ERICKSON ANCHORAGE OF ROOF-TOP EQUIPMENT
PROJECT ID: CEEN_2018CPST_002

by

B-RAY Engineering
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A Capstone Project 30% Completion Report

Submitted to

Bahaar Taylor
Erickson Structural

Department of Civil and Environmental Engineering
Brigham Young University

December 10, 2018

Executive Summary

PROJECT TITLE: ERICKSON ANCHORAGE OF ROOF-TOP EQUIPMENT
PROJECT ID: CEEn_2018CPST_002
PROJECT SPONSOR: Erickson Structural
TEAM NAME: B-RAY Engineering

Project Objectives:

Create Excel spreadsheet appropriate for calculating gravity and lateral anchorage of rooftop equipment (including solar panels, mechanical units, etc.)

Create AutoCAD details to depict typical connections of rooftop equipment to the building structure.

Create template proposal for use for such projects (similar examples will be provided). Constraints & Goals: Excel spreadsheet should be automated as much as possible to accommodate several different scenarios such as pitched roofs, varying sizes of equipment, different wind and seismic loading requirements, snow drift loading, etc.

Constraints & Goals: AutoCAD details should be easily customizable as far as possible. Engineering Specialty: Structural

Deliverables:

Excel Spreadsheet

AutoCAD Model

Proposal Template

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Introduction

The anchorage of rooftop equipment is structural analysis focused project for Erickson Structural Consulting Engineers. Which is a company that focuses upon working with existing structures, including forensic investigations of building structures and failures, assessments of, and remediation designs for, distressed building structures, structural analysis of existing buildings, design of structural renovations and modifications to existing buildings, evaluation of insurance claims involving structural loss, and seismic evaluation and rehabilitation of existing buildings. Hence, in order to make their jobs easier this company has asked us to create an Excel spreadsheet that uses the equations and standards and codes from the ASCE minimum design loads for buildings and other structures manual, to calculate seismic design force, displacements any other seismic demands, and to calculate wind loads on structures and building appurtenances. Along with the calculations on the spreadsheet we need to create and AutoCAD file that depicts typical rooftop connections and equipment that goes on the buildings structure and create template proposal for use for such projects.

Schedule

9/10/2018	Formed capstone group in class
9/17/2018	Received capstone assignment
9/24/2018	Met with Dr. Borden, the team's faculty advisor.
10/5/2018	Did a video call with the team's sponsors, Bahaar Taylor and Joshua Peterson from Erikson Structural Consulting Engineers.
11/12/2018	Created a basic outline in Excel demonstrating the template of the team's spreadsheet and sent it to the sponsors for feedback.
11/27/2018	Conference call with sponsors. Discussed details concerning the spreadsheet and the ASCE codes we will need to complete the project.
12/7/2018	Conference call with sponsors.

Assumptions & Limitations

Assumptions the team had to make included the following:

- A user interface will need to be created with Visual Basic code, so structural analyses can be streamlined
- All formulas found in ASCE 7-16 will be included in the final product
- AutoCAD models will be similar to those in the examples provided
- The AutoCAD models and proposal template will need to allow for user input

Limitations the team encountered included:

- The sponsors reside out-of-state, creating difficulties with communication.
- Sponsors have been very busy with their work, so it has been hard to keep in contact with them.

Design, Analysis & Results

After having talked to Bahaar Taylor and Josh Peterson, we understood that we needed to get the manual called “Minimum Design Loads for Buildings and Other Structures” in order to find out the formulas needed to calculate seismic demands and wind loads. We read and analyzed section 13 called “seismic design requirements for nonstructural components” from the manual to find those formulas out. We were able to identify some of the key formulas that will be used in the spread sheet in order to calculate seismic demands and wind loads. Some of these formulas are the following:

To determine the horizontal seismic design force, Fp. It shall be applied at the component’s center of gravity and distributed relative to the component’s mass distribution.

$$F_P = \frac{0.4 a_p S_{DS} W_p}{\left(\frac{R_p}{I_p}\right)}\left(1 + 2\frac{z}{h}\right) \quad (13.3\text{-}1)$$

F_p is not required to be taken as greater than

F_p is not required to be taken as greater than $F_p = 1.6 S_{DS} I_p W_p$ (13.3-2)

and F_p shall not be taken as less than $F_p = 0.3 S_{DS} I_p W_p$ (13.3-3)

