UNIT 442 GEOTECHNICS AND SOIL MECHANICS

Lesson 1: Introduction to the unit **Suggested Teaching Time:** 2 hours

Learning Outcome: Understand common rock types, their formation and use

Topic	Suggested Teaching	Suggested Resources
Introduction to the unit	• The tutor should go through the unit specification and explain the need for an understanding of the properties of the materials upon which civil engineering structures bear, and the way in which soils behave under load. The progressive link between the four learning outcomes should be stressed. A short question-and-answer session should be used to check learner understanding of what is to be covered, but it is clearly not a requirement for learners to understand the content before it is taught. • The learners should be provided with a glossary of the terms to be used in the unit and encouraged to align each term against specific assessment criteria, as and where relevant. Each term will of course be fully explained later, at the appropriate stage of the teaching and learning process. • The tutor should use the unit specification to explain how the unit is to be assessed. This should deal with whether the assessment is to be external or internal, by examination or assignment, and the nature of the evidence that will need to be provided.	• Unit specification • Glossary of terms • Sample assessment materials **Websites:** www.ice.org (Institution of Civil Engineers) www.issmge.org (International Society for Soil Mechanics and Geotechnical Engineering)

Lesson 2: Classification of rock types **Suggested Teaching Time:** 4 hours

Learning Outcome: Understand common rock types, their formation and use

Topic	Suggested Teaching	Suggested Resources
Describe the classification of rock types (AC 1.1)	• The tutor should identify the three main classifications of rock as igneous, sedimentary and metamorphic and explain the different ways each type of rock is formed. • The class should then be split into three smaller groups, with each being given one of the three classifications to research. Each group should produce a presentation of the rocks to be found in each type, their general physical and chemical properties, and where they are to be found. Each group should be prepared to answer questions about the presentation. • Granite, basalt, dolerite, andersite, gabbro, rhyolite, syenite, limestone, sandstone, mudstone, shale, slate and schist should be classified appropriately. • The above should be supported by the use of classroom rock packs. These provide samples of common rocks of all types together with teacher's notes and activities. • Incomplete hand-outs could be used a focus of the discussion. These should contain partial information relating to rock types, their appearance and their properties, and the learners should complete the hand-outs and submit them for formative assessment.	**Websites:** www.ukge.com (Classroom rock packs) http://tinyurl.com/ntychfn www.gsa.org.au/resources/factites/factites/Rocks.pdf www.ice.org (Institution of Civil Engineers) www.issmge.org (International Society for Soil Mechanics and Geotechnical Engineering) **Books:** Waltham, Tony, *Foundations of Engineering Technology* (3rd edition), Taylor and Francis Ltd, 2009, ISBN-10: 0415469600, ISBN-13: 978-0415469609

Lesson 3: Common rock forming minerals and their mode of formation **Suggested Teaching Time:** 4 hours

Learning Outcome: Understand common rock types, their formation and use

Topic	Suggested Teaching	Suggested Resources
Common rock forming minerals and their mode of formation (AC 1.2)	• The tutor should introduce the learners to the common rock-forming minerals quartz, mica, feldspar and calcite. Samples of each should be made available to the learners for visual examination and simple testing. • The class should be divided into four groups and each group should research one of the minerals above and determine their properties, characteristics and appearance. Each group should present their findings to the rest of the class and be prepared to answer questions. • An incomplete hand-out should be prepared by the tutor. The learners should complete this using the results of the presentations. The tutor should check the outcomes in a formative manner and correct any errors. • The tutor should emphasise that rocks are naturally occurring aggregates of minerals, rock fragments and organic matter, and demonstrate how the origin of rocks can be derived from texture and mineral composition. This need not be over-complex. It is the basic idea of how rocks are formed by minerals that matters. This is not the time or place for advanced chemistry.	**Websites:** www.ukge.com (Classroom rock packs) http://tinyurl.com/mmxtwt4 www.sandatlas.org/minerals/ www.ice.org (Institution of Civil Engineers) www.issmge.org (International Society for Soil Mechanics and Geotechnical Engineering)

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Lesson 4: Features of geological maps and the structural Implications for foundation design **Suggested Teaching Time:** 4 hours

