley Regional Vocational Technical High School**
**Student Portfolio- Project Reflection**

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| **Date** | **5/22/2024** |
| **Student Name** | **Om Patel** |
| **Subject** | **Keystone Library Renovation – CEA (11th)** |
| **Instructor's Name** | **Mrs. dos Santos** |
| **Instructor's Signature** | **Mrs. dos Santos** |

For this project, I had to renovate a broken-down building into a public library that must incorporate universal design elements, such as an elevator and handicap-accessible bathrooms, a second floor, and a publicly accessible green roof, all of which must follow the ordinances and building codes of Noblesville, Indiana. These ordinances include having two exits, due to the building's occupancy, and being built of non-combustible materials all of which are stated in section 303.4 following the assembly A-3 group regulations. Additionally, the building must have appropriate grading and stormwater management. The library must include a vestibule, a mechanical room, a history room, two meeting rooms, a staff restroom, a staff break area (that includes a kitchenette), a head librarian office, public restrooms, room for open stacks and computers, a children's help desk, a children's area, and a front desk. On the second floor, there must be public bathrooms and an open area for book stacks.

The first task that I did to tackle this project was to research the land use and development regulations for Noblesville, Indiana. This includes finding the assembly type, A-3, the material requirements, type II, and amounts of egresses, two. Understanding these will help me ensure that the renovation complies with all local codes and safety standards. Next, I created detailed floor plan sketches for the first and second floors that included all the necessary rooms and amenities while maximizing space and functionality as any open space, I used for either seating, computers, or stacks. One of the most difficult challenges while creating my sketches was trying to size the bathroom, as they had to hold handicap assessable stalls as well as normal stalls. As this is a public area, there must be two bathrooms; one for men and one for women, meaning these bathrooms take up a hefty amount of space on the first and second floors. Another challenge that I faced while creating my design was trying to avoid the structural columns spreading within the building, as they cannot be removed without ruining the integrity of the second floor and roof. Once I created my sketches, I then added walls into Revit, a CAD software used to model buildings and sites, to outline all the rooms from my sketches. Once I created the major rooms, I then added stairs and an elevator so the public could access the second floor and green roof.

After creating a major outline in Revit, I then did some research on commercial wall systems. Within my research, I examined CMU, cast-in-place, tilt-up concrete, light gauge metal framing, and curtain wall systems. I learned about the makeup of all these walls, looking at and labeling section views for these five walls. All of these systems have their own benefits however the benefits of CMU walls being fire resistant, energy effective, high density, and durable all align with the needs of the Keystone Library. With my wall system selected, I then researched roof systems. For the commercial buildings, they often have low-sloped roofs. However, these low-sloped roofs come in all different shapes in sizes, spanning from EPDM, BUR, and Vinyl. For my roof, I used EDPM, as it is a tough material that can withstand foot traffic, is energy efficient, and is commonly used on recreational decks; a quality needed for the publicly available green roof. EPDM is also fire-resistant and eco-friendly. With my roofing type selected, I then need to research green roof systems, as those also have many types. I chose a granular drainage system, as it is one of the most cost-effective systems while also allowing for biodiversity, has good water retention, and is low maintenance. With my roof material and green roof system selected I then selected a floor system. I was given two options, a composite slab design made of cast-in-place concrete or hollow core precast concrete floor panels. The cast-in-place system is formed on-site and can be shaped as needed, allowing for a simple, efficient, and durable floor, the reason why I chose this floor system. A hollow core precast system is created off-site and is then transported and installed in the structure, this makes this system less efficient than the first system. With all my systems selected, I could then create and replace each system in Revit. To do so I would edit the properties of a wall, roof, or floor and then edit the structure to change the materials that each system is made of. I would then create a cross-section view that would show the materials in each system for construction workers and other engineers to read, understand, interpret, and build.

