KIEWIT NORTH CAROLINA LNG STORAGE FACILITY GEOTECHNICAL EVALUATION
PROJECT ID: CEEN_2018CPST_008

by

MZM Enterprises
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A Capstone Project 30% Completion Report

Submitted to

Jaren Knighton
Kiewit Engineering Group, Inc.

Department of Civil and Environmental Engineering
Brigham Young University

December 10, 2018

Executive Summary

PROJECT TITLE: KIEWIT NORTH CAROLINA LNG STORAGE FACILITY GEOTECHNICAL EVALUATION
PROJECT ID: CEEn_2018CPST_008
PROJECT SPONSOR: Kiewit Engineering Group, Inc.
TEAM NAME: MZM Enterprises

The following items are to be completed for a geotechnical evaluation of a proposed liquefied natural gas (LNG) storage facility near Fayetteville, North Carolina, sponsored by Kiewit Engineering Group, Inc. (referred to herein as "the client"), and undertaken by MZM Enterprises (referred to herein as "the team"):

- Seismic site classification
- Soil analysis summary
- Selection of shallow foundation type
- Determination of design values for deep foundations
- Design of truck trafficking roadway
- Discussion of constructability considerations
- Identification of potential geotechnical risks

The objective of the project is to provide a geotechnical review memorandum to the client that will enable the cost estimates crew to recommend an accurate bid on the project. Additionally, the team will produce a poster and presentation summarizing the conclusions of the project.

The following parameters have been determined:

- Seismic site classification: **C**
- Soil analysis summary: **Mostly clay, design bearing capacity = 950 psf**; see attached
- Selection of shallow foundation type: **Strip shallow spread footings**

The remaining items are pending. See attached for reference. This report marks the completion of 30% of the project assigned to MZM Enterprises. Please promptly contact MZM Enterprises with concerns and questions.

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Introduction

Convenient to the city of Fayetteville, North Carolina, a facility for storing liquefied natural gas is to be constructed. The facility will consist of two LNG storage tanks, auxiliary buildings for equipment and operations, and asphalt roads for truck and shipping traffic.

The project submittal is to consist primarily of a Geotechnical Review Memorandum. The memorandum will include foundation recommendations, pavement design, soil data, and other information needed to produce an accurate cost prediction for the geotechnical design of the project.

Data regarding soil properties has been extracted from soil profiles provided by the client. Soil bearing capacity has been estimated by accepted methods from the blow count data provided for each soil profile from the client. Loads acting on shallow foundations have been approximated, and strip footings are recommended for the auxiliary structures. In accordance with the 2018 North Carolina Building Code (referred to herein as NCBC) 1613.3.5, the seismic design category has been determined.

Based off approximated LNG storage tank loads, deep foundations will be sized for the LNG storage tanks in accordance with NCBC 1810. A graph will be produced which compares spacing to size of deep foundations. Estimated average annual truck traffic has been provided by the client to determine equivalent single axle loads (ESALs). From the traffic information and the soil specifications, the pavement will be designed. Constructability will also be considered in addressing the need for engineered fill and potential geotechnical risks that may be applicable to the project.

The project will be completed in the following order: seismic design category, soil property analysis, shallow spread footing foundation engineering, deep foundation engineering, pavement design, constructability, and compilation.

In addition to the memorandum, a poster will be created describing the conclusions of the memorandum. An exhaustive report describing the design process and the final product will also be prepared. The poster will be used to communicate the results of the report and the memorandum to the client in a presentation near the end of the project. This presentation will also be given in a classroom setting to many of the civil engineering students at Brigham Young University.

This document constitutes a report declaring 30% of the project to be complete. The project will be completed in April 2019. See included for additional reference.

For convenience, all referenced tables and figures are included in Appendix B or the body.

Schedule

The following schedule is effective immediately and will continue until the team, mentor, or client expresses contrary plans. Each week on Monday at 3:00 PM, the team will have a regular team meeting to review tasks that are due that week and the following. Assignments will be given to team members, and more detailed planning will take place on how to complete each task. Immediately following at 4:00 PM will be the classroom instruction, which will usually last one hour. A status report will be submitted each week to the instructor and the client.

