ROAD CONSTRUCTION AND MAINTENANCE

Level III

September, 2023 Curriculum Version - II

Module Title: Road Construction Material Sampling & Testing

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List of Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
BS/ EN	British Standards or European regulatory standard
CAPA	Corrective and Preventative Actions
COSHH	Control of Substances Hazardous to Health 2002
DMS	Document Management Systems
EN	European regulatory standard
EPE	Environmental Policy of Ethiopia
EIA	Environmental Impact Assessment
FAQs	Frequently Asked Questions
IS	International Standard
ISO	International Organization for Standardization
ISO	International Organization for Standardization
KN	kilo Newton
LIMS	Laboratory Information Management System
MSDS	Materials Safety Data Sheets
NCS	National Conservation Strategy
OHS	Occupational health and safety
PG	paving grades
PPE	Personal Protective Equipment
QR	Quick-Response
RFID	Radio Frequency Identification
RSI	Repetitive Strain Injury

SOPs	Standard Operating Procedures
UTS	Ultimate Tensile Strength

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Introduction

The Construction Material Sampling and Testing module is an enriching learning experience designed to equip students with a strong understanding of sampling and testing requirements specific to construction materials. It meticulously covers various facets such as sampling procedures, material testing techniques and methodical documentation practices, fostering a comprehensive knowledge base. The module encourages the development of critical practical skills, enabling the accurate execution of sampling and testing tasks in real-world scenarios. Simultaneously, it instils an attitude of diligence and precision, reinforcing the significance of every detail in the quality and safety of construction projects. With the trifecta of knowledge, skills, and attitude, this module aims to create well-rounded individuals in the field of construction material testing.

This module covers the units:

- Sampling &Testing requirements
- Sampling
- Material testing
- Documentation

Learning objectives of the Module

At the end of this session, the students will able to:

- Plan and prepare sampling and testing requirements
- Prepare and Take samples
- Conduct Material testing
- Record and Report test results & Documentation

Module Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Read the information written in the information Sheets
3. Accomplish the Self-checks
4. Perform Operation Sheets
5. Do the “LAP test

1 Unit One: Sampling & testing requirements

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Basic Concept of Sampling and Testing
- Work Instructions & Requirements
- Safety Requirement
- Tools & Equipment
- Construction Materials.
- Environmental Protection Requirement

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, the trainee will be able to:

- Define Basic Concept of Sampling and Testing
- Confirm and apply Work instructions material testing
- Obtain Safety requirements
- Operate tools and equipment.
- Use Construction materials
- Identify Environmental protection requirement

1.1 Basic Concept of Sampling and Testing

Sampling and testing in road construction is a process that involves collecting samples of various materials used in road construction and conducting tests to determine their quality, properties, and suitability for use in the construction project. The basic concept is to ensure that the materials meet the required specifications and standards for durability, strength, stability, and performance. The sampling process involves selecting representative samples from different sources such as quarries, stockpiles, or transport vehicles. These samples are collected at different stages of the project, starting from the source of materials to the construction site. The samples are usually collected using appropriate sampling methods, ensuring that they are representative and free from contamination.

Road construction material sampling and testing is to ensure that the materials used in the construction of a road meet the specified requirements and will perform as expected. This is done by taking samples of the materials and testing them to determine their properties and quality which vary depending on the type of material and the requirements of the project.

1.2 Work Instructions & Requirements

Work instructions are step-by-step guides or procedures that provide detailed information and instructions on how to perform a specific task or job. They outline the necessary steps, tools or materials required safety precautions, and quality standards to be followed during the execution of a particular task. Work instructions are often used in manufacturing, assembly lines, service industries, and other work environments to ensure consistency, efficiency, and compliance with standards and regulations.

Work Instructions for Sampling and Testing Requirements:

- Identify the specific requirements that need to be tested. Performance, functionality, safety, compliance, or any other relevant criteria.
- Determine the sampling method that will be used to select the items for testing. This could be a random sample, a stratified sample, or a targeted sample based on specific criteria.

- Develop a testing plan that specifies the procedures and criteria to be used during the testing process. What tools or equipment will be needed, and any specific instructions or guidelines for the testers.
- Communicate the testing plan to the relevant stakeholders, including the testing team, project managers, and other key personnel involved in the requirements development and implementation.
- Obtain the necessary resources and equipment for the testing process. Specific software, hardware, or other tools needed to properly assess the requirements.
- Begin the sampling and testing process according to the plan. This may involve collecting samples, conducting physical or virtual tests, or evaluating documentation or other evidence to determine if the requirements have been met.
- Record and document the results of each test. This should include detailed notes on any deviations or issues encountered during the testing process, as well as any recommendations or improvements that may be needed.
- Analyze the test results to determine if the requirements have been met or if further action is needed. This may involve comparing the test results to the specified criteria, conducting statistical analysis, or seeking input from other experts or stakeholders.
- Communicate the test results to the relevant stakeholders, including project managers, developers, and other key personnel. This should include a clear and concise summary of the findings, as well as any recommendations or actions that need to be taken.
- Follow up on any necessary actions or improvements identified during the testing process. This may include retesting certain requirements, making modifications to the requirements, or implementing changes to the development or implementation process.
- Finally, document and archive all testing documentation, including test plans, results, and any related correspondence or communication. This will ensure a thorough record of the sampling and testing process and provide a reference for future projects or audits.

Overall, the work instructions for sampling and testing requirements should emphasize thoroughness, accuracy, and consistency in order to ensure that the requirements are properly assessed and met.

1.3 Safety Requirement

Safety requirements refer to the specific measures, conditions, or actions that must be put in place or followed to ensure the safety and well-being of individuals, equipment, or the environment. These requirements are developed based on the potential risks or hazards associated with a particular activity, process, product, or system. Safety requirements are typically outlined in laws, regulations, standards, or guidelines and are intended to prevent accidents, injuries, or damage. They may include aspects such as training, protective equipment, proper handling procedures, maintenance, emergency response plans, and the implementation of safety controls and protocols.

1.3.1 Personal Protective Equipment

Personal Protective Equipment (PPE) refers to protective clothing, equipment, or gear that is used to minimize exposure to various hazards or risks in the workplace. PPE is designed to safeguard individuals from physical, chemical, biological, radiological, or other workplace hazards that may cause injury or illness. Examples of PPE include helmets, gloves, goggles, masks, face shields, earplugs, high-visibility clothing, respirators, safety harnesses, and safety footwear. The specific type of PPE required depends on the nature of the hazards present in the workplace. PPE is essential in industries such as construction, healthcare, manufacturing, and emergency response to protect workers and ensure their safety.

Equipment (PPE) is essential in laboratory safety.

Commonly required PPE in laboratories:

- Lab Coat or Apron: This is worn to protect clothing and skin from potential chemical splashes, spills, or contamination.

Figure 1-1Lab Coat or Apron

- Safety Goggles: These protect the eyes from chemical splashes, aerosols, and flying debris. They should have a snug fit and a wrap-around design for maximum protection.

Figure 1-2Safety Goggles

- Gloves: Different types of gloves are used depending on the task and the chemicals being handled. Examples include latex gloves, nitrile gloves, and neoprene gloves. Gloves provide hand protection against chemical exposure, cuts, and spills.

Figure 1-3Glove

- Face Shields: In addition to safety goggles, face shields are used to provide extra protection to the face, especially when dealing with potential explosions, high-heat sources, or hazardous substances.

Figure 1-4Face Shields

- Footwear: Closed-toe shoes are a requirement in laboratories to protect against potential spills, falling objects, or accidents. They should be sturdy and have non-slip soles.

Figure 1-5Footwear

- Respiratory Protection: Depending on the type of laboratory work and potential airborne contaminants, respiratory protection may be needed. This can include dust masks, particulate respirators, or respirators with chemical cartridges.

Figure 1-6Respiratory Protections

- Hearing Protection: In labs where loud noise is generated, such as with equipment or machinery, wearing earplugs or earmuffs may be necessary to prevent hearing damage.

Figure 1-7Hearing Protection

It is important to adhere to specific PPE requirements as outlined by the laboratory safety guidelines or regulations of the facility you are working in. Additionally, proper training on the use and maintenance of PPE is essential to ensure its effectiveness in protecting the individual.

1.3.2 Safety regulations

Safety regulations refer to specific rules and guidelines put in place to ensure the safety and well-being of individuals within a particular environment or industry. These regulations outline the minimum standards that must be met in order to prevent accidents, injuries, illnesses, or other dangers. Safety regulations can cover a wide range of areas, including workplace safety, transportation safety, product

safety, construction safety, food safety, and more. They are typically set by governments or regulatory bodies and may be legally enforceable, with penalties for non-compliance.

Figure 1-8Safety regulations

1.3.3 Hazards/risks

Hazards and risks refer to potential dangers or uncertainties that can cause harm, damage, or loss. They are commonly encountered in various settings, such as workplaces, public spaces, or even in everyday activities. Hazards are situations, substances, or events with the potential to cause harm, while risks are the likelihood or probability of encountering those hazards and the resulting impact or consequence. Assessing and managing hazards and risks is crucial to ensure safety and prevent accidents and negative outcomes.

There are numerous hazards and risks that exist in various aspects of life. Here are a few examples:

- Natural disasters: These include earthquakes, floods, hurricanes, wildfires, and tsunamis. They can cause significant damage to property, infrastructure, and human life.
- Workplace hazards: Depending on the nature of the job, workers can be exposed to various risks such as falls, chemical exposure, physical injuries, ergonomic issues, and workplace violence.
- Environmental hazards: Pollution, contamination of air, water, and soil, climate change, and loss of biodiversity pose threats to both human health and ecosystems.

- Health hazards: Infectious diseases, illnesses caused by environmental factors, foodborne diseases, and occupational illnesses are some examples of health risks.
- Technological risks: Industrial accidents, nuclear accidents, transportation accidents, and cyber-attacks are technological hazards that can result in significant harm to people and the environment.
- Social and economic risks: Poverty, unemployment, social inequality, economic recessions, and geopolitical conflicts can lead to social unrest, unrest, and pose risks to the stability and well-being of societies.

