Nepal Earthquake Recovery Building Code Review & Update

Project ID: CEEn_2017CPST_011

by

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A Capstone Project Final Report

Submitted to

Bishnu H. Adhikari

Department of Civil and Environmental Engineering
Brigham Young University

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Executive Summary

PROJECT TITLE: Nepal Earthquake Recovery Building Code Review and Update>
PROJECT ID: CEEn-2016CPST-011
PROJECT SPONSOR: Bishnu H. Adhikari
TEAM NAME: Team Bhukampa Aid

Bishnu Adhikari requested that we prepare a report making recommendations for updates to the Seismic Design section of the Nepal Building Code. He specifically asked that we compare the existing building code to current international buildings codes and make recommendations to bring the Nepal Building Code up to the same standard as the international codes.

We compared NBC 1994 to the IBC and ASCE 7 and made the following recommendations:

1.Update equations and coefficients to match newer methods of design as documented.

2. Include minimum and maximum boundaries for equations where necessary.

3. Include a map from the Nepali Department of Mines of Geology that shows the epicenters of past earthquakes, principal tectonic features, lithological groups, and seismic zones.

4. Change the recurrence interval of the design earthquake from 475 years to 2500 years. This changes the probability of occurrence in 50 years from 10% to 2%.

5. Update and clarify the formulas and methods used in the Seismic Coefficient Method and the Modal Response Spectrum Method for clarity and to bring them in accordance to current international building codes.

6. The preface should explain the purposes of the building code.

7. The introduction should explain the need for continuous development and improvement of the code, possibly by requiring an update every 3 to 5 years.

8.The section concerning the promulgation of redevelopment should include estimated time spans.

9. The code should be written to avoid ambiguity and in systematic and professional manner.

10. References to Indian Standard Code need to be updated to include section titles, not just numbers, to prevent confusion.

The goal of these recommendations is to increase the safety of all the buildings of Nepal and to minimize the destruction and casualties. Also, the updated code should help critical buildings to operate during emergencies.

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Introduction

The country of Nepal has always been a location of intense seismic activity. The most striking physical feature of the country is the Himalayan Mountain range, running across the northern border of the country. The tallest mountains in the world, this mountain range is the result of the Indian tectonic plate slowly being forced underneath the Eurasian plate. The associated stresses, strains, and faults from this tectonic movement have resulted in countless earthquakes and will certainly continue to do so.

The most recent notable earthquakes, the Gorkha earthquakes of 2015, resulted in almost 9,000 deaths. This is the highest death toll in the country's history. Indeed, the death toll could have been much higher--it occurred on a Saturday at mid-day--so the Nepali people were largely outside and not collected in schools and places of work where collapses would have caused mass casualties. Another earthquake of the same magnitude could potentially triple the number of casualties. Even still, the nation of Nepal area has the potential for an even larger quake.

Through adequate engineering and proper construction, lives can be saved during earthquakes. The country of Nepal is particularly vulnerable to the adverse effects earthquakes because of inadequate building codes, failure to enforce the existing building codes, and deficiencies in construction materials and practices. As with all earthquakes, casualties in Nepal were primarily the result of buildings collapsing with people still inside. The building failures either kill the occupants instantaneously or trap them within the building. Nepal is one of the poorest countries in the world. As such, most of its inhabitants cannot afford to construct high quality buildings and homes. Most residential buildings in Nepal do not receive any rational design for strength, especially in rural areas. Although most cities in Nepal do have a system of granting building permits, they are mostly to regulate zoning and property lines; most building permits can be obtained without actual structural drawings. More than 98% of buildings in Nepal are built by the owners using their experience and judgement coupled with advice from their contemporaries. (Parajuli, Bothara, Dixit, Pradhan, & Sharpe, 2000).

After the 1988 Udaypur earthquake in eastern Nepal, which killed over 700 people and damaged or destroyed 20,000 buildings, the Ministry of Physical Planning and Works in Nepal realized that they needed a program to mitigate earthquake damage. They requested the outside help of the United Nations Development Programme for seismic hazard mapping and risk assessment, preparation of Nepal's first building code, and development of alternative building materials and technologies (Sangachhe, 2009). Through the help of consultants from New Zealand, Canada, the United States, the Nepal National Building Code drafting began in 1992. It was officially finished and published in 1994.