October 2018
- Complete and submit Statement of Work
- Seismic Site Classification
- Create team lead measures and scoreboard
- Soil settlement analysis

November 2018
- Determine soil bearing capacity
- Design shallow spread footing foundations
- Begin 30% completion report

December 2018
- Complete and submit 30% completion report
- Preliminary plan for Winter Semester

Winter Semester

Week 1 (January 7—January 11)
- Finalize plan for Winter Semester
- Set appropriate lead measures and goals

Week 2 (January 14—January 18)
- Preliminary deep foundation research
- Discuss ideas with Dr. Rollins for deep foundations for gas tanks (Melanie)

Week 3 (January 21—January 25)
- No meeting on Monday (MLK Day)
- Proceed with deep foundation design ideas (Zachary)

Week 4 (January 28—February 1)
- Deep foundation design

Week 5 (February 4—February 8)
- Begin to design deep foundations (Matthew)

Week 6 (February 11—February 15)

- Complete deep foundation design (Zachary)

Week 7 (February 18—February 22)

- Meet Tuesday February 19 (University scheduled Monday classes due to Presidents' Day)
- Preliminary pavement research

Week 8 (February 25—March 1)

- Begin pavement design
- Meet with Dr. Guthrie to discuss pavement ideas (Melanie)

Week 9 (March 4—March 8)

- Pavement design
- Investigate constructability and construction practices (Zachary)

Week 10 (March 11—March 15)

- Complete pavement design (Matthew)
- Examine merits of engineered fill and potential geotechnical risks (Melanie)

Week 11 (March 18—March 22)

- Prepare constructability report (Matthew)

Week 12 (March 25—March 29)

- Create a presentation to be shared in a seminar (All)
- Brainstorm ideas for poster (All)

Week 13 (April 1—April 5)

- Combine all report elements into a geotechnical memorandum draft (All)
- Complete poster (All)
- Practice presentation (All)

Week 14 (April 8—April 12)

- Finalize geotechnical memorandum (All)
- Prepare a final report (All)
- Give presentation on Thursday April 11 (All)

Week 15 (April 15—April 19)

- Submit all deliverables

This schedule is subject to change as the team, mentor, or client sees fit. The schedule may be revised if requested.

Assumptions & Limitations

- The SPT blow counts were assumed to be correct and to be an accurate representation of the soil under which the footings will be placed.
- The soil descriptions were assumed to be correct and to be an accurate representation of the soil under which the footings will be placed.
- A correlation was made between SPT blow counts and unconfined soil strength. The conservative value was selected.
- The bearing capacity equation used is inherently inaccurate, so a factor of safety of 3 was applied for an allowable bearing capacity. With more complete soil profile data, this factor of safety may be found to be too conservative.
- In the seismic analysis, because exact location was unknown, a general region near Fayetteville, North Carolina was used.

See included calculations for additional assumptions.

Design, Analysis, and Results

Shallow Foundation Design:

- The boring with the lowest SPT N values was used—boring B-2, with a shallow N value of 5. Soil profiles are shown below in Figure 1. Locations of the borings are shown in Figures 2 and 3.
- Per NCBC Table 1806.2, the unfactored maximum value of bearing capacity usable with the allowable stress design load combinations cannot be taken as more than 1500 psf.
- Using the correlations from Karl Terzaghi and Ralph B. Peck found in Table 1, a conservative unconfined compressive strength of 1000 psf are used in subsequent calculations.
- With a factor of safety of 3, the net allowable bearing capacity of the soil was found to be 950 psf.
- Should a higher capacity be desired, excavation and compaction of existing soil or engineered fill are recommended.
- With no Atterberg limits or consolidation data, soil settlement cannot be accurately predicted or designed for. Settlement conditions could exist because the soil is predominantly fine-grained.