It's important to note that this is not an exhaustive list, and the specific hazards and risks can vary based on geography, industry, and individual circumstances.

Figure 1-9Hazards/risks

1.3.4 Occupational Health and Safety (OHS) procedures

Occupational health and safety (OHS) procedures are processes and protocols put in place to ensure the welfare, safety, and well-being of employees in the workplace. These procedures are designed to prevent accidents, injuries, and health hazards, and comply with local laws and regulations.

Some common OHS procedures include:

- Risk assessments: Identifying and evaluating potential hazards in the workplace to determine the level of risk and develop appropriate control measures.

- Hazard identification and control: Regular inspections and assessments of the workplace to identify potential hazards, followed by implementing measures to control those hazards or eliminate them altogether.
- Personal protective equipment (PPE): Ensuring employees have access to suitable protective equipment like gloves, goggles, helmets, and masks to minimize their exposure to workplace hazards.
- Emergency preparedness: Developing and implementing emergency response plans, including evacuation procedures, employee training, and the availability of emergency equipment and supplies.
- Incident reporting and investigation: Establishing procedures for reporting workplace incidents, accidents, and injuries, followed by conducting thorough investigations to determine the root cause and prevent future occurrences.
- Health and wellness programs: Promoting employee health and well-being through initiatives such as health screenings, mental health support, ergonomic assessments, and workplace wellness activities.
- Training and education: Providing OHS training to employees at all levels, ensuring they are aware of potential hazards, emergency procedures, and safe work practices.
- Workplace hygiene: Establishing procedures for cleanliness, waste management, proper ventilation, and maintenance of facilities to minimize health risks associated with poor hygiene.
- Compliance with legal requirements: Ensuring the workplace meets all relevant OHS laws, regulations, and standards set by government authorities and industry bodies.
- Continuous improvement: Regularly reviewing and updating OHS procedures to reflect changing workplace conditions, technological advancements, and lessons learned from incidents or accidents.

Implementing and adhering to OHS procedures not only benefits the employees by providing a safe and healthy working environment, but it also helps businesses reduce costs associated with accidents, injuries, and legal liabilities.

1.3.5 Contingency measures

Contingency measures refer to plans and actions implemented in response to a potential or actual crisis, emergency, or unexpected event. They are pre-determined strategies meant to minimize the negative impact of the situation and ensure business continuity. Contingency measures can include various steps such as implementing backup systems, creating alternative supply chains, establishing communication protocols, training staff for emergency situations, and developing risk management plans. These measures are intended to mitigate potential risks and ensure that organizations can effectively respond to and recover from unforeseen events.

Contingency measures in sampling and testing requirements refer to the actions or plans put in place to address any unforeseen issues or challenges that may arise during sampling and testing processes. These measures are essential to ensure the accuracy, reliability, and validity of the sample or test results even in adverse or unexpected circumstances

Common contingency measures:

- Duplicate sampling: This involves taking additional samples to serve as backups in case the primary samples are compromised or invalidated.
- Multiple testing methods: Using more than one testing method or technique to cross-validate the results and minimize the risk of errors or biases.
- Quality control measures: Establishing quality control protocols such as the use of control samples, regular calibration, and verification of equipment to ensure consistent and reliable results.
- Replicate testing: Performing multiple tests on the same sample or conducting independent testing by different laboratories to assess the reproducibility and reliability of results.
- Process validation: Validating the sampling and testing processes to ensure they are capable of producing accurate and representative results, especially in complex or critical situations.
- Documentation and traceability: Maintaining comprehensive records of each sampling and testing activity, including the identification of individuals involved, equipment used, and any deviations from standard protocols.

- Contingency plans for equipment failure: Having backup equipment readily available or having alternative laboratories identified to conduct the necessary tests if the primary equipment fails or cannot be used.
- Statistical analysis: Using statistical techniques to identify and flag any unusual patterns or results that may indicate errors or anomalies in the sampling and testing process.
- Regular training and competency assessments: Ensuring that personnel involved in sampling and testing receive adequate training and are regularly assessed for their competency to minimize errors and improve accuracy.
- Continuous improvement: Regularly reviewing and improving the sampling and testing processes based on lessons learned from past experiences and feedback from stakeholders. Implementing these contingency measures, organizations can minimize the potential impact of unexpected events or challenges on the sampling and testing process, enhancing the overall reliability and integrity of the results obtained.

1.4 Environmental Protection Requirement

Environmental protection requirements are regulations that are designed to protect the environment from pollution and other harmful effects. They can be set by national governments, state governments, or local governments. The requirements can vary depending on the type of environmental hazard, the location, and the activities that are being regulated.

Common environmental protection requirements:

Air pollution regulations: These regulations control the emission of pollutants into the air, such as greenhouse gases, smog, and particulate matter.

Water pollution regulations: These regulations control the discharge of pollutants into water bodies, such as rivers, lakes, and oceans.

Waste disposal regulations: These regulations control the disposal of waste, such as hazardous waste, municipal waste, and construction and demolition waste.

Noise pollution regulations: These regulations control the level of noise that is allowed in certain areas, such as residential areas and schools.

Land use regulations: These regulations control the development of land, such as the construction of buildings and roads.

Environmental protection requirements are important because they help to protect human health and the environment. They can also help to conserve natural resources and prevent climate change.

The Clean Air Act: This law regulates air pollution from factories, power plants, and other sources.

The Clean Water Act: This law regulates water pollution from factories, sewage treatment plants, and other sources.

The Resource Conservation and Recovery Act (RCRA): This law regulates the disposal of hazardous waste.

The Toxic Substances Control Act (TSCA): This law regulates the production and use of chemicals.

The Endangered Species Act: This law protects endangered and threatened species and their habitats.

Environmental protection requirements in Ethiopia

The Environmental Impact Assessment Proclamation (No. 299 of 2002): This proclamation requires all major development projects to undergo an environmental impact assessment (EIA) before they can be implemented. The EIA process is designed to identify and assess the potential environmental impacts of the project and to develop mitigation measures to minimize these impacts.

The Environmental Pollution Control Proclamation (No. 300 of 2002): This proclamation regulates the emission of pollutants into the air, water, and soil. It also regulates the disposal of hazardous waste.

The Solid Waste Management Proclamation (No. 301 of 2002): This proclamation regulates the collection, transportation, and disposal of solid waste.

The Noise Pollution Control Proclamation (No. 302 of 2002): This proclamation regulates the level of noise that is allowed in certain areas.

The Environmental Protection Organs Establishment Proclamation (No. 295 of 2002): This proclamation establishes the Environmental Protection Authority (EPA), which is responsible for implementing the environmental protection laws and regulations in Ethiopia.

The environmental protection requirements in Ethiopia are enforced by the EPA and other government agencies. Individuals and businesses that violate these requirements can be subject to fines and other penalties.

The Ethiopian government is committed to protecting the environment. The environmental protection requirements in place are an important part of this commitment. By enforcing these requirements, the government is working to ensure a clean and healthy environment for all Ethiopians.

The National Conservation Strategy (NCS): This strategy outlines the government's vision for environmental conservation in Ethiopia. It identifies a number of priority areas for conservation, including forests, wetlands, and wildlife.

The Environmental Policy of Ethiopia (EPE): This policy sets out the government's principles and goals for environmental protection. It emphasizes the need for sustainable development and the participation of all stakeholders in environmental protection.

The Environmental Impact Assessment (EIA) Guidelines: These guidelines provide detailed procedures for conducting an EIA. They are designed to ensure that EIAs are conducted in a consistent and transparent manner.

1.5 Wastes and environmental impacts

Regulations on Construction and Material Handling

Materials storage

Safe and efficient storage of materials depends on good communication and collaboration among all involved including clients, contractors, suppliers and tradesmen. The arrangements for storage of materials should be discussed on all projects and agreed by contractors and the client. Larger notifiable projects should have material storage arrangements included in the Construction phase plan.

Designated storage areas

Segregated pedestrian routes that should be kept clean and without materials obstructing the access routes that could cause a slips or trips.

Flammable materials stored away from other materials

If materials are to be stored on height, it is necessary to put a guard rails so people don’t fall when stacking or collecting the materials.

Keep the amount of materials on site to a minimum by planning the deliveries.

Lifting and manual handling

Incorrect manual handling is one of the most common causes of work-related injury. Bad posture when lifting or carrying heavy material can cause musculoskeletal disorders (MSDs). Therefore, the risks from manual handling should be carefully considered into a risk assessment. Manual Handling Operations Regulations 1992 provides guidance on how to avoid, assess and reduce the risk of injury from manual handling.

Control of Substances Hazardous to Health 2002 (COSHH)

Many processes in the construction industry involve the use of substances which could be harmful to health. COSHH Regs 2002 state that employers must prevent or reduce employees' exposure to substances, such as chemicals, fumes, dusts and etc. There are wide varieties of situations in which employees could be exposed to substances that are harmful to their health. For example, concrete is one of the highly hazardous materials because it could be harmful for the interior and the exterior of humans. Contact with the concrete without the relevant Personal Protective Equipment (PPE) can cause dermatitis and skin problems or if the worker breaths in the cement dust, he/she can caught a respiratory disease and damage their lungs. That's why it is important to use the necessary PPE for the relevant job. The main PPE consists of safety boots, safety clothing, gloves, glasses and mask. Every substance that is harmful in any manner will have a COSHH label on it as part of the regulation and will express exactly what it is.