In Nepal, as in many developing countries, there have been significant challenges with the implementation of a standardized building code. In 2007, the United Nations Centre for Regional Development presented an analysis report based on a questionnaire sent to national and local governments to collect information on building safety regulations and the implementation of building code. The problems they found included an absence of a supervision system, the building code not being revised timely, lack of professional training, high cost to follow codes, a large ratio of self-built informal construction, and low levels of awareness within the public (Mishima 2007). A building permit process does exist in Nepal, but only accounts for compliance relating to planning and building by-laws. In addition, these permits are often seen as a rapacious fee imposed by the government (Parajuli et al, 2000). The combination of these obstacles has led to the construction of buildings that are inadequate for earthquake safety.

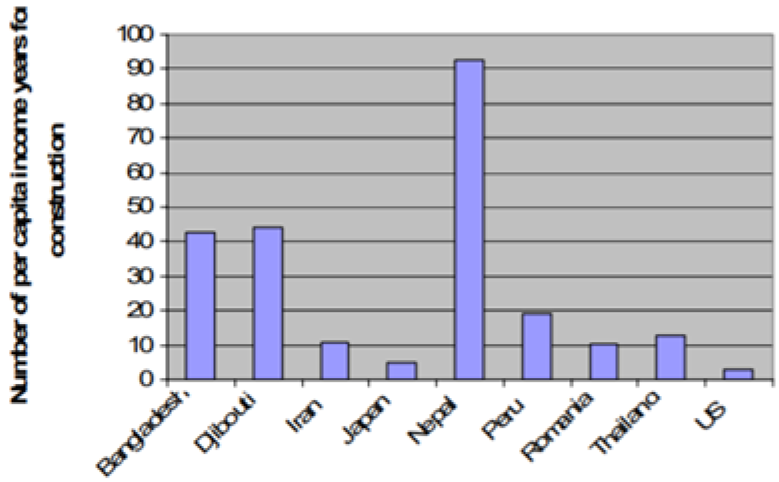

Figure 1: Cost of reinforced concrete construction (Mishima, 2007)

The cost of reinforced concrete construction in Nepal is substantially higher than other countries. Figure 1 shows that it takes 90 years of income to correctly build a safely engineered reinforced concrete building. For this reason, 90% of buildings are non-engineered (Mishima, 2007). While there is reinforced concrete construction in Nepal, this statistic fits well with the idea that the houses that do use reinforced concrete forgo the proper engineering design in order to save on cost. People still construct reinforced concrete structures, but adequate steps are not taken to ensure that the building is safe. This result was seen in the studies done after the Gorkha Earthquake. Unless done correctly, reinforced concrete construction is still susceptible to seismic failure.

More than 90% of the housing units in Nepal have been constructed by individuals according to their personal needs and budget. As discussed before, this means that they follow the owner-builder model, meaning there is little to no professional supervision. Even some of the engineered buildings, while they generally perform better during an earthquake, still are not built with sufficient safety measures to truly be safe (Sangachne, 2009). Engineering input is often limited to preparing architectural plans and unfortunately does not extend to site-based work (Dixit, 2008). This lack of earthquake safety knowledge and supervision is where the necessity for a good building code that is properly enforced comes into play.

This report seeks to make recommendations to improve the building code so that the buildings of Nepal will be safer during the next seismic event. The following recommendations are the result of research into current seismic resistant building practices and comparison with current international building codes. The authors of this report have limited experience with seismic building codes and are not licensed engineers, but the research behind the recommendations comes from accredited professionals around the world.

Schedule

January 8, 2018—Met with Dr. Richards, our Capstone faculty mentor. Discussed the IBC and ASCE 7. After meeting with Dr. Richards we proceeded to compare the NBC with the seismic sections of ASCE 7.

February 8, 2018—Met with Paul Thorley, a member of the Capstone Committee. Discussed the progress of our Capstone progress and where to focus our efforts. Concluded the best course of action was to compile the research done on Nepal earthquake safety over the past 30 years.

March 6, 2018— Prepared a 50% report outlining what has been accomplished for the project at the halfway point to the project deadline.

March 15, 2018—Met with Bishnu Adhikari during his visit to BYU. During the meeting we reported our progress to date and received further guidance on what is expected for the project. Discussed with Mr. Adhikari similar work done by Coffman Engineering and what we could do to attain similar results.