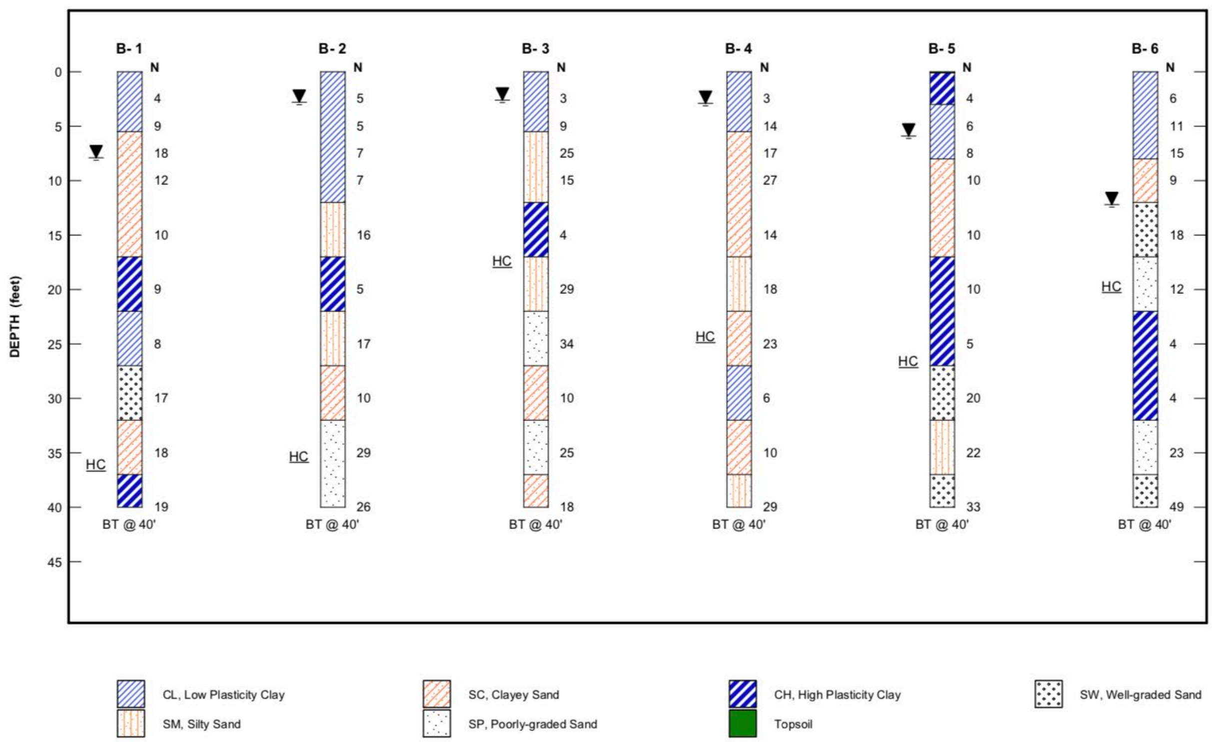

Figure 1: Test Boring Data

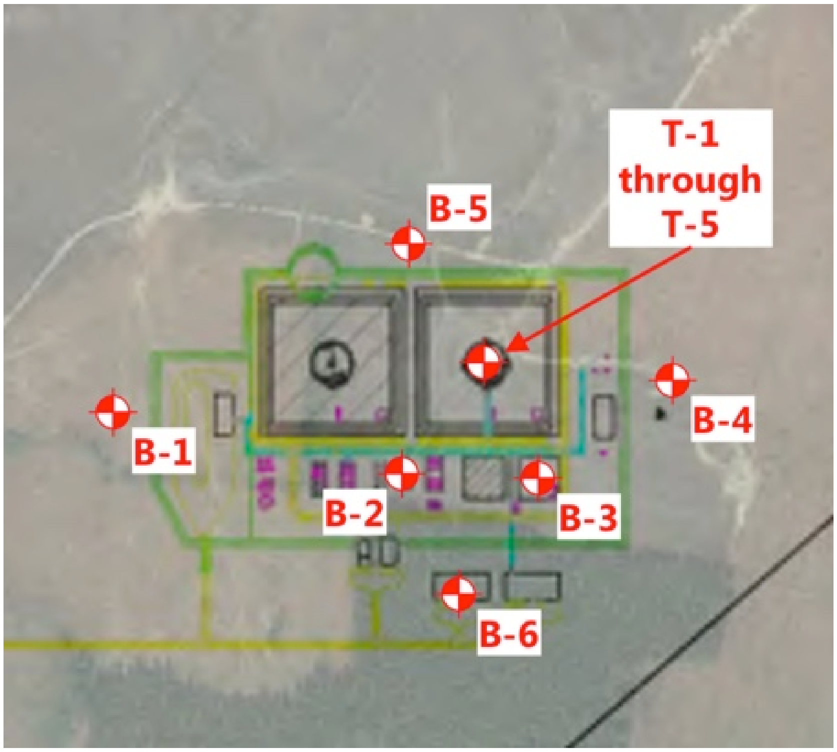

Figure 2: Location of Borings in Relation to Structures

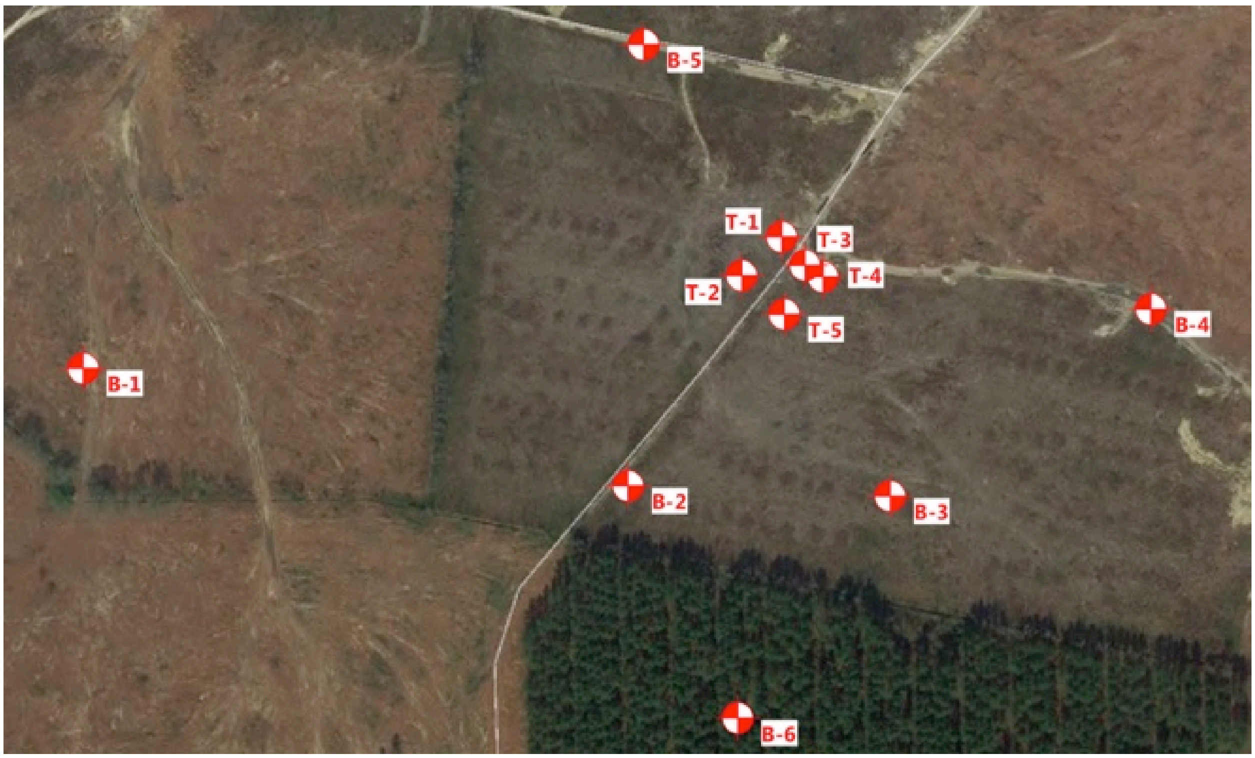

Figure 3: Location of Borings in Relation to Existing Geographical

Table 1: Cohesive Soil Consistency from SPT

N Value	Consistency	UCS (q_u)
< 2	Very Soft	< 500 psf
2–4	Soft	500 to 1000 psf
4–8	Medium	1000 to 2000 psf
8–15	Stiff	2000 to 4000 psf
15–30	Very Stiff	4000 to 8000 psf
> 30	Hard	> 8000 psf

<u>Seismic Design Category:</u>

- Risk Category (I, II, III, or IV), determined from table 1604.5: **III or II**
- Seismic Spectral Response Acceleration:
  - 1-second acceleration, S_1, determined from Figure 1613.3.1(4) = **0.11**
  - 0.2-second acceleration, S_S, determined from Figure 1613.3.1(3) = **0.30**
- Site Class, according to 1613.3.2: **D** *(Insufficient data to determine site class from ASCE 7 chapter 20)*
- Site Coefficients:
  - F_a determined from Table 1613.3.3(1) = **1.56**
  - F_v determined from Table 1613.3.3(2) = **2.36**
- Adjusted spectral responses for maximum considered earthquake:
  - S_{MS} according to 1613.3.3 = 1.5*0.34 = **0.468**
  - S_{M1} according to 1613.3.3 = 2.4*0.11 = **0.260**
- Design spectral responses from 1613.3.4
  - $S_{DS} = (2/3)S_{MS}$ = **0.312**
  - $S_{D1} = (2/3)S_{M1}$ = **0.173**
- Seismic Design Category from Table 1613.3.5(1) and 1613.3.5(2) ((2) governs): **<u>C</u>** *from NCBC 1613*

Seismic design category is based off design spectral response acceleration parameters, S_{DS} and S_{D1} (site is assigned the more severe category from these two parameters). S_{DS} and S_{D1} are determined by multiplying (2/3) by S_{MS} and S_{M1} respectively. S_{MS} is the product of the site coefficient F_a and 0.2-second spectral response acceleration S_s, while S_{M1} is the product of the site coefficient F_v and 1-second spectral response acceleration S_1. Site coefficients are derived from Site Class, which is determined from soil properties by methods contained in ASCE 7. If data is insufficient to determine site class according to ASCE 7 chapter 20, site class can be taken as D. Site coefficients are contained in Tables 1613.3.3(1) and 1613.3.3(2).

