Multidisciplinary Evaluation and Rehabilitation Design of Sacred Heart Catholic Church

Project Description

Sacred Heart Catholic Church was constructed in the 1920's and includes a church, rectory and school. Improvements requiring engineering analysis and design include: structural integrity, seismic upgrades, environmental remediation, mechanical systems, and transportation safety.

Civil engineering students & faculty provided critically needed engineering analysis and leadership to engage the larger engineering community to assist Sacred Heart in creating a plan to move forward. The resulting project represents nearly a year of work and involved: civil engineering students, licensed engineering faculty, practicing professional engineers, an architect, contractors, and building service specialists.

Collaboration Quotes

"…This project allowed our firm's professional engineering staff to work with future members of the engineering community (students) to evaluate a unique historic structure that is an important asset to our city." - Civil Engineering PE

"Students working on the Sacred Heart project learned how a structural PE would prepare for and conduct a site visit associated with a seismic study. " - Civil Engineering PE

Project Objectives and Outcomes

Collaboration

- 7 practicing PEs & 4 PE Faculty licensed in structural, transportation, environmental, building systems, mechanical, and electrical engineering worked with 122 civil engineering students
- Interaction involved condition assessments, site inspections, project design meetings, and contractor meetings, see timeline for detailed summary
- Students learned how to conduct building inspections, prepare engineering reports, adhere to standards of practice and represent a client within in required budget constraints

Health, Safety & Welfare of the Public

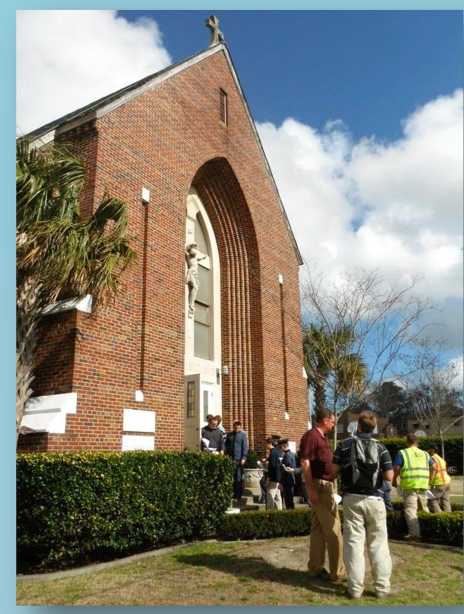
- Students recognized that many inner city churches lack financial resources to make timely repairs; as a result, deferred maintenance is a common issue faced in engineering practice
- Environmental evaluation included a thorough asbestos and lead paint assessment of all areas inside the church (e.g., walls, doors, windows, ceilings)
- Seismic and wind load assessments were performed to identify life safety issues with the buildings
- Students conducted engineering assessments and prepared cost effective design solutions, guided by PE interaction, within the restrictive budget constraints identified by church officials
- Students took personal responsibility to help the church determine greatly needed cost effective and design code appropriate solutions; consequently, students gained valuable insight into how engineers fulfill the high calling of representing clients whom are trusting in their expertise

Multidiscplinary Components

- A multidiscplinary project approach was a critical component of the design process involving interactions with PE's in civil engineering, mechanical engineering & electrical engineering
- Students interacted with numerous other professionals including an architect, contractors, local media, church leadership and school administrators
- Students met onsite with 10 construction contractors invited to provide detailed cost estimates to mitigate condition issues discovered during the evaluation process.
- Students worked in teams to conduct project work and interact with PE's in structural, environmental and transportation engineering

Knowledge Gained

- Students gained knowledge of how different professions work together in determining engineering solutions within a full building envelope
- Students gained knowledge, through guidance of PE's, of the level of rigor required to prepare a detailed engineering evaluation identifying cost effective design solutions that meet appropriate standards of professional practice.
- Students learned about the important relationship between construction contractors & engineers
- Students gained knowledge of the importance of project management in adhering to a project schedule, coordinating concurrent tasks and commutating effectively with all stakeholders



Project Timeline

PE Project Interactions

- 4 engineering firms & 7 practicing PEs agree to work with students to provide technical guidance in project advisory role
- On-site condition assessments lead by practicing civil, structural, & mechanical PEs with follow-up advising on condition assessments and report preparation
- On-site comprehensive building evaluations lead by practicing PEs (civil, structural, environmental & mechanical) & an architect
- Practicing PEs (civil, structural, environmental & mechanical) & an architect meet & advise students on use of material test results, design standards, analysis procedures & determination of design improvements
- Engineering community & PEs advise students in design report preparation, commit resources via donations ($20k) for design services, materials testing, & construction contracts

2014								2015			
May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April