April 12, 2018—Presented final project results to BYU ASCE and BYU Capstone Committee

Assumptions & Limitations

The limitations we have faced in our project is our own knowledge and expertise with code development and understanding structural engineering. Many professionals and researchers throughout the world have given critiques of the NBC, performed analyses and tests, and gathered information. We were not qualified or equipped to perform independent research so this report presents research performed by others.

Design, Analysis & Results

Much work has already been done in terms of providing recommendations for the NBC and our knowledge is not adequate enough to dispute any findings of PhD researchers and engineers. We have taken on the role of studying the research and writings of those professionals and then organizing the information into a concise summary. The following recommendations are presented by their respective category within the code.

Code Structure & NBC 000: 1994

Code structure is vital to clarify the hierarchy and precedence of the Nepal National Building Code in relation to other standards, codes, specifications, and bylaws. A clear delineation of the order of importance for each should be provided. The NBC is a collection of individual codes, but it would be more effective when compiled into one unified code with other codes (fire, plumbing, urban planning, electrical, and construction safety codes), and include provisions for how to adopt the codes. The following recommendations are given for NBC 000 and mainly concern the structure and organization of the building code.

NBC 000: 1994

This section is fundamentally a preface to the rest of the building code, including a history, foreword, scope, and instructions on how to use the NBC. The organization of this section should be more comprehensive and organized, as it sets the tone for the rest of the building code. The following recommended sections should be included or rewritten, using the IBC 2015 as an outline.

Preface

In the update of the code they should include an introduction to explain the purpose of the building code. The introduction should also give credit to all other codes referenced in the development of the code.

Development & Maintenance

Remarks should be made on the original development of the 1994 code. It should also be explained why the code is being updated, as well as why the old code should no longer be used. This section should also explain the need for continuous document development and improvement, including an expected schedule for when the next update(s) should be expected (e.g. every 3 years). A disclaimer should also be made to declare that neither the advisory panel nor any individual member is liable for any compliance or non-compliance to the code recommendations.

Scope & How to Use this National Building Code

Part I gives the requirements for State-Of-The Art Design. The goal of the building code should be to set a standard for state-of-the-art structures. Other requirements and rules of thumb should fall under building regulations and by-laws. It should be the primary goal of the building code to declare design requirements for a single category before trying to divide into multiple categories (MULTI, 2009). The building category flowchart should be removed so that the focus is on state-of-the-art design.

Section 1.2: Seismic Design

This part of the building code should no longer be labeled as "draft standards," nor should any part, as this contradicts the purpose of the code and weakens the position of those who wish to enforce the code.

There is an incomplete sentence that ends in a blank. There should be no incomplete sentences in the final edition of the building code.

Section 1.3: Other Loads

In this section, as well as all sections of NBC, many references by section number to the Indian Standard Code are no longer valid, as that code has been updated. Merely referring to the section number without specifying either the section title, or version of the code, could mislead readers who are trying to use the code after a new version of the Indian Standard Code is released.

Seismic Base Shear

In ASCE 7-10, to determine the seismic base shear, V, the seismic weight is multiplied with the seismic response coefficient (ASCE 7-10 sec. 12.8.1)

$$V = C_s W$$

NBC 105 has this same equation (NBC 105 sec. 8.1)

$$V = C_s W_t$$

where W_t is the combination of the total vertical dead load and 25% of the live loads above the level of lateral restraint provided by the ground similar to ASCE 7-10. C_d and C_s are found differently. In ASCE 7-10, C_s is determined with spectral response acceleration parameter (S_{DS}), the response modification factor (R), and the importance factor (I_c).

$$C_s = \frac{S_{DS}}{\frac{R}{I_e}}$$

In NBC 105, C_d is calculated using the fundamental translational period (C), the seismic zoning factor (Z), importance factor (I), and structural performance factor (K).

$$C_d = CZIK$$

It has become increasingly common to drop the structural performance factor in favor of the reciprocal of the response modification factor. R is dependent on the building type and its ductility. Using R leads to more realistic values of acceleration. It implies that the design force is much lower than what is expected in a strong earthquake (MULTI, 2009). ASCE 7-10 has boundaries for C_s that NBC 105 does not have.