Lessons Learned

- Limited data – The team learned to supplement given data with appropriate and accepted approximation methods not explored in the classroom setting as they realized such methods are not only acceptable but economical for practical applications.
- Direct communication – The team had some questions which they first conveyed through e-mail, but they ultimately found that direct communication (i.e. telephone conversation) is often more efficient and effective for obtaining answers.
- Team collaboration – The team worked on some tasks separately, but they determined that some tasks are better completed when conducted collectively.

Conclusions

Data regarding soil properties has been extracted from soil profiles provided by the client. Using accepted methods, Soil bearing capacity has been estimated from the blow count data provided for each soil profile. Loads acting on shallow foundations have been approximated, and strip footings have been recommended for the auxiliary structures. In accordance with NCBC 1613.3.5, the seismic design category has been determined.

The LNG storage facility was determined conservatively to have a risk category of III as defined in NCBC 1604 Table 1604.5. Following procedures in NCBC 1613.3.5, the seismic design category was determined to be C. However, it is noted that even if this project were classified as risk category II, the calculations would not be altered significantly, and the seismic design category would still be C.

The soil was found to be mostly clay or silty clay with little variation. Using accepted approximation methods from Terzaghi (*Soil Mechanics in Engineering Practice*), the soil's bearing capacity was determined conservatively to be 950 psf. This conservative value can safely be applied to the entire site.

On recommendation from the client and based on common construction practice, shallow spread strip footing foundations are recommended for the construction of auxiliary structures to maximize economy and performance.

All other conclusions are currently pending. Please contact the team with any concerns or questions regarding these conclusions. Consult the "Data, Analysis, and Results" section for additional details. Examine Appendix B for referenced figures and tables. This information is summarized in the following section, "Recommendations".

Recommendations

- Subsurface conditions – **Medium-soft clay** with some **sandy clay**
- Design bearing capacity – **950 psf**
- Seismic site classification – **C**
- Shallow spread foundation footing type – **Strip**
- Deep foundation design chart – Pending
- Roadway design – Pending
- Constructability discussion – Pending
- Potential geotechnical risks – Pending

The team notes that additional soil and site analysis may permit more economical design parameters. Contact the team for details.

Appendix A

Résumés

Matthew D. Martino EIT

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EDUCATION

PASSED CIVIL FUNDAMENTALS OF ENGINEERING EXAMINATION *Apr 2018*

BACHELOR'S OF SCIENCE: CIVIL ENGINEERING *Dec 2019*
BRIGHAM YOUNG UNIVERSITY *Provo, UT*

- GPA: 3.70
- Relevant Coursework: Linear Finite Element Methods, Reinforced Concrete Design, Structural Analysis, Computational Methods, Drafting with CAD Applications, Applications of ArcGIS
- Civil Engineering Capstone: Collaborated with a team to engineer deep and shallow foundations for a liquefied natural gas storage complex in North Carolina for Kiewit Engineering, Inc.

EXPERIENCE

PRODUCTION ENGINEER - STUDENT *Jul 2018 –*
ACUTE ENGINEERING, INC. *Orem, UT*

- Engineered 200+ light frame residential homes
- Communicated with 15+ clients and researched code to provide 200+ building official letters

RESEARCH ASSISTANT – CIVIL ENGINEERING *Apr 2018 – Jun 2018*
BRIGHAM YOUNG UNIVERSITY *Provo, UT*

- Analyzed and extracted 50+ highway coupons for structural maintenance tests

TEACHER'S ASSISTANT *Aug 2016 – Jul 2017, Jan 2018 – Jul 2018*
BRIGHAM YOUNG UNIVERSITY *Provo, UT*

- Taught Structural Analysis and Engineering Mechanics: Statics, Strength of Materials, and Dynamics
- Created 50+ online class components, including quizzes and homework assignments
- Led 4+ review sessions of 20-60 students each in preparation for exams