With my walls, roof, and floor in Revit, I then identified the design loads for each structural element in the Keystone Library, allowing me to select structural elements such as roof decking and steel joists. To do this we would use factors such as the materials in the roof, the lengths of the beams, and the live load to calculate the total design load. This design load also includes the total snow load, which is the force of the snow that accumulates on a roof and can be figured out by the location of the roof and the roof slope. With the design load calculated, I would use a load table to find a double-span deck that fits our specified regulations. I would use this load table to find a deck and steel joists for the interior and exterior beams. I then practiced further analyzing beams to determine the beam strength necessary to resist six different scenarios of applied loads, in which I could then create shear and moment diagrams to visualize the beams' distribution of mass. This allows for optimization and prevention of design failures. A shear diagram is a diagram that depicts the forces acting on the beam at different points. A moment diagram depicts where, and what the maximum moment is on a beam. To analyze the beams I would hand calculate the reaction forces and maximum moment acting on a beam. However, there are much more efficient ways to find these variables such as using beam formulas or MDSolids. To practice using the beam formulas, I would recalculate the beams' reaction forces and maximum moments. To practice MDSolids, I would create each scenario in the software and create new shear and moment diagrams. After practicing, I then designed beams for the Keystone Library, making sure the beam would provide enough shear and bending strength to limit deflection whilst also being cost-effective. To begin, I would calculate the reaction forces and maximum moment by using mathematical formulas, once again creating shear and moment diagrams. With these variables computed, I could then find the nominal moment, used to find the plastic section modulus. From there I referenced a table and the calculated section modulus to select a viable beam. Once I selected the beam, I then checked if that beam could handle the forces applied by analyzing the maximum deflection. The last step I took was to check my calculations using MDSolids.

After reviewing the building's structural integrity, I then reviewed the foundation's structural integrity. This means I investigated the soil and environmental conditions for the Keystone Library’s site to gain the information necessary to select one of the many foundation types. But to select a foundation type I must first learn about the different foundations. Typical foundations are a continuous strip footing with a foundation wall system, spread footings, slab-on-grade foundation, mat foundation, a pile and pile cap system, and a cast-in-place pile and grade beam system. Each of these systems has its own usage but the one that most aligned with the Keystone Library was a combination of a continuous strip footing system and a spread footing system. To determine the size of the foundation wall one must examine the environmental constraints. Using a Flood Insurance Rate Map, one can see the site is located in an A-zone, meaning the site is in an area where floods are not significant. However, the building must be dry floodproof, meaning the lowest floor must be above the base flood elevation. The keystone library is built on spread footings, meaning a civil engineer must be able to size a spread footing before analyzing the library for any defects. To do this, I used site-specific soil information to size spread footings for several different scenarios. One must first find the area of a footing, the thickness, and the type of soil the footing lays on. From there I would plug this information into a formula that would give me the minimum area a footing must be to withstand the loads it holds. If the current area of a footing is less than this newfound number one must change it. Now for the library, it is a little different, as one must first calculate the loads that are being applied on a column, as the footings are attached and hold the column and its applied weight. By simply using the roof load, interior beam load, and interior girder load, I could find the total column load. From there, I would use the footing's thickness to identify the soil bearing pressure due to footing weight and subtract that from the calculated total allowable soil bearing pressure. Using this newfound value, I could then divide it by the total column load and find the minimum area that a footing must be. I did these calculations for 3 different columns, all having different loads due to location, in which I found that the interior column on line 4 needed to be replaced to an 8’x8’x2’ footing, and the interior column on line 3 needed to be replaced to a 9’x9’x2’ footing. With these new footings in place, the Keystone Library will be adequately supported.

This project has been an incredibly valuable learning experience for me. From researching local building codes and ordinances to designing floor plans and selecting building materials, I have gained a deep understanding of the complexities involved in renovating a building to meet specific requirements. Overall, I have learned to overcome challenges such as space optimization and structural limitations. Additionally, the process of creating detailed models in Revit and identifying design loads has given me insight into the technical aspects of structural engineering and construction. Ultimately, this project has taught me the significance of thorough research, attention to detail, and the ability to adapt to various constraints in order to create a functional and compliant architectural design.

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Technical competencies and academic skills demonstrated by completing this assignment.

| Framework Standard | Description |
|---|---|
| 2.C.13.5 | Describe and explain parts of a structure, e.g.,, foundation, flooring, decking, wall, roofing systems. |
| 2.F.02.10 | Design a simply supported beam including an analysis of shear, bending moment and deflection requirements. |
| 2.H.02.06 | After review and update of the initial design, create or recreate a working design (if possible, using computer aided design (CAD) tools) typical of your EEA industry |
| 2.D.02.02 | Prepare clear and accurate hand sketches using orthographic and perspective views |
| **Embedded Academics** | **Description** |
| 2.C.13.2.2.4 | Calculate the resultant force(s) for a combination of live loads and dead loads. |
| 2.C.05.2.2.6 | Recognize the purposes of zoning laws and building codes in the design and use of structures |
| 2.D.02.01.5 | Relate volume to the operations of multiplication and addition and solve real-world and mathematical problems involving volume. |
| 2.B.01.05.7 | Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. |