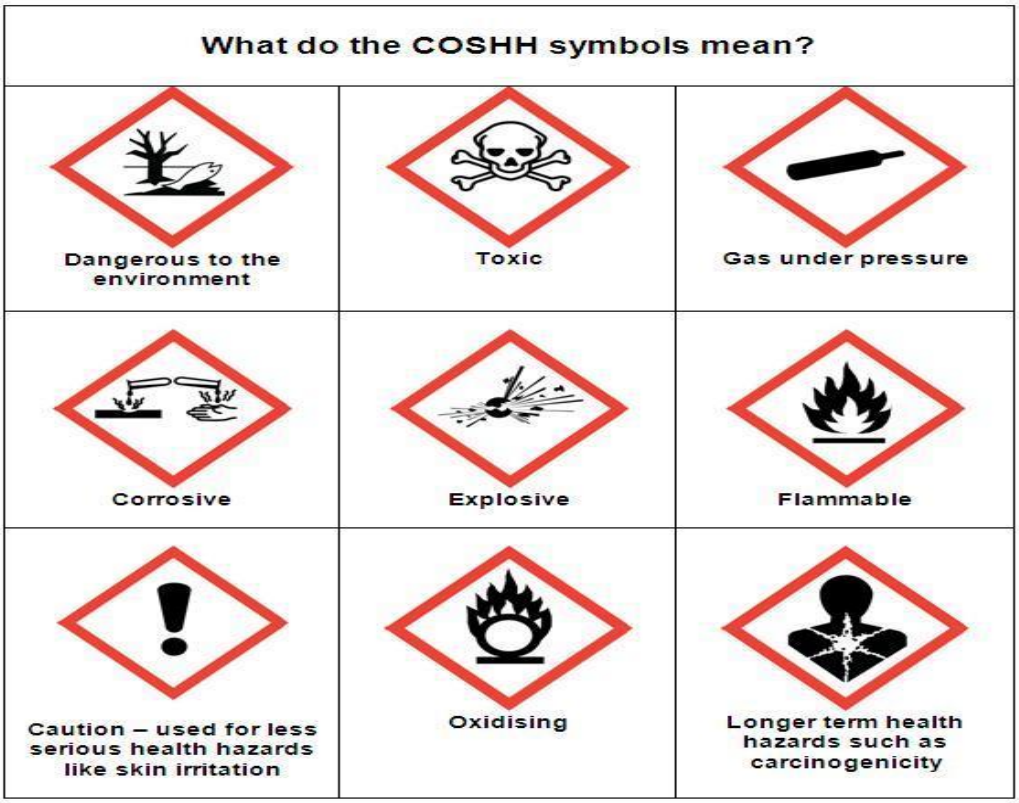


Figure 1-10COSHH labels (RospaTraining, 2013)

Working in confined spaces

The biggest danger of working in the confined spaces is that those are restricted to natural ventilation. Most common confined spaces in construction are basements and under-floor spaces. When working in confined spaces emergency arrangements in event of an accident should always be considered. As well as, risk assessment for the people who will have to enter the confined space should a rescue be required and available personnel who are trained to remove unconscious operatives from the confined space. The relevant regulation that apply to this type of works is Confined Spaces Regulations 1997.

Working at Height Regulations 2005

The purpose of these regulations is to control the large number of fatalities that are caused by a fall from height. These Regulations apply to employers who contract others to work at height and they must ensure that the work is properly planned and carried out by trained people. This involves providing the workers with the right type of equipment for working at height. There are many other factors that need to be considered when working at height, including:

Weather conditions

Check if the place is safe before the work commences

Ensure that materials are stored safely and there is no risk of materials falling and injure somebody

Plan for emergencies and evacuation

Material Environmental profiling and lifecycle assessment

The Environmental Profiles Methodology is a method for defining and assessing the environmental effects of construction materials during their lifecycle from cradle-to-grave. All the stages of its life from extraction to disposal and focuses on the four main processes:

- ISO 14040 and 14044 – extraction of the material
- ISO 14025 – processing
- EN 15804 – how the material will be material used
- EN 15978 – where the material will be used and how it will be disposed.

The safe disposal of hazardous materials and other laboratory wastes is an important environmental protection requirement. Hazardous materials can pollute the air, water, and soil, and they can also pose a health risk to people and animals.

It is important to follow the proper procedures for the safe disposal of hazardous materials. This will help to protect the environment and human health.

The Federal Democratic Republic of Ethiopia has a number of environmental protection requirements in place. These requirements are designed to protect the environment from pollution and other harmful effects.

Environmental impacts of hazardous waste:

- Air pollution: Hazardous waste can release harmful pollutants into the air, such as dioxins, furans, and heavy metals. These pollutants can cause respiratory problems, cancer, and other health problems.
- Water pollution: Hazardous waste can contaminate groundwater and surface water, which can harm aquatic life and drinking water supplies.
- Soil pollution: Hazardous waste can contaminate soil, which can make it unsafe for growing food or building homes.
- Human health problems: Hazardous waste can cause a variety of health problems, including cancer, respiratory problems, and birth defects.
- Ecosystem damage: Hazardous waste can damage ecosystems, such as forests and wetlands.

The safe disposal of hazardous materials is an important part of environmental protection. By following the proper procedures, we can help to prevent the harmful environmental impacts of hazardous waste.

1.5.1 Safe disposal of hazardous materials and other laboratory wastes. Storage and Disposal

Samples that remain after testing will be sealed and stored in the designated storage area for at least 30 days (or a time period specified by the client) after the test report is published. The storage area will be such that contamination or damage to the test samples

Will not occur. Further storage or transfer of samples can be made at the client's expense upon written request.

Where items must be stored under specific environmental conditions, these Conditions Shall be maintained and monitored.

Always follow the manufacturer's instructions for the safe disposal of hazardous materials.

- Never mix hazardous materials together.
- Dispose of hazardous materials in the appropriate container.
- Label all containers of hazardous materials clearly.
- Store hazardous materials in a safe place.
- Notify the proper authorities if you have a spill or leak of hazardous materials.

1.6 Construction materials.

Construction materials are materials that are used to build and construct roads, structures, and infrastructure. The choice of construction materials depends on factors such as the type of project, location, durability, cost, and the specific requirements of the construction project.

These materials can be natural or man-made and can include a wide range of products such as selected material, borrow material, natural gravel, crushed aggregate, bitumen, rock, sand, cement, reinforcement bar and water.

Selected material

Selected material refers to a specific type of material that is chosen or handpicked for a particular purpose or application. It means that the material has been carefully selected or curated from a larger range of options based on its specific qualities, characteristics, or suitability for a given task or requirement. The selection process typically involves evaluating various factors such as durability, strength, weight, cost, aesthetics, and functionality. Selected materials are often chosen for their superior properties or unique features that make them well-suited for a specific use or project.

Borrow material

Borrow material refers to a material that is sourced from outside the construction site and is temporarily used as a substitute for the required construction material. It is typically used when the desired material is not readily available on site or when a construction project requires additional material. Borrow material is usually obtained from nearby sources such as quarries or excavation sites. This material is tested to ensure that it meets the required specifications and standards before it is used in the construction process.

All fill materials, structural backfill and topsoil obtained from locations on or off the jobsite. Borrow materials shall be free from sod, stumps, logs, debris, waste, contamination and perishable/deleterious matter.

Natural gravel: This is a type of aggregate that is made up of small, rounded rocks. Natural gravel is often used in concrete, asphalt, and other construction materials.

Crushed aggregate: is a type of aggregate that is made up of crushed rocks. Crushed aggregate is often used in concrete and asphalt because it is stronger than natural gravel.

Bitumen: is a sticky, black material that is made from petroleum. Bitumen is used to bind together aggregate materials in asphalt and other construction materials.

Rock: any naturally occurring solid mass. Rock can be used in construction in a variety of ways, such as for foundations, walls, and roofs.

Sand: a loose, granular material that is made up of small, smooth particles. Sand is often used in concrete, mortar, and other construction materials.

Cement: is a powdery material that is used to bind together aggregate materials in concrete. Cement is made from limestone, clay, and other minerals.

Reinforcement bar: A type of steel bar that is used to strengthen concrete. Reinforcement bars are often used in concrete beams and columns.

Water: is essential for many construction processes, such as mixing concrete and mortar. Water also helps to cure concrete and make it stronger

1.7 Sampling & Testing, Tools & Equipment

Sampling and testing is a process of collecting a representative sample or subset from a larger population or group in order to make inferences or draw conclusions about the whole population. It is commonly used in various fields such as research, quality control, and manufacturing for assessing the characteristics or properties of a given sample. Tools and equipment play a crucial role in the

sampling and testing process as they enable the collection, analysis, and evaluation of samples. The specific tools and equipment used can vary depending on the type of sampling and testing required.

Commonly used tools and equipment in sampling and testing:

- Sample Collecting Tools: These include items like sampling bottles, tubes, bags, scoops used to collect different types of samples, such as liquids, gases, solids, or biological samples.
- Analytical Instruments: are used to analyze and measure the properties or characteristics of samples.
- Sampling Pumps: Used to collect air samples, these devices allow for the determination of airborne pollutants or contaminants.
- Testing Kits: pre-packaged sets of tools and reagents to perform specific tests, such as water quality testing kits.
- Temperature and Humidity Monitoring Equipment: Used to measure and monitor temperature and humidity during the sampling and testing process, ensuring accurate and reliable results.

General Equipment

laboratory equipment and accessories that are used for general purposes and are suitable to perform properly different measuring procedures of liquids and solids, weighing, temperature, containers, still, pH, chemicals, reagents etc.

- Scoop

It is a utensil/tool resembling a spoon, with a short handle and a deep bowl/dish, used for removing dry or semi-solid substances from a container.

Figure 1-11scoop tool

- Spatula

A spatula is a small implement with a broad, flat, flexible blade used to mix, spread and lift material including mortar, paste, foods, drugs, plaster and paints.

Figure 1-12spatula tools

- Oven dry

It used to dry wet or immersed material samples with the required temperature.

Figure 1-13 oven dray soil test equipment

- Balance

It used to measure the weight of the sample. There are different types of balance such as digital,

Figure 1-14sampling tools

Table 1-1Sampling tool

	Type	Purpose
Chisel		chisel is a tool with a characteristically shaped cutting edge of blade on its end, for carving or cutting a hard material such as wood, stone, or metal by hand, struck with a mallet,
Pick axe		The digger out purposes like excavation work and for agricultures.
Shovel		Shovel is used to stir the mortar paste soils prepare in the barrel or drums and keeps the mix to right and uniform consistency.
Auger		An auger is a type of giant corkscrew that uses a metal bit to drill holes. Hand augers have been around for centuries; they are used to drill holes in soil, wood, ice and other materials. Augers are useful because they are light, do not vibrate and are easy to control

1.7.1 Sample Containers and Bags

Protecting samples from spillage, moisture, dust, and contaminants during collection and transport to the lab is an integral part of materials testing.

