Draft (February 2014)

Arizona Board of Technical Registration

GEOLOGICAL ENGINEERING

CANDIDATE HANDBOOK

2014

CONTENTS

DESCRIPTION OF EXAMINATION

Examination Schedule and Timetable

The Geological Engineering Exam is 80 questions, open-book, and uses a multiple-choice format. References are permitted. Battery-operated, silent, non-printing, non-programmable calculators are also permitted.

The Geological Engineering Exam is administered at the Board office in Phoenix, Arizona. The exam is given during two 4-hour sessions on the same day (i.e., AM and PM session). The exam is prepared by a committee comprised of practicing geological engineers. These engineers supply the content expertise that is essential in developing a quality examination to assess the competency of geological engineers.

Questions regarding the examination should be directed to the Arizona Board of Technical Registration:

1110 West Washington Street, Suite 240
Phoenix, Arizona 85007
Telephone: (602) 364-4930

Exam Content

The questions in the Geological Engineering Exam represent the important tasks needed for competent practice in the profession and are based on the results of a recent task analysis research study of geological engineering practice. The findings were used to identify those tasks deemed most important to public protection and also to develop the test blueprint for the Geological Engineering Exam (see page 4). More weight is assigned to tasks that are most directly related to public protection.

Sample Questions

Sample questions are presented on page 6. The sample questions do not make up a complete examination. However, they do illustrate the general content areas and format and may be helpful in your preparation for the examination.

Scoring Procedures

Scores are calculated by summing the number of correct responses within an examination. Credit is given for correct responses while no points are received for incorrect responses.

All questions are written using a multiple-choice format. You should select the <u>one best answer</u> for each of the questions in the examination. Credit will <u>not</u> be given for questions with no answer or response <u>or</u> for questions receiving two or more responses. Also, there will be no penalty for guessing, and therefore, it is to your advantage to complete each and every question in the examination.

TAKING THE EXAMINATION

Distribution of Test Booklets

Proctors will distribute test booklets and answer sheets. Graph paper will be provided. Read all instructions carefully. Special attention should be given to the information on the front of the booklet.

Copying, reproduction, or any action taken to reveal the contents of this examination in whole or in part is unlawful. Removal of test questions from the examination room by unauthorized persons is prohibited.

Answer Sheets

Use only #2 pencils or mechanical pencils with HB lead. Marks in ink or felt-tip pens will not be scanned properly. For proper scoring, the answer spaces must be blackened completely.

Special Accommodations

If you require special accommodations in the test-taking procedure because of a disabling condition, communicate your need well before the examination to the:

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Geological Engineering Test Blueprint (Total Items = 80)

I. PROJECT PLANNING - 11%
Review and assess available project geologic, engineering, and historical site data.
Conduct site reviews to evaluate key field conditions and cost constraints impacting projects.
Identify permitting and approval requirements for projects.
II. SITE INVESTIGATION - 34%
Perform detailed site reconnaissance to observe field conditions and collect geological engineering data.
Perform site mapping using remote sensing images, aerial photographs, topographic maps, and subsurface information.
Map geomorphic, lithologic, and geologic structural features from surface and subsurface exposures.
Design site exploration programs by selecting methods to evaluate surface and subsurface conditions.
Identify potential hazards related to site exploration programs.
Design slope monitoring systems to evaluate location and rate of ground movement.
Design groundwater monitoring systems to evaluate groundwater conditions and chemistry.
Log geology and engineering properties of earth materials.
Identify site stability conditions (e.g., surface slopes, rock mass discontinuities, karst).
Evaluate location, physical, and chemical properties of environmental contamination using geophysical surveys, subsurface exploration, and laboratory testing.
Collect soil, rock, water, and waste material samples to evaluate site conditions.
Identify and implement physical and chemical laboratory tests to characterize earth materials (soil, rock, water).
Identify geologic constraints and conditions that impact mining and reclamation plans.
III. SITE CHARACTERIZATION AND ANALYSES - 33%
Construct maps and cross-sections to depict surface and subsurface geologic conditions.
Utilize laboratory test results to quantify material and chemical properties of earth and waste materials.
Characterize fault systems, rock mass discontinuities, and displacements.
Characterize stability of natural and fill slopes, excavations, and/or underground openings.
Characterize areas of collapsible, compressive, expansive, and subsiding soils.
Characterize geologic hazards related to floods, earth flows, volcanic activity, and karst terrain.
Characterize seismic hazards including fault systems, ground shaking, ground failure, tsunamis, and seiches.

