

ARROWHEAD STRUCTURAL/GEOTECHNICAL
Project ID: CEEEn_2017CPST_001

by

KADD Engineering
Daniel Schwicht
Austin Burton
David Davies
Kendl Hansen

A Capstone Project Final Report

Submitted to

Bob Tandler
Fritzi Realty

Department of Civil and Environmental Engineering
Brigham Young University

March 3, 2018

Executive Summary

PROJECT TITLE: Arrowhead Structural/Geotechnical

PROJECT ID: CEEEn-2016CPST-001

PROJECT SPONSOR: Bob Tandler

TEAM NAME: KADD Engineering

The existing Arrowhead Center structure has been inspected and partially analyzed. For the new sections of the building, many columns have been damaged by workplace accidents and will need to be replaced. The roof structure in the EDSCO building was found to be inadequate to support the loads and will need to be retrofitted. The walls of this section of the building appear to be adequate to resist seismic loading, assuming they have been properly reinforced.

The structure of older section of the Arrowhead Center (wood frame) has been inspected. The wood members of this portion of the building have either been split or have excessive water damage. The wood structure of the building will need to be replaced. There is evidence that the masonry walls of the older section are not reinforced. These walls will need to be retrofitted to include proper seismic reinforcement or will need to be completely replaced.

Geotechnical reports have been reviewed and it has been determined that new structures will need to be placed on compacted fill. It has also been determined that part of the land being analyzed is in a flood plain. This plot of land will need to take this into consideration before structural design or can be used as an open area or a park.

Table of Contents

Executive Summary.....	2
Table of Contents.....	3
List of Figures	4
Introduction	5
Schedule.....	6
Assumptions & Limitations	7
Design, Analysis & Results	8
New Structure (EDSCO and eBay):.....	8
Old Structure (Wood Frame):	9
Geotechnical:	11
Reports and Studies Needed for Proposal 004.....	12
Reports and Studies Needed for Proposal 005.....	12
Reports and Studies Needed for Bob Tandler's Proposal.....	12
Lessons Learned.....	13
Conclusions	14
Recommendations	15
Appendix A.....	16

List of Figures

Figure 1: Damaged Columns	8
Figure 2: Split Member	9
Figure 3: Split (right) and Water Damaged (left) Members	9
Figure 4: Split (right) and Water Damaged (left) Members	10
Figure 5: Split Members	10
Figure 6: Masonry Wall with No Visible Reinforcement.....	11
Figure 7: Structural Layout of EDSCO Based on Site Visit.....	17
Figure 8: RISA Analysis of EDSCO Warehouse	18
Figure 9: Spanish Fork Floodplain	19
Figure 10: Geotechnical Report	20

Introduction

Bob Tandler of Fritzi Realty is planning to further develop the Arrowhead Center and Development Property in Spanish Fork, Utah. As a part of this endeavor, Bob has reached out to the BYU Capstone program. Several teams were formed to help facilitate the process. The CEEEn_2017CPST_001 team was given responsibility for the structural and geotechnical aspects of the project.

The structural aspect of the project primarily relates to an existing building on the property. The building is owned by Fritzi Realty, who rents the building out to local businesses, such as Habitat for Humanity and EDSCO. The building is dated and thus requires a structural analysis to determine its current structural stability and its level of conformity to current code. If the building were to be preserved as a part of the development of the area, it is also required to determine needed retrofits and their associated costs.

Another important piece of the project is to determine what structural and geotechnical reports are required by the city of Spanish Fork for further development. This includes an extensive study of the geotechnical conditions of the site, which has previously been performed by AVEC, and structural plans for proposed buildings, which will be provided by licensed engineers. Flood plains are also considered as a part of the project.

Schedule

October 27, 2017 – Team meeting discussing goals, expectations, and proposal tasks. Review photos and documents from Bob Tandler.

November 8, 2017 – Preliminary site visit, gathering information about surrounding area and interior structural information.

November 13, 2017 – Finalize and turn in initial project proposal.

January 2018 – Analyze documents, determine what is needed.

February 3, 2018 – Inspection of structural efficiency. Take measurements of structural members, determine safety and quality of building.

February 2018 – Determine loads and building requirements.

February-March 2018 – Analyze structure, determine possible retrofit options. Begin initial cost analysis of retrofit requirements.

