CHAPTER 10: MATERIAL TESTING

10.1 Introduction of the Unit of Learning

This unit specifies the competencies required to Conduct Material Testing. It involves preparing for material testing, sampling construction materials, and performing tests on alignment soils, concrete, structural steel, bitumen materials and timber. It also includes documenting test results.

10.2 Performance Standard

Prepare for material testing, sample road construction materials, undertake tests on the alignment soils, perform concrete tests, carry out structural steel tests, perform bitumen tests, and perform timber tests as per the contract documents, project requirements, material testing manual, expertise and qualifications, standard tests and procedures, test procedures and requirements, and SOPs.

10.3 Learning Outcomes

10.3.1 List of Learning Outcomes

a) Prepare for material testing
b) Sample road construction materials
c) Undertake tests on the alignment soils
d) Perform concrete tests
e) Carry out structural steel tests
f) Perform bitumen tests
g) Perform timber tests

10.3.2 Learning Outcome No 1: Prepare for Material Testing

10.3.2.1 Learning Activities

Learning Outcome No 1: Prepare for Material Testing	
Learning Activities	**Special Instructions**
1.1 Conduct preliminary site investigations 1.2 Provide and maintain material laboratory 1.3 Obtain material testing manuals and contract documents 1.4 Acquire ***Material testing equipment*** 1.5 Identify material laboratory personnel 1.6 Develop sampling procedures 1.7 Determine types of material tests 1.8 Operate and maintain testing equipment	• Direct instruction • Field trips • Discussions • Demonstration by trainer • Practice by the trainee

10.3.2.2 Information Sheet No10/1: Prepare for material testing

Introduction to learning outcome

This learning outcome covers site investigations, construction material laboratory, material testing, construction material and development of sampling procedures.

Definition of key terms

Construction material – in civil engineering, construction materials are any materials used for construction purposes. These may include; sand, rocks, cement etc.

Material testing- this is the act of determining the properties of raw materials using standard techniques. These properties include physical, mechanical and chemical properties.

Testing tools – in civil engineering, testing tools are items or objects used in determining the properties of raw materials.

Content/Procedures/Methods/Illustrations

1.1 Conduct preliminary site investigations as per contract document

Site Investigation

This is an inspection of the proposed site for construction to obtain information about its subsurface conditions thus determining the suitability of the proposed site. The steps for conducting a site investigation include:

- Conduct a ***site pre-visit*** to the proposed site of the construction.
  This is the first stage of site investigation and involves a field visit to the proposed site to obtain information on the topographical and geological features of the site. The pre-visit reveals information on the behaviour and type of adjacent structures noticeable slags, cracks and sticking doors and windows.
- Perform ***a preliminary site investigation*** to the area.
  This is the second stage of site investigation and is also known as general site investigation. Its main objective is to obtain an approximate assessment of the suitability of the site. Experimental borings and shallow tests are dug to collect soil samples and perform simple tests such as unconfined compressive test and moisture content.
- Conduct a ***detailed site investigation***
  This is the third stage of site investigation and is preferred for complex projects such as the construction of dams, bridges and high-rise buildings. It involves a detail assessment of the proposed site by performing more complex detailed field tests such as plate load test, in-situ vane shear test.
- Prepare a ***detailed soil investigation report***
  This is the fourth stage of site investigation whereby a detailed report of the site investigation findings is recorded and documented.

1.2 Provide and maintain material laboratory according to contract document

Materials laboratory- This is a laboratory specifically dedicated for assessing the physical and mechanical properties of construction materials. Maintaining a materials laboratory involves maintain the laboratory equipment present in the laboratory.

Five ways of maintaining a materials laboratory

- Repairing laboratory equipment
- Refurbishing laboratory equipment at regular intervals thus increasing their efficiency and functionality.
- Regular calibration services of the materials laboratory equipment.
- Performing in-house maintenance of equipment or at times outsourcing maintenance services.
- Regular cleaning of laboratory equipment.

1.3 Obtain material testing manuals and contract documents based on project requirements

Approved Material Testing manuals used in Kenya include the following;

- BS 1377-2-1990: For soil classification tests.
- BS1377-4-1990: For soil compaction tests.
- Road Design Manual Part III: For pavement material tests
- Road Design Manual Part III Section 17: For concrete works tests.

(BS – British Standard Codes)

1.4 Acquire Material testing equipment according to contact document and material testing manual

Material testing equipment- these are tools and objects used in determining the physical and mechanical properties of construction materials.

Material Testing Equipment and their uses

- **Penetrometer** – used in testing the plasticity of soils
- **Weighing Machine** – used in measuring the weight of material samples.
- **Oven** – used in drying material samples thus determining the moisture content of sample materials.
- **Measuring cylinder** – used in measuring liquid material samples.
- **Crushing machine** – used in determining the compressive strength of concrete sample.
- **Moisture bags** – used for preserving the moisture content in soil samples obtained from the field or from borrow pits.
- **Standard sieves** – used in the sieve analysis test, to determine the particle size of material samples.

Given the material tests to be conducted as per the contract, one should ensure that the necessary material testing equipment is available.

1.5 Identify material laboratory personnel according expertise and qualifications.

A **material's laboratory personnel** performs field or laboratory tests of construction and geological materials according to prescribed test procedures.

Identification of Material Laboratory Personnel is as follows;

Table 20: Identification of Material Laboratory Personnel

Material Labouratory Personnel	**Expertise**	**Qualifications**
Foreman	Is an intermediary between workers and management to organize, assign and directly supervise the work of a manual labourer?	Maintains cooperative work relationships with project engineers, contractors, vendors and employees
Specialist/ Lead Technician	Assigns work, sets schedules, determine methods, provides training and instruction, evaluates and approves completed tasks.	Effective scheduling and operation of the labouratory
Lead Technologist	Is more independent as compared to the trainees and uses standard techniques and methods to perform more complex material testing, including bituminous and concrete design mixes.	Accuracy in test measuring, documentation and verification
Sub-trainee	Assists in both field and labouratory material testing. Performs a number of standard tests on concrete, aggregates and soils.	Increased consistency and proficiency in performed tests.
Trainee	Works under close supervision and review of those ahead of him/her.	Application of test procedures to a number of construction materials and documenting test results.

1.6 Develop sampling procedures according to standard tests procedures

Considerations to me made while developing sampling procedures;

- Care should be used in the selection of a representative rather than an extreme sample.
- The sampling procedures should focus on specifying how many samples should be tested from each lot. A great error may occur if very few samples are chosen resulting in the contactor having to carter for the extra payments due to erroneous calculations. On the other hand, if too many samples are considered, this many end up consuming time and money without necessarily improving accuracy.
- Procedure for developing sampling procedures should be according the standard tests procedures.

1.7 Determine types of material tests according to test procedures and requirements

Types of Material Tests include but are not limited to;

- **Soil classification tests**: Liquid Limit test, shrinkage test, plasticity index test, sieve analysis, determination of moisture content etc.
- **Soil compaction tests**: Proctor test, CBR test, Sand replacement method(MDD, Maximum dry density test)
- **Bituminous material tests**: Marshall test
- **Concrete works tests**: Slump test, Concrete strength test.
- **Aggregate tests**: ACV (Aggregate crushing value), FI (flakiness Index), Sodium Soundness Test (SSS).

1.8 Operate and maintain testing equipment as per the SOPs

Maintenance of testing equipment is one of the most important aspects of quality assurance as it contributes to the accuracy or labouratory reports.

A maintenance program for testing equipment should include the following concepts;

- Recording all breakdowns of testing equipment.
- Regular calibration of equipment to ensure accurate records of results.
- Registration of all equipment indicating their serial numbers, identification numbers and specific location in the labouratory.
- Mechanism for validating testing equipment
- Ensuring all new equipment are checked before installation thus ensuring safety of equipment.
- Performing periodic performance checks as recommended by the manufacturer.

Daily duties of maintaining material testing equipment are:

- Ensuring the testing equipment is cleaned after every use.
- Oiling the Shrinkage limit, CBR and Proctor molds before use.