NBC 205 is a mandatory rule of thumb for reinforced concrete that provides standard dimensions, reinforcement, and restrictions for a seismically stable structure. The given C_d values come from NBC 105 and should be adjusted along with any changes to NBC 105.

Design Forces

In ASCE 7-10, the equation for wall anchorage forces is given as (ASCE 7-10 sec. 12.11.2)

$$F_p = .4 S_{DS} k_a I_e W_p$$

where S_{DS} is the spectral response acceleration parameter as previously given, k_a is the amplification factor determined by the span of the flexible diaphragm, I_e is the importance factor, and W_p is the weight of the wall tributary. F_p has a boundary where F_p cannot be less than $0.2k_aI_eW_p$. When k_a is calculated it takes into account a rigid diaphragm, a scenario not accounted for in NBC 105.

In NBC 105, the equation for design forces is given as (NBC 105 sec. 10.2.1)

$$F_p = C_p P K_p W_p$$

where C_p is equal to C_d as previously given, P is the structure response factor, K_p is the seismic performance factor and W_p is weight of the element. The equations are very similar and should be compared to see if the computed forces vary greatly. The NBC equation does not have a minimum requirement and should consider having a minimum if calculations have not been sufficient.

Boundaries

In ASCE 7-10, there are equations that have limits on design equations. In a practice where factors of safety and simplification of equations is common, limits prevent designing below what has been determined as minimal safety, and prevents overdesigning. NBC 105 does not have these bounds and should implement limits for both the seismic base shear and design force equations.

Seismic Hazard Levels

Determining the expected ground motion is a critical step in the design of earthquake resistant buildings. It can also be the most complicated part of the process because it relies heavily on earthquake science and soils studies. All of the methods used to predict ground motion are inexact and therefore any parameters for ground motion should be used conservatively in the design process.

Currently, NBC 105 does not contain detailed information on the seismic hazard levels in different parts of the country. It would be helpful for planners and builders to have maps showing the epicenters of past earthquakes, principal tectonic features, geological features including principal lithological groups, and seismic zones. The Nepali Department of Mines and Geology has documented such features and has presented a seismic hazard map of Nepal (See Pandey, 2002). It would be helpful to include these features in the appropriate sections of the NBC.

