CHART ENGINEERING

Temple Steeple Design

Optimizing Seismic Performance and Cost Design

Hillary Argyle, Brent Chase, Rachelle Rosendahl, Daniel Talbert

11/21/2011

BRIGHAM YOUNG UNIVERSITY

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

MEMORANDUM

TO: The Church of Jesus Christ of Latter-day Saints

FROM: CHART Engineering

DATE: November 21, 2011

SUBJECT: Temple Steeple Design for the Church of Jesus Christ of Latter-day Saints

CHART Engineering is submitting the following proposal for the design of a temple steeple for a temple located in an area of high seismic activity. Our company aims to design a structural framing system that will meet the seismic requirements while optimizing cost and keeping the architectural integrity required of temple design. This proposal will outline:

- Executive Summary and Approach to the Project
- Project Team Qualifications
- Scope of Work and Schedule Forecasting
- Proposed Budget

This proposal will present an outline for solving the presented problem by analyzing and comparing two different approaches to structural design. Please consider this proposal for the optimization and design of the temple steeple.

Feel free to contact CHART Engineering at chartengineering@gmail.com and (503) 830-5397 with any questions or concerns you have about the proposal or project.

Sincerely,

Hillary Argyle

Brent Chase

Rachelle Rosendahl

Daniel Talbet

Executive Summary

The Church of Jesus Christ of Latter-day Saints is in need of a steeple structure design for a temple in a high seismic activity zone. This steeple must meet performance and architectural requirements while optimizing cost.

Members of the Church of Jesus Christ of Latter-day Saints worship in temples regularly, and for some members, this may require traveling significant distances and require great personal sacrifices. For this reason, temples are in high demand and are being built around the world at an increasing rate for members in various countries and circumstances. Each temple is designed accordingly for the specific location, as each location has unique geographical characteristics. Differing methods of construction and design must be utilized to meet these characteristics. These areas often include the possibility of a natural disaster such as hurricanes, floods or earthquakes.

This challenge has presented itself with the design of a new temple in an unannounced location. This location, as mentioned above, is a high seismic area. A structural framing system for the steeple must be designed to withstand significant seismic loading and meet the architectural and performance criteria that are standard for any temple. The structure must remain safe for the Maximum Considered Earthquake (MCE) and only suffer minimal damage under the design basic earthquake (2/3 MCE).

This task includes evaluating two different American Society of Civil Engineers (ASCE) approaches to seismic design along with many different systems. The steeple structure is one of most important parts to the exterior of temples. Steeples must be structurally sound and aesthetically pleasing, as they are often the first recognized part on a temple when seen from a distance. For this reason the highest quality of materials, most advance seismic design analysis, and highest standards must be considered and used.

Project Team

Dr. Paul Richards, a professor at Brigham Young University for the Civil and Environmental Engineering Department, will act as the project team's advisor. His experience in seismic and steel design will be a valuable resource as we complete the project.

Hillary Argyle will act as Project Leader, insuring each deadline is met and that work is distributed equally, as well as contributing to the project. Rachelle Rosendahl will act as the primary Design Engineer, insuring that the architectural integrity of the final product is maintained. Daniel Talbert will be the primary Structural Engineer, heading the approaches for seismic and steel design, and Brent Chase will be the primary Cost Engineer, insuring that cost is optimized for the product.

Statement of Qualifications

Our group is uniquely qualified for this project due to the fact that we are all majoring in Civil Engineering at BYU with an emphasis in structures. All members of CHART Engineering are excited to learn more about real-world applications of structural engineering and to apply what we have already learned to this project. Each member of CHART has taken Structural Analysis (CE EN 321) and will be taking Structural Steel Design (CE EN 421) next semester. Being enrolled in steel design while we are working on this project will be helpful because of its applicability to the project. Each member of our group has unique qualifications that will contribute to the success of this project.

Hillary Argyle is organized and self-motivated. She is a course assistant for the Statistics Department where she works with both students and professors to teach and organize classes. This job has helped her develop good interpersonal skills and continue to develop her already organizational skills. These skills will help to keep our team on task and ensure that we meet deadlines throughout the time we work on the temple steeple. She has experience with the computer programs that are needed for this project, specifically: AutoCAD, Revitt, Robot and RAM. Hillary has a passion for structural engineering, which is manifest in the fact that she plans to pursue a Master's Degree in structural engineering after she graduates.

Rachelle Rosendahl has leadership experience thanks to her time in the presidency of the BYU chapter of the American Society of Civil Engineers (ASCE). She is currently the publications chair and helps to organize volunteer opportunities and activities for the Civil Engineering students. Through this position she has gained substantial experience interacting with professionals and professors, learning what it means to be an engineer. As we work to complete this project it will be important to have a group member who can make sure we are organized and complete everything in a professional manner. Rachelle has extensive experience with AutoCAD due to two semesters as a teaching assistant, helping students to effectively use the program. She also has experience with BIM, REVIT, Revit Robot, Navisworks, RAM, and QTO. Rachelle plans to get a Master's Degree in Architecture after she graduates. Her artistic abilities and interest in architecture will prove to be helpful in the design of the steeple.

Daniel Talbert has CAD experience, which includes AutoCAD, ProE, Catia and NX. He has both leadership and group-work experience that will be helpful during this project. Dan's most recent leadership experience came last year when he was an Event Lead BYUSA. He is currently enrolled in the Global Engineering Outreach class where he is working with a group to develop a washing machine for a third-world village. Dan is gaining practical knowledge on the design process, from data-gathering and preliminary design to optimization and conceptualization within a group. This experience will be applicable through the design process of the temple steeple. In addition to majoring in Civil Engineering, Dan is working toward a Minor in Art. This shows that he loves to learn and his artistic abilities will be helpful in keeping the design of the temple steeple beautiful.