March-April 2018 – Analyze cost efficiency of retrofitting the building, or demolishing building and starting over. Discuss findings with other arrowhead groups. Determine the best option for the facility.

April 2018 – Finalize report and formal presentation.

Assumptions & Limitations

Assumptions:

- Roof Dead and Live Loads based on ASCE 7-10
- Strength of damaged/split members is insufficient
- Seismic reinforcement exists in new sections of building and is adequate.
- Sizing of some of the structural members (no structural plans were provided)
- Z purlins on the side of the walls of the eBay and EDSCO structures are the same as the purlins supporting the roof

Limitations

- Because loads were assumed, conservative estimates were used which allows for analysis to be over designed. Some members failed that may have not failed if design loads for the structure were provided.
- Any member that is split or damage would need to be tested in order to determine structural adequacy. Many members have been damaged which leads to a lot of replacements.
- Sizing of members was conservative when exact measurements were unavailable which led to failure of members that might have passed with adequate information.
- If the Z purlins on the walls of the eBay and EDSCO structures are smaller or larger than the purlins on the roof, the calculations and analysis will be conservative or non-conservative respectively.

Design, Analysis & Results

New Structure (EDSCO and eBay):

Many columns have been damaged, as shown in Figure 1, and will need to be replaced.



Figure 1: Damaged Columns

For the roof structure in the EDSCO warehouse building, an assumed live load of 20 psf and a dead load of 3 psf (only supporting metal seam and weight of beam is included in RISA automatically) was used. Using ASCE 7-10, a ground snow load of 45 psf was reduced to a roof snow load of 37 psf. With these loads, the roof structure in the EDSCO warehouse building was found to be inadequate to support the loads and will need to be retrofitted. The RISA analysis of these members can be seen in Figure 8 in the appendix. Since the purlins fail at only 110%, the retrofit can be small. A possible retrofit option for this portion of the building would be to attach a C-purlin of similar depth to the existing Z-purlins. The walls of this section of the building appear to be adequate to resist seismic loading, assuming they have been properly reinforced.

Old Structure (Wood Frame):

All of the wood members here have either been split or have excessive water damage, as shown in Figures 2-6. The wood structure of the building will need to be replaced.



Figure 2: Split Member



Figure 3: Split (right) and Water Damaged (left) Members



Figure 4: Split (right) and Water Damaged (left) Members



Figure 5: Split Members

There is evidence that the masonry walls of the older section are not reinforced, as shown in Figure 10. These walls will need to be retrofitted to include proper seismic reinforcement or will need to be completely replaced.



Figure 6: Masonry Wall with No Visible Reinforcement

Geotechnical:

Geotechnical reports have been reviewed and it has been determined that new structures will need to be placed on compacted fill. Heavier, commercial buildings will need to have deeper compacted fill and residential buildings will need a shallower compacted fill. From the Spanish Fork Floodplain document shown in Figure 9 in the appendix, it has been determined that Parcel 1 is located in a flood plain. This plot of land will need to take this into consideration before structural design or can be used as an open area or a park.

Reports and Studies Needed for Proposal 004

Parcel 1: Commercial – Additional geotechnical reports will be needed and drainage will need to be accounted for as this is the only parcel located in the floodplain. General structural reports needed.

Parcel 2: Commercial – General geotechnical and structural reports needed.

Parcel 3: Residential – General geotechnical and structural reports needed.

Parcel 4: Residential – General geotechnical and structural reports needed.

Reports and Studies Needed for Proposal 005

Parcel 1: Green Space – No reports or studies needed.

Parcel 2: Commercial – General geotechnical and structural reports needed.

Parcel 3: Commercial – General geotechnical and structural reports needed.

Parcel 4: Residential – General geotechnical and structural reports needed.

Reports and Studies Needed for Bob Tandler's Proposal

Parcel 1: Commercial – Additional geotechnical reports will be needed and drainage will need to be accounted for as this is the only parcel located in the floodplain. General structural reports needed.

Parcel 2: Commercial – General geotechnical and structural reports needed.

Parcel 3: Residential – General geotechnical and structural reports needed.

Parcel 4: Residential – General geotechnical and structural reports needed.