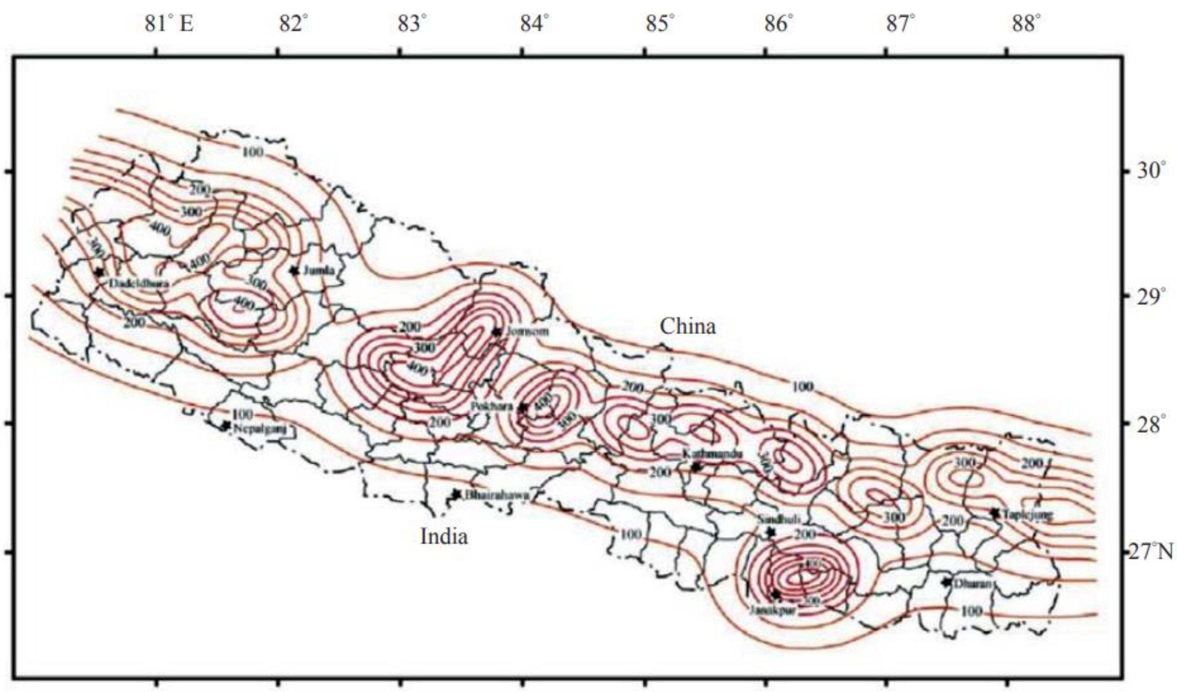

Figure 2: Seismic Hazard Map of Nepal (Pandey, 2002)

When NBC 105 was written, the principal international seismic building codes came from NEHRP and UBC. The design basis earthquake in these codes had a recurrence interval of 475 years, which corresponds to a 10 percent probability of exceedance in 50 years. 50 years is the commonly accepted design life of a building. Newer international codes, such as the IBC, have changed to using the Maximum Considered Earthquake as the basis for design. The MCE represents the seismic hazard with a recurrence interval of 2500 years, which corresponds to a 2% probability of exceedance in 50 years.

The seismic loading in NBC 105 is set at a seismic hazard level with a recurrence interval of 50 years, which corresponds to a probability of exceedance in 30 years of 45 percent. 30 years is the estimated economic life of a structure in Nepal. This design earthquake level is not conservative enough and strongly needs revision. The expected service life of new buildings in Nepal is certainly longer than 30 years, and the risk level associated with the design earthquake used in NBC 105 is much too high when compared to the risk level in modern international building codes.

Seismic Design

NBC 105 presents two methods of analysis for seismic design. The first is the Seismic Coefficient Method, a method where analysis is done using static loads to simulate the effects of earthquake ground motion. The second is the Modal Response Spectrum Method, which uses a method of dynamic analysis in which a given earthquake design spectrum is applied to a mathematical model of the structure and the response of several modes are determined, and combined. Below are recommendations for changes to how both methods are presented in the code.

Seismic Coefficient Method

1. Update the formula for seismic base shear so that the term W is defined as seismic weight and seismic weight is also explained.

2. The formula for distribution of design base shear used in NBC 105 is shown below in the first equation. It should be changed to the distribution formula developed by ATC 3-06 (1978), shown below in the second equation.

$$F_i = \frac{W_i h_i}{\sum_{i=1}^{n} W_i h_i}$$

$$F_i = \frac{W_i {h_i}^2}{\sum_{i=1}^{n} W_i {h_i}^2}$$

3. The provision regarding the direction of forces under sub-heading 8.2.1 should be changed so the structure will be designed for design earthquake load in one horizontal direction at time.

Modal Response Spectrum Method

1. The definitions for eccentricity and the accompanying formula needs to be re-written and clarified. There is a need for clauses for free-(?)vibration analysis to obtain the natural periods (T) and mode shapes (φ).

2. The phrase in section 11.3.1 that says modal interactions should be calculated using established methods should name a specific method.

Lessons Learned

During the course of the project, the main challenges were the result of a lack of understanding of seismic design principles and unfamiliarity with seismic building codes. The NBC was originally adopted in 1994, over 20 years ago. In the 20 years since its adoption, various earthquakes have caused significant damage to the infrastructure of Nepal and it has been readily apparent that NBC 1994 was not sufficient. Many professionals and academics more qualified than our research team have already suggested revisions and improvements.

When we first took on this project we found ourselves trying to make recommendations that would depend on experimentation and original research. This was beyond the scope of our project. During this time, we did not make much progress as we were trying to come up with new content that would require more time, funding, and qualifications. After consulting with Paul Thorley, a member of our Capstone Committee, and our sponsor, we adjusted our efforts to focus on collecting other's research and presenting it in the most helpful way possible. We hope to present a report that will be helpful to the people of Nepal. We feel we can accomplish that goal by unifying the research and experimentation that has all been performed into one cohesive document.

Before starting this project, we had little to no understanding of the seismic building codes found in the IBC, ASCE 7, or even the Nepal National Building Code. We learned there are different methods for determining the capacities and loads on a structure and each is chosen based on local circumstances. At the beginning, we had trouble knowing if differences between the IBC and NBC were a result of an outdated code or a difference in methods. After going more in depth, we were able to differentiate between old equations and different methods and report which equations need updating.