ENGINEERING INTERN *Jul – Aug 2016*
HOMEYER ENGINEERING, INC. *Flowermound, TX*

- Engineered 3+ specialized water resource improvements currently in development
- Qualified 3+ civil construction plans to comply with local code
- Met deadlines for 5+ individually prepared submittals

SKILLS & ABILITIES

- AutoCAD, Revit, Civil 3D, ArcGIS Pro, Microsoft Excel (including Visual Basic), and Microsoft Word

VOLUNTEER EXPERIENCE

- Served in leadership positions for groups of 14+ missionaries while serving a 2-year proselytizing mission for the Church of Jesus Christ of Latter-Day Saints in Las Vegas, NV

INTERESTS

- Music, skiing, and food

MELANIE **LATHAM**

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melanielatham5@gmail.com
https://www.linkedin.com/in/melanie-latham

I want pursue a license as a professional engineer with a focus on water resources planning and management. I am dedicated, self-motivated and collaborative, with practical experience working both in teams and individually to present creative solutions to problems. My specializations and interests include **geotechnical engineering, interpersonal communication, mathematic computation, pavement engineering** and **music.**

EDUCATION

B.S., Civil Engineering, **BRIGHAM YOUNG UNIVERSITY** — **PROVO, UT**
EXPECTED APRIL 2019
GPA 3.51

SKILLS

- ArcGIS
- Microsoft Office Suite
- GMS-MODFLOW
- Google Suite
- LANGUAGE: English
- LANGUAGE: Spanish

WORK EXPERIENCE

Research Intern — **June 2018-August 2018**
TEXAS A&M UNIVERSITY — **COLLEGE STATION, TX**

- Examined recharge rates in the Gulf Coast aquifer of Texas using MODFLOW and Excel.
- Developed 20+ contour maps to compare the aquifer at different recharge rates.
- Contributed research to a funded research project and its associated journal article.

Research Intern — **June 2017-August 2017**
NORTH CAROLINA STATE UNIVERSITY
RALEIGH, NC

- Modeled 30+ dams in Excel; created and modified regional maps in ArcGIS
- Presented report at university-wide symposium

AFFILIATIONS AND HONORS

American Society of Civil Engineers, MEMBER — 2015-PRESENT
Tau Beta Pi Induction, ENGINEERING HONORS SOCIETY — MARCH 2016
Spanish Language Certificate: Advanced, BRIGHAM YOUNG UNIVERSITY — MARCH 2017

- BASED ON AMERICAN COUNCIL OF THE TEACHING OF FOREIGN LANGUAGES GUIDELINES AND SUPPORTING COURSEWORK.

VOLUNTEER

Full-Time Volunteer Representative — **August 2013-February 2015**
RELIGIOUS ORGANIZATION — **OSORNO, CHILE**

- Taught 30+ English-language workshops to native Chileans and other Spanish speakers
- Taught 1000+ character-improving lessons to community members in Spanish

Zachary Farnsworth EIT

496 North 750 East, Provo, UT 84606 | (210) 332-7640 | zachfarns@gmail.com

Education

Passed Civil Fundamentals of Engineering Examination *Mar 2018*

Bachelor of Science, Civil Engineering; Minor, Mathematics *(anticipated Apr 2019)*
Brigham Young University *Provo, UT*

- 3.76 GPA
- Civil Engineering Capstone: Designed deep and shallow foundations for a liquified natural gas storage facility in North Carolina for Kiewit Engineering, Inc.
- Relevant Coursework: Foundation Engineering, Reinforced Concrete Design, Structural Steel Design, Structural Analysis, Computational Methods, Drafting with CAD Applications

Engineering Experience

Research Assistant - Civil Engineering *Jun 2018–*
Brigham Young University *Provo and Lehi, UT*

- Oversaw the design and analysis of all 25+ structural steel components of the project
- Collaborated with a team on the geotechnical analysis of data from over 900 strain gauges
- Performed 30+ nuclear density gage tests and 200+ total station, digital electronic level, and surveyors level measurements
- Operated light and heavy excavation and compaction machinery on the dismantling and rebuilding of an MSE wall

Field Assistant - Civil Engineering *Mar–Jun 2018*
Brigham Young University *Provo, UT*

- Conducted a GIS survey and detailed inventory of 400+ catch basins and manholes
- Performed data entry for the hydraulic computer modeling of BYU's storm water system

Other Work and Volunteer Experience

Delivery Driver *May–Aug 2017*
Domino's Pizza *San Antonio, TX*

- Demonstrated a willingness to act as a team player in taking undesirable shifts, assignments, and responsibilities