- Ensuring the materials testing labouratory's surfaces are cleaned after every use.
- Cleaning the sieves with a hard brush to remove stuck material particles on the sieves.
- Regular calibration of equipment to ensure accurate records of results and availability of equipment for the required testing (Jennings et.al 2017)

Conclusion

This learning outcome covered site investigations, construction material labouratory, material testing, construction material and development of sampling procedures.

Further Reading

Read further in Site Investigation from the book Engineering Geology by F.G Bell 2nd ed. Go through the Road Design Manual Part III to see detailed procedures on material testing.

10.3.2.3 Self-Assessment

Written Assessment

1. A civil engineer has won his first tender for constructing additional classes in a high school. Which of the following will he not do in the preliminary site visit?
    a) Explore the ground conditions at the surface of the proposed construction site
    b) Explore the ground conditions below the surface of the proposed construction site
    c) Come up with detailed design drawings of the proposed classrooms
    d) Dig test pits
2. In a certain road project, the new trainee was asked to record test results from certain soil classification tests. Which of the following was not one of them?
    a) Sieve Analysis
    b) CBR (California Bearing Ratio)
    c) Shrinkage test
    d) Plasticity Index

3. The County Government of Kakamega was performing a maintenance check on its material testing labouratories. Which of the following material equipment was calibrated?
    a) Measuring cylinder
    b) Moisture bags
    c) CBR Crushing machine
    d) Mechanical Standard sieves
4. Evaluate the steps taken when conducting a preliminary site investigation.
5. Explain three types of aggregate tests outlining their testing tools and equipment.
6. Summarize five ways of maintaining material testing equipment
7. Using a sketch explain the slump test method of testing concrete works.
8. Discuss the Marshall test method of testing for bituminous mixes

Oral Assessment

Explain the main objective of conducting a preliminary site investigation

Oral Assessment

During the early stages of a pavement construction project, the level of compaction of the earth-works was tested using the sand-replacement method. Why was the soil obtained from the test pit, not carried back to the laboratory in an open container?

Practical Assessment

With guidance from your materials labouratory technician, obtain a soil sample from a suitable borrow pit and perform soil classification and compaction tests to determine the following;

i. Moisture content
ii. Liquid limit, Plastic limit, Plasticity index- cone penetrometer method
iii. Linear shrinkage
iv. CBR value

10.3.2.4 Tools, Equipment, Supplies and Materials

- Computers
- Software
- Cameras
- Construction manuals
- Projectors
- Flip charts
- Calculators
- Rulers, pencils, erasers
- Charts with presentations of data

- Drawing sheets
- Internet
- Relevant videos

10.3.2.5 References

Jennings et.al. (2017). Capacity Building and Knowledge Management Study of MTRD Kenya. Nairobi: Government Printers

10.3.3 Learning Outcome No 2: Sample Road Construction Materials

10.3.3.1 Learning Activities

Learning Outcome No 2: Sample Road Construction Materials	
 **Learning Activities**	**Special Instructions**
2.1 Identify sources of **road construction materials** 2.2 Obtain sample procedures and manuals 2.3 Identify sampling tools and equipment and assembled 2.4 Carry out sampling 2.5 Store samples awaiting analysis 2.6 Operate and maintain testing equipment maintained	• Direct instruction • Field trips • Discussions • Demonstration by trainer • Practice by the trainee

10.3.3.2 Information Sheet NO10/L02: Sample Road Construction Materials

Introduction to learning outcome

This learning outcome covers sources of road construction materials, sampling procedures, sampling tools and equipment, material sample analysis and storage of samples.

Definition of key terms

Sources of road construction materials – These are the places of origin of the materials that are used in road construction. The materials are either naturally occurring or man-made and the selection of sources of road construction materials mainly depend on the purpose of the road, the availability of that particular material, the location where the construction will take place and the climatic conditions of that region.

Sampling procedures and standard manuals - sampling procedures is term used to refer to how the selection of a representative portion of a material to be used in road construction is done and the standard manuals are small conveniently handled books with instructions on the standard procedures for carrying out tests on construction materials.

Sampling tools and equipment - These are devices or technical apparatus that are used to collect a representative sample of a material in order to test, monitor and analyse it.

Material sample analysis - This is a detailed study of a sample of a material used in road construction so as to understand it better.

Storage of samples- This is the proper keeping of collected sample materials in the lab from the time they are acquired till disposal.

Content/Procedures/Methods/Illustrations

2.1 Sources of road construction materials (Borrow pits, Quarries, River beds, Timber yard, Manufacturers) based on contract document

Sources of Construction Materials include:

Borrow pits- refers to an area where construction material have been dug for use at a different location.

Quarries- refers to a large deep pit from which stone and other constructions materials such as quarry dust, ballast etc. have been extracted.

River beds- refers to the ground at the bottom of the river from which sand and gravel as construction materials are obtain.

Timber yard- this is a specific location whereby products used in construction or for projects of home improvements, specifically wood related products, are processed or stored.

Manufactures- aggregates required in road construction can also be made in factories as a result from the modification of materials, which may involve both physical and chemical changes. These types of materials are sometimes called synthetic or artificial aggregates.

2.2 Obtain sample procedures and manuals as per standard sampling procedures.

These sample procedures and manuals tend to derive sampling plans that may enable one to carry out the standard tests required for road construction materials.

Manuals and procedures used for sampling road construction materials include:

- ASTM-D1452
- ASTM: C 183-86 (a)
- SABS 471
- SABS 620
- SABS 626
- SABS 831
- SABS 824
- SABS Method 861

2.3 Identify sampling tools and equipment and assembled according to standard procedures

Sampling by Auger

Tools and equipment

- Hand augers with diameter of about 50 to 300 mm
- A riffler with openings of 25mm and pans.
- Shovels.
- Power augers of about 600 mm diameter.
- A prospecting pick.
- Tape measure to determine the sampling depth in millimeters.
- Suitable canvas or plastic sampling bags.
- Suitable canvas sheets of about 2 x 2m.
- Containers of about 500 mm diameter.
- Picks.

Natural rock mass sampling

Tools and equipment

For acquiring samples obtained from test pits that have been blasted with explosives

- A spade
- Containers suitable for rock samples e. g canvas bags (strong) prospecting pick.
- A pick
- A sledge-hammer with about 5 kg mass.
- Canvas sheets of about 2 x 2 m.
- A crowbar.

Tools used for obtaining core samples with the aid of a core drill

- Suitable enough containers to pack the cores such that they can be firmly packed to prevent sliding or mixing up in the process of transportation and handling.
- A suitable enough tape measure.

Sampling of stock piles

Tools and equipment

- Basin with a diameter of about 500mm diameter
- Shovels.
- Suitable canvas sheets.
- Picks.
- Suitable container or sample bags
- A mechanical loader-digger (if present).
- 25mm openings riffler and six matching pans.

Sampling of samples obtained from sampling pit in natural soil, gravel and sand

Tools and equipment

- A pick
- 19 mm sieve with 450mm diameter.
- A prospecting pick.
- Appropriate sampling containers.
- Tape measure.
- A spade
- Strong canvas or plastic bags as containers.
- Canvas sheets of about 2 x 2m
- A riffler with oenongs of about 25mm wide, with six matching pans.
- A basin of about 500mm diameter.

Sampling of cement and lime

Tools and apparatus

- Clean and appropriate containers such as tins that have tightly-fitting lids and have the capacity to hold be hold 5 kg of cement or lime.
- Suitable apparatus for taking samples e. g a grooved sampling device that can take samples from large containers, and a tube type sampling device that can take samples from small containers like bags

2.4 Carry out sampling as per standard sampling procedure

Procedure for sampling by auger

Drilling should be done by drilling the auger into the ground to the required depth, then withdrawing it, and the soil should then be removed so as to carry out sampling and examination.

The auger should then be reinserted in the hole then the process repeated where the various types of soil horizon occurs once enough material has been obtained for testing, e. g when adequate material has been removed by drilling, a labouratory sample is acquired by quartering and riffling.