Learning Outcome: Understand common rock types, their formation and use

Topic	Suggested Teaching	Suggested Resources
Features of geological maps and the structural implications for foundation design (AC 1.3 and 1.4)	• The tutor should introduce the concepts of bedding, dip strike, cline, fold faults, slip, settlement and drift. Annotated geological maps should be made available for learners to scrutinise and unmarked maps should be used to demonstrate to the students the characteristics of each of the above concepts. Useful links should be made with bore-hole logs. • A whole-class discussion should be used to lead the learners towards an understanding of the structural implications of the above for foundation design, including difficulties associated with excavations and possible fragmentation of the rocks.	**Websites:** www.ukge.com (Illustrative graphs and geographical maps) www.ice.org (Institution of Civil Engineers) www.issmge.org (International Society for Soil Mechanics and Geotechnical Engineering) **Books:** Waltham, Tony, *Foundations of Engineering Technology* (3rd edition), Taylor and Francis Ltd, 2009, ISBN-10: 0415469600, ISBN-13: 978-0415469609

UNIT 442 GEOTECHNICS AND SOIL MECHANICS

Lesson 5: Soil classification methods **Suggested Teaching Time:** 4 hours

Learning Outcome: Understand the properties of soil

Topic	Suggested Teaching	Suggested Resources
Soil classification methods (AC 2.1)	• The tutor should introduce the common methods used to classify soils such as particle-size analysis, consistency limits and plasticity indices. A tutor-led whole-class discussion should follow on how each of these could affect the properties of the soil and how soils behave in a civil-engineering environment. • The class should be split into small groups with each group being given one of the above topics to research. Each group should make a short presentation to the rest of the class and be prepared to answer questions. • Where possible, learners should have the chance to undertake simple tests to ascertain the parameters described, although this is not the primary focus of the lesson. Visits to soil-testing facilities would also be helpful. Where this is not possible, video and website materials can be used as indicated. • Where appropriate standard calculations should be used to underpin the learners' understanding of the concepts involved, although there is no formal requirement for any calculations.	**Websites:** http://tinyurl.com/k9zyy9x (Soil description and classification; UWE) http://tinyurl.com/kv7s3gh (Soil consistency, Atterberg limits) **Videos:** http://tinyurl.com/pk7lre8 (Particle size analysis for soils) http://tinyurl.com/n2l77ff (Grain size analysis)

UNIT 442: GEOTECHNICS AND SOIL MECHANICS

Lesson 6: Soil properties **Suggested Teaching Time:** 4 hours

Learning Outcome: Understand the properties of soil

Topic	Suggested Teaching	Suggested Resources
Soil properties (AC 2.2)	• The properties of soils should be introduced and defined by the tutor. The relationships between the properties should be established, where relevant, together with any formulae. The relevant properties are dry, bulk, saturated and submerged density; void ratio, porosity, moisture content and liquid limit; degree of saturation and permeability; specific gravity. • Where possible, learners should have the chance to undertake simple tests to ascertain the properties described, although this is not the primary focus of the lesson. Visits to soil-testing facilities would also be helpful. Where this is not possible, video and website materials can be used as indicated. • Where appropriate standard calculations should be used to underpin the learners' understanding of the concepts involved, although there is no formal requirement for any calculations.	**Websites:** http://www.soils4teachers.org/lessons-and-activities **Videos:** http://tinyurl.com/ofv8435 (Science – properties of soils) http://tinyurl.com/nlxy9zz **Books:** Craig, R. F., and Knappett J. A., *Craig's Soil Mechanics*, CRC Press, 8th Edition, 2012, ISBN-10: 0415561256, ISBN-13: 978-0415561259

UNIT 442: GEOTECHNICS AND SOIL MECHANICS

Lesson 7: Soil stresses and the movement of water through soils **Suggested Teaching Time:** 4 hours

Learning Outcome: Understand the properties of soil

Topic	Suggested Teaching	Suggested Resources
Soil stresses and the movement of water through soils (AC 2.3 and 2.4)	• The tutor must distinguish between total, effective and neutral pressure and emphasise the important effect of water on soil properties and the factors that affect the movement of water through soils, including soil permeability and hydraulic gradient. • The learners should be given the opportunity to scrutinise a range of soil pressure graphs in order to identify the effects of soil stresses on gradient, intercepts and discontinuous points on the graphs. • Learners can undertake individual research by accessing the two websites shown. The basics are included together with some of the underpinning mathematics. Learners could demonstrate their developing understanding by defining all the terms used and identifying the relationship between the terms. • The tutor should show the learners the two videos mentioned to the right. Close attention to the worked examples will help underpin understanding of the basic principles of stresses acting in soil that contains water. • Where available, a hydraulic bench can be used to demonstrate what is meant by the term hydraulic gradient, but calculations are not required here.	**Websites:** terms (Stresses in the soil) http://tinyurl.com/l3k6k3h (Total, effective & natural stress) **Videos:** http://tinyurl.com/nz98q6x (Effective stress – basic principles) http://tinyurl.com/ldnagy6 (Effective stress – worked examples)

