Project Description: Redeveloping an Abandoned Religious House

Overview

For over a hundred years, a farmhouse has stood near the shores of a midwestern lake. For ninety of those years, the farmhouse served as home to several religious orders. The building and the adjoining ten acres were recently purchased by the growing suburban city that surrounds the site. The city is using the property as a public park but wants to enhance the aesthetic appeal of the site and increase the recreational and economic opportunities that it offers for the community.

A multidisciplinary team of four senior engineering design students accepted the challenge of developing the site. Each member of the student team brought a specific area of expertise to the project. Overall design coordination, tracking of time, and adherence to the project schedule was championed by one student, who served as the project manager. The result is an innovative design for renovating the former residence and providing additional facilities that meet the city's goals.

Project Description

The property was once a farm, and the original three-story wood frame house was built adjacent to the lake in 1894. The property passed through many owners until it was converted into a religious order residence in 1929. Since the city's purchase, the building has been unoccupied. Alterations to the existing house disqualified it from registration as a historical landmark. The property is currently being used as a public park, despite having few amenities.

With a desire to improve the property for community use, the city issued a formal Request for Proposal (RFP) to the student team. The objective identified by the city in the RFP was to, "reimagine the historic property and adjacent shoreline site to elevate the site's rich history and cultural significance; support the contemporary community's interests and well-being; and to be a steward to this unique landscape."

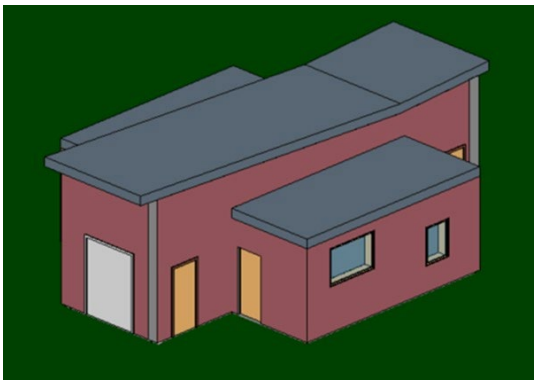
Specific goals identified in the RFP included:

- Maintaining the historical characteristics of the site
- Respecting the unique, natural beauty of the forested lakeshore
- Providing appropriate treatment of the site's Native American burial grounds
- Generating revenue from the facility while supporting the local economy
- Providing additional recreational facilities for the community's use

The student team tackled the project head on and successfully developed a comprehensive design to cost effectively meets the city's objectives. The final design includes a modification to the existing residence and the construction of a new facility to upgrade the recreational opportunities onsite.

Pictured left to right: original, existing, and proposed images of the house.

Modifications and additions in the final design will elevate the public's ability to enjoy the outdoors on the property, while also providing them with access to an indoor hospitality space. The plan meets the city's goal to restore the location and improve and enhance its usability, while also supporting local economic growth.



The proposed new building.

Three design alternatives were considered and presented to the city by the student team. Each alternative considered the addition of a new building, built out of split face concrete masonry units for easy, sustainable construction. The new building will house a refreshment stand, boat and canoe rental stand, restrooms, and a first aid area. The new building is positioned closer to the lake than the existing building for easy access to the water. All alternatives offer additional vehicle parking, including several spaces for the disabled.

The first alternative focuses on rehabilitating the existing house for contemporary facilities. This includes converting the first floor into a coffee shop and catering kitchen and adding an elevator to service the basement through the second floor.

The second alternative also modifies the existing house by adding external dry and cold storage space on the northeast corner of the building, an elevator to service the basement through the third floor, and a two-story deck facing the lake. These modifications would incorporate a restaurant and event space with a full-sized industrial kitchen in the existing kitchen and dining spaces.

The third alternative proposes demolishing the existing house and replacing it with a new open pavilion that has a fireplace for community members to sit at and enjoy the lake. However, this alternative does not provide the city with all the requested amenities, and it can only be used for part of the year.