In the situation of harder rock, in an instance where the power auger may end up causing pulverization, it is more advisable to:

- Drill a hole with diameter of about 600 mm, to the full required depth.
- Drill a second hole about 0.5 to `1.0 m away from the first hole, on the quantity of material required for the particular sample, to the depth of the first horizon that needs to be sampled.
- All the material between the two holes up to this depth should be removed and placed it on a hard, clean soil surface or on a canvas sheet.

- The second hole to the depth of the second horizon which is to be sampled is then drilled and all the material between the two holes removed and placed on a separate canvas sheet. The process is then to be repeated to the full depth of the first hole.

Still, samples may be obtained from a single hole by cutting down a groove in the material starting from the side that has the hole.

Procedure for Natural rock mass sampling

For Test pits that have been blasted with explosives which have then been manually opened;

Inspection should be carried out of the sides of the test pit to their full depth and results recorded with any observable changes in the rock and also the depths recorded between which such changes occur. Properties which should be considered are color, texture, rock type, hardness etc.

A crowbar should be used or the loosen pieces of each type of rock from each wall of the test pit should be picked and placed in a separate container. In a situation where the pieces are too large for the containers, they may be broken up by use of a sledgehammer. Some of the loose material taken from the test pit can be selected outside of the pit if there are no large types of rocks then each type can then be placed in a separate/different container. Loose earth or gravel layers of any kind appearing on top of the rock mass or which occurring in seams between the layers of rock must be sampled separately if by any chance it is to be used for some or other purpose later on.

The containers with samples must all be clearly marked so as to enable easy identification of the samples once they arrive in the labouratory.

Procedure for sampling of stock piles

Doing Sampling while the stockpile is being formed by the off-loading of material

i. Randomly selecting one or two positions on the consolidated surface of each layer of that stockpile while the pile is being formed.
ii. Vertical test hole should be made as deep as possible through the layer with the pick and shovel.
iii. A canvas sheet should then be placed in the bottom of the hole and a groove cut in the side of the hole from top to bottom that can let this material fall onto the canvas sheet.
iv. Gathering of enough quantity of material by cutting successive grooves, and frequently raising the canvas sheet from the hole then tipping its contents onto a different canvas sheet on the surface.
v. Mixing of the material on the canvas sheet and dividing it using the riffler and a method known as quartering method into the required size such that each sample bag has a representative sample of the material taken from the test hole.

Sampling from an already completed stockpile

- At least twelve sampling positions should be selected in a random manner. About half the positions may be on the stockpile if by chance, its surface is fairly large

Procedure for sampling of samples obtained from sampling pit in natural soil, gravel and sand

i. Begin by Inspecting the sides of the test pit to their full upper edge of the test pit then sample every distinguishable sand, gravel or soil layer by holding to the lower level of the layer a spade or canvas sheet against the side of the pit then cutting with a spade or pick a sheer groove to the full depth of the layer.
ii. The material is then obtained in this way in enough bags. The sheet of canvas may also be spread out on the floor of that test pit with at least twice the amount of material required for the final sample must be loosened from the layers.
iii. The material from each layer must be combined on either a clean, hard, even surface or on a canvas sheet as soon as all the layers have been sampled and properly mixed with the use of a spade.
iv. It is required to fill one small sample bag which can carry about 10kg, and two or three other larger bags with each of them holding about 30 to 40 kg.
v. When several test pits are made in a deposit and the materials have a slight difference, it is only necessary to fill large bags of each material type at each second or third test pit. At this point, the sampler must be guided by his /her discretion and experience. The sample containers must all be clearly labeled so that the samples can be easily identified in the labouratory with the identifying reference agreeing with that given in the covering report or form.

2.5 Store samples awaiting analysis based on test requirements

Particulars to consider when storing construction materials sample;

a) As the analysis is being done, the samples need to be stored in a position such that they will not be interfered with at any point.
b) Full particulars of each of those samples being stored must be given with full details including:
    - The sample size,
    - The size of containers used to put the samples,
    - The method of collection sample marked number,
    - The locations and
    - Depths at which the samples were taken.

Conclusion

This learning outcome covered sources of road construction materials, sampling procedures, sampling tools and equipment, material sample analysis and storage of samples

Further Reading

Read more on:

1. The determination of sample size and density based on the various road design manuals.
2. Building materials; third edition by S.K Duggal

10.3.3.3 Self-Assessment

Written Assessment

1. When carrying out sampling, what is the diameter of the 19mm sieve
    a) 40mm
    b) 450mm
    c) 950mm
    d) 5mm
2. Summarize the procedure for carrying out sampling by auger requires drilling.
3. Compare sampling procedures during the formation of a stockpile as opposed to sampling from an already completed stock pile.
4. Distinguish between test pit and quarries.
5. Which of the following is not a source of road construction materials?
    a) Quarries
    b) Trees
    c) Test Pits
    d) Manufacturers
6. Explain the use of a tape measure in sampling of construction materials.
7. Evaluate the testing tools and equipment used in natural rock mass testing
    a) Crowbar
    b) Pick
    c) Spade
    d) Stone
8. Differentiate between sampling manuals and sampling procedures.

9. Measure the scopes of the following sampling methods?
    i. Sampling by auger
    ii. Natural rock mass sampling
    iii. Sampling of stock piles
10. Summarize the ways of operating and maintaining testing equipment as per the SOPs
11. Explain precautions should be taken when collecting samples obtained from a sampling pit in natural soil, gravel and sand
12. Explain the selection of aggregators as road construction materials.
13. Classify the methods used for sampling stockpile.

Oral Assessment

1. Summarize the procedure for sampling by auger
2. Explain the importance of following the standard test procedures

Project Assessment

Conduct a practical assessment to find out the possible reasons as to why a section of John Momanyi Road in Nakuru County sunk to the ground in May 2020. You can use relevant data presentation techniques if necessary

10.3.3.4 Tools, Equipment, Supplies and Materials

- Computers
- Software
- Cameras
- Construction manuals
- Projectors
- Flip charts
- Calculators
- Rulers, pencils, erasers
- Charts with presentations of data
- Drawing sheets
- Internet
- Relevant videos

10.3.3.5 References

David Doran, Bob Cather (2013) Construction Materials Reference Book, Edition2 revised: Routledge

Nicholas J. Garber, Lester A. Hoel (2014) Traffic and Highway Engineering, SI Edition

S. K Duggal (2008). Building Materials. Allahabad: New Age International Publishers.

10.3.4 Learning Outcome No 3: Undertake Tests on the Alignment Soils

10.3.4.1 Learning Activities

Learning Outcome No 3: Undertake Tests on the Alignment Soils	
Learning Activities	**Special Instructions**
3.1 Identify ***Soil tests*** 3.2 Obtained standard manuals and procedures 3.3 Identify and gather soil testing tools and apparatus 3.4 Obtain alignment soil samples according to test requirement *3.5 C*onduct ***Soil tests*** 3.6 Record and analyse results 3.7 Prepare and present report 3.8 Operate and maintain testing equipment	• Direct instruction • Field trips • Discussions • Demonstration by trainer • Practice by the trainee

10.3.4.2 Information Sheet No10/LO3 Undertake Tests on the Alignment Soils

Introduction to learning outcome

This learning outcome covers soil tests, standard manuals, gathering of tools and equipment, alignment of soil samples, conduct soil samples, recording and analysing results, prepare and present report and operate and maintain testing equipment.

Definition of key terms

Shear test- This is a labouratory or field test that is used to measure the shear the strength properties of rock or soil materials.

Triaxial- This is a test used to measure the mechanical properties of deformed solids such as soil and rocks.

Plastic limit- This refers to the water moisture content at which 3.2mm diameter strand of clay soil stops behaving like a plastic material and begins to crumble.

Content/Procedures/Methods/Illustrations

3.1 Identify *Soil tests* according to contract document

CBR- this is a penetration soil test used to evaluate the subgrade strength of road and pavements.

Atterberg Limit- This is the water level at which the state of soil changes from one form to the other. In this test, there is measuring of the critical water content of fine-grained soils. They are the Plastic Limits (PL), Shrinkage Limits (SL) and Liquid Limits (LL).

Liquid Limit (LL) - This is an atterberg test that determines the water content at which clayey soil tends to change it's from plastic to liquid form. It measures the moisture content at which the soil sample will flow until it closes the one-half inch groove within it after dropping the standard LL equipment 25 times.