UNIT 442: GEOTECHNICS AND SOIL MECHANICS

Lesson 8: Methods of site investigation **Suggested Teaching Time:** 4 hours

Learning Outcome: Understand the properties of soil

Topic	Suggested Teaching	Suggested Resources
Methods of site investigation (AC 2.5)	• The tutor must introduce the learners to the concepts of disturbed and undisturbed soil sampling. This can be supported by the relevant video as shown on the right. • Learners should be split into four groups and asked to research into one method of taking soil samples per group (trial pits, hand augers, rotary boring, percussion rig boring). They should decide whether they produce undisturbed or disturbed samples and state what it is that each method tells us about the soil sampled. Each group must make a presentation to the rest of the class and be prepared to answer questions. • Learners can do independent research by accessing the video material on the websites shown. • A tutor-led whole-class discussion should be used to sum up what has been learned and to make suggestions as to how the samples obtained are used in soil-testing procedures.	**Videos:** https://www.youtube.com/watch?v=jo64QIE4hr4 http://tinyurl.com/k2me9ad (Borehole site investigation) http://tinyurl.com/puz4nh5 (How to take soil samples…) **Books:** Craig, R. F., and Knappett J. A., *Craig's Soil Mechanics*, CRC Press, 8th Edition, 2012, ISBN-10: 0415561256, ISBN-13: 978-0415561259

UNIT 442: GEOTECHNICS AND SOIL MECHANICS

Lesson 9: Explain the mechanics of soil friction and cohesion **Suggested Teaching Time:** 4 Hours

Learning Outcome: Understand the properties of soil

Topic	Suggested Teaching	Suggested Resources
Mechanics of soil friction and cohesion (AC 2.6)	• The tutor should explain that friction pays a large part in the shear strength of the soil. This should be supported by worked graphical examples of problems relating to the use of Mohr's circles to solve two-dimensional stress systems. • This should be related to the concepts of shear failure for various soil types, the shear strength envelope and shear testing for different drainage conditions. Example of shear failure should be used to support discussion. • Prepared examples of Mohr's circles showing normal, shear and principal stresses, on planes at various angles to the vertical, will help embed the basic principles. The relevant video will help (but take care with units used). • The learners should then complete worked exercises on the above. The tutor should correct these and make formative suggestions to improve learner understanding as necessary. It is the principle that is important not the maths. • A whole-class teacher-led discussion should be used to develop an understanding of the link between soil friction and the cohesion of soils. The second website address will be useful for independent learner research.	**Videos/Websites:** http://tinyurl.com/k9sl7t8 (Soil strength example) http://tinyurl.com/o392mbj (What is soil cohesion?) http://tinyurl.com/lepm5bo (Soil mechanics and foundations) http://tinyurl.com/owxobhe (Shear strength of soil)

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Lesson 10: Determining shear strengths from tests **Suggested Teaching Time:** 4 hours

Learning Outcome: Understand the properties of soil

Topic	Suggested Teaching	Suggested Resources
Determining shear strengths from tests (AC 2.7 and 2.8)	• Where possible, leaners should be given the opportunity to perform shear box and triaxial compression tests on soil samples that they have collected for themselves. • Where this is not possible, because of lack of access to suitable equipment, it is acceptable to substitute videos of the tests, and to use secondary data. • However the data is accessed, learners must draw graphs of the results, perform calculations and make decisions based on those results. • Completed graphs of the results from previous tests should be made available for scrutiny by learners in order to support their understanding. • A tutor-led whole-class discussion should be used to link the results to how the shear strength values obtained are used in soil mechanics and structural design.	**Videos/Websites:** http://tinyurl.com/nxeuf6z (Shear stress testing) http://tinyurl.com/lepm5bo (Soil mechanics and foundations) http://tinyurl.com/oolcytb (Direct shear test)

Lesson 11: Engineering properties of soils **Suggested Teaching Time:** 8 Hours

Learning Outcome: Be able to analyse the shear strength of soils and the mechanics of cohesion