Lessons Learned

Some challenges encountered in January were setting up a site visit, obtaining building plans, and communication issues regarding expectations. To solve these issues, we worked with John Ashworth and scheduled a site visit. We also reached out to Mitch, Bob, LEI, and the city of Spanish Fork for more information and eventually were able to obtain the needed information from the site visit. Challenges faced in February were determining what loads to use for the structural analysis and determining necessary geotechnical information. To solve these issues, we used generic loads found in ASCE 7-10 and we found documents on the flood plains in Spanish Fork.

Conclusions

The Arrowhead Center is built on relatively soft soil. Any structures built on any of the parcels of land will need to be built on compacted fill. Parcel 1 is located within a floodplain which will need to be taken into account when deciding what will be placed there.

The existing structure is generally in poor condition and will either need to be extensively retrofitted, or demolished. Calculations have been performed and pictures have been provided to confirm this. Any new structures will need structural reports that show the building is sufficient.

Recommendations

Further analysis has yet to be performed. However, based upon the completed analyses and the conditions observed during the site visit, the building has been determined to be structurally unstable. An attempt to retrofit the building would require extensive seismic retrofits, replacement of a number wood structural members, and overall strengthening of the existing structure. A cost analysis has yet to be performed, but it is safe to say that it would be a significant expense. It is therefore recommended that the existing building be demolished and the land for other purposes. Further support for this recommendation will be compiled in preparation for the final report.

In addition, Parcel 1 has been found to be contained within the flood plain. Adequate drainage or a water barrier will need to be provided if the land is used for industrial or residential purposes. Another option may be to reserve Parcel 1 for open space to avoid the need to adjust for the flood plain. Further research needs to be done to develop a more specific recommendation for addressing the flood plain issue. It is also noted that the geotechnical report still needs to be searched to determine its compliance with the development requirements of Spanish Fork.