Plastic Limit - This refers to the water moisture content at which 3.2mm diameter strand of clay soil stops behaving like a plastic material and begins to crumble.

Proctor/compaction - This is a way of determining the optimum moisture content at which a particular soil type will become the densest enabling it to achieve maximum dry density when experimented on in the labouratory.

Field density- This is a common test which is used to find the field density of a particular pavement or soil sample. The test works on the principle that sand with a known density is used to replace soil excavated materials hence we can calculate the volume of the sand that is required to fill the hole.

Particle size distribution Analysis – this is a test that determines and reports information on the size and range of particles representative of a given material.

3.2 Obtain standard manuals and procedures in accordance with test requirement

The standard manuals and procedures used to carry out these soil tests are;

- **ASTM D 422** - Test Method for Particle-Size Analysis of Soils
- **ASTM Standard**: D653 Standard Definitions of Terms and Symbols Related to Soil and Rock Mechanics**.**
- **NYSDOT** Geotechnical Engineering Bureau method of determining the moisture content of soils etc.
- **BS 1377 – 2 – 1990:** for soil classification tests
- **BS 1377 – 4 – 1990:** for soil compaction tests

3.3 Identify and gather soil testing tools and apparatus based on test requirements

Soil testing instruments include;

- C.B.R. Test tools are C.B.R molds, soaking basin, C.B.R testing machine, hammer.
- Atterberg limit test tools are penetro meter, casagrade. Brass dish and shrinkage troughs

- Proctor test tools are proctor molds, hammer of mass 2.5 kg large mixing pan, weighing balance and detachable base plate.
- Field density testing tools are sand cone density plate, sand cone density apparatus test, and calcium carbonate chamber and moisture bag.
- Particle size distributions testing tools are testing sieves from 5 inches to 20 inches, sieve shakers and hard hand brush

3.4 Obtain alignment soil samples according to test requirement

The soil test sample testing is carried out in the alignments as outlined below:

- Standard test method for the unconsolidated - undrained strength testing of soils. This is a procedure that outlines the method which is used by the NYSDOT, geotechnical
- Engineering bureau in the unconsolidated - undrained strength testing of Soils. Its applicable documents are ASTM standard: D653 standard definitions of terms and symbols relating to soil and rock mechanics.
- Standard test for the consolidated - undrained Strength of soils. This procedure tends to outline the method used by the NYSDOT, geotechnical.
- Engineering bureau for determining the consolidated - undrained strength parameters of soils with applicable documents as ASTM standards: D653 standard definitions of terms and symbols relating to soil and rock mechanics.
- Standard test for the consolidated undrained Strength with pore pressure of soils. This is a procedure outlines the method used by the NYSDOT geotechnical
- Engineering bureau for determining the effective consolidated - undrained strength parameters of soils with applicable documents as ASTM standards: D653 standard definitions of terms and symbols relating to soil and rock mechanics. Standard tests for the labouratory determination of moisture content of soils.
- Is a procedure that outlines the NYSDOT geotechnical engineering bureau method of determining the moisture content of soil?
- Standard tests for the one - dimensional consolidation testing of soils. In this section, the procedures described are those used by the soil mechanics labouratory. To determine the one-dimensional consolidation properties of the soils tested with applicable documents as ASTM standards: D653 standard definitions of terms and symbols relating to soil and rock mechanics. D2435 standard method for one-dimensional consolidation of soils.

3.5 Conduct Soil tests as per standard procedures

The specific soil tests are then supposed to be conducted as per the standard test procedures while following the steps provided to the later so as to ensure that the results acquired are as accurate as possible

Approved standard manuals for soil tests include;

- BS 1377-2-1990: For soil classification tests.
- BS1377-4-1990: For soil compaction tests.
- Road Design Manual Part III: For pavement material tests

3.6 Record and analyse results according to standard procedures

Recording results is basically the act of putting down obtained results from the practical.
Analysis of results is comparing the obtained results to the expected appropriate results by putting the results into a meaningful and well understood form that one can easily interpret.

Recording and analyzing of data is done to ensure that correct conclusions are made concerning the tested sample.

The obtained data calculation and/or analysis is presented in the following ways;

- charts,
- graphs,
- Tables etc.

3.7 Prepare and present report based on contract document requirement

After carrying out of the tests while following the required procedures then collecting and analysing the acquired data, the student will be required to prepare a detailed report on the relevant steps that were followed. This report follows the following structure;

i. Title of the given test – this is basically the heading for the given test.
ii. Introductions –this comprises of short theoretical explanation of the test undertaken.
iii. Objective of the test – this basically explains the purpose for taking the given test.
iv. A list of tools and equipment used for the test.
v. Procedure followed during the test – the procedure should be in reported speech since by the time the student is writing the report, he/she has already done the test.
vi. Results obtained- this is a record of values obtained from taking the results.
vii. Analysis of obtained results – this can be done by the help of mathematical calculations, tables, graphs etc.
viii. Conclusion – this is an explanation for the analysis.

Conclusion

This learning outcome covered soil tests, standard manuals, gathering of tools and equipment, alignment of soil samples, conduct soil samples, recording and analyzing results, prepare and present report and operate and maintain testing equipment.

Further Reading

Read more on: Soil tests, for both soil classification tests and soil compaction tests.

10.3.4.3 Self-Assessment

Written Assessment

1. Distinguish the following Atterberg limit test.
    a) Plastic limit
    b) Shrinkage limit
    c) Condensation limit
    d) Liquid limit
2. Outline the steps undertaken in testing for shrinking limits.
3. Compare and contrast the CBR test and proctor test.
4. The water level at which the state of soil changes from one form to the other is known as?
    a) Field density
    b) Atterberg limit
    c) Plasticity Index
    d) Proctor
5. Categories soil testing apparatus according to the following test.
    a) Field density
    b) CBR test
    c) Proctor test
    d) Atterberg test
6. Classify soil testing methods according to soil classification tests and soil compaction test
7. Summarize the content of a detailed soil report.
8. Explain the triaxial test.
9. Compare the different types of Atterberg limits?
10. Contrast soil testing equipment used for soil classification test and soil compaction test.

11. Classify the difference standard manuals used in soil test.
12. Distinguish between plastic limit and liquid limit?
13. Clearly outline the contents of a detailed labouratory report on soil tests.
14. Summarize the various ways of analyzing and presenting data acquired from soil tests?

Oral Assessment

1. Explain the procedure of carrying out particle size distribution.
2. Evluate the benefits of preparing a final labouratory report.

Case Study Assessment

Perform an assessment on the effect of that drastic rise in environmental temperature has on soils used in construction.

10.3.4.4 Tools, Equipment, Supplies and Materials

- Computers
- Software
- Cameras
- Construction manuals
- Projectors
- Flip charts
- Calculators
- Rulers, pencils, erasers
- Charts with presentations of data
- Drawing sheets
- Internet
- Relevant videos

10.3.4.5 References

American Society for Testing and Materials. (2002). The Unified Soil Classification System. Annual Book of ASTM Standards, Vol. 4.08, West Conshohocken, PA.

Jamal, Haseeb. (Retrieved 23rd Sept.2019) "CBR Test". AboutCivil.Org.

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10.3.5 Learning Outcome No 4: Perform Concrete Tests

10.3.5.1 Learning Activities

Learning Outcome No 4: Perform Concrete Tests	
Learning Activities	**Special Instructions**
4.1 Identify **concrete tests** 4.2 Obtain standard manuals and procedures 4.3 Concrete testing tools and apparatus are identified and gathered 4.4 Obtain samples 4.5 Prepare samples 4.6 Cast cubes 4.7 Cure cubes 4.8 Test, obtain and record cubes, and results 4.9 Carry out and report analysis of test result	• Direct instruction • Field trips • Discussions • Demonstration by trainer • Practice by the trainee

10.3.5.2 Information Sheet No10/LO4 Perform Concrete Tests

Introduction to learning outcome

This learning outcome covers concrete tests, concrete testing tools, preparation of samples, cast cubes, cure cubes and testing and recording of test results and report analysis

Definition of key terms

Casting cubes: This is a process of placing concrete in cube molds and socking them in water for 7 to 28 days to allow them to gain strength before performing compression test.