Where:

- F_p= seismic design force
- S_{DS}= spectral acceleration, short period, as determined from Section 11.4.4
- a_p= component amplification factor that varies from 1.00 to 2.50 (select appropriate value from Table 13.5-1 or 13.6-1)
- I_p= component importance factor that varies from 1.00 to 1.50 (see Section 13.1.3
- W_p= component operating weight
- R_p= component response modification factor that varies from 1.00 to 12 (select appropriate value from Table 13.5-1 or 13.6-1)
- z = height in structure of point of attachment of component with respect to the base. For items at or below the base, z shall be taken as 0. The value of z/h need not exceed 1.0
- h = average roof height of structure with respect to the base

13.3.2 Seismic Relative Displacements

$D_{pI} = D_p I_e$

where

- I_e = the importance factor in Section 11.5.1
- D_p = displacement determined in accordance with the equations set forth in Sections 13.3.2.1 and 13.3.2.2.

We have not used all of the formulas listed above in our spread sheet. This is because we spent some time reading and trying to understand all these formulas in this particular section. However, we have created a spread with some formulas and tables as shown in picture below:

Lessons Learned

Our team has learned a few things from our progress so far on this project. We have learned the importance of effective and efficient communication. Our sponsors reside in another state and are naturally busy with their day to day whirlwind of work. We could only communicate with them through email and telephone so learning how to use that precious time with them wisely was crucial. We had some trouble understanding what was expected for the project initially and since our only communication is emails and short telephone calls we still had some confusion throughout the semester. Another thing that we learned is how fast a deadline can approach whether you're ready or not. It is important to schedule your time wisely and spread out your workload before it becomes too late. There were times when we were rather busy with other school work and didn't prioritize the project. This came back to harm us in the end as we fell behind. We also learned that in the professional world, others won't hold your hand and guide you through your work. Oftentimes it is up to you to figure out what you need to do and ask the important questions to help you out. We are starting to understand how to be more independent and accountable in the workplace.

Conclusions

This project will be focused on structural analysis of seismic design forces, displacements, and wind loads. The two main outcomes will be an Excel spreadsheet for the automated calculations for different scenarios and a customizable AutoCAD file along with the written proposals.

Effective communication and thinking of the right questions to ask is key for the success of this project since sponsors are not in the same city. However, after recent communication with our sponsor, we feel like we have a better idea of what is expected for our project.

Recommendations

We recommend that our sponsor perhaps be a little more specific on what their expectations on for the project and assist us in understanding the steps we need to make to complete the project. Due to the fact that we cannot meet in person with our sponsor, we also recommend that the sponsor reach out more to assure we are comfortable with what we need to do and all of our questions are answered. In case sponsors aren’t able to have a lot of time to explain everything in detail then data, previous reports, example projects, example details and proposals would really help clarify any questions the team might have.

Appendix A

Brandon Roberts

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Education

Bachelor of Science in Civil Engineering Dec 2019
Brigham Young University *Provo, UT*

- Cumulative GPA: 3.42
- Relevant Coursework: Engineering Mechanics (Statics, Dynamics, Materials), Hydraulics and Fluid Flow Theory, Soil Mechanics, Geomatics (GIS)
- Extracurricular Experience: Tau Beta Pi Honor Society, American Society of Civil Engineering

Professional Experience

Land Development Intern May 2018 - July 2018
EPS Group Inc. *Mesa, AZ*

- Prepared cross-sectional flow modeling for presentation to 5+ stakeholders
- Designed base maps and roadway striping plans in AutoCAD/Civil 3D 2018
- Ensured correct referencing and quality of plans and reports
- Executed post-design construction activities including contractor requests for information and deliverables
- Supported 1 Senior Project Manager and 2 Project Managers in 2+ project simultaneously
- Collaborated with 6 team members and 10+ external consultant groups on project development

Inventory Supervisor May 2017 - July 2017
Pinto Creek Co. LLC (Grower, Packer, Shipper of Fresh Vegetables) *Eloy, AZ*