Missionary Representative *Jun 2014–Jun 2016*
The Church of Jesus Christ of Latter-day Saints *Anchorage and Fairbanks, AK*

- Trained and oversaw groups of 8–16 other volunteers; resolving conflicts and fostering unity
- Developed interpersonal and intercultural skills, confidence in public speaking, and professionalism

Skills and Honors

- Proficient in Microsoft Excel with Visual Basic; limited ability in SAP 2000, Mathcad, and Revit
- Tau Beta Pi member: Engineering Honor Society
- Heritage Scholarship recipient: 4-Year, Full Tuition (merit based)
- Eagle Scout

Appendix B

Referenced Tables and Figures

TABLE 1604.5
RISK CATEGORY OF BUILDINGS AND OTHER STRUCTURES

RISK CATEGORY	NATURE OF OCCUPANCY
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: • Agricultural facilities. • Certain temporary facilities. • Minor storage facilities.
II	Buildings and other structures except those listed in Risk Categories I, III and IV.
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: • Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300. • Buildings and other structures containing Group E occupancies with an occupant load greater than 250. • Buildings and other structures containing educational occupancies for students above the 12th grade with an occupant load greater than 500. • Group I-2 occupancies with an occupant load of 50 or more resident care recipients but not having surgery or emergency treatment facilities. • Group I-3 occupancies. • Any other occupancy with an occupant load greater than 5,000.[a] • Power-generating stations, water treatment facilities for potable water, wastewater treatment facilities and other public utility facilities not included in Risk Category IV. • Buildings and other structures not included in Risk Category IV containing quantities of toxic or explosive materials that: Exceed maximum allowable quantities per control area as given in Table 307.1(1) or 307.1(2) or per outdoor control area in accordance with the *International Fire Code*; and Are sufficient to pose a threat to the public if released.[b]
IV	Buildings and other structures designated as essential facilities, including but not limited to: • Group I-2 occupancies having surgery or emergency treatment facilities. • Fire, rescue, ambulance and police stations and emergency vehicle garages. • Designated earthquake, hurricane or other emergency shelters. • Designated emergency preparedness, communications and operations centers and other facilities required for emergency response. • Power-generating stations and other public utility facilities required as emergency backup facilities for Risk Category IV structures. • Buildings and other structures containing quantities of highly toxic materials that: Exceed maximum allowable quantities per control area as given in Table 307.1(2) or per outdoor control area in accordance with the *International Fire Code*; and Are sufficient to pose a threat to the public if released.[b] • Aviation control towers, air traffic control centers and emergency aircraft hangars. • Buildings and other structures having critical national defense functions. • Water storage facilities and pump structures required to maintain water pressure for fire suppression.

a. For purposes of occupant load calculation, occupancies required by Table 1004.1.2 to use gross floor area calculations shall be permitted to use net floor areas to determine the total occupant load.
b. Where approved by the building official, the classification of buildings and other structures as Risk Category III or IV based on their quantities of toxic, highly toxic or explosive materials is permitted to be reduced to Risk Category II, provided it can be demonstrated by a hazard assessment in accordance with Section 1.5.3 of ASCE 7 that a release of the toxic, highly toxic or explosive materials is not sufficient to pose a threat to the public.

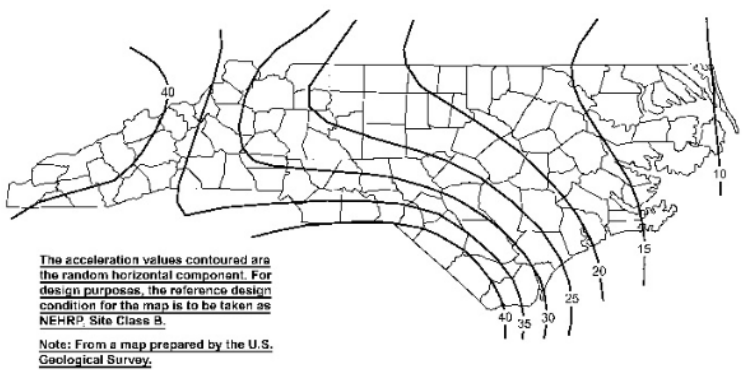

FIGURE 1613.3.1(3)
MAXIMUM CONSIDERED EARTHQUAKE GROUND MOTION FOR NORTH CAROLINA OF 0.2 SECOND SPECTRAL RESPONSE ACCELERATION (5 PERCENT OF CRITICAL DAMPING), SITE CLASS B