Curing cubes: This is a process of socking concrete cubes in water for about 7 to 28 days before testing for compression using the compression testing machine at day 7,14 and 28 consecutively.

Compressive strength: It is the ability of a material to resist breaking when subjected to compression forces.

Slump test: It is the measure of consistence of fresh concrete.

Content/Procedures/Methods/Illustrations

4.1. Identify concrete tests (Compressive strength, Slump, Cleanliness, Particle size distribution) according to contract document

As discussed in other outcomes, concrete is a mixture of cement, fine aggregates, coarse aggregates and water. Different tests need to be performed on these elements before they can be used to make concrete. This ensures that the produced concrete is of high quality. These tests include:

- **Compression test**

Compression test is performed to determine the compressive strength of concrete, which is defined as load per unit area.

- **Slump test**

Slump test is used to measure the wetness of concrete. It is mainly done to confirm workability of concrete. A slump can be true slump, collapse and shear slump as shown below.

Figure 103: Slump test
Source: www.concrete.org.uk

- **Cleanliness**

Aggregates which make part of concrete can affect the properties of concrete if they have any organic matter such as clay. It is therefore important to test the cleanliness of aggregate to ensure it is safe for use.

- **Particle size distribution**

This is also referred to us gradation. It is a test that determines and report information on the size a range of aggregates representative of a larger sample of aggregates.

4.2 Obtain standard manuals and procedures in accordance with test requirement

Standard manuals and procedures are meant to guide the student on how to perform a specific test and attain desired results without a lot of struggles.

These Standard manuals include;

- Road Design Manual Part III Section 17: For concrete works tests.
- BS1881: Part 102:1983 – Slump test
- BS1881: Part 108:1983 - Making of Concrete Test Cubes
- BS1881: Part 116:1983 - Concrete Cube Strength

4.3 Identify and gather concrete testing tools and apparatus based on test requirements

Tools and apparatus are often used to conduct the test. They are parts that make up for the success of any practical.

Testing tools and apparatus for ***Slump concrete test*** include;

- A 300mm rule graduated on 5mm intervals
- spatula
- Slump mold of galvanized iron or steel
- tamping rod
- Sampling tray

Testing tools and apparatus for ***concrete cubes test*** include;

- Spatula
- Sampling tray
- Tamping rod or vibrating table
- Cube or spherical mold of galvanized iron or steel.
- Plasterer's steel float.

Testing tools and apparatus for ***concrete cube strength test*** include;

- Compression testing machine
- A weighing balance

4.4 Obtain samples as per test requirement and contract document

A **sample** is a presentation of a whole.

For different tests, samples are tested and the results represent a whole of the same make.

For example;

- Compression test and Slump test

Samples of cement and aggregates are used

- Cleanliness and particle size distribution

Samples of aggregates are used

4.5 Prepare samples according to standard test procedures

Methods for taking samples in concrete tests include;

i. When performing the slump test, the concrete sample should be taken from the labouratory mix 2 minutes after mixing and the slump determined instantly.
ii. In the event that the concrete is delivered to the site by a mixing truck, the concrete slump test sample should be collected from the initial discharge.
iii. In obtaining samples for the concrete cube test, a sample should be collected directly from the construction site and thoroughly mixed before it is placed in the mold
iv. Two test cube specimens should be prepared from each sample of fresh concrete.

4.6 Cast cubes as per standard test procedures

Standard test procedures vary. Below is a common procedure for casting cubes.

Procedure for cube casting;

- Take the concrete mortar and place it in a 150*150*150mm mould in 3 layers, ensuring that you compact using a tamping rod after every layer using 35 Nos of strokes
- Leave the cube for 24 hours and then remove it from the metal mould
- Do the above to make 2 more moulds and for each mould, test for compressive strength after 7 days and 28 days of soaking in water.

Once this procedure is completed, an analysis of the collected data is done.

4.7 Cure cubes as per standard test procedures

Curing is done when determining the compressive strength of concrete. It occurs when the cube is left in water for a number of days.

Curing of cubes can be attained in the following different ways;

- Ponding
- Sprinkling
- Wet coverings
- Membrane curing compounds
- Formwork

Depending on the test and specifications of the procedure manual, one of the above curing methods is adopted.

4.8 Test, obtain and record cubes, and results according to standard procedures

For every labouratory test, you will be needed to do the test in at least 3 samples. Once you get your sample and you have obtained the required cubes, you will need to record and label the samples such as Sample A, B… This will help you not to confuse your analysis. Remember that 1 or 2 sample tests are not adequate and could both be faulty at the same time, hence the need for a third test. Below is an example of a recording chart for most lab works.

Table 21: Recording Chart

SAMPLE	RESULTS
A1	3.2
A2	3.1

4.9 Carry out and report analysis of test result according to standard procedure and contract document

- Once the practical is concluded, you will be required to do your analysis. Analysis can be either graphical, calculations etc.
- A well-done analysis results to an accurate conclusion.
- For example, assuming the results gained above are true values, then, the average of the results is taken as the actual result. That is, (3.2+3.1)/2 hence 3.15 is the actual result for the sample

Conclusion

This learning outcome covered concrete tests, concrete testing tools, preparation of samples, cast cubes, cure cubes and testing and recording of test results and report analysis

Further Reading

Read further on concrete tests in the mentioned standard manuals.

10.3.5.3 Self-Assessment

Written Assessment

1. Concrete is made up of each of the following except?
    a) Cement
    b) Aggregates
    c) Lime
    d) Water
2. Which of the following is not an organic material?
    a) Clay
    b) Silt
    c) Aggregate
    d) Manure
3. Which of the following is true?

    Table 22: Concrete Curing Duration

CONCRETE CURING DURATION	STRENGTH
Day 1	99%
Day 14	50%
Day 28	14%

4. Which of the following is the odd one out?
    a) Gap graded
    b) Open graded
    c) Wide graded
    d) Uniformly graded
5. The following are ways of analyzing data. Which one is not?
    a) Graphically
    b) Mathematically
    c) Using calculations
    d) Observation
6. There are different types of concrete tests. Which one is not?
    a) Aggregate Crushing test
    b) Compression test
    c) Slump test
    d) Cleanliness test
7. Classify concrete and explain its preparation process.
8. Explain the curing process.
9. Summarize the slump test.
10. Differentiate casting and curing

11. Differentiate the different types of slump test

Essay questions

1. Explain the compression test.
2. Evaluate the preparation of concrete cubes.

Oral Assessment

1. Estimate the performance of concrete test
2. Distinguish the factors considered when conducting concrete test.

Oral Assessment

1. Classify the reasons why test are necessary.
2. Who is responsible for conducting tests in Kenya for actual projects?

Practical Assessment

What was your take on the results you got from the laboratory practical's?

10.3.5.4 Tools, Equipment, Supplies and Materials

- Computers
- Software
- Cameras
- Construction manuals
- Projectors
- Flip charts
- Calculators
- Rulers, pencils, erasers
- Charts with presentations of data
- Drawing sheets
- Internet
- Relevant videos

10.3.5.5 References

Duggal, S. (2008). Building materials. New Delhi: New Age International.
Rajput, R. (2000). Engineering materials. New Delhi: S. Chand & Company.

10.3.6 Learning Outcome No 5: Carry out Structural Steel Tests

10.3.6.1 Learning Activities

Learning Outcome No 5: Carry out Structural Steel Tests	
Learning Activities	**Special Instructions**
5.1 Obtain structural steel sample 5.2 Identify, obtain and calibrate tensile testing 5.3 Conduct test according to standard test procedures 5.4 Record and analyze results 5.5 Prepare and present report 5.6 Operate and maintain testing equipment	• Direct instruction • Field trips • Discussions • Demonstration by trainer • Practice by the trainee

10.3.6.2 Information Sheet No10/LO5 Carry out Structural Steel Tests

Introduction to learning outcome

This learning outcome covers structural designs, calibration tensile testing, recording and analysing results, preparation and presenting of report and operation and maintenance of testing equipment.