Using the right containers, lids and closures allows for easy handling and storage of samples collected and helps preserve the integrity of the sample to be tested. Sample Containers are available in a variety of sizes, materials, and closure accessories Sample Buckets

Figure 1-15Metal Sample Containers

Figure 1-16Plastic Sample Containers

Figure 1-17Tin Sample Cans

Self-check: Written Test

Test-I choose

Instruction: Select the correct answer for the give choice. You have given 1 Minute for each question. Each question carries 2 Point.

1. Which of the following is NOT a hazard or risk?

A. A natural disaster
C.A health hazard
B.A workplace hazard
D.A technological hazard

2. Which of the following is NOT an example of an occupational health and safety (OHS) procedure?

A. Risk assessments
C. Personal protective equipment (PPE)
B. Hazard identification and control
D. Health and wellness programs

3. Which of the following is NOT a contingency measure in sampling and testing requirements?

A. Duplicate sampling
C. Quality control measures
B. Multiple testing methods
D. Process validation

4. Which of the following is NOT a common quality control measure?

A. Use of control samples
C. Consistent and reliable results
B. Regular calibration and verification of equipment
D. Independent testing by different laboratories

5. Which of the following is NOT a common contingency plan for equipment failure?

A. Having backup equipment readily available
C. Minimizing errors and improving accuracy
B. Having alternative laboratories identified to conduct the necessary tests
D. Identifying and flagging any unusual patterns or results

6. Which of the following is NOT a step in the work instructions for sampling and testing requirements?

A. Identify the specific requirements that need to be tested.
C. Communicate the testing plan to the relevant stakeholders.
B. Determine the sampling method that will be used to select the items for testing.
D. Obtain the necessary resources and equipment for the testing process.

7. Which of the following is NOT a type of personal protective equipment (PPE) that is commonly required in laboratories?

A. Lab coat or apron
C. Gloves
B. Safety goggles
D. Face shield

8. Which of the following is NOT a potential hazard in a laboratory?

A. Chemical splashes
C. Flying debris
B. Aerosols
D. Loud noise

9. Which of the following is the most important factor to consider when choosing PPE?

A. The nature of the hazard
C. The comfort of the PPE
B. The type of work being done
D. The cost of the PPE

10. Which of the following is NOT a good practice when using PPE?

A. Wearing the PPE properly
C. Replacing the PPE when it is damaged or expired
B. Inspecting the PPE regularly for damage
D. Cleaning the PPE after each use

True or false questions

1. Personal protective equipment (PPE) is not required in all laboratories.
2. Lab coats are the only type of PPE required in laboratories.
3. Contingency measures are only necessary for emergency situations.
4. Duplicate sampling is a quality control measure, not a contingency measure.

Fill in the blank Space

1. The specific type of _____ required in a laboratory depends on the nature of the hazards present in the workplace.
2. In addition to safety goggles, _____ are used to provide extra protection to the face, especially when dealing with potential explosions, high-heat sources, or hazardous substances.
3. One of the common contingency measures in sampling and testing is _____.
4. One of the common quality control measures is _____.

2 Unit Two: Sample preparation and testing

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Basic concept of sample preparation and testing
- Containers and Sampling Tools
- Procedures for Taking Samples
- Handling, Labeling, and Storing Samples
- Physical Separation of Samples
- Chemical Separation of Samples
- Transport Media for Samples
- Monitoring and Controlling Sample Conditions
- Distribution of Samples

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Define Basic concept of sample preparation and testing
- Obtain Containers and Sampling Tools
- Take Samples
- Hand, Label, and Store Samples
- Perform Physical Separation of Samples
- Perform Chemical Separation of Samples
- Place appropriate Transport Media for Samples
- Monitor and Control Sample Conditions
- Distribute of Samples.

2.1 Basic concept of sample preparation and testing

2.1.1 Sample Preparation:

Before conducting tests on road construction materials, proper sample preparation is necessary to ensure accurate and representative results. The following steps should be followed during sample preparation:

A. Collection of Samples:

Samples should be collected from various locations within the construction site to account for any variations in material properties.

B. Sample Reduction:

In some cases, the collected samples may be too large for testing purposes. Sample reduction techniques, such as quartering or splitting, are employed to obtain a representative portion for testing. This process involves dividing the sample into smaller, manageable sizes while maintaining the overall characteristics of the original sample.

C. Sample Homogenization:

Homogenization is the process of thoroughly mixing the sample to ensure uniformity.

D. Sample Drying:

Moisture content can significantly affect the properties of road construction materials. Therefore, samples are often dried to a specific moisture content before testing. Sample

2.1.2 Testing:

Samples are properly prepared, a range of tests is conducted to evaluate the quality and performance of road construction materials.

The specific tests depend on the type of material being tested, but some common tests include:

A. Gradation Analysis: This test determines the particle size distribution of aggregates, such as sand, gravel, or crushed stone. It helps assess the suitability of the material for specific applications, such as base or surface courses.

Figure 2-1Gradation Analysis test

A. **Compaction Test:** Compaction tests, such as the Proctor test, evaluate the ability of soil or aggregate materials to be compacted to a desired density. These tests are crucial for determining the optimum moisture content and maximum dry density for compaction during road construction.

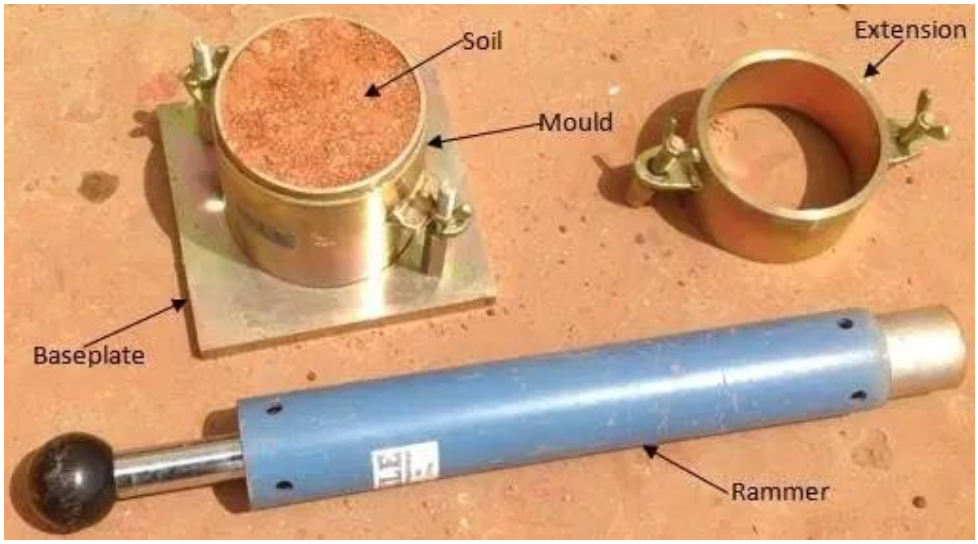


Figure 2-2Compaction Test

B. Marshall Stability Test: The Marshall Stability test is conducted on asphalt mixtures to assess their resistance to deformation and cracking under traffic loads. It helps determine the optimum asphalt content and design parameters for asphalt pavement construction.

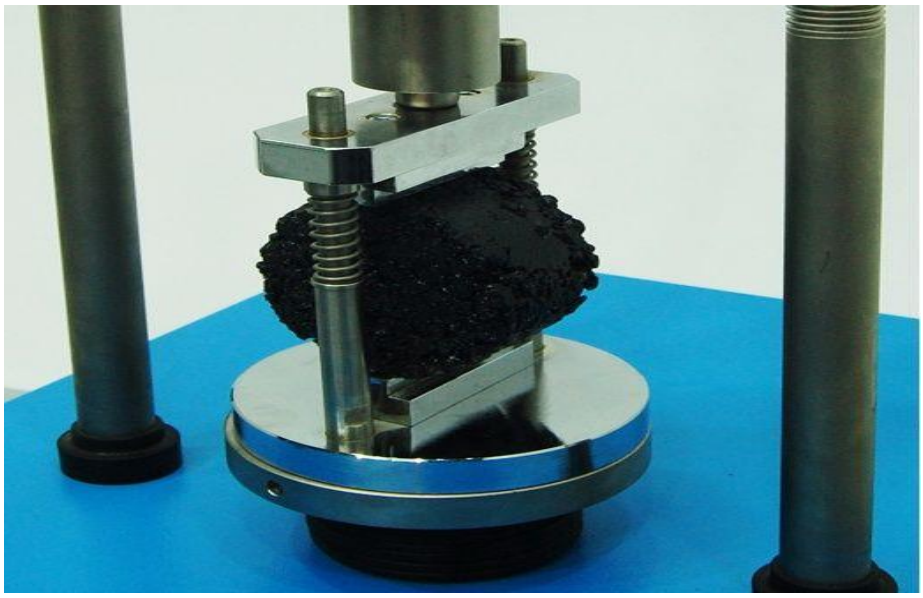


Figure 2-3Marshall Stability Test

C. Concrete Compressive Strength Test: This test measures the compressive strength of concrete samples to ensure they meet the required strength specifications. It is a vital parameter for assessing the durability and load-bearing capacity of concrete structures in road construction.