Appendix A

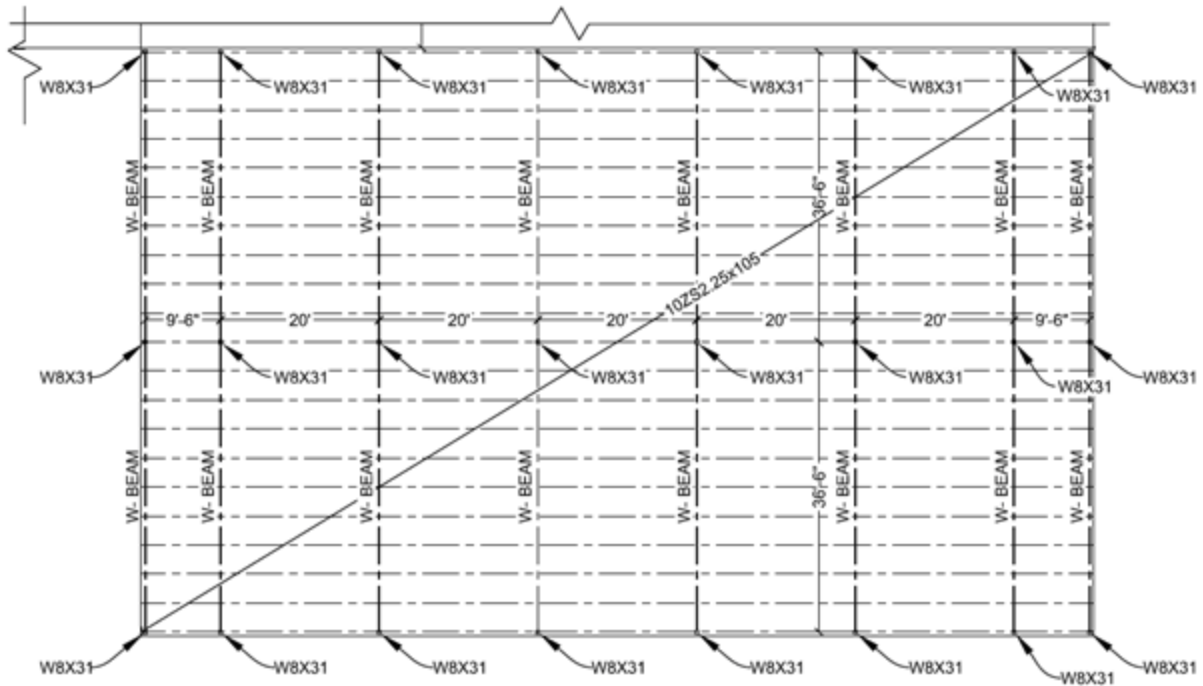


Figure 7: Structural Layout of EDSCO Based on Site Visit

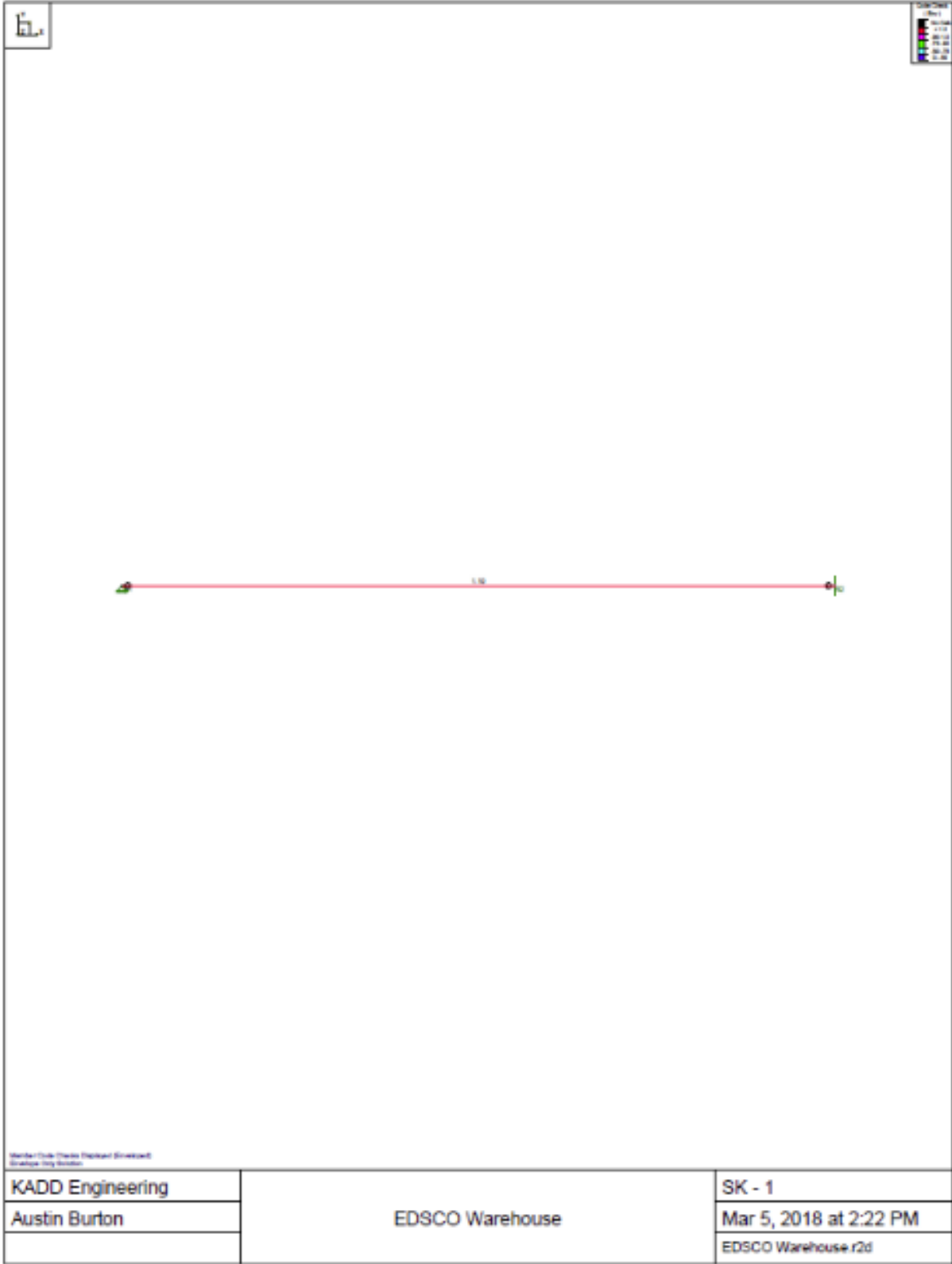


Figure 8: RISA Analysis of EDSCO Warehouse

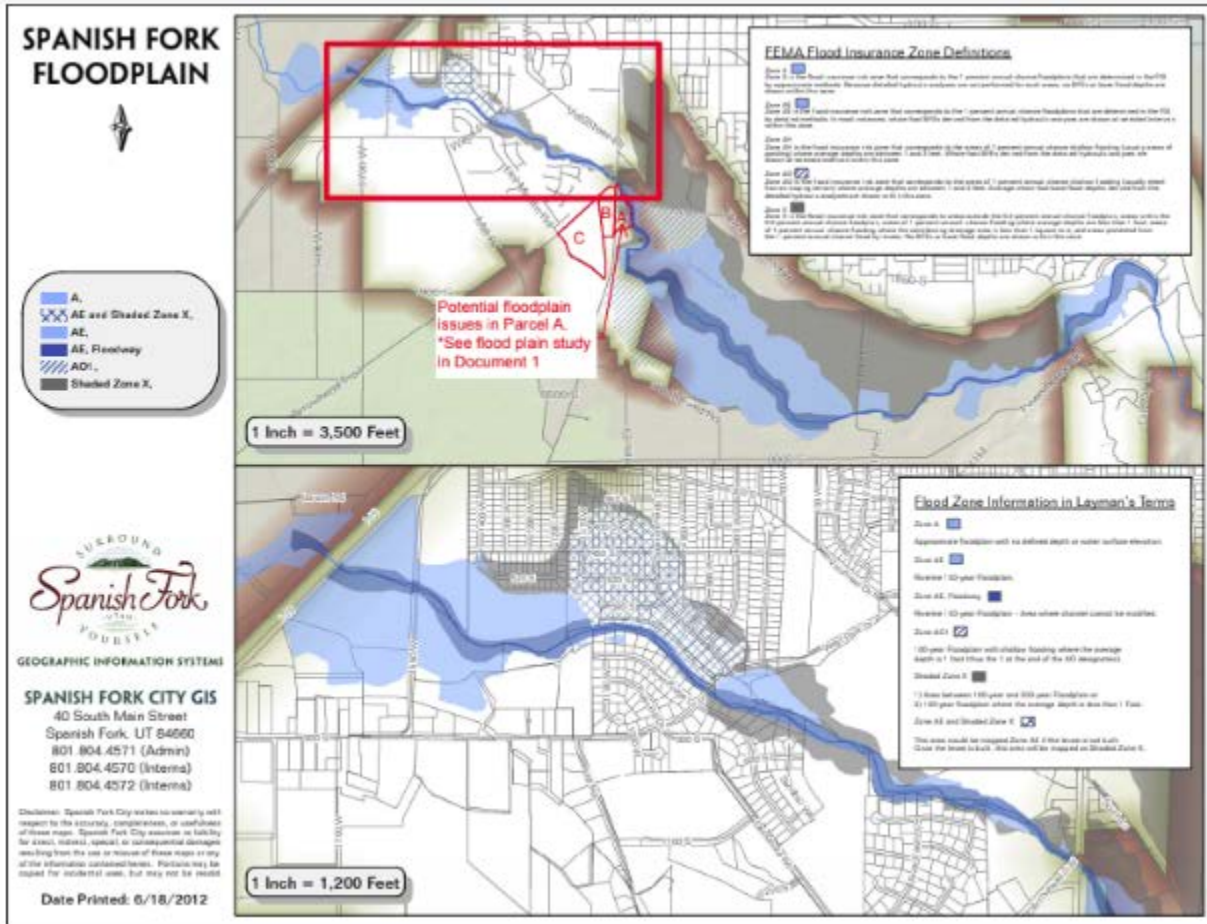


Figure 9: Spanish Fork Floodplain

3. Geotechnical Report Requirements. The results of the field and laboratory programs shall be evaluated by a Utah registered professional geotechnical engineer. Based on the results of their evaluation, an engineering report shall be prepared that details the results of the testing performed, provides logs of the borings and a diagram of the site/boring layout and provides geotechnical recommendations and information regarding following:

- a. General suitability of the site for the planned development
- b. Recommended precautions and limitations
- c. Subsurface exploration procedures
- d. Soil and rock conditions encountered
- e. Groundwater depth during and after drilling
- f. Geologic setting
- g. Geologic hazards
- h. Slope stability including provisions, recommendations and designs to mitigate the effects of unstable slopes and other geologic hazards that may adversely impact planned developments above and below the slope(s)
- i. Special design and construction provisions for footings or foundations near steep slopes, including type and depth of foundation system and set back distance from slopes
- j. Surface water runoff control and drainage
- k. Subsurface drainage
- l. Site grading and earthwork requirements, as appropriate