Definition of key terms

Tensile strength: It is the ability of a material to resist tension stresses/forces.

Structural designs: This is an investigation of structures rigidity and strength and subsequently giving provisions to the material standard to be used.

Calibrate tensile testing: This is the verification of the accuracy of the tensile testing machine to ensure that measurements are within the outlined tolerance and if not, they are adjusted.

Content/Procedures/Methods/Illustrations

5.1 Obtain structural steel sample based on structural designs

Procedure for Sampling Structural Steel

i. Ideally, requests for sampling structural steel normally come from the Design division. Therefore, the first step is to obtain copies of the plan of site, plan of the structure and structural steel details.
ii. Determine the location of the structure (I.e. Bridge) and its site limitations.
iii. Prepare proposed sample locations having in mind possible challenges that may arise with these locations such as water below the structure, heavy traffic, railway tracks etc.
iv. Obtain the structural steel samples from the proposed location or from locations advised by the Ministry of Transport. Ensure a sufficient number of samples are obtained to provide a good average for testing.
v. Samples are commonly taken from compression areas since steel has a good tensile strength compared to its compression ability.

Steel members include but are not limited to:

- H - sections
- I - sections
- T - sections

5.2 Identify, obtain and calibrate tensile testing as per test requirement and manufacturers manual

The following are reasons why Calibration is done for testing equipment;

- Statutory as provided for in relevant legislation
- Driven by event such as; damage of the equipment, new equipment, rental equipment.
- Driven by time events such as; heavily used equipment, un-used equipment for an extensive period of time, prescribed calibration schedules.

Factors to be considered when performing calibration for testing equipment;

- The person performing the calibration should be conversant with the calibration procedure for that particular piece of equipment.
- Equipment owner's manual should be reviewed with the respect to the procedure.
- The company policy should be reviewed and understood if available.
- All proper forms should be in hand and kept where easily available.

When to calibrate;

- In case of equipment damage.
- When equipment is subjected to shock.
- Equipment has been repaired.
- New equipment.
- Expiry of the stated time limit

5.3 Conduct test according to standard test procedures

Tests conducted for structural steel are as follows;

Charpy Impact Test – This is used to determine fracture toughness for structural steel. Steel samples are tested by immersing them in an oil bath at temperature above 40^0F for 24 hours. The steel samples are then placed into the Charpy machine to test for their fracture toughness.

Tensile Test – This is used to determine yield, ultimate load strengths, percentage elongation and percentage reduction of area.

The procedure for conducting the tensile test is as follows:

i. Prepare the steel sample and record it initial dimension.
ii. The tensile test machine is prepared.
iii. The prepared sample is gripped in an apparatus (tensile machine) and subjected to tensional force
iv. Record the time until the sample fractures.
v. The increase in length for the material is converted to strain while the pulling force (load) is converted to stress.
vi. The process is repeated for other samples with results being recorded.

Chemical Analysis: This is used to determine the presence of chemical elements and their percentages in steel. Chemical elements that are generally tested for include;

- Carbon
- Silicon
- Sulphur
- Phosphorous
- Manganese

The test results are then compared to the recommended ASTM standards.

5.4 Record and analyze results as per standard procedures

Recording results is basically the act of putting down obtained results from the practical while **analysis** is comparing the obtained results to the expected appropriate results by putting the results into a meaningful and well understood form that one can easily interpret. Recording and analyzing of data is done to ensure that correct conclusions are made concerning the tested sample. During testing activity, the one conducting the test is required to ensure that they have put down in writing all observations. It is necessary to note that different procedures require different recording and analysis techniques depending on the type of apparatus used. The analysis could be in terms of tables, charts, graphs or equations.

Below is an example of recorded data from the tensile test;-

Table 23: Data recording table

	Sample A	**Sample B**	**Sample C**
Maximum load	20kN	18kN	21kN
Initial length	30mm	30mm	30mm
Final length	42mm	41mm	43mm
Initial diameter	5mm	5mm	5mm
Final diaeter	3.8mm	3.6mm	4mm
Testing duration	100seconds	94seconds	102seconds

Analysis of tensile tests is normally done by the use of a graph as shown below:

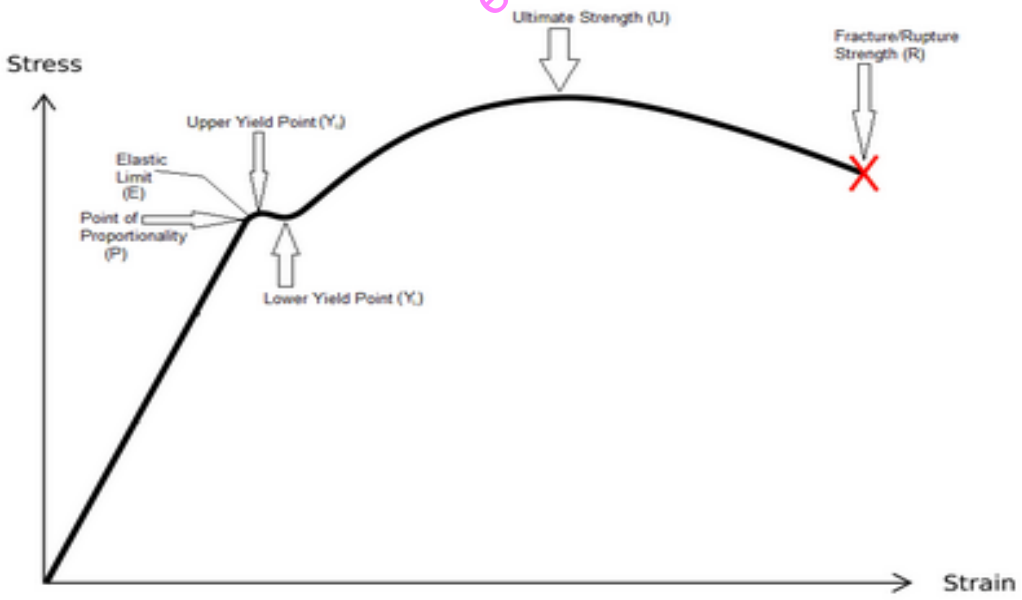

Figure 104: Analysis of tensile tests

Source: Strength of materials, 2010

5.5 Prepare and present report according to the contract document

At the end of the test, you will be required to prepare a report normally called a labouratory report. The format for preparing a report is as outlined below;

- **Introduction:** The introduction contains a brief description of the test that have already been done.
- **Literature review:** This section is meant to explain a small background regarding the tests being done.
- **Methodology:** Methodology is a section where one explains the procedures used. Note that in this case, procedures are in past tense.
- **Data collection and analysis:** This section contains data collection sheets as well as graphs and equations used into the analysis.
- **Conclusion and recommendations:** After completion of analysis, you will be required to draw a conclusion of the obtained data.
- **References:** This is a list of books that one referred to.

Conclusion

This learning outcome covered structural designs, calibration tensile testing, recording and analyzing results, preparation and presenting of report and operation and maintenance of testing equipment

Further Reading

Read further on structural steel tests from the recommended standard manuals

10.3.6.3 Self-Assessment

Written Assessment

1. Tensile testing is used to measure the following except?
    a) Yield strength
    b) Elongation
    c) Compressive strength
    d) Elastic modulus

2. Which metal is commonly used for construction?
    a) Aluminum
    b) Steel
    c) Iron
    d) Copper
3. A report should contain each of the following except?
    a) Body
    b) Introduction
    c) Conclusion
    d) Data collection and analysis
4. Poor maintenance could lead an equipment into?
    a) Crushing
    b) Underperforming and failure
    c) Cracking
    d) Over-performing
5. Where do we get procedures for practical's?
    a) Internet
    b) Labouratory technician
    c) Text books
    d) Our lecturer
6. Steel is strong in?
    a) Compression
    b) Tension
7. Classify structural design?
8. Distinguish tensile strengths.
9. Describe in your own words the following
    a) Elastic modulus
    b) Elongation
    c) Tensile strength
10. Design literature review of the report.
11. Analyze the maintenance procedures of the equipment.
12. Prepare a tensile test.
13. Summarize what is structural steel.