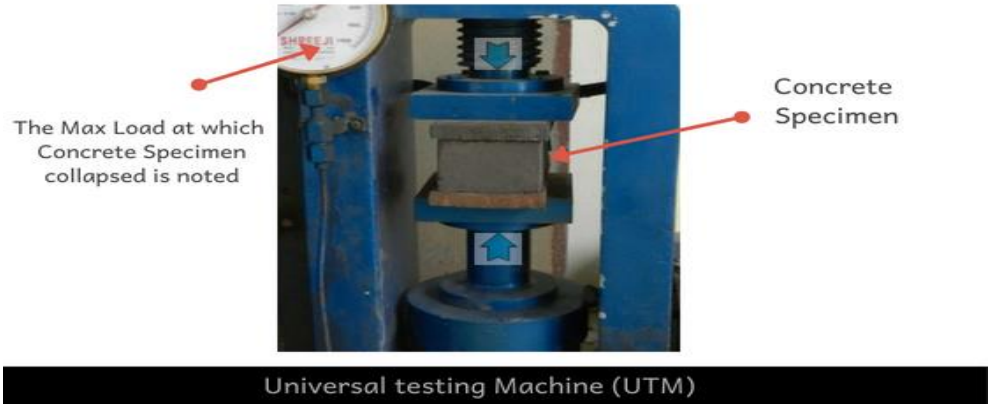


Figure 2-4Concrete Compressive Strength Test

D. **Tensile Test:** This is a mechanical test performed on a material to determine its reaction to forces applied from opposing directions. By stretching the material under examination, it measures the maximum tensile strength, yield strength, and elongation a material can withstand before failure or fracture.

Figure 2-5Tensile Test:

E. **Ductility Test:** This is a test that measures a material's ability to deform and elongate before it fractures under high tensile stress.

Figure 2-6Ductility Test:

F. Penetration Test of Bitumen: This is a test that measures the hardness or softness of bitumen by determining the depth in tenths of a millimeter to which a standard needle will penetrate vertically, under specified conditions of load, time, and temperature.

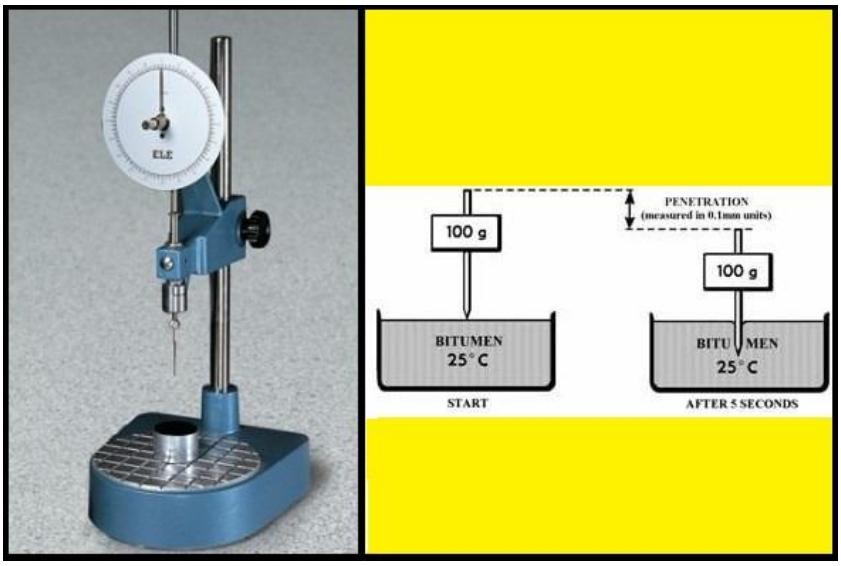


Figure 2-7Penetration Test of Bitumen

G. Viscosity Test of Bitumen: This test assesses the viscosity, or thickness, of bituminous materials. It gives information regarding the temperature dependence of flow, providing a measure of the ease at which the bitumen can be mixed, spread, and compacted.

Figure 2-8Viscosity Test of Bitumen

2.2 Containers and Sampling Tools

Obtaining suitable containers and sampling tools is a critical aspect of road construction material sampling and testing. By using clean containers and tools, selecting appropriate options based on approved procedures and standards, and ensuring their freedom from contaminants, the integrity and accuracy of the collected samples can be maintained. The selection of containers and tools should be based on the specific characteristics of the materials being sampled, and regular inspection and quality control checks should be conducted to ensure their reliability. By following these practices, road construction projects can ensure the quality and performance of the constructed roads.

2.2.1 Importance of Using Clean Containers and Tools:

A. Maintaining sample integrity:

Using clean containers and tools is essential to prevent contamination of the samples. Contaminants such as dust, dirt, moisture, or residues from previous samples can alter the properties of the collected materials, leading to inaccurate test results. Clean containers and tools help ensure that the collected samples represent the true characteristics of the road construction materials being tested.

B. Avoiding cross-contamination:

Cross-contamination can occur when samples from different locations or materials are mixed unintentionally. This can compromise the accuracy and reliability of the test results. By using clean containers and tools, the risk of cross-contamination is minimized, ensuring that each sample is representative of its specific location or material.

2.2.2 Selection of Appropriate Containers and Tools:

A. Approved procedures and standards:

The selection of containers and tools should be based on approved procedures and standards, such as those outlined by relevant regulatory bodies or industry organizations. These guidelines provide specific recommendations regarding the types of containers and tools suitable for different sampling scenarios, ensuring consistency and accuracy in the testing process.

B. Consideration of sample characteristics:

The choice of containers and tools should also take into account the characteristics of the road construction materials being sampled. For example, cohesive soils may require specific containers,

such as Shelby tubes, to maintain sample integrity during extraction. Similarly, granular materials may require sample boxes or bags that can accommodate larger volumes.

2.2.3 Ensuring Containers and Tools are Free from Contaminants:

A. Cleaning and maintenance:

Containers and tools should be thoroughly cleaned and maintained to remove any potential contaminants. This involves regular washing, drying, and disinfecting of the containers and tools to eliminate any residues that may affect subsequent samples. Proper storage and handling practices should also be followed to prevent contamination during transportation or storage.

B. Inspection and quality control:

Regular inspection and quality control checks should be conducted to ensure that containers and tools are free from defects or damages that may compromise sample integrity. This includes checking for cracks, leaks, or signs of wear and tear that could introduce contaminants or affect the accuracy of the sampling process.

Commonly Used Containers and Tools:

1. **Sample bag:**

Sample bags are commonly used for collecting small-sized samples of road construction materials. They are made of durable, tear-resistant materials such as polyethylene and are available in various sizes to accommodate different sample volumes.

Figure 2-9Sample bag:

2. **Shelby tube:**

Shelby tubes are cylindrical sampling tubes made of stainless steel or plastic. They are used for collecting undisturbed soil samples, particularly cohesive soils, to preserve their natural structure and moisture content.

Figure 2-10Shelby tubes

3. **Plastic jar:**

Plastic jars with airtight lids are suitable for collecting liquid or fine-grained samples.They provide a secure and leak-proof container for transporting and storing samples that may be susceptible to moisture loss or contamination.

Figure 2-11Plastic jar:

4. Sample box:

Sample boxes are commonly used for collecting larger-sized samples, such as aggregates or asphalt mixtures. They are made of rigid materials, such as wood or plastic, and are designed to withstand the weight and volume of the collected materials.

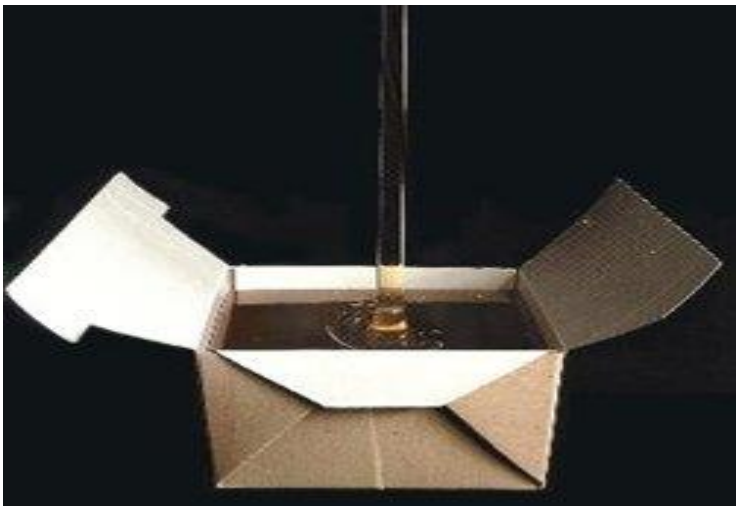


Figure 2-12Sample box:

5. Spade, pick, chisel, and auger:

These tools are used for extracting samples from the ground or breaking down larger materials for sampling purposes. They should be made of durable materials, such as hardened steel, to ensure their effectiveness and longevity.

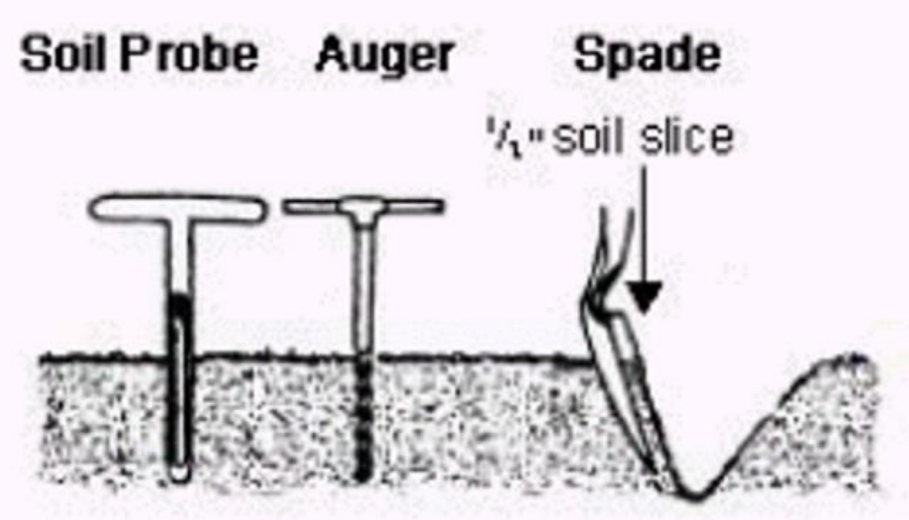


Figure 2-13Spade, pick, chisel, and auger

2.3 Taking Samples

Road construction projects require careful sampling and testing of materials to ensure the quality and durability of the infrastructure. This focus on the importance of following approved procedures and job instructions, adhering to sampling methods specified by relevant standards, and employing proper techniques for sample collection to ensure representative samples.