Detailed individual boring logs and graphical cross sections summarizing soil / rock profiles and slope stability analysis and results shall be included in the geotechnical report. The logs shall contain sufficient detail to render a clear description of the soil stratigraphy, soil descriptions and classifications, SPT blow counts, sample locations and depths, ground water depths and appropriate laboratory test results. Individual boring logs shall include a description of the boring location, exploration equipment used, relative or actual elevation, date of exploration and other pertinent information relative to the field exploration. The cross sections shall contain sufficient detail to render a clear description of the slope stability analysis results and any mitigation measures required. The cross sections shall contain soil profile data and a summary of engineering properties and parameters used in the analysis for each significant soil / rock layer.

The final geotechnical report shall bear the geotechnical engineer's stamp and seal. One (1) electronically submitted PDF copy of the report shall be delivered to the City of Spanish Fork within sufficient time for review and comment. The City will have the report reviewed by its own geotechnical engineer. The cost of that review will be borne by the applicant.

Figure 10: Geotechnical Report

Kendl Hansen

632 W 1925 N Provo, UT 84604

Phone: 951-805-0474 E-Mail: kendlhansen92@gmail.com

Objective

Show experience and qualification in skills and education for Civil Engineering.

Experience (Reference contact info upon request)

BYU Men's Tennis Team – Assistant Coach

Fall 2014-Fall 2015

- Assisted in running practices, developing the games of our players from a technical and strategic approach. I also coached on court during our intercollegiate matches, helping to keep the players focused and developing the right strategies to win.

Riverside Country Club

Spring 2015-Present

- Designed and scheduled the tennis program at RCC as the head tennis professional.
- Led many groups of tennis players from competitive juniors, to recreational seniors and everywhere in between (ages 3-60+) My skills in communication helped me to adapt to all ages and skill levels leading to the most success Riverside Country Club's tennis program has ever experienced.
- Oversaw the hiring of a second coach to help bear the burden of the popularity of the program.

Vector Structural Engineers

Spring 2017-Present

- Analyzing a variety of roof structures to determine adequacy for solar installation.
- Performing foundation designs for ground-mounted solar arrays.
- Train new interns on methods for producing quality analyses on structures in order to determine adequacy for solar installation, both roof and ground mounted.
- Develop retrofit designs to enhance structural adequacy for increased loading by solar arrays.

Education

- Graduated from McKinney Boyd High School in 2010.
- Furthered my education at BYU, where I'm currently studying Civil Engineering, projected to graduate in April of 2018 with a Bachelor's degree in Civil Engineering.

Skills

I have found that many of the skills I have acquired through my tennis career transfer directly to engineering. I work very well with people, and help to unify and include individuals working toward a specific goal. I also have a strong background in mathematics and physics directly relating to structural analysis, and am able to assess basic problems. I have an entry-level understanding of engineering software such as CAD design, Revit, and RISA 3D. I am proficient in Microsoft Office, VBA, and Bluebeam.

David G. Davies

(385) 321-7704 • dgdavies33@gmail.com

EDUCATION

Brigham Young University- Ira. A Fulton College of Engineering & Technology

Pursuing a Bachelor of Science in Civil
Engineering

EXPERIENCE

Project Manager (Internship)

Vector Structural Engineers

Sandy, UT · May 2016 – Present

- Perform structural analysis on roofs for solar panel set-up, residential and commercial.
- Perform structural analysis on foundations for ground-mounted solar panels.
- Study different design systems and decide which to implement based on safety, practicality, and cost efficiency.
- Work directly with clients: provide engineering letters, list retrofit options, answer questions, email, etc.
- Train new employees in solar analysis, RISA 3D analysis, office policies, using Bluebeam, etc.
- Design retrofitted roof systems to support excess loads using excel programs, AutoCAD, and RISA 3D.
- Design preliminary setup of monopole/monopine using tnxTower.

Teaching Assistant

Brigham Young University

Provo, UT · August 2015 – May 2016

- Work with 150+ students to understand key concepts of mechanics for statics (course ID: CEEEn 103).
- Prepare students for exams by giving review lectures and answer conceptual questions.
- Grade weekly homework and exams for 50+ students.