Oral Assessment

1. What is a structure?
2. Categorize the instances in which steel is not used in constructions.

Oral Assessment

1. Which companies are responsible for manufacturing steel?
2. Are there instances when steel is not used in construction? Elabourate.

Practical Assessment

What was your take home after conducting the tensile test practical? What are your recommendations and what should be improved?

10.3.6.4 Tools, Equipment, Supplies and Materials

- Computers
- Software
- Cameras
- Construction manuals
- Projectors
- Flip charts
- Calculators
- Rulers, pencils, erasers
- Charts with presentations of data
- Drawing sheets
- Internet
- Relevant videos

10.3.6.5 References

Rajput, R. (2000). Engineering materials. New Delhi: S. Chand & Company.
Duggal, S. (2008). Building materials. New Delhi: New Age International.
Rajput, R. (2000). Engineering materials. New Delhi: S. Chand & Company.

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10.3.7 Learning Outcome No 6: Perform Bitumen Tests

10.3.7.1 Learning Activities

Learning Outcome No 6: Perform Bitumen Tests	
Learning Activities	**Special Instructions**
6.1 Identify **Bitumen tests** 6.2 Obtain standard manuals and procedures 6.3 Identify and gather testing tools and apparatus 6.4 Obtain samples 6.5 Prepare samples 6.6 Conduct test 6.7 Record and analyze test results 6.8 Prepare and present report 6.9 Operate and maintain testing equipment	• Direct instruction • Field trips • Discussions • Demonstration by trainer • Practice by the trainee

10.3.7.2 Information Sheet No10/LO6 Perform Bitumen Tests

Introduction to learning outcome

This learning outcome covers bitumen tests, gathering of testing tools and equipment, obtaining of samples, conducting of test, recording and analyzing test results, preparation and presenting report and operation and maintenance testing of equipment.

Definition of key terms

Bitumen: It used as the surface layer during road construction.

Bitumen tests: These are the various tests used to determine the quality of bitumen.

Samples: These are small pieces taken from bitumen that are used for analysis.

Content/Procedures/Methods/Illustrations

6.1 Identify Bitumen tests according to contract document

The bitumen tests are used to test the various properties of bitumen and whether it is suitable for use during road construction. The following are the tests:

Penetration test: It calculates the hardness or softness of bitumen. It is done by determining the distance in which the penetration needle pierces through the bitumen sample at standard conditions.

Cleanliness: This is the removal of bitumen. It can be done using solvents that are able to dissolve it.

Viscosity test: This test measures the resistance to flow of bitumen. It helps in identifying the consistency of bitumen in different grades of bitumen and how they should be mixed to bring out the best.

Ductility test: Ductility is the ability of a material to straighten. In this case, this property is tested in bitumen. It is necessary to make sure that bitumen does not crack upon force being applied by traffic load.

Flash test: Hot bitumen emits hydrocarbon compounds that are flammable. This test determines the lowest temperatures at which this vapour catches fire temporary then puts itself out.

Fire test: This determines the lowest temperatures in which the hot bitumen catches fire and burns. It helps in coming up with suitable precautionary measures to avoid danger during heating of bitumen.

Float test: This test is used to determine steadiness of bitumen that other tests are unable to.

Loss on heating test: This test is carried out after bitumen has cooled off. A sample is weighed first then heated for some time. The sample specimen is weighed again and the loss is expressed as a percentage.

Specific gravity: The specific gravity of bitumen is the ratio of its weight to the weight of equal volume of water at 27° C. The specific gravity is measured using either pycnometer. The specific gravity of bitumen ranges from 0.97 to 1.02.

Softening point test: This tests the temperatures in which bitumen attains softening.

Spread rate test: This determines the rate at which bitumen spreads.

Importance of Bitumen Tests

- To determine the consistency of bitumen.
- To check its appropriate usage under different climatic conditions and various constructions
- To determine its elongation properties.

- To determine its ability to withstand extreme temperatures that is, very low and very high temperatures.
- To determine the mixing ratio of different bitumen grades.
- To determine its resistance to flow hence determine where to use it.

6.2 Obtain standard manuals and procedures in accordance with test requirement

The manual includes:

- Road design manual Part III: Materials and Pavement Design for new roads. It clearly states how the procedures should be followed for the testing of any material.

6.3 Identify and gather testing tools and apparatus based on test requirements

The testing apparatus for bitumen include:

- **Asphalt Ignition Oven** – for heating the bitumen
- **Cleveland Flash and Fire Point Apparatus** – conducts Flash and Fire test on bitumen
- **Ductility Testing Machine-** for conducting Ductility test
- **Float Test Apparatus** – for conducting Float test
- **Penetrometer** – for conducting Penetration test
- **Ring and Ball Apparatus** – for conducting softening point test on bitumen.
- **Viscometer** – for conducting viscosity test

6.4 Obtain samples as per test requirement and contract document

Process of obtaining the samples

i. Determine the location in which the samples are going to be collected.
ii. There are various places as to where bitumen can be found;
iii. Asphalt Mix plant where bitumen is processed.
iv. An ongoing road construction site.
v. Determine the sample size.
vi. Prepare the equipment you are going to use for collecting the sample such as scoop, shovel, sampling containers, dish containers etc
vii. Collect the samples and take them for testing. The process of collecting includes the following:
    - A shovel is used to collect the sample from the site and placed in sampling containers.
    - A scoop is used to collect a portion from the sampling containers until the right size is acquired.
    - The sample is placed in a dish container and then taken for testing preparations.

6.5 Prepare samples in accordance with test procedures

Process of preparing bitumen samples

(i) The sample is then heated in an oven until it is fluid-like.
(ii) It is then poured into a container.
(iii) The sample is then stirred to remove the air that is trapped within it.
(iv) The sample is allowed to cool under room temperature
(v) The sample is now ready to be conducted for other tests.

NB: Some tests may require water bath

6.6 Conduct test according to standard procedures and contract document

Process of conducting test

i. Obtain the right machinery for testing.
ii. Obtain the right conditions before commencement of any test eg. the temperature, air pressure, humidity etc. In case the conditions cannot be met, modify or use alternative ones.
iii. The machines should be examined for damage and should be dried and clean. A suitable bitumen solvent is used for cleaning the equipment.
iv. Connect the parts that need to be attached.
v. The sample is then placed for testing.
vi. Results are obtained and recorded.

6.7 Record and analyse test results according to standard procedures

The results should contain the following:

- The form and grade of bitumen tested
- The properties tested
- The testing procedures used according to the standard manual
- The results of the tests
- The SI units of the values.
- The range in which the values should lie that is, the minimum and maximum values

6.8 Prepare and present report as per contract document

The report should have:

- Name of the Labouratory that conducted the test
- The date, time, form, grade and quantity tested.
- The testing procedures used
- Test results
- Approval
- Signatory

Conclusion

This learning outcome covered bitumen tests, gathering of testing tools and equipment, obtaining of samples, conducting of test, recording and analyzing test results, preparation and presenting report and operation and maintenance testing of equipment.

Further Reading

Read through the various bitumen tests in detail.

10.3.7.3 Self-Assessment

Written Assessment

1. The prerequisite of any bitumen test is heating it until its fluid-like. Which of the following does not require heating?
    a) Bitumen emulsion
    b) refined bitumen
    c) Cut back
    d) Paving grade
2. Which grade of Bitumen is the softest?
    a) 30/40
    b) 60/70
    c) 80/100
    d) None
3. What should be the minimum distance between samples in a penetration test?
    a) 30mm
    b) 50mm
    c) 10mm
    d) 200mm
4. What is the significance of the following tests?
    a) Ductility
    b) Float test
    c) Flash and fire
5. Evaluate the standard conditions of bitumen before carrying out the tests?
6. Evaluate the properties of bitumen.
7. Classify the safety precautions that should be undertaken when collecting the samples?

Oral Assessment

1. Summarize the factors affecting each test?
2. Categorize bitumen.

Case study Assessment

Evaluate how bitumen is laid during road construction.

Oral Assessment

1. Select the precautionary measures when carrying out the bitumen test.
2. Distinguish the penetration grades in warmer and colder regions.