2.3.1 Approved Procedures and Job Instructions:

A. **Compliance with approved procedures** is crucial to maintain consistency and accuracy in sample collection and testing. These procedures are developed based on industry best practices and are designed to ensure reliable results.

B. **Job instructions** provide specific guidelines for sampling and testing in a particular project. They take into account site-specific conditions, project requirements, and safety considerations. Following these instructions is essential to ensure that the collected samples accurately represent the materials being tested.

2.3.2 Adhering to Sampling Methods Specified by Relevant Standards:

A. **Relevant standards**, such as those set by the American Society for Testing and Materials (ASTM) or the International Organization for Standardization (ISO), provide detailed

guidelines for sampling road construction materials. These standards ensure consistency and comparability of results across different projects and laboratories.

B. **Adhering to the specified sampling methods** ensures that the collected samples are representative of the entire material batch. This is crucial to obtain accurate test results that reflect the quality and characteristics of the material being used in the construction.

i. Techniques for Sample Collection

A. **Random sampling** is a widely accepted technique for collecting representative samples. It involves selecting samples from different locations within the material batch to account for potential variations.

B. **The use of appropriate sampling tools**, such as core drills, augers, or sampling tubes, is essential to collect samples without altering their composition or introducing contaminants.

C. **Proper sample handling and storage** are crucial to prevent sample degradation or contamination. Samples should be properly labeled, sealed, and stored in appropriate containers to maintain their integrity until testing.

2.4 Handling, Labeling, and Storage of Samples

Proper handling, labeling, and storage of samples are essential for accurate and reliable road construction material sampling and testing. Adhering to approved procedures and job instructions ensures consistency and comparability of results. Accurate sample labeling helps prevent confusion or misidentification, while proper storage conditions maintain sample integrity and prevent degradation. By following these practices, the quality and characteristics of road construction materials can be accurately assessed, leading to informed decision-making and the construction of durable and safe infrastructure.

2.4.1 Importance of Proper Handling, Labeling, and Storage:

A. **Proper handling ensures that samples** are not contaminated or altered during the collection, transportation, and testing processes. Contamination can lead to inaccurate test results and compromise the quality assessment of road construction materials.

B. **Accurate labeling of samples** allows for easy identification and traceability throughout the testing process. It helps prevent confusion, misidentification, and potential mix-ups that could compromise the reliability of the results.

Figure 2-14labeling

C. **Proper storage conditions** are crucial to maintain the integrity of the samples. Inadequate storage can lead to sample degradation, alteration of properties, or loss of moisture content, all of which can affect the accuracy of subsequent testing.

2.4.2 Approved Procedures and Job Instructions for Sample Handling:

A. Approved procedures and job instructions provide specific guidelines for the proper handling of samples. These guidelines take into account industry best practices, safety considerations, and project-specific requirements.

B. Adherence to approved procedures ensures consistency and accuracy in sample handling across different projects and laboratories. It helps maintain the reliability and comparability of test results, allowing for meaningful analysis and decision-making.

2.4.3 Ensuring Samples are Labeled Accurately to Avoid Confusion or Misidentification:

A. Accurate labeling of samples includes providing essential information such as sample identification number, location of collection, date and time of collection, and any relevant project-specific details.

B. Properly labeled samples allow for easy tracking and identification throughout the testing process. This ensures that the samples are correctly associated with the corresponding test results, minimizing the potential for errors or mix-ups.

2.4.4 Proper Storage Conditions to Maintain Sample Integrity and Prevent Degradation:

A. Samples should be stored in appropriate containers that protect them from external factors such as moisture, temperature fluctuations, sunlight, and contaminants.

B. Storage containers should be sealed tightly to prevent sample exposure to air, which can lead to moisture loss or gain and alter the material's properties.

C. Samples should be stored in designated areas that are clean, well-organized, and free from potential sources of contamination or damage.

D. It is important to follow specific storage requirements outlined in approved procedures and job instructions to ensure the integrity and stability of the samples until testing.

2.5 Physical Separation of Samples

Physical separation of samples is a critical step in road construction material sampling and testing. It allows for the creation of representative and homogeneous sub-samples, which are essential for accurate and reliable test results. Techniques such as quartering, coning and quartering, and riffling are commonly used for sample separation. Proper labeling and documentation of sub-samples, including unique identifiers and relevant information, are crucial for maintaining traceability and ensuring accurate interpretation of test results.

2.5.1 Understanding the need for physical separation of samples

In the field of road construction material sampling and testing, physical separation of samples is a crucial step in the sample preparation process. It involves dividing the collected sample into smaller portions, known as sub-samples, for further testing or analysis. The primary purpose of physical separation is to ensure representative and homogeneous sub-samples, which are essential for accurate and reliable test results. Physical separation is necessary because road construction materials, such as aggregates, asphalt, or concrete, often exhibit variations in their composition and properties. These variations can occur due to factors like particle size distribution, moisture content, or the presence of contaminants. By separating the sample into smaller portions, we can minimize the impact of these variations and obtain more precise and meaningful test results.

2.5.2 Techniques for separating samples

Several techniques are commonly employed for the physical separation of samples in road construction material testing. These techniques include:

A. **Quartering: Quartering** is a widely used method for dividing bulk samples into smaller portions. In this technique, the sample is spread out on a clean, flat surface, and then divided into four equal quadrants using a dividing tool, such as a shovel or a sample splitter. Two opposite quadrants are discarded, and the remaining two are combined and mixed thoroughly to obtain a representative sub-sample.

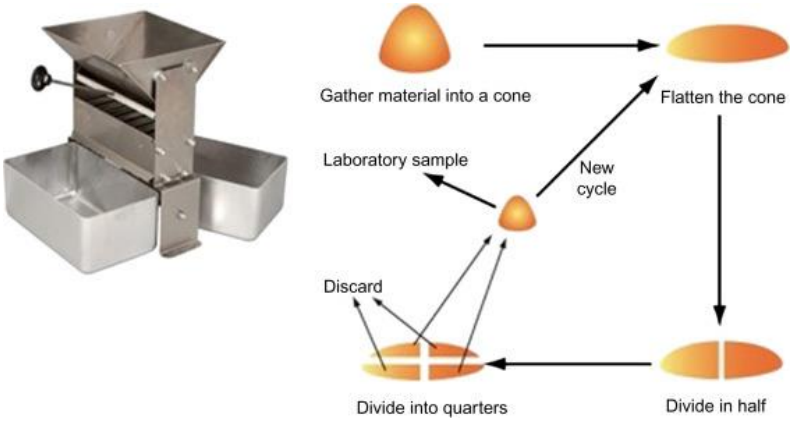


Figure 2-15Quartering: Quartering

B. **Coning and Quartering:** Coning and quartering is a variation of the quartering method, primarily used for cohesive materials like soils or fine aggregates. In this technique, the sample is shaped into a cone and then divided into four equal quadrants using a sample splitter. Similar to the quartering method, two opposite quadrants are discarded, and the remaining two are combined and mixed to obtain a representative sub-sample.

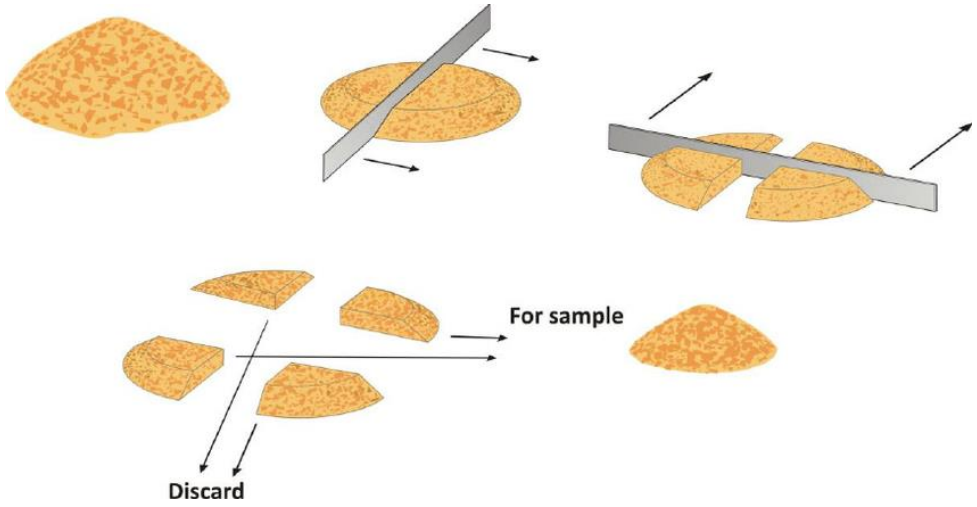


Figure 2-16Coning and Quartering

C. **Riffling:** Riffling is a technique commonly used for dividing fine-grained materials, such as sands or powders. It involves the use of a riffle box, which consists of a series of chutes or compartments with slots of decreasing size. The sample is poured into the riffle box, and by shaking or tapping the box, the material is distributed into the compartments. The material from one or more compartments is then combined and mixed to obtain a representative sub-sample.

Figure 2-17Riffling

2.5.3 Proper labeling and documentation of sub-samples

Proper labeling and documentation of sub-samples are essential to maintain traceability and ensure accurate interpretation of test results. When separating samples into smaller portions, it is crucial to label each sub-sample with unique identifiers, such as sample numbers or codes, to avoid confusion or misinterpretation. The labels should be clearly written or printed on durable tags or labels that can withstand the testing process. In addition to labeling, it is important to document relevant information about each sub-sample, such as the date and time of sampling, location, depth or elevation, and any specific conditions or observations. This information should be recorded in a standardized format, such as a laboratory notebook or a digital database, to facilitate data management and retrieval. Furthermore, it is recommended to maintain a chain of custody record, which documents the transfer of samples from one person or location to another. This record helps ensure the integrity and accountability of the samples throughout the testing process.