Construction Worker

Cornerstone Concrete LLC.

Lehi, UT · May 2014 – September 2015

- Learned firsthand how to develop strong foundations and use necessary and cost-efficient materials for various sizes of structures.
- Teamed with other employees to complete various tasks (set up job site, designed and put together concrete forms, etc.).

SKILLS

- Proficient in building design software (RISA 3D, AutoCAD, Revit, tnxTower), Excel (Visual Basic), Word, and Bluebeam.

Austin Burton

488 N 100 E #1, Provo, UT 84606 | 435-590-1290 | austin.burton47@gmail.com

Objective

Present related experience and qualifications in civil engineering

Education

Civil and Environmental Engineering
Present *Brigham Young University*
2018

January 2015-
Expected Graduation June

- Current GPA 3.95/ 4.0
- Pursuing a degree in Civil and Environmental Engineering with a structural emphasis
- Related Coursework
 - Educated in Statics, Structural Analysis, Mechanics of Materials
 - Programming and Calculations in Excel and VBA
 - Modelling in CAD and Revit
- Participated in ASCE and SEAU in order to learn more about the civil engineering field as well as use my knowledge and skills to serve others

Experience

Structural Drafting

February 2017-

Present *Dean L. Webb & Associates*

- Created structural/architectural drawings in AutoCAD
- Accompanied and aided engineers on site visits
- Worked closely under structural engineers

Construction

Summer

2012 *Private Contracting*

- Aided in the construction of a cabin, including detail work
- Learned practical construction skills to better perform my tasks
- Labored closely alongside an experienced private contractor, providing a quick learning experience

Custodian- Lead Student

January 2015-February

2017 *Brigham Young University*

- Cleaned and maintained the chemistry building on campus
- Trained new employees to help them understand their assignments
- Early hours (4:30 a.m.)

DANIEL SCHWICHT

dewschwicht@gmail.com | 385.204.3852

EDUCATION

- **Civil Engineering Master of Science** (Anticipated) April 2018
Brigham Young University, mentored by Dr. Kyle Rollins
- **Civil Engineering Bachelor of Science** June 2017
Brigham Young University; 3.01 GPA

RELEVANT EMPLOYMENT

- **High-speed Rail Abutment Graduate Research Assistant** 2017 - present
Brigham Young University, mentored by Dr. Kyle Rollins
 - Organized and reported data for large-scale testing of earthquake loading of abutment
 - Reported findings for immediate implementation by Caltrans
- **Materials Testing Technician** 2016
RBG Engineering; Provo, UT
 - Performed gradations (grain size), field and lab concrete tests, nuclear density tests, asphalt burn and rice tests, Atterbergs, etc.
 - Trained new employees in ASTM standards and lab and field procedures
- **Geotechnical Engineering, Materials Testing, and AutoCAD Intern** 2013 - 2015
Hattenburg Dilley & Linnell Engineering Consultants; Anchorage, AK
 - Worked in certified lab, geotechnical drilling, and in field
 - Corrected and verified drawings in Autodesk, ArcGIS

VOLUNTEER AND LEADERSHIP EXPERIENCE

- **Full-time Religious and Service Missionary** 2010 - 2012
Baltimore, MD
 - Two full years of unpaid, voluntary teaching and community service
 - Developed contacts by word of mouth and referrals
 - Trained other missionaries in teaching, contacting, etc.

AWARDS AND ACCOMPLISHMENTS

- **Benjamin B. Talley engineering scholarship recipient** 2014
Society of American Military Engineers, Anchorage Alaska chapter
- **Eagle Scout** 2009
Boy Scouts of America, Great Alaska Council
 - Coordinated Eagle Scout service project landscaping at Blood Bank of Alaska
 - Directed over 500 man hours of service and solicited donations of construction materials

SKILLS AND CERTIFICATIONS

- Professional experience with Autodesk, ArcGIS, Excel, Word, and some Visual Basic (VBA)
- Troxler Nuclear Gauge Operator certified, HAZMAT certified, 2013
- American Concrete Institute (ACI) Concrete Strength Testing certified, 2013
- ACI Concrete Field Testing certified, 2013
- Spanish translation experience, 2010 - 2012