Practical Assessment

Prepare the penetration test for bitumen

10.3.7.4 Tools, Equipment, Supplies and Materials

- Computers
- Software
- Cameras
- Construction manuals
- Flip charts
- Calculators
- Rulers, pencils, erasers
- Charts with presentations of data
- Drawing sheets
- Internet
- Relevant videos

10.3.7.5 References

Road design manual Part III – Materials and Pavement Design for new roads. (2001). Pdf. Retrieved from http://kenha.co.ke

10.3.8 Learning Outcome No 7: Perform Timber Tests

10.3.8.1 Learning Activities

Learning Outcome No 7: Perform Timber Tests	
 **Learning Activities**	**Special Instructions**
7.1 Identify timber tests 7.2 Obtain standard manuals and procedures 7.3 Identify and gather testing tools and apparatus 7.4 Obtain samples 7.5 Prepare samples 7.6 Conduct test 7.7 Record and analyze test results 7.8 Prepare and present report 7.9 Operate and maintain testing equipment	• Direct instruction • Field trips • Discussions • Demonstration by trainer • Practice by the trainee

10.3.8.2 Information Sheet No10/LO7 Perform Timber Tests

Introduction to learning outcome

This learning outcome covers timber tests, gathering of testing tools and equipment, obtaining of samples, conducting of test, recording and analysing test results, obtaining of samples, conducting tests, preparation and presenting report and operation and maintenance testing of equipment.

Definition of key terms

Timber samples: These are small pieces of timber picked from the whole and are used for testing.

Samples: Small pieces of an object that is to be tested that are used to represent the whole.

Contract document: This is a document that contains details of an agreement between two or more parties.

Content/Procedures/Methods/Illustrations

7.1 Identify timber tests according to contract document

Timber that is free from defects should undergo these tests. The tests are used to determine its properties. These properties are elastic, strength and vibration properties. The tests include:

- **Compression test:** This test involves applying forces towards each other at the sides of a material. This may lead to the material crushing and so a universal test machine is used to determine the compression strength. It is basically, how long a material can take before it gets crushed.

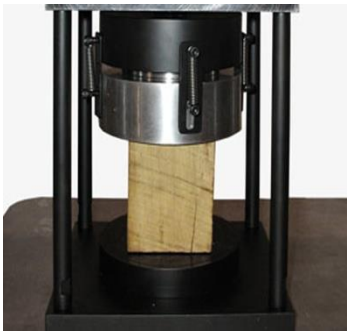

Figure 105: Compression test
Source from www.intron.us

- **Tension test:** Forces heading in opposite direction are applied at the sides of the material. The material will be pulled until it fractures.
- **Shear test:** forces are applied in a material such that part of the material slides in the opposite direction to the other.

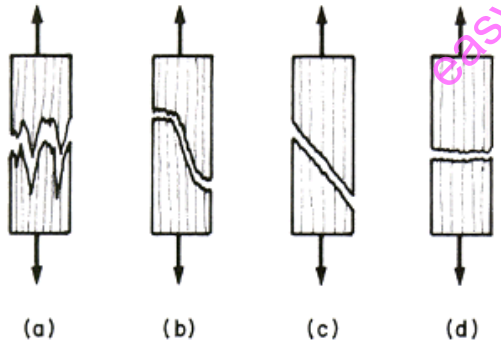

Figure 106: Examples of shear on timber
Source from classes.mst.edu

7.2 Obtain standard manuals and procedures in accordance with test requirement

The manuals used are:

- BS 5268-2:2002
- BS EN 380 which provide the testing requirements.

7.3 Identify and gather testing tools and apparatus based on test requirements

They include:

- Universal Test Machine – it carries out the various tests in timber
- Machete or power saw – for cutting the timber

- Measuring tape – for taking the measurements
- Marker – for putting marks on the samples

7.4 Obtain samples as per test requirement and contract document

Process for obtaining the samples

i. Where to obtain the samples
    - Safety precautions should be considered
    - The accessibility should be considered
    - Getting permit if necessary
ii. When to obtain the samples
    - Climatic conditions of the location
    - The season
iii. What type of specimen do you require- the maturity and species are considered?
iv. Method of sampling – mostly through cutting
v. Tools to be used

7.5 Prepare samples in accordance with test procedures

Process of sample preparation

i. The samples should be obtained from their members. They should have the following characteristics; they should be small, clear, straight-gained and free from defects.
ii. They should then be cut into the dimensions stated in the standards e.g. compression test samples should be 2" by 2" and 8" in length along the grain.
iii. Markings should be made to differentiate the e.g. sample no.1 from member 4.
iv. The specimen should then be conditioned to standardize its moisture content and then kept for testing.

NB: The samples should be cut carefully to ensure that the grain surfaces are parallel to each other.

7.6 Conduct test according to standard procedures and contract document

The procedure for conducting timber tests

i. A universal test machine is used and the standard test method is applied.
ii. The various tests are applied that is, compression, tension and shear tests and they are applied both perpendicularly and parallel to the sample grain.
iii. Results are taken and recorded.

The purpose of conducting the tests

- It is to determine the behaviour of timber when subjected to stain, stress and shear.
- To determine certain parameters such as elastic limit, ultimate compressive strength, elastic modulus, yield strength, ultimate tensile strength, elastic limit, yield strength etc.
- To determine the various kind of failure that may occur in timber.
- To determine the suitability of timber.

7.7 Record and analyse test results according to standard procedures

Procedure for recording and analysing test results

i. Calculations are carried out according to test procedures
ii. The test results should be recorded in a table form. The table should contain the following:
    - The source of the sample
    - The sample number
    - The type of test carried out
    - The testing procedures used
    - The results
    - The SI units of the values
    - The specifications if available
iii. Appropriate graphs are drawn
iv. Conclusions are stated

7.8 Prepare and present report as per contract document

The report should contain the following:

- Name of the Labouratory that conducted the test
- The subject
- The sample number
- Date and time of the test
- The testing procedures used
- Test results
- Approval
- Signatory

Conclusion

This learning outcome covered bitumen tests, gathering of testing tools and equipment, obtaining of samples, conducting of test, recording and analysing test results, preparation and presenting report and operation and maintenance testing of equipment.

Further Reading

Read on more tests that are carried out in timber
Describe the various properties of timber
Read more on the defects of timber and how they affect its quality.

10.3.8.3 Self-Assessment

Written Assessment

1. In timber, shearing action occurs;
    a) Across the grain
    b) Parallel to the grain
    c) Along the grain
    d) All of the above
2. What is the ratio of stress to strain in shear?
    a) Modulus of elasticity
    b) Young's modulus
    c) Modulus of rigidity
    d) Rolling shear
3. Which method is used to carry out shear test?
    a) Non-destructive testing
    b) Creep test
    c) Tensile test
    d) Torsion test
4. Using relevant diagrams describe a timber specimen.
5. Compare the force applied on timber grain.
6. Evaluate which are engineered timber and give examples.
7. Explain the compression test of timber.
8. Classify the errors eliminated during individual test results?
9. Categorize the method used in measuring the strength of timber.

Oral Assessment

1. Distinguish the crack formed in timber
2. Explain the results obtained from a compression test of timber.

Case Study Assessment

Compare the trees near your area and determine the strongest using observational skills.

Oral Assessment

1. Evaluate the significance of carrying out each of the timber tests.
2. Summarize the various failures visible in the trees and timber structures around your area.

Practical Assessment

Prepare the strength, compression and shear tests of both natural timber and engineered timber and compare the results.

10.3.8.4 Tools, Equipment, Supplies and Materials

- Computers
- Software
- Cameras
- Construction manuals
- Projectors
- Flip charts
- Calculators
- Rulers, pencils, erasers
- Charts with presentations of data
- Drawing sheets
- Internet
- Relevant videos

10.3.8.5 References

EAS. (2002). Timber – Sampling Methods and General Requirements for Physical and Mechanical Tests

Khokhar., A. (2009). Determination of Shear Strength of Timber Joists by Torsional Testing.

Standards Policy and Strategy Committee. (2002). British Standard 5286. (5th ed., pp. 151-154).