2.6 Chemical Separation of Samples

2.6.1 Importance of chemical separation in certain testing procedures

Chemical separation plays a crucial role in various testing procedures within road construction material sampling and testing. It involves the separation of different components or phases of a sample to facilitate accurate and precise analysis. This process is particularly important when dealing with complex mixtures or when specific constituents need to be isolated for further analysis. One of the key reasons for chemical separation is to eliminate interferences that may affect the accuracy of test results. For instance, in the determination of aggregate gradation, chemical separation is essential to remove fine particles and organic matter that can distort the results. By isolating the desired components, chemical separation ensures that the subsequent testing procedures are focused on the specific properties of interest. Moreover, chemical separation allows for the identification and quantification of individual components within a mixture. This is especially relevant in tests such as asphalt extraction, where the separation of asphalt binder from the aggregate is necessary to determine the binder content accurately. By isolating the components, chemical separation enables precise measurements and analysis, leading to more reliable results.

2.6.2 Approved procedures for chemical separation

To ensure the accuracy and reliability of the separation process, it is crucial to follow approved procedures. These procedures are established by recognized standards organizations such as the American Society for Testing and Materials (ASTM) or the American Association of State Highway and Transportation Officials (AASHTO). When conducting chemical separation, it is essential to refer to the specific test method or standard relevant to the material being analyzed. These standards provide detailed instructions on the required equipment, reagents, and techniques for separation. They also outline the necessary precautions and safety measures to be taken during the process. By adhering to approved procedures, one can ensure consistency and comparability of results across different laboratories and testing facilities. Following standardized protocols also helps to minimize errors and uncertainties associated with the separation process, thus enhancing the overall quality of the testing procedure.

2.6.3 Ensuring accuracy and precision in the separation process

Chemical separation of samples of construction materials is a process of isolating the different components of a material using chemical means. This can be done for a variety of purposes, such as to identify the components of the material, to characterize their properties, or to recover valuable materials.

There are many different chemical separation methods that can be used for construction materials. Most common methods :

A. **Extraction:** This method involves dissolving the components of the material in a solvent and then separating the solvent from the dissolved components. This method is used to extract valuable materials from construction materials, such as metals from ores or oils from shale.
B. **Chromatography:** This method separates the components of a mixture by their different affinities for a stationary phase and a mobile phase. This method is used to identify and quantify the different components of construction materials, such as pollutants in concrete or the resins in composites.

C. **Distillation:** This method separates the components of a liquid mixture by their different boiling points. This method is used to separate the different components of construction materials, such as water from solvents or gasoline from crude oil.
D. **Crystallization:** This method separates the components of a solution by their different solubility's. This method is used to produce pure crystals of construction materials, such as gypsum or cement.
E. **Adsorption:** This method separates the components of a mixture by their different affinities for a solid surface. Adsorption: This method is used to remove contaminants from construction materials, such as lead from paint or asbestos from insulation.

The choice of chemical separation method will depend on the specific material being separated and the desired outcome.

To achieve accurate and precise results during the chemical separation process, several factors need to be considered. These include the selection of appropriate separation techniques, the use of high-quality reagents, and the implementation of proper quality control measures. Firstly, the choice of separation technique depends on the nature of the sample and the specific components to be isolated. Common techniques used in chemical separation include filtration, precipitation, distillation, extraction, and chromatography. Each technique has its advantages and limitations, and the selection should be based on the specific requirements of the test method. Secondly, the quality of reagents used in the separation process is crucial. Impure or contaminated reagents can introduce errors and affect the accuracy of the results. It is essential to use reagents that meet the required purity standards and to properly store and handle them to prevent degradation or contamination. Lastly, implementing quality control measures throughout the separation process is vital. This includes regularly calibrating and verifying the performance of equipment, conducting blank tests to assess potential contamination, and running replicate samples to evaluate the precision of the separation method. By monitoring and controlling these factors, one can ensure the accuracy and precision of the separation process.

2.7 Placing Samples in Transport Media

In the field of road construction material sampling and testing, it is crucial to ensure that samples are properly transported to the laboratory for accurate analysis. The importance of using appropriate

transport media, identifying suitable options based on sample characteristics and testing requirements, and ensuring proper packaging and labeling for transportation.

2.7.1 Appropriate Transport Media:

A. Significance of Appropriate Transport Media:

Transport media play a vital role in preserving the integrity of the samples during transportation. They provide a protective environment that prevents contamination, degradation, or alteration of the samples. Proper transport media also help maintain the physical and chemical properties of the samples, ensuring accurate and reliable test results.

B. Factors Influencing the Choice of Transport Media:

1. **Sample Characteristics**: Different road construction materials have varying properties, such as moisture content, particle size, and reactivity. These characteristics must be considered when selecting the appropriate transport media. For example, cohesive materials like clay may require airtight containers to prevent moisture loss, while granular materials may require breathable packaging to avoid moisture accumulation.
2. Testing Requirements: The specific tests to be conducted on the samples also influence the choice of transport media. Some tests require samples to be transported in a specific condition, such as maintaining a certain temperature or preventing exposure to light. It is essential to consult the testing standards or laboratory guidelines to ensure compliance with the requirements.

2.7.2 Identifying Suitable Transport Media:

A. Commonly Used Transport Media:

1. **Airtight Containers:** Airtight containers, such as sealed plastic bags or jars, are suitable for samples that require protection from moisture, air, or volatile substances. These containers prevent sample contamination and maintain the sample's original moisture content and chemical composition.
2. **Breathable Packaging:** Breathable packaging, such as paper bags or cloth sacks, is suitable for samples that need to maintain their moisture content or allow for moisture evaporation. This type of packaging is commonly used for granular materials like aggregates or soils.

3. **Liquid Transport Media:** Liquid transport media, such as water or specific chemical solutions, are used for transporting samples that require immersion or preservation in a liquid state. This method is commonly employed for asphalt binder samples or samples requiring specific chemical treatments.

B. Selection Criteria:

When choosing the appropriate transport media, consider the following factors:

- Compatibility with the sample type and testing requirements.
- Ability to maintain sample integrity during transportation.
- Compliance with laboratory guidelines or testing standards.
- Availability and cost-effectiveness of the transport media.

2.7.3 Proper Packaging and Labeling for Transportation:

A. Packaging Guidelines:

- Use clean and uncontaminated packaging materials to prevent cross-contamination.
- Ensure the packaging is of sufficient strength to withstand transportation conditions without sample damage.
- Seal the packaging securely to prevent leakage or loss of sample material. 4. Consider using secondary packaging, such as boxes or coolers, to provide additional protection during transportation.

B. Labeling Requirements:

- Clearly label each sample container with essential information, including sample identification number, date, location, and any specific testing requirements.
- Attach a chain of custody form to track the sample's movement from collection to analysis, ensuring accountability and traceability.

2.8 Monitoring and Controlling Sample Conditions

In the field of road construction material sampling and testing, maintaining the integrity of samples is crucial to ensure accurate and reliable test results. This focuses on the importance of monitoring and controlling sample conditions, techniques for preserving sample integrity before, during, and after processing, and implementing measures to prevent contamination or degradation of samples.

2.8.1 Importance of Monitoring and Controlling Sample Conditions:

A. Ensuring Representative Results: Monitoring and controlling sample conditions are essential to obtain representative results that reflect the true characteristics of the road construction materials. Any deviation in sample conditions can lead to inaccurate test results, which can have significant implications for project design, construction, and performance.

B. Compliance with Testing Standards: Monitoring and controlling sample conditions are necessary to comply with testing standards and guidelines. These standards outline specific requirements for sample handling, storage, and processing to ensure consistency and comparability of test results across different laboratories and projects.

2.8.2 Techniques for Maintaining Sample Integrity:

A. Pre-Processing Stage:

1. Proper Sample Collection:

Ensure that samples are collected using appropriate sampling techniques to obtain representative samples that accurately reflect the material's characteristics. Follow established guidelines, such as ASTM D75-19, for aggregate sampling, or AASHTO T2-91 for soil sampling, to ensure consistency and reliability.

2. Sample Identification and Labeling:

Assign unique identification numbers or codes to each sample and label them clearly with relevant information, such as location, date, and sample type. This helps in maintaining sample traceability and prevents mix-ups or confusion during processing and testing.

B. During Processing and Testing:

1. Temperature and Humidity Control:

Maintain suitable temperature and humidity conditions during sample processing and testing, especially for materials sensitive to moisture or temperature variations. Adhere to specific testing standards, such as ASTM D3665-16 for bituminous materials, which may require controlled environmental conditions.

2. Avoiding Cross-Contamination:

Take precautions to prevent cross-contamination between samples during processing and testing. Clean and sanitize equipment, tools, and containers between samples to eliminate any residual material that could influence subsequent test results.

C. Post-Processing Stage:

1. Proper Storage:

Store samples in appropriate conditions to maintain their integrity until testing is complete. Follow recommended storage guidelines, such as storing aggregates in a dry and covered area or storing asphalt binder samples in a temperature-controlled environment.

2. Sample Retention:

Retain a portion of each sample after testing, as per laboratory or project requirements. This allows for future verification or additional testing if needed.

2.8.3 Implementing Measures to Prevent Contamination or Degradation:

A. Sample Handling:

Handle samples with care to avoid physical damage or alteration of their properties. Use appropriate tools and equipment to minimize the risk of contamination or degradation during transportation, processing, and testing.

B. Contamination Prevention:

1. Clean Work Environment:

Maintain a clean and organized work area to minimize the risk of contamination. Regularly clean surfaces, equipment, and tools to remove any potential contaminants.

2. Personal Protective Equipment (PPE):

Wear appropriate PPE, such as gloves, lab coats, or masks, when handling samples to prevent contamination from external sources, such as skin oils or airborne particles.

C. Storage and Packaging:

1. Proper Packaging:

Package samples in suitable containers or bags that provide adequate protection against contamination, moisture, or physical damage during storage and transportation. Refer to relevant standards, such as ASTM D3665-16, for specific packaging requirements.

2. **Labeling and Documentation:**

Clearly label each sample container with relevant information, including sample identification, date, and any specific storage requirements. Maintain proper documentation, including chain of custody forms, to track the sample's movement and ensure accountability.

2.9 Distribution of Samples

This discuss various strategies for efficient sample distribution, including grouping samples based on testing requirements, maintaining sample integrity during distribution, distributing request forms, and verifying sample receipt by laboratory personnel.