- Coordinated packing of vegetables for retail and wholesale orders using real-time industry specific software system
- Coordinated shipping process with sales department and freight carriers
- Oversaw shipping of 15 Semi Loads of product per day to retail and wholesale customers in United States and Canada
  - (Customers included: Walmart, Costco, Safeway, Supervalu, Meijer, Bashas, Target)
- Worked with team in fast paced, dynamic, and stressful environment where accuracy and timeliness were paramount

Student Piano Technician October 2015 - Present
BYU Piano Shop *Provo, UT*

- Tune pianos within 5 cents of accuracy
- Perform maintenance work on 15+ pianos
- Trusted to handle $250,000 pianos and take care of assigned pianos
- Diagnose and remedy regulation problems among 1200+ parts

Volunteer Work

Volunteer Representative Aug 2013 - Aug 2015
The Church of Jesus Christ of Latter-day Saints *Villahermosa, Mexico*

- Increased effectiveness by training 3 other representatives over 3-month period each
- Prepared and taught training meetings to 8+ representatives weekly
- Presented 20+ lessons of self improvement and behavioral changes in community
- Analyzed and reported performance indicators weekly

Awards and Skills

Advanced Spanish fluency (reading, writing, speaking)
Engineering related software: AutoCAD/ Civil 3D 2018, ArcGIS, FLO-2D, Extensive knowledge of Microsoft Office
Eagle Scout

Roman Calderon

rcp_calderon@hotmail.com (352)-722-1148

EDUCATION

B.S. Civil Engineering Dec 2019
Brigham Young University
Provo, UT

- Minors in Math, and Business Management
- 3.52/4.0 GPA
- Relevant Course Work: Computational methods; Metals, Woods, & Composites; Concrete, Masonry, & Asphalt; Mechanics of Materials; Elementary Soil Mechanics; Intro to Transportation Engr; Hydraulics & Fluid Flow Theory; Structural analysis; Geometric Design of Highways

Associate's Degree in Business with an accounting certificate Apr 2015
LDS Business Collage
Salt Lake, UT

- 3.93/4.0 GPA

WORK EXPERIENCE

Custodian May 2015 - Current
Brigham Young University
Provo, UT

- Supervise a group of 5 students to clean and maintain some BYU buildings in excellent conditions
- Assist with training of new staff in work methods and procedures
- Developed a new system of teamwork resulting in a remarkable improvement in performance and effectiveness of each team member

Custodian Aug 2014 - Apr 2015
The Church of Jesus Christ of Latter-Day Saints
Salt Lake, UT

- Worked with a multidisciplinary team for the possible implementation of new equipment
- Developed an outstanding ability to coordinate maintenance activities with management and other custodial staff
- Improved and documented all SOP (Standard Operating Procedures) concerning custodial duties

LEADERSHIP AND SERVICE

Boxing Club President May 2015 – Dec 2016
Brigham Young University *Provo, UT*

- Increased the total number of active members by 200%
- Planned and organized several activities such as: info sessions, community service projects and mentorship sessions.

Student Committee Coordinator Jul 2010 – Apr 2011
Polytechnic University of Pachuca
Pachuca, Mexico

- Motivated over 250 students to overcome their fear of sharing their ideas to school administrators
- Responsible for performance measures and well-being of more than 100 students.

SKILLS

- Modeling/Rendering: AutoCAD CIVIL 3D, NX10
- Computer: MS Office
- Programming: Visual Basic for Applications
- QuickBooks