Evaluate the susceptibility of the project site to seismically induced ground failure, liquefaction, and compaction.
Analyze the seismic stability of natural and constructed slopes.
Analyze the stability of surface and subsurface openings, including tunnels and mine workings.
Analyze ground-movement monitoring and survey data for subsidence, settlement, and ground stability.
Analyze ground conditions for foundation and earth retaining systems.
Analyze soil conditions and/or rock fracture properties, rock strength, and stress fields for underground excavations.
Analyze geologic and groundwater data to estimate water location, gradient, flow direction, quality, and aquifer characteristics.
Assess impact of environmental contamination on projects.
IV. DESIGN - 16%
Design surface and subsurface excavations and fills.
Design slope stabilization and dewatering systems.
Design monitoring systems to evaluate ground movement.
Design embankment and impoundment structures using earthen and geosynthetic materials.
Design foundation and earth-retaining systems.
Develop and present geological engineering design recommendations.
V. CONSTRUCTION AND POST-CONSTRUCTION MONITORING - 6 %
Provide construction quality assurance services.
Oversee installation and field testing of ground stabilization and foundation systems.
Evaluate field data to verify functionality of site improvements.

Sample Questions

1. A railroad spur is to be built along the north bank of a stream channel that is flanked by multiple stream terraces. Thick marine shale deposits are exposed along most of the proposed railroad alignment, with a few thinner marine sandstone members. The sandstone members strike N35E and dip 15 to 20 degrees to the southeast. The proposed alignment crosses a number of landslide-susceptible areas. During field reconnaissance, you observe what appears to be an area of subtly hummocky terrain that is heavily vegetated. There are also several amphitheater-shaped but highly eroded scarp-like features.

Which of the following field exploration techniques would you recommend for use to confirm that a mass movement has occurred?

A. test pits and trenches

B. air rotary drilling with split-barrel sampling at shallow depths and diamond-core barrels at greater depths.

C. direct push drilling using Shelby Tubes at shallow depths and the Denison Sampler at greater depths

D. both A and B

2. When rock fracture spacings are measured for a defined fracture set along a drill hole or along a sampling line used for detailed-line mapping, these are known as apparent spacings because they have not necessarily been measured perpendicular to the fracture planes. The apparent spacings are converted to true spacings by:

A. dividing by the tangent of the angle between the sampling line and the average dip of the fracture set

B. multiplying by the cosine of the angle between the sampling line and the mean normal of the fracture set

C. dividing by the cosine of the angle between the sampling line and the mean normal of the fracture set

D. multiplying by the sine of the angle between the sampling line and the mean normal of the fracture set

3. The SPT test is commonly used in a site investigation program to:

A. identify subsurface soil layers that may be prone to saturation

B. collect disturbed soil samples and provide indicators of insitu soil density and strength

C. verify subsurface soil conditions observed in shallow test pits

D. estimate the clay content and moisture content of subsurface soil layers

4. An NX-sized core barrel returns the following core recovery for a 60-inch core run:

Core Recovery recorded by piece length (in inches)
10
2
2
3
4
5
3
4
6
4
2
5

Calculate the Rock Quality Designation.

A. 10%

B. 50%

C. 65%

D. 83%

5. One of the common approaches to characterizing the stability of slopes is to use a simple plane failure assumption within a limit equilibrium analysis. Assume that the failure plane is at an angle of β to the horizontal, the weight of the slide mass is W, the measured angle of internal friction along the slide plane is φ, water pressure on the failure plane is u, and a Coulomb friction model is applicable.

Identify the disadvantage of using the Coulomb friction model for rock slopes.

A. The Coulomb friction model was invented for rock slopes, hence, is ideal for characterizing rock slope stability.

B. The Coulomb friction model fails to properly characterize rock joint roughness and the change in frictional resistance as movement occurs.