A. Grouping Samples Requiring Similar Testing Requirements:

One effective strategy for efficient sample distribution is to group samples that require similar testing requirements. This grouping can be based on factors such as material type, location, or project phase. By doing so, laboratories can streamline their testing processes and optimize the use of resources. For example, samples of asphalt mixtures can be grouped separately from soil samples, allowing technicians to focus on specific testing protocols for each material type.

B. Distributing Samples while Maintaining Sample Integrity:

Maintaining sample integrity is crucial during distribution to ensure accurate and reliable test results. To achieve this, it is essential to handle samples with care and prevent any contamination or damage. Proper packaging and labeling of samples are vital to maintain their integrity during transportation. Additionally, using appropriate containers and following standardized protocols for sample handling can minimize the risk of sample degradation or alteration.

C. Distributing Request Forms for Data Entry or Filing:

Efficient sample distribution also involves distributing request forms for data entry or filing in accordance with enterprise procedures. These forms contain essential information about the samples, such as project details, sample identification numbers, and testing requirements. By distributing

request forms along with the samples, laboratory personnel can ensure that all necessary information is readily available for data entry or filing. This practice helps streamline the administrative process and reduces the chances of errors or delays in sample processing.

D. Checking Sample and Request Form Receipt by Laboratory Personnel:

To maintain accountability and track the progress of sample testing, it is crucial to check that samples and relevant request forms have been received by laboratory personnel. This step ensures that samples are not lost or misplaced during the distribution process. Laboratory personnel should have a system in place to record the receipt of each sample and cross-reference it with the corresponding request form. This practice helps identify any discrepancies or missing samples promptly, allowing for timely resolution and preventing delays in testing.

SELF CHEEK

1. What is the purpose of sample reduction in road construction material testing?

A. To increase the sample size for testing purposes
B. To divide the sample into smaller, manageable sizes while maintaining its overall characteristics
C. To mix the sample thoroughly to ensure uniformity
D. To dry the sample to a specific moisture content before testing

2. Which test determines the particle size distribution of aggregates in road construction materials?

A. Tensile test
B. Ductility test
C. Gradation analysis
D. Compaction test

3. What is the purpose of the Marshall Stability test in road construction?

A. To measure the compressive strength of concrete samples
B. To assess the resistance of asphalt mixtures to deformation and cracking
C. To determine the optimum moisture content and maximum dry density for compaction
D. To measure the hardness or softness of bitumen

4. What does the tensile test measure in road construction materials?

A. The compressive strength of the material
B. The resistance of the material to deformation and cracking
C. The maximum tensile strength, yield strength, and elongation of the material
D. The ability of the material to deform and elongate before fracturing

5. Why is using clean containers and tools important in road construction material sampling?

A. To maintain sample integrity and prevent contamination
B. To ensure accurate test results
C. To minimize the risk of cross-contamination
D. All of the above

6. What is the primary purpose of accurate sample labeling in road construction material testing?

A. To prevent contamination during the collection and testing processes
C. To maintain the integrity and stability of samples during storage

B. To ensure easy identification and traceability of samples
D. All of the above

7. Why is physical separation of samples important in road construction material testing?

A. It allows for the creation of representative and homogeneous sub-samples
C. It ensures accurate and reliable test results
B. It helps minimize variations in composition and properties of the materials
D. All of the above

8. Which technique is commonly used for dividing bulk samples into smaller portions?

A. Quartering
C. Riffling
B. Coning and quartering
D. All of the above

9. What is the purpose of chemical separation in road construction material testing?

A. To eliminate interferences that may affect test results
C. To ensure accurate measurements and analysis
B. To isolate specific components for further analysis
D All of the above

10. Why is it important to follow approved procedures for chemical separation?

A. To ensure consistency and comparability of results across different laboratories
C. To enhance the overall quality of the testing procedure
B. To minimize errors and uncertainties in the separation process
D. All of the above

11. What is the purpose of appropriate transport media in sample transportation?

A. To prevent contamination and degradation of samples
C. To ensure accurate and reliable test results
B. To maintain the physical and chemical properties of samples
D. All of the above

12. Which factor(s) influence the choice of transport media?

A. Sample characteristics
C. Both a and b
B. Testing requirements
D. None of the above

13. Which type of transport media is suitable for samples that require protection from moisture, air, or volatile substances?

A. Airtight containers
C. Liquid transport media
B. Breathable packaging
D. None of the above

14. What are the selection criteria for choosing appropriate transport media?

A. Compatibility with sample type and testing requirements
C. Compliance with laboratory guidelines or testing standards
B. Ability to maintain sample integrity
D. All of the above

15. What information should be clearly labeled on each sample container?

A. Sample identification number
C. Location
B. Date
D. All of the above

Say true or false

1. Proper sample preparation is not necessary for accurate and representative results in road construction material testing

2. Using clean containers and tools is not important in road construction material sampling and testing.

3. Accurate labeling of samples allows for easy identification and traceability throughout the testing process.

4. Chemical separation plays a crucial role in various testing procedures within road construction material sampling and testing.

5. Proper transport media help maintain the physical and chemical properties of samples during transportation.

6. Maintaining sample integrity during distribution is important for ensuring accurate and reliable test results.

Fill in the blank Space

1. The process of road construction material sampling and testing begins with the collection of samples from the _____.

2. Proper sample preparation is necessary to ensure _____ and _____ results.

3. Accurate labeling of samples allows for easy _____ and traceability throughout the testing process. Answer: identification

4. Proper storage conditions are crucial to maintain the _____ of the samples. Answer: integrity

5. Proper transport media play a vital role in preserving the _____ of samples during transportation. -

6. Maintaining sample _____ is crucial during distribution to ensure accurate and reliable test results. -

Operational sheet

Title

Sampling method of bitumen for penetration testing. Ductility testing and viscosity testing.

Purpose

To collect representative samples of bitumen for penetration testing. Ductility testing and viscosity testing.

Apparatus

- Clean, dry container
- Sharp knife or spatula
- Gloves
- Mask
- Safety glasses
- Bitumen penetration tester
- Bitumen ductility tester
- Water bath
- Thermometer
- Bitumen viscometer

Procedure

1. Clean and dry the container.
2. Put on gloves, mask, and safety glasses.
3. Cut or scrape a sample of bitumen from the surface.
4. Place the sample in the container.
5. Label the container with the following information:
    - Date

- Time
- Location of sample
- Type of bitumen

Precautions

- Be careful not to contaminate the sample with dirt, water, or other materials.
- Avoid contact with the bitumen, as it can be harmful to skin and eyes.

Storage

Store the sample in a cool, dry place.

Transportation

Transport the sample in a sealed container.

Testing

The sample can be tested for penetration using a bitumen penetration tester. The tester consists of a needle that is inserted into the sample and the depth of penetration is measured. The penetration value is expressed in millimeters.

The sample can be tested for ductility using a bitumen ductility tester. The tester consists of two clips that are attached to a pulling machine. The sample is placed between the clips and the machine is turned on. The machine pulls the clips apart at a constant speed and the distance at which the sample breaks is measured. The ductility value is expressed in centimeters.

The sample can be tested for viscosity using a bitumen viscometer. The viscometer consists of a capillary tube and a timer. The sample is placed in the capillary tube and the time it takes for the sample to flow through the tube is measured. The viscosity value is expressed in centipoise (cP).

Interpretation of Results

The penetration value is an indication of the softness or hardness of the bitumen. A higher penetration value indicates a softer bitumen, while a lower penetration value indicates a harder bitumen. The penetration value is used to determine the suitability of the bitumen for different applications

The ductility value is an indication of the ability of the bitumen to stretch without breaking. A higher ductility value indicates a more ductile bitumen, while a lower ductility value indicates a less ductile bitumen. The ductility value is used to determine the suitability of the bitumen for different applications

The viscosity value is an indication of the resistance of the bitumen to flow. A higher viscosity value indicates a more viscous bitumen, while a lower viscosity value indicates a less viscous bitumen. The viscosity value is used to determine the suitability of the bitumen for different applications.

Operational sheet 2

Title

Sampling method of Concrete compression test and reinforcement bar tensile test

Objective:

To collect representative samples of concrete for compression testing and reinforcement bars for tensile testing.

Apparatus:

- Clean, dry container
- Sharp knife or spatula
- Gloves
- Mask
- Safety glasses
- Concrete compression testing machine
- Reinforcement bar tensile testing machine

Procedure:

1. Clean and dry the container.
2. Put on gloves, mask, and safety glasses.
3. Cut or scrape a sample of concrete from the surface.(reinforcement bar from a beam or slab)
4. Place the sample in the container.
5. Label the container with the following information:
    - Date
    - Time
    - Location of sample
    - Type of concrete

Precautions:

- Be careful not to contaminate the sample with dirt, water, or other materials.
- Avoid contact with the concrete, as it can be harmful to skin and eyes.

Storage:

Store the sample in a cool, dry place.

Transportation:

Transport the sample in a sealed container.

Testing:

The sample can be tested for compression using a concrete compression testing machine. The machine consists of two plates that are brought together to compress the sample. The load is applied gradually until the sample fails. The compressive strength of the sample is calculated by dividing the maximum load by the cross-sectional area of the sample.

The sample can be tested for tensile using a reinforcement bar tensile testing machine. The machine consists of two grips that are used to hold the sample. The grips are attached to a load cell that measures the force applied to the sample. The sample is elongated gradually until it fails. The tensile strength of the sample is calculated by dividing the maximum load by the original cross-sectional area of the sample.

Interpretation of Results:

The compressive strength of the concrete is an indication of its ability to resist compression. A higher compressive strength indicates a stronger concrete. The compressive strength of the concrete is used to determine the suitability of the concrete for different applications.

The tensile strength of the reinforcement bar is an indication of its ability to resist tensile forces. A higher tensile strength indicates a stronger reinforcement bar. The tensile strength of the reinforcement bar is used to determine the suitability of the reinforcement bar for different applications.

LAP Test	

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions:

1.) You are required to perform the following: You are