Conclusions

During the 2015 Gorkha earthquakes, far too many lives were lost due to poorly-constructed buildings and homes. Because of the high seismic activity in the nation of Nepal, an update of the Nepal National Building Code is an important step forward to reduce the risk to life and property during future seismic events.

Through research of already-established building codes, several deficiencies in the Nepal National Building Code have been identified. The seismic hazard mapping of Nepal should be assessed and updated to match current international seismic hazard and geological maps. The earthquake recurrence intervals should be also modified to be more conservative. Several equations and coefficients should be altered to appropriately calculate forces on buildings for seismic design. Much of the code structure and organization can also be improved to avoid ambiguity and clarify the standards set forth by the NBC. These changes should both increase the level of safety accomplished by following the code and make it easier to implement.

Qualified professional engineers and others experienced in code development should review the existing building code and these recommendations. Those familiar with construction techniques and methods used in Nepal and similar countries should evaluate these recommendations for their potential for implementation in Nepal. A panel of professionals from all areas of engineering, construction, and code development should be organized. Then, the Nepal National Building Code should be updated according to recommendations made in this report, while also taking into account the many other recommendations that have been made in months and years past.

Recommendations

1.Update equations and coefficients to match newer methods of design as documented.

2. Include minimum and maximum boundaries for equations where necessary.

3. Include a map from the Nepali Department of Mines of Geology that shows the epicenters of past earthquakes, principal tectonic features, lithological groups, and seismic zones.

4. Change the recurrence interval of the design earthquake from 475 years to 2500 years. This changes the probability of occurrence in 50 years from 10% to 2%.

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10. References to Indian Standard Code need to be updated to include section titles, not just numbers, to prevent confusion.

Appendix

Works Cited

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Rai, D. C., Singhal, V., Raj S, B., and Sagar, S. L. (2016). Reconnaissance of the effects of the M7. 8 gorkha (nepal) earthquake of april 25, 2015. Geomatics, Natural Hazards and Risk, 7(1), 1-17.

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Team Member Resumes

Taylor D. Dayton

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EDUCATION

Brigham Young University (BYU) **Provo, UT**
Bachelor of Science in Civil Engineering December 2018

- **GPA:** 3.75 / 4.0; **Passed FE Civil Exam**
- President of the American Society of Civil Engineers BYU Student Chapter

WORK EXPERIENCE

Acute Engineering **Orem, UT**
Structural Engineering Apprentice January 2017 – Current

- Engineering of residential and commercial projects for clients, such as D.R. Horton
  - Communicate effectively with dozens of clients to provide engineered solutions to reduce project cost
    - Reversed costly mistakes made by other parties by quickly and concisely providing fixes
  - Improved speed and quality of our product, resulting in faster turnaround times for the customer
    - Saw a 33% increase in company revenue in 2017
  - Collaborate as a team with other engineers to find the most effective solutions to engineering problems
    - Boosted team efficiency by instructing on how to save time while marking up digital plans

Park Engineering **Heber, UT**
Engineering Intern and Draftsman April 2016 – January 2017

- Served the principal engineer as an assistant to check calculations and ensure quality of the final product
- Consulted with other employees and abolished the timewasting culture in the company

Hogan & Associates Construction **Farmington, UT**
General Laborer June 2015 – August 2015

- Constructed footings and foundations at a commercial construction site
- Worked with a team to meet deadlines and reduced construction cost through effective use of material

OTHER RELEVANT EXPERIENCE

American Society of Civil Engineers **Provo, UT**
President of BYU Student Chapter April 2017 – January 2018

- Led our student chapter to be the best in the country, receiving national awards, recognition, and funding
- Conducted regular meetings with officers, instructing and training how to best help the other members
- Organized weekly seminar events for students to learn from professionals in the field
- Increased membership of the club and member interest through engaging social and service activities

Volunteer Representative in the West Indies **French West Indies, Caribbean**
Non-Profit Organization May 2013 – May 2015

- Led groups of 10-12 volunteers, conducted weekly training meetings, and worked 12-hour days
- Planned, organized, and taught workshops on goal-setting, relationship building, and leadership skills
- Became fluent in reading, writing and speaking French; refined public speaking skills in two languages