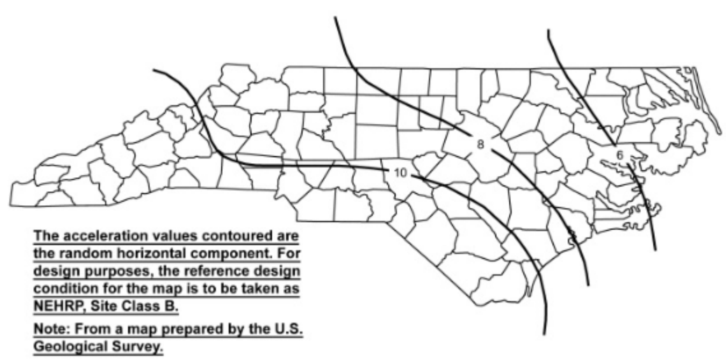

FIGURE 1613.3.1(4)
MAXIMUM CONSIDERED EARTHQUAKE GROUND MOTION FOR NORTH CAROLINA OF 1.0 SECOND SPECTRAL RESPONSE ACCELERATION (5 PERCENT OF CRITICAL DAMPING), SITE CLASS B

TABLE 1613.3.3(1)
VALUES OF SITE COEFFICIENT F_a[a]

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIOD				
	$S_s \le 0.25$	$S_s = 0.50$	$S_s = 0.75$	$S_s = 1.00$	$S_s \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at short period, S_s.
b. Values shall be determined in accordance with Section 11.4.7 of ASCE 7.

TABLE 1613.3.3(2)
VALUES OF SITE COEFFICIENT F_V[a]

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT 1-SECOND PERIOD				
	$S_1 \le 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \ge 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at 1-second period, S_1.
b. Values shall be determined in accordance with Section 11.4.7 of ASCE 7.

TABLE 1613.3.5(1)
SEISMIC DESIGN CATEGORY BASED ON SHORT-PERIOD (0.2 second) RESPONSE ACCELERATION

VALUE OF S_{DS}	RISK CATEGORY		
	I or II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50g \le S_{DS}$	D	D	D

TABLE 1613.3.5(2)
SEISMIC DESIGN CATEGORY BASED ON 1-SECOND PERIOD RESPONSE ACCELERATION

VALUE OF S_{D1}	RISK CATEGORY		
	I or II	III	IV
$S_{D1} < 0.067g$	A	A	A
$0.067g \le S_{D1} < 0.133g$	B	B	C
$0.133g \le S_{D1} < 0.20g$	C	C	D
$0.20g \le S_{D1}$	D	D	D

1613.3.5.1 Alternative seismic design category determination.
Where S_1 is less than 0.75, the *seismic design category* is permitted to be determined from Table 1613.3.5(1) alone when all of the following apply:

1. In each of the two orthogonal directions, the approximate fundamental period of the structure, T_a, in each of the two orthogonal directions determined in accordance with Section 12.8.2.1 of ASCE 7, is less than 0.8 T_s determined in accordance with Section 11.4.5 of ASCE 7.
2. In each of the two orthogonal directions, the fundamental period of the structure used to calculate the story drift is less than T_s.
3. Equation 12.8-2 of ASCE 7 is used to determine the seismic response coefficient, C_s.
4. The diaphragms are rigid or are permitted to be idealized as rigid in accordance with Section 12.3.1 of ASCE 7 or, for diaphragms permitted to be idealized as flexible in accordance with Section 12.3.1 of ASCE 7, the distances between vertical elements of the seismic force-resisting system do not exceed 40 feet (12 192 mm).

TABLE 1806.2
PRESUMPTIVE LOAD-BEARING VALUES

CLASS OF MATERIALS	VERTICAL FOUNDATION PRESSURE (psf)	LATERAL BEARING PRESSURE (psf/ft below natural grade)	LATERAL SLIDING RESISTANCE	
			Coefficient of friction[a]	Cohesion (psf)[b]
1. Crystalline bedrock	12,000	1,200	0.70	—
2. Sedimentary and foliated rock	4,000	400	0.35	—
3. Sandy gravel and/or gravel (GW and GP)	3,000	200	0.35	—
4. Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25	—
5. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500	100	—	130

For SI: 1 pound per square foot = 0.0479kPa, 1 pound per square foot per foot = 0.157 kPa/m.

a. Coefficient to be multiplied by the dead load.
b. Cohesion value to be multiplied by the contact area, as limited by Section 1806.3.2.