A preliminary opinion of probable cost for construction, including engineering fees, was prepared for each alternative.

- Alternative 1 - $703,000
- Alternative 2 - $1,103,000
- Alternative 3 - $547,000

A multi-criteria decision matrix was developed to weigh each of the alternatives being considered for the redevelopment. Input from the city helped establish the criteria used and the weight of each criterion in the matrix. The total life cycle cost was calculated, including projected revenues from the restaurant, refreshment stand, recreational equipment rentals, and event spaces as appropriate. The environmental and sustainability criteria reflected the goals of the city, as identified in the RFP.

Goal * Max or Min?	Criteria	Weight	Units	Alternative 1	Alternative 2	Alternative 3
Min	Construction Cost	30%	$	639,000	1,003,000	497,000
Max	Meeting Community Needs/Desires	25%	Percentage Met	0.7	1	0.2
Max	Generated/Economic Impact	20%	Percent Profit	2.5%	6.0%	25.0%
Max	Operational Duration	20%	Months/Year	9	12	5
Min	Environmental/Sustainability Impact	5%	kg CO2	2918380.85	3508672.75	7152674.1
	Totals:	100%		30.11%	35.79%	34.10%

Decision matrix for the three alternatives.

A key step in the alternative evaluation was the student team's formal presentation. A PowerPoint presentation was created summarizing the three options, with a focus on the pros and cons of each one. Each student on the team presented a portion of the project through the lens of their technical specialty. A three-dimensional building model was created to provide a virtual walkthrough of each alternative.

The student team ultimately recommended Alternative 2 as the best option to meet the city's goals. The city agreed and selected the second alternative to pursue for final design and construction. Although it's the most expensive of the three, Alternative 2 provides the city and community with all the requested functions, while also maintaining the historic nature of the site. It is the best alternative to provide the community with a place to enjoy the waterfront and property year-round. Moreover, the addition of a kitchen, event space, and boat rentals will provide the city with a year-round revenue stream.

Proposed site plan for Alternative 2.

The second alternative also minimizes alterations to the surrounding grounds and limits construction-related environmental contamination. A community garden will continue to be maintained and used for community meals prepared onsite. This alternative allows the public to connect with nature and the historical significance of the area while leaving the Native American burial grounds untouched.

After Alternative 2 was selected, the team proceeded with final design. During this process, they maintained close contact with the city and the professionals serving as instructors and mentors.

The projected construction schedule is as follows:

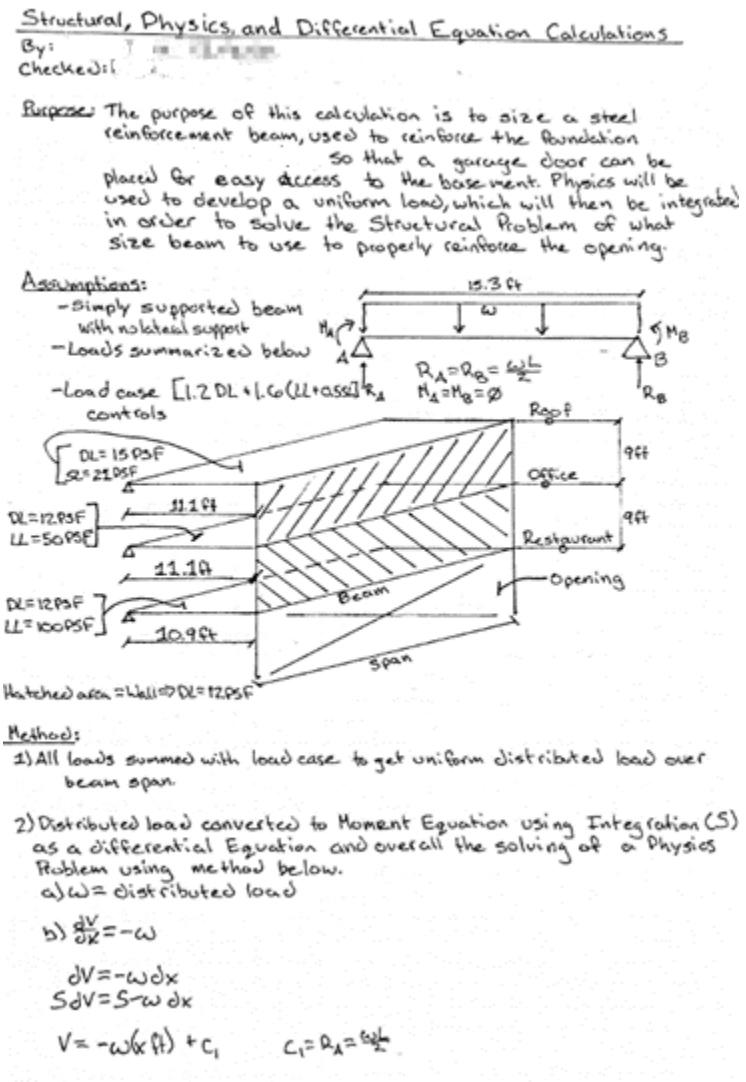
- Final Design Submittal — December 2021
- Submit Permit Applications — December 2021
- Bidding Process and Awarding of Bid — April 2022
- Mobilization — July 2022
- Selective Removals and Abatement — September 2022
- Structural Modifications — March 2023
- Rehabilitation — April 2023
- Commissioning — July 2023
- Occupancy — September 2023