- Faculty/students initiate project w/ church
- Faculty/students solicit commitment from engineering community
- Students adopt project scope of work (involving work from freshmen, juniors, and seniors), participate in series of 10 on-site visits/meetings, conduct project condition assessments and prepare evaluation report
- Senior students participate in on-site comprehensive building evaluations for use in design solutions, including a total of over 30 on-site trips/meetings
- Senior students work in teams to analyze data, apply standards, & develop detailed structural, environmental, transportation and building improvement designs
- Senior students present comprehensive Engineering Project Design Report to church officials at public meeting

Student Design Activities

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ABSTRACT

Approximately 122 students and 4 licensed faculty from a college in the southeastern United States worked together with 7 practicing professional engineers, 1 architect, 10 contractors, and several other professionals to solve a major community problem common to many cities. Students recognized that several churches located near their inner city campus were neglected and upon further research they learned that most inner city churches lack the financial resources to make timely repairs. As a result, deferred maintenance becomes the norm rather than the exception, which leads to higher repair bills when a future crisis occurs (e.g., leaking roof, termite damage, heating and air issues). Most inner city churches cannot afford evaluation studies to outline the need and cost of maintenance, repair, and rehabilitation options in order to meet current building code regulations. Parishioners and church staff typically lack the skill set to evaluate what needs to be done and to prioritize these needs. Inner city churches often have long histories of individuals doing a variety of undocumented repairs without continuity between volunteers or consideration of building code requirements. Thus, church structures become a confusion of materials, designs, installations, and maintenance approaches. In May 2014, students and faculty at the College reached out to the pastor of Sacred Heart Catholic Church and learned, as expected, that his parish had serious maintenance issues. To complicate matters, Sacred Heart Catholic Church is located in a high seismic and high wind area making the building vulnerable to natural disasters. This document summarizes activities conducted by the Civil and Environmental Engineering (CEE) department at the College related to evaluation and rehabilitation of Sacred Heart Catholic Church from May 2014 until April 2015.

In summary, all freshmen, all seniors, and key juniors in CEE at the College participated in the multidisciplinary evaluation and rehabilitation design of a historic, yet somewhat dilapidated, urban church near their campus. Students worked under the constant supervision of outside practicing engineers and licensed faculty members to perform a myriad of evaluation, design, fundraising, simple construction, and construction cost estimating activities for Sacred Heart Catholic Church. Key services performed by the students included a complete building envelope evaluation (structural, architectural, environmental, mechanical, electrical, plumbing), seismic and hurricane structural and nonstructural assessments, and rehabilitation design and cost estimations for all deficiencies noted during the evaluations. A final deliverable was presented to the church pastor on April 21, 2015.

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Project Description

Since its conception in 1920, Sacred Heart Catholic Church has undergone extensive construction and renovations in order to serve its community. Originally, the church was a simple frame, Knights of Columbus hut moved from the local Navy Yard. On September 29, 1938, an F1 or F2 class tornado swept through the city and destroyed the "Old Sacred Heart Church." The pastor and several staff were in the building during the tornado and were severely injured. The new Sacred Heart Church was designed to hold 528 people, complete with a ten room rectory, and it was dedicated on November 29, 1939. The church pastor who survived the tornado promised to make the new church "like a bunker" to protect it against future wind events.

Figure 1. Sacred Heart Catholic Church and adjacent school. The church (to the left of the basketball court) consists of a sanctuary, bell tower, and rectory (from left to right).

The rebuilt Sacred Heart Catholic Church (see Figure 1) was a thriving church for years and was supported by the affluent local community. However, common to many urban areas, those parishioners funding the church eventually moved to the suburbs. The result of changing demographics in the area left the church without the resources required for an adequate maintenance program, which has led to deficiencies in the structural integrity of the building, as well as deterioration of the characteristic elements of the church. In addition to structural and cosmetic issues of the building itself, two statues in the front lawn of the church were vandalized (see Figure 2).

Figure 2. Demolished statue at church (left; provided by local newspaper) and student constructing student-designed statue cover for use until new statue is made (right). Students raised funds needed to pay deductibles for both demolished statues at the church.

In fall 2014, civil , structural, and building systems (i.e., mechanical) engineers, as well as licensed CEE faculty members, guided the entire freshman civil engineering class and select juniors and seniors on an initial condition assessment of the church building structure and the surrounding grounds. The freshman class wrote a summary report of observations and these findings were used to plan design activities for the spring semester. Freshman focused on the more obvious deficiencies, such as those noted in Figure 3. Subsequent spring 2015 activities involved all freshman individually redesigning a livable new layout of the church rectory to meet the pastor's needs and architectural code requirements.