SKILLS, ACTIVITIES & INTERESTS

Technical Skills: Microsoft Visual Basic, Matlab, AutoDesk Revit, Adobe Suite
Activities: Sang the National Anthem at an NBA game and LA Angels minor league game; intramural champion
Languages: Fluent in French

Eric Holmstead

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SUMMARY OF QUALIFICATIONS

- 3 years of undergraduate study in Civil and Environmental Engineering
- 2 engineering internships in land development and water resources
- Technical design using Civil 3D and AutoCAD
- Collecting and presenting information using GIS
- Fluent Spanish speaker

EDUCATION

Brigham Young University, Provo Utah

August 2011-May 2012, August 2014-present
BS Civil and Environmental Engineering
3.80 GPA

WORK EXPERIENCE

Bowen Collins & Associates

Water Resources Engineering Intern, Summer 2017
Assisted PE in pipeline and water tank design
Coordinated with surveyors and contractors on large-scale projects throughout northern Utah
Performed hydraulic modeling using Microsoft Excel

VIKA Engineering

Engineering Intern, Summer 2016
Supported project managers in land development projects
Interfaced with 5 different organizations in the permitting process
Built a GIS database of past and current engineering and surveying projects

Brigham Young University Office of IT

Network Technician, 2015-2016
Organized and implemented campus-wide repair of internet systems
Responsible for team of technicians during $3 million building upgrade

Calleva Outdoors

Instructor, Summers of 2009-2011, 2014
Planned and led educational and adventure trips for up to 20 people
Constructed basic shelters and ropes course elements
Coordinated with parents, other staff, children, and teenagers

LEADERSHIP

The Church of Jesus Christ of Latter-day Saints

Full-time missionary, May 2012-May 2014
Led and trained several groups of 20+ missionaries to work diligently and effectively
Organized missionary efforts of 15+ church congregations
Developed fluency in Spanish

KEVIN GIBELYOU

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EDUCATION

Bachelor of Science, Civil Engineering (Expected December 2018)
Brigham Young University, Provo ,UT
- GPA 3.57
- Half Tuition Scholarship

Relevant Coursework
- Concrete Design
- Structural Analysis
- Metals, Woods, & Composites
- Computational Methods
- Engineering Mechanics-Materials
- Engineering Mechanics-Dynamics

EXPERIENCE

AGEC, Field Technician, Sandy, Utah *(May 2017—August 2017)*
- Inspected field compaction for soils and advised contractors on how they could fix failing tests
- Wrote daily technical reports on compaction tests to inform owners and document progress

Vivint Smart Home, Sales Representative, Wichita Falls, Texas *(April 2016—August 2016)*
Alterra Pest Control, Sales Representative, Chicago, Illinois (*April 2015—August 2015)*
- Strengthened business growth by seeking out individuals guiding them to purchase our services
- Resolved customer and technical concerns with 40+ new clients
- Achieved personal quota by managing daily and weekly goals and adjusting personal work schedule

Brigham Young University, Grounds Crew Laborer, Provo, Utah *(August 2014—April 2015)*
- Enhanced the landscape and quality of the BYU campus while working with in a 5 man team
- Learned to operate small construction tools and machinery to increase efficiency

Grand Canyon Resort, IT Technician, Peach Springs, Arizona *(February 2014—August 2014)*
- Solved technical issues experienced by employees in order to maintain point of sales operations
- Improved computer network to better unify separate 7 business locations
- Worked 20 hours a week while maintaining 15 credits of school work

Angle Homes, General Laborer, Kingman, Arizona *(May 2011—August 2011))*
- Preserved 20+ lots for construction and cleaned houses between construction phases
- Completed landscaping for 10 finished custom homes

VOLUNTEER EXPERIENCE

Church of Jesus Christ of Latter-day Saints, Representative, Denver, Colorado (*February 2012—February 2014*)
- Directed 15+ missionaries in weekly meetings and goal setting conference calls
- Organized 6+ weekly service projects with food banks, YMCA's, and transient housing renovations
- Built houses through Habitat for Humanity for the homeless community

TECHNICAL SKILLS

Spanish – Intermediate, written and spoken
Revit – Basic Revit design for houses and landscaping