Brent Chase has an extensive experience base that will be helpful in the design of the temple steeple. He has taken classes in Architecture in which he has studied temple blueprints. Brent is proficient in AutoCAD as he took classes pertaining to CAD during high school and at BYU. Brent has worked in construction, becoming familiar with many of the building materials that will be used in the design of the steeple. Brent has taken initiative to join the Steel Bridge Design Group where he will learn more about steel design that will be applicable to the temple steeple design.

Scope of Work

CHART Engineering will design a steeple for a temple located in a high seismic zone. This project will require extensive research into steel and seismic design in order to optimize performance, cost and architectural design. The following plan is outlined to complete this goal in a timely manner while maintain optimal quality is maintained.

- As the location of this temple is unknown, CHART Engineering realizes a specific site visit may not be possible. There are thirteen temples in the state of Utah and as a group we plan to visit many to gain a better knowledge of the specific architecture required. Three temples, Brigham City, Payson and Provo are currently under construction and we plan to visit those to gain knowledge of construction for temples as well.

- CHART Engineering will research and create preliminary designs for two methods: a two-stage approach as outlined under ASCE 7-10 Section 12.2.3.2 or a component using ASCE 7-10 Chapter 13. Designs will insure the structure is safe for the Maximum Considered Earthquake. Response Modification Factors for at least three earthquake-resisting systems will be analyzed under each approach in order to determine which design will optimize cost, safety and design.

- After the extensive research outlined, one system will be recommended and all necessary calculations will be performed in order to insure this system meets the performance criteria. Autodesk Revit Architecture® and Autodesk Revit Structures® will be used to provide drawings of the proposed System.

- These drawings made with the Autodesk programs will be used with optimizing and calculation programs Autodesk Robot® and RAM® to further support the teams design proposal.

- Throughout the project CHART Engineering will maintain a constant communication with our expert advisor, Dr. Paul Richards. CHART Engineering has potential connection to current temple engineers working on uncompleted temples in Utah and communication with these experts will be a priority.

- Weekly meetings will ensure the completion of the above objectives. The schedule on the following page outlines important milestones and dates that will be strictly adhered to. The contract will terminate on April 19, 2011 and as scheduled, the project will be completed two weeks before this date in order to account for unexpected delays or complications. Specific dates for project milestones are also given in the subsequent pages.

Computer programs will be used as outlined on the previous page. Excel and other Microsoft® products will be used to compile all work and present a professional report. If granted the proposal, The Church of Jesus Christ of Latter-day Saints will provide our firm with an architectural profile of the tower as well as the properties of a generic temple structure.

Scheduling

The following calendar outlines the specific week or weeks for which each intermediate objective is planned in order to reach the final goal. Attention is called to the two weeks in April in which nothing is planned – this is to account for potential delays or complications within an earlier objective. Important project milestones are listed below the schedule in more detail along with the specific expected completion date.

The project team will meet once a week for three hours on every Thursday, from two in the afternoon until five in the evening. Each team member will be required to put in three additional hours of personal time before that Thursday each week to finish any work assigned to them. This outlines minimal hours; more hours will be added as needed to produce a quality product.

	January				February					March				April		
	4	11	18	25	1	8	15	22	29	7	14	21	28	4	11	19
Preliminary Effort																
Visitation of Project Sites																
Gathering of Data																
Research of Approaches																
Research of Systems																
Design Analysis																
Determination of R Factors																
Cost Analysis																
Comparison between Systems																
Recommendation and Calculations																
Concluding Efforts																
Computer Generated Drawings																
Compilation of Report and Poster																
Presentation and Delivery																

January 25 Data gathering and preliminary design, comparison of ASCE 7-10 design approaches and discussion of possible structural systems listing advantages and disadvantages, selecting three systems to study further

February 8 Determination of R factors for each system

February 15 Cost analysis for each system

February 22 Comparison of each system based on performance and cost

February 29 Recommendation of seismic resisting system

March 7 Calculations showing that chosen system meets the performance criteria

March 14 Multiple drawings showing tower framing configuration, coordination with architectural cladding, windows, and Moroni Statue

March 28 Report submission

Cost Proposal

Individual **Title**	Dr. Paul Richards Mentor	Hillary Argyle Project Leader	Brent Chase Cost Engineer	Rachelle Rosendahl Design Engineer	Dan Talbert Structural Engineer	Total Hours
Hourly Rate	$115	$50	$50	$50	$50	
Preliminary Effort						
Visitation of Project Sites		1	1	1	1	4
Gathering of Data	1	3	3	3	5	15
Research of Approaches	1	2	2	2	2	9
Research of Systems	1	6	6	6	6	25
Design Analysis						
Determination of R Factors	1	3	3	3	3	13
Cost Analysis			4			4
Comparison between Systems	1	2	2	2	5	12
Recommendation and Calculations	1	2	2	2	2	9
Concluding Efforts						
Computer Generated Drawings		4		4		8
Compilation of Report and Poster		4	2	2	2	10
Presentation and Delivery		1	1	1	1	4
Total Labor Hours	6	28	26	26	27	113
Total Labor Cost	690	1400	1300	1300	1350	6040
					Printing and Supplies Cost	$50
					Total Cost	$6,090

Appendix

CHART Enginnering Resume's

Hillary Argyle
Brent Chase
Rachelle Rosendahl
Daniel Talbert

Prioritized List of Projects