Foreign Language

Spanish: Native and English: Proficient

- Portuguese

Appendix B—Figures

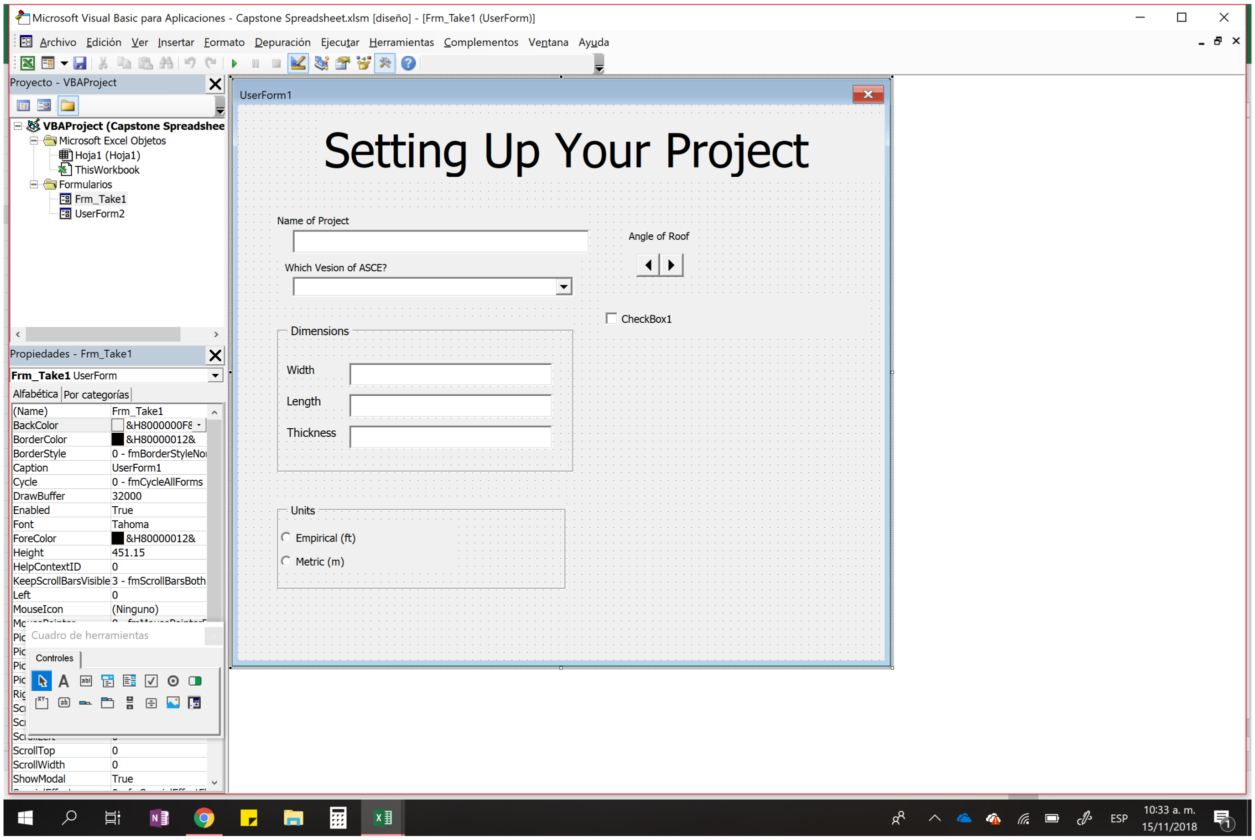

Figure 1: Screen Shot of the Preliminary User Interface

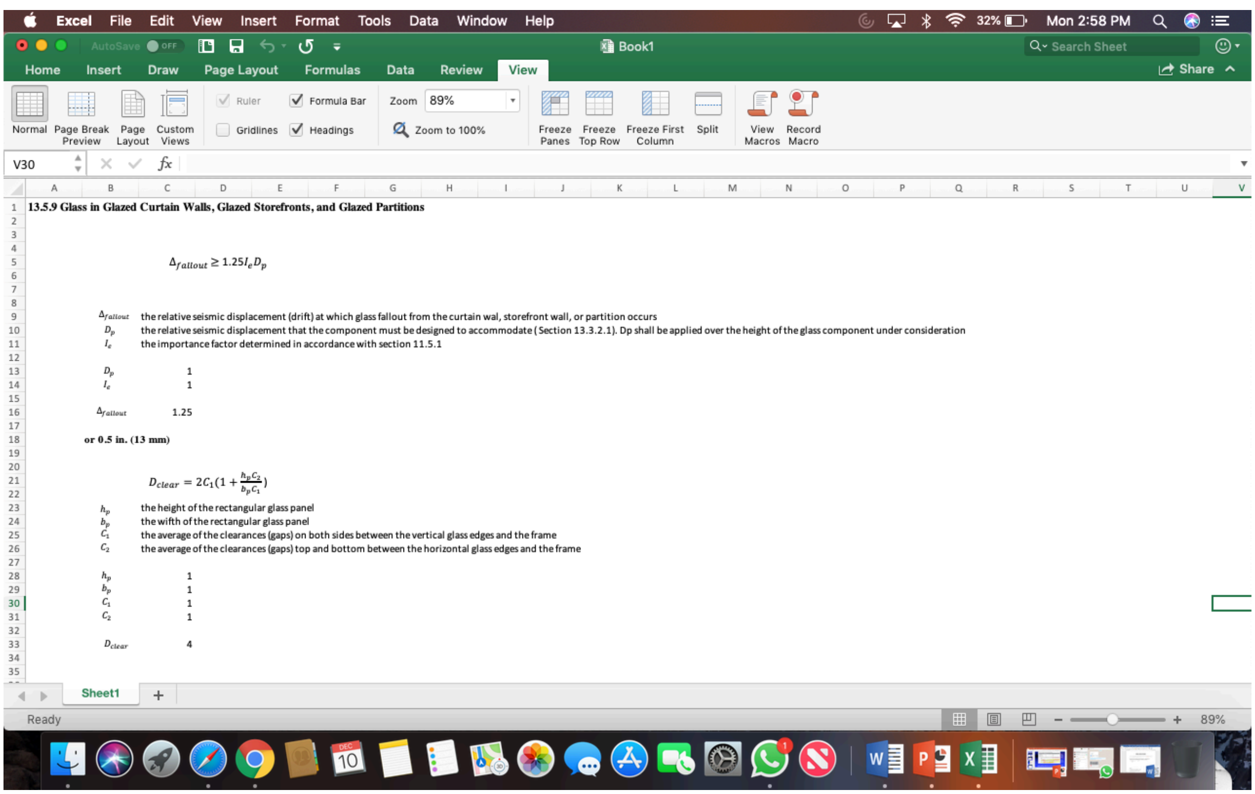

Figure 2: Screen Shot of Preliminary Spreadsheet with Formulas and Variables Explained

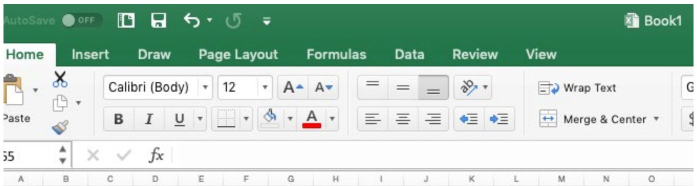

Table 13.5-1 Coefficients for Architectural Components

Architectural Component	a_p[a]	R_p[a]
Interior nonstructural walls and partitions[b]		
Plain (unreinforced) masonry walls	1.0	1.5
All other walls and partitions	1.0	2.5
Cantilever elements (Unbraced or braced to structural frame below its center of mass)		
Parapets and cantilever interior nonstructural walls	2.5	2.5
Chimneys where laterally braced or supported by the structural frame	2.5	2.5
Cantilever elements (Braced to structural frame above its center of mass)		
Parapets	1.0	2.5
Chimneys	1.0	2.5
Exterior nonstructural walls[b]	1.0[c]	2.5
Exterior nonstructural wall elements and connections[b]		
Wall element	1.0	2.5
Body of wall panel connections	1.0	2.5
Fasteners of the connecting system	1.25	1.0
Veneer		
Limited deformability elements and attachments	1.0	2.5
Low deformability elements and attachments	1.0	1.5
Penthouses (except where framed by an extension of the building frame)	2.5	3.5
Ceilings		
All	1.0	2.5
Cabinets		
Permanent floor-supported storage cabinets over 6 ft (1,829 mm) tall, including contents	1.0	2.5
Permanent floor-supported library shelving, book stacks, and bookshelves over 6 ft (1,829 mm) tall, including contents	1.0	2.5
Laboratory equipment	1.0	2.5
Access floors		
Special access floors (designed in accordance with Section 13.5.7.2)	1.0	2.5
All other	1.0	1.5
Appendages and ornamentations	2.5	2.5
Signs and billboards	2.5	3.0
Other rigid components		
High deformability elements and attachments	1.0	3.5
Limited deformability elements and attachments	1.0	2.5
Low deformability materials and attachments	1.0	1.5
Other flexible components		
High deformability elements and attachments	2.5	3.5
Limited deformability elements and attachments	2.5	2.5
Low deformability materials and attachments	2.5	1.5
Egress stairways not part of the building structure	1.0	2.5

Figure 3: Table with referenced values