This schedule was also summarized in a Gant Chart, which was included in the presentation to the judges.

A geotechnical report was prepared based on soil boring data from an adjacent property, which was the best available data at the time. The city is expected to perform new soil borings and provide an updated geotechnical report before proceeding with implementation.

Building plans for the existing farmhouse were not available, so the student team conducted an on-site inspection and measurement of the structure. The inspection also examined the existing mechanical, plumbing, and electrical systems.

With data gathered during the inspection, an abbreviated project manual was developed. It includes structural calculations, drawings, and specifications. The specifications include bid forms, terms and conditions, and sections for key project elements. The drawing set includes architectural, site, and structural plans. A formal presentation by the entire student team was made to the client and a panel of judges. It included a slide show that explains the


Structural, Physics, and Differential Equation Calculations

By:

Checked:

Purpose: The purpose of this calculation is to size a steel reinforcement beam, used to reinforce the foundation so that a garage door can be placed for easy access to the basement. Physics will be used to develop a uniform load, which will then be integrated in order to solve the Structural Problem of what size beam to use to properly reinforce the opening.

Assumptions:
- Simply supported beam with no lateral support
- Loads summarized below
- Load case [1.2 DL + 1.6(LL+ASSL)] controls

15.3 ft
ω
M_A
M_B
A
B
$R_A = R_B = \frac{\omega L}{2}$
$M_A = M_B = 0$
R_A
R_B
Roof
DL = 15 PSF
LL = 21 PSF
9ft
Office
11.1 ft
DL = 12.8 PSF
LL = 50 PSF
9ft
Restaurant
11.1ft
Opening
DL = 12.8 PSF
LL = 100 PSF
Beam
10.9ft
span
Hatched area = Wall ⇒ DL = 12 PSF

Method:
1) All loads summed with load case to get uniform distributed load over beam span.
2) Distributed load converted to Moment Equation using Integration (5) as a differential Equation and overall the solving of a Physics Problem using method below.
a) ω = distributed load
b) $\frac{dV}{dx} = -\omega$
$dV = -\omega\, dx$
$\int dV = \int -\omega\, dx$
$V = -\omega(x\ ft) + C_1$ $\quad C_1 = R_A = \frac{\omega L}{2}$

A sample of the structural calculations.

design and considerations used to establish the final configuration. The projected construction schedule, final opinion of probable cost, and copies of the project manual were included in the presentation materials.

Collaboration

Collaboration was emphasized by the class instructors and was critical to project success.