Topic	Suggested Teaching	Suggested Resources
Engineering properties of soils (AC 3.1)	• The tutor must revise the properties below and, as far as possible, expose the learners to the tests needed to determine dry, bulk, saturated and submerged densities, void ratio, porosity, moisture content and liquid limits, degree of saturation, permeability and specific gravity. • Where possible, leaners should be given the opportunity to perform the above tests on soil samples that they have collected for themselves. • Where this is not possible, because of lack of access to suitable equipment, it is acceptable to substitute videos of the tests, and to use secondary data. • However the data is accessed, learners must draw graphs of the results, perform calculations and make decisions based on those results. • Completed graphs of the results from previous tests should be made available for scrutiny by learners in order to support their understanding. • A tutor-led whole-class discussion should be used to link the results to how the values of the properties obtained are used in soil mechanics. • The tutor should use worked examples to demonstrate how the properties of soil are linked. Learners should then attempt calculations based on this.	**Videos:** http://tinyurl.com/mfr6ve5 (Index properties of soils) http://tinyurl.com/jwx4ztk (Soil properties) **Books:** Craig, R. F., and Knappett J. A., *Craig's Soil Mechanics*, CRC Press, 8th Edition, 2012, ISBN-10: 0415561256, ISBN-13: 978-0415561259

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Lesson 12: Determination of total stresses **Suggested Teaching Time:** 4 Hours

Learning Outcome: Be able to analyse the shear strength of soils and the mechanics of cohesion

Topic	Suggested Teaching	Suggested Resources
Determination of total stresses (AC 3.2 and 3.3)	• It is assumed that the important terms are now understood and the learners are familiar with the tests used to establish the appropriate values of these important terms. The tutor should now introduce the learners to the calculations used to determine effective stresses and hydrostatic pore pressures for ground conditions. • The videos indicated on the right will support individual learner research. • The stresses should include those on Inclined planes, for 2-D systems, and direct and shear stress on any plane, including maximum shear stresses. • The tutor should use worked examples to demonstrate how the calculations are developed. Learners should then attempt calculations based on what they have been shown. Tutors should correct any errors and set new calculations until the learners demonstrate the necessary understanding. • All calculations should be done within realistic parameters and the answers checked against software systems designed to determine totals tresses in soils under a variety of conditions.	**Software:** www.geiengineer.org **Websites:** http://tinyurl.com/lo66qbs (Effective/total stresses in soil) http://tinyurl.com/o5l6zd3 (Effective stress) **Books:** Craig, R. F., and Knappett J. A., *Craig's Soil Mechanics*, CRC Press, 8th Edition, 2012, ISBN-10: 0415561256, ISBN-13: 978-0415561259

UNIT 442: GEOTECHNICS AND SOIL MECHANICS

Lesson 13: Soil compaction and consolidation **Suggested Teaching Time:** 4 Hours

Learning Outcome: Understand the basic principles of soil compaction and consolidation

Topic	Suggested Teaching	Suggested Resources
Soil compaction and consolidation (AC 4.1 and 4.2)	• The tutor must introduce the concepts of soil compaction and consolidation and explain the important differences between the two concepts. • Independent learner research should be used to develop an understanding of the basic principles underpinning soil compaction and consolidation. • A visit to any civil-engineering site is likely to show both compaction and consolidation processes in action. • A simple rig could be developed in a laboratory to demonstrate the two processes in an environment where measurements can be made.	**Websites:** http://tinyurl.com/q4qdacv http://tinyurl.com/pkyh47g http://tinyurl.com/lldbx4k (What is the difference…) **Books:** Craig, R. F., and Knappett J. A., *Craig's Soil Mechanics*, CRC Press, 8th Edition, 2012, ISBN-10: 0415561256, ISBN-13: 978-0415561259

UNIT 442: GEOTECHNICS AND SOIL MECHANICS

Lesson 14: Lateral pressures and retaining walls **Suggested Teaching Time:** 6 Hours

Learning Outcome: Understand the basic principles of soil compaction and consolidation

Topic	Suggested Teaching	Suggested Resources
Lateral pressures and retaining walls (AC 4.3, 4.4 and 4.5)	• The tutor must introduce the Rankine theory of pressures and the Coulomb wedge theory. It is important that the difference between retaining soil and water is explained, what the influence of ground water is, where the Rankine coefficient is needed and how it is calculated. • Scale models of retaining walls can be made from concrete and the effects of lateral pressure from soils of varying water content demonstrated visually. It should be possible to view failures due to sliding and overturning. • Learners should do independent research on the basic methods used to calculate lateral forces on a structure. The websites shown to the right will be very useful in supporting that research. • The tutor should use worked examples to demonstrate how the calculations are developed. Learners should then attempt calculations based on what they have been shown. Tutors should correct any errors and set new calculations until the learners demonstrate the necessary understanding. • All calculations should be done within realistic parameters and the answers checked against software systems designed to determine lateral pressures on retaining walls under a variety of conditions.	**Software:** www.geiengineer.org **Websites:** http://tinyurl.com/k9mbyvs (Retaining wall guidance) http://tinyurl.com/9dpd5dr (Lateral earth pressure) http://tinyurl.com/p6mealo (Horizontal stresses and retaining walls)