C. The Coulomb friction model fails, because the concept of friction is invalid for rock slopes.

D. None of the above.

6. Your site area has several large fault scarps at the base of a nearby range of mountains. These scarps are indicative of past large earthquakes nearby. It is important for you to estimate the interoccurrence times of future earthquakes near your site and estimate the size of future earthquakes. Choose the most reasonable approach below to proceed with this task.

A. The existence of fault scarps does not necessarily indicate that future earthquakes will occur. A brief study of the historical seismicity in the vicinity will indicate whether the fault scarps are associated with recent earthquakes. If historical earthquakes are recorded, these can be used for design. In no historical earthquakes are recorded, the faults can be declared inactive.

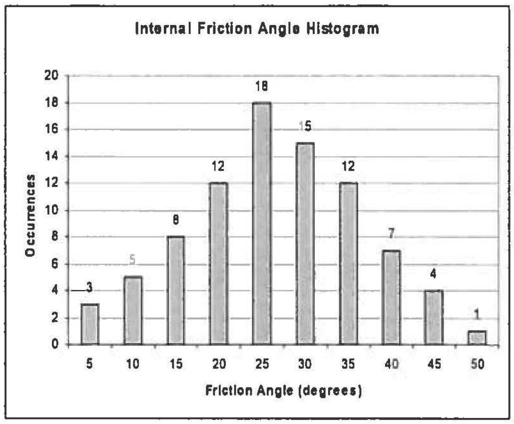
B. The fault shape and stratigraphy can be used to estimate the ages of previous fault ruptures. Trenches across the fault scarps should reveal information on the timing and number of fault displacements. Unfortunately the lack of historical seismicity is not a dependable indicator of seismic hazard, as the historical period may be too short to be meaningful. The length of the fault scarps reveals information on the fault segment size that is common for large characteristic earthquakes in the area. This can be used through the seismic moment to estimate future earthquake size.

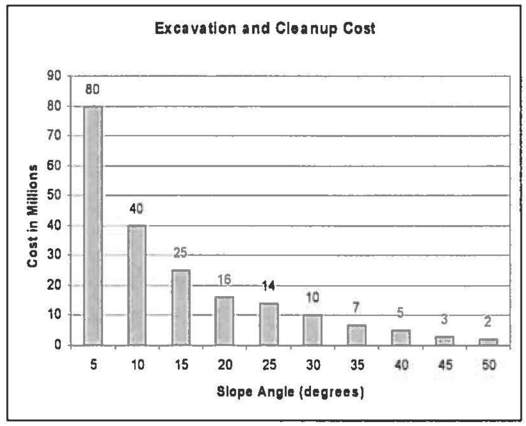
C. The size (scarp height) and length of the fault scarps indicates the interoccurrence time of earthquakes that have occurred in the past. As a rule of thumb, divide the total scarp length by 10, and the scarp height by 3 to arrive at an estimate of the interoccurrence time. For example, a scarp length of 50km and a total scarp height of 9m results in the following estimate of interoccurrence time.

(50km/10)(9m/3)(1000) = 15,000 years between rupture events.

D. Nothing can be estimated using old scarps because of erosion. The longer scarps are present, the more erosion modifies them. The best approach is to choose the largest historical earthquake (Maximum Credible Earthquake) in the region and assume that it occurs along the fault nearest to the site.

7. You have been asked to design an economically optimum slope for a road cut. Consider plane failure mechanisms only with no pore pressure and a simple Coulomb friction model. Histograms showing laboratory measurements of friction angle, φ, in degrees along with the cost associated with excavating the slope to different angles are provided below. Steep angles are the most economical to excavate, but the cost of failure is high in terms of cleanup and life risk. Low slopes are less susceptible to failure, but cost more to excavate. Assume that the cost of slope failure in terms of cleanup, road repair and litigation is estimated at $50,000,000.





Choose the economically optimum slope angle from the choices below.

A. The economically optimum slope angle is approximately 50 degrees.

B. The economically optimum slope angle is approximately 10 degrees.

C. The economically optimum slope angle is approximately 25 degrees.

D. None of the above.

Answer Key for Sample Items

1. D
2. B
3. B
4. C
5. B
6. B
7. C