The proposal prepared in response to the city's RFP set the tone for collaboration between team members. A project manager was selected by the students, and the anticipated design activities and project roles were divided among them, based on each student's study emphasis and career interests. However, no individual had sole authority over any aspect of the project, and the project manager coordinated these activities to ensure equal participation.

Perhaps the best example of team collaboration are the preliminary and final design presentations before a panel of judges. The presentations were seamless and professional, with all team members contributing to the slides and speaking to their individual specialty and role.

Collaborative efforts extended outside the team as well and included two professional mentors that were assigned to the team. One mentor was a licensed professional engineer, and the other was a registered architect. Both mentors helped guide the project and shared advice, grounded in years of experience. The panel of judges included an architect, two P.E.s, the city's representative, and several members of the public. In addition to evaluating the alternatives and design, judges asked questions and offered suggestions for improvement. All these activities were coordinated by three principal instructors for the class, all of whom are licensed professional engineers.

Protection of Public Welfare

With public welfare in mind, the team rigorously evaluated applicable health and safety regulations, including appropriate building codes. A partial list of codes referenced includes:

- City Code of Ordinances, Chapter XXX Building Construction
- International Building Code (IBC), 2015
- The State's Burial Sites Preservation Law (State Stats XXX.XX)
- State Chapter XXX City and Village Shoreland-Wetland Protection Program

Particular attention was given to ensure access disabled persons would have access to all facilities. Design features addressing this focus include ADA compliant parking spaces, installing an elevator to service the basement and all three floors above it, and wheelchair ramp access to the deck and first floor from grade level.

The suitability of the design was measured against the needs and desires of the local community, as defined in the RFP and represented by the city during the design process. This was a heavily weighted criterion in the process of developing and recommending alternatives.

Economic evaluation, which reflected the team's understanding of their fiduciary responsibilities to the local community, was an important factor in making design decisions. However, the recommendation of Alternative 2 over the least expensive alternative, demonstrates the team's awareness of the public's needs and their determination to meet them.

The project site has great natural beauty that is enhanced by the adjacent lake. The final design minimizes the environmental impact and enhances the natural aesthetics of the area. Project specifications include construction methods and restrictions to reduce erosion and degradation of the site.

Sustainability was also carefully considered during the design process to protect public welfare. One example of this is inclusion of CO_2 production during construction and operation as one of the criteria in the evaluation matrix.

Cultural awareness and respect were exhibited by the team's sensitivity to the Native American burial grounds on the site. The final site configuration and proposed construction activities were coordinated with the State's Historical Society and followed the guidance of State's Burial Sites Preservation Law.

Multidisciplinary Activities

It is rare for a civil engineering project to not involve multiple engineering disciplines, and this project was no exception. The instructors built the student teams with the specific intent of covering multiple disciplines and skill sets. Additionally, the city's RFP explicitly identified the multidisciplinary nature of the project and requested specific engineering capabilities be included:

- Construction engineering
- Environmental engineering
- Hydraulic engineering
- Structural engineering
- Transportation engineering
- Surveying and geospatial

The makeup of the student team met the need for multiple disciplines, and included students with course emphasis in construction management, structural engineering, geotechnical engineering, and transportation engineering. The mentors and judges also exhibited a spectrum of experience and expertise.

The work product of the team demonstrated their broad capabilities. Examples of the engineering analysis were structural, geotechnical, and transportation evaluations. Extensive economic evaluations for ongoing operations and probable revenue streams supplemented the opinion of probable cost. The team also showed sound judgement in assessing the more intangible considerations of recreational opportunities and community expectations.