Figure 3. Examples of church deterioration, including peeling paint caused by excessive water on masonry (left) caused by leaky gutter (middle), as well as evidence of leaky roof (right).

In spring 2015, civil, structural, building systems, and environmental engineers, as well as a certified hazardous materials manager (CHMM) and an architect, led senior civil engineering students in performing comprehensive building envelope, seismic, and environmental evaluations of the building structure. The building envelope assessment examined the entire exposed structure to include not only aesthetic items, such as the stained glass windows, but also potential structural issues, including water damage and roof deterioration. Senior engineering students performed a Tier 1 seismic and overall wind evaluation in order to identify items that were not in compliance with current building code regulations. Finally, an environmental assessment was performed to determine if lead paint or asbestos was present anywhere on site.

Deficient items identified during spring 2015 by seniors were added to the preliminary deficiencies list developed in fall 2014 by freshmen. Estimated costs for remediating items on the master deficiency list were obtained from contractors specializing in each type of work. The cost estimates total more than $300,000. The cost estimates for all should be viewed as not to exceed limits which are ideal for raising funds and prioritizing activities. Although costs may increase in the future, many contractors have pledged to honor their estimates. Under the supervision of a licensed transportation faculty member, students also performed a traffic, school pickup, and parking study for the adjacent, yet affiliated, school property. Students worked to compile a summary report, which was delivered to school staff (see Figure 4). Finally, a map of all floor cracking in the sanctuary (with crack sizes) was constructed by the students. The purpose of the map of floor cracking is to compare it to future cracking if no remediation is made at this time.

Figure 4. Students presenting findings of traffic study to adjacent (affiliated) school staff.

Collaboration of Faculty, Students, and Licensed Professional Engineers

During the entire one year over which the project has taken place, there has been constant collaboration of licensed faculty (4), students (approximately 122), and professional engineers (7). The evaluation and rehabilitation design of Sacred Heart Catholic Church involved over 30 total faculty/student/professional engineer visits that included field trips, meetings with contractors, meetings with church staff, and other critical data gathering sessions. Involved professional engineers participated in field trips with students and data gathering sessions, which allowed them to guide students in hands-on, experiential learning. Furthermore, professional engineers and faculty worked closely with students as they developed a master report for the pastor of Sacred Heart Catholic Church. The three main lessons the students learned from the project were (a) how to write a practical engineering report that references current codes and standards, (b) how to perform a building inspection, and (c) how to think and solve problems quickly in the field. For example, students were amazed by how quickly one licensed engineer was able to identify a cut brace deficiency in the church attic (see Figure 5).

Figure 5. Wood brace cut for duct passage. Structural engineer made a quick calculation in front of the students and determined that the brace was redundant and not needed anyway.

Protection of health, safety, and/or welfare of the public

The evaluation and rehabilitation design of Sacred Heart Catholic Church had at its core a primary goal of protecting the health, safety, and welfare of the public. In fact, the environmental and structural assessment procedures used at the Church are based on national standards and are applicable to all structures built prior to the development of modern building codes. The environmental evaluation of the church included a thorough asbestos and lead paint assessment of all areas inside the church (e.g., walls, doors, windows, ceilings). Under the leadership of a licensed environmental engineer and a separate hazardous materials expert, seniors specializing in environmental engineering participated in this activity. Since the activity was new to the students, they were led through the discovery process so that appropriate samples could be obtained. Given associated dangers, further analysis was conducted by external laboratories, although the hazardous materials expert worked with students to summarize findings. Overall, a trace amount of asbestos was found in the original floor tile area, while significant levels of lead paint were found throughout the rectory. After the students obtained the results of the hazardous materials assessment, they quickly learned the impact of engineering decisions. Choosing to perform the hazardous materials assessment led to the knowledge of toxic materials on site, which meant that no rehabilitation could occur (i.e., no permit could be obtained) until the hazardous materials were removed from the building. The licensed environmental engineer was aware of this issue in advance and discussed the potential outcome with the pastor and faculty prior to performing the assessment. Students were purposely not made aware of this discussion (in advance) in order to foster an understanding of engineering responsibility.

Seismic and wind assessments were performed by the students to analyze the efficacy of the church structure to protect human lives during natural disasters. Since no structural damage was recorded after Hurricane Hugo, a category five hurricane that struck the area in 1989, wind was concluded to not be a major concern. In fact, the existing heavy slate kept the roof from failing under the associated strong winds. On the contrary, the structure has never been tested by a seismic event. Students, following ASCE 31-03 (a national standard), discovered that the old unreinforced brick structure had some seismic safety concerns and many nonstructural issues that could lead to death following a seismic event. Sample critical concerns were the large, heavy, unbraced statue and frame structures near the alter that would likely fall over during significant ground shaking. Similarly, it was determined that the large chimney at the church exterior (and near an exit) would fall over during significant ground shaking and could easily fall on people trying to exit the structure (see Figure 6). Students designed and obtained cost estimates for rehabilitations needed to address life safety issues. The seismic evaluation also fostered the students' understanding of responsibility as they openly discussed the importance of finding all life safety hazards associated with the church. The sense of responsibility made many student groups want to list more issues with the structure than would be required by standard practice.