Knowledge and Skills Gained

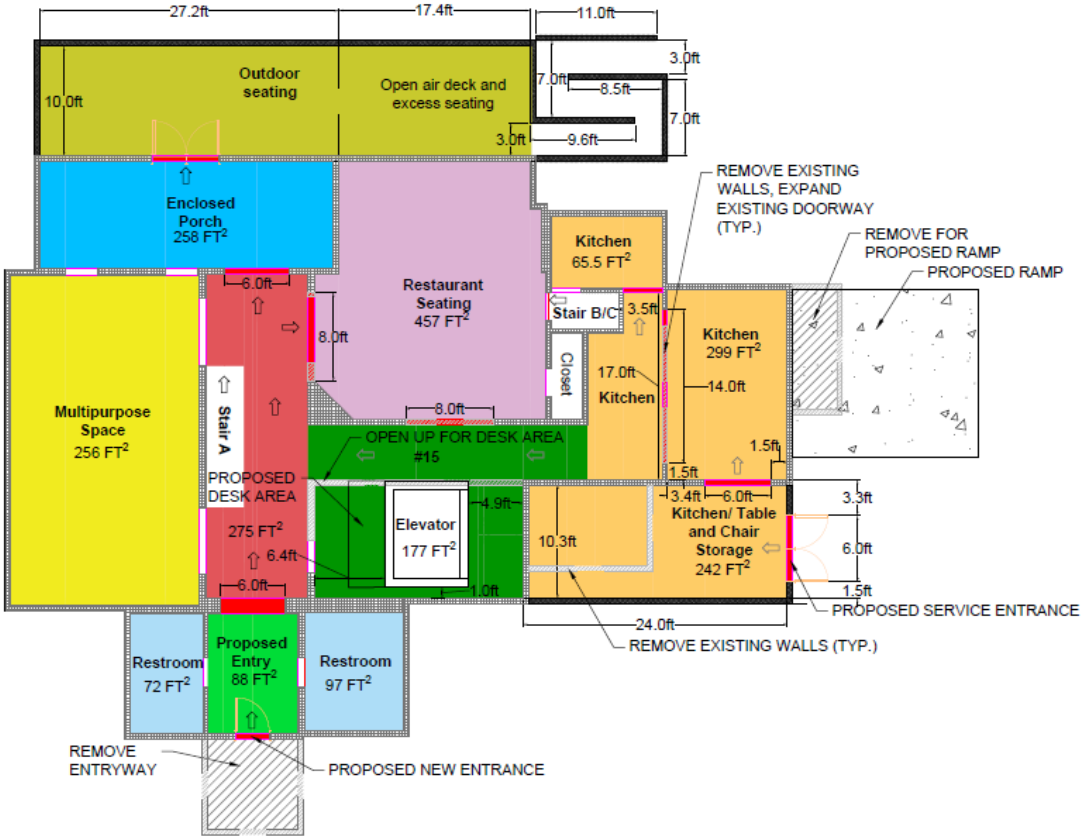
Perhaps the most valuable knowledge gained by the team in executing the project was their exposure to and understanding of best practices for civil engineering projects. Out of necessity, undergraduate work concentrates on the principles and methods of engineering analysis. Experienced professionals know that many of the decisions made and problems addressed in engineering practice are non-technical in nature. Because this was a "real-world" project and not an exercise, the team was required to perform both technical and non-technical tasks.

The team also learned about the administrative side of engineering. They had to develop cost estimates for the engineering, track time, and do performance reviews of other team members. The team also had to adhere to rigid schedules for design and meet inflexible deadlines. This pushed them to develop their planning skills and the goal-oriented activities that result.

Most problems encountered in undergraduate engineering courses are well defined and have a definite answer. This redevelopment project exposed the students to open-ended problem solving. The team had to develop their research skills, work with incomplete information, and learn to derive necessary information from associates and clients.

There were also technical skills gained during the project. One of the most challenging tasks for the team was learning the drafting skills needed to create construction drawings. This meant not only learning CAD software, but more importantly, learning the expectations for content and format of professional drawings.

This experience reinforced the value of teamwork and the value that each team member brings to the table, further preparing students for their future careers. The success of this design project is the collaborative result of students, mentors, and clients working to achieve a complex objective that benefits and enhances the community.



Example project drawing.