Figure 6. Back of church structure. Unbraced chimney near the exit is a life safety issue due to high seismicity which was not considered during original construction in 1939.

Multidiscipline and/or Allied Profession Participation

The evaluation and rehabilitation design of Sacred Heart Catholic Church involved several engineering disciplines. In addition to civil engineering, environmental, mechanical, and electrical engineering were heavily involved. While working on this project, students were under the constant supervision of licensed engineers. Four licensed faculty were involved in the structural, transportation/parking, environmental, and freshman drawing/design aspects of the project. Site condition assessments (major field trips with students) were led by seven licensed civil, structural, and building systems engineers. The building systems engineer was a licensed mechanical engineer who led the assessment of mechanical and electrical systems in the building. Building envelope evaluations (major field trips with students) were led by an architect, civil engineer, and building systems engineer. A structural engineer led the students through a thorough seismic evaluation of the structure and even walked them through the entire seismic report writing exercise from start to finish (see Figure 7). As previously discussed, a licensed environmental engineer and a hazardous materials expert led the students through a complete asbestos and lead paint assessment of all areas inside the church. It is important to note that the interaction between outside professional engineers and students was continuous over the entire year and included several iterations of report submissions. In fact, the professional engineers actually helped the students author the final report and ensured that all conclusions were sound and in accordance with standard engineering practice and expectations. Outside of engineering, other professions were involved in the project, including contractors, newspaper reporters, and church leadership (pastor and staff). Ten contractors were brought to the site to provide detailed cost estimates to mitigate issues discovered during the evaluation process. Students were always on site to meet the contractors and to walk them through the mitigation alternatives.

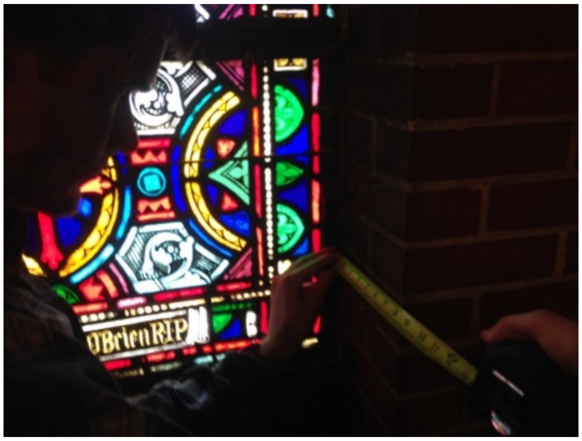

Figure 7. Students meeting with structural engineer during initial phase of the seismic assessment (left) and student verifying masonry wall thickness for seismic calculations (right).

Knowledge or Skills Gained

A conclusion made almost each week by the students was that the knowledge and skills gained by working directly with licensed engineers and contractors was invaluable. Many students stated that they learned more in the field than they did the same week in course lectures. The full building envelope evaluations which involved architecture, structural engineering, environmental engineering, mechanical engineering, and electrical engineering showcased how all disciplines must work together to ensure a successful project. Although the students indicated that evaluation techniques (e.g., field measurements) were a primary and necessary civil engineering skill learned during this project (and not specifically taught in the traditional curriculum), a survey at the end of the project revealed that "report writing" may have been the most significant skill learned. Licensed engineers stressed that professional report writing is paramount to the practicing engineer and an important aspect of daily activities. The final product developed by the students was nothing like an academic lab report. At project completion, the students delivered a comprehensive 100 page report to the church pastor (see Figure 8). The licensed engineers working with the students on the project taught the students correct formatting for laying out reports and appropriate methods to address a particular client's concerns.

Figure 8. Students delivering final report to Sacred Heart pastor (left) and church and student participants gathered at project completion (right).

Finally, project management played a major role in the entire project. Students actually participated in all of the building evaluations. In fact, at times, the structural, seismic, and wind assessments were led as much by the students as the licensed engineers. However, during the building systems (electrical and mechanical) and architectural assessments, students played the role of project managers as they scheduled and met the other discipline leaders onsite, since they were unqualified to perform the assessments themselves. Similarly, after the mitigation designs were developed, students played the role of project manager with all the contractors. Each contractor was contacted by students and met on site to ensure that the contractors' cost estimates to fix deficiencies were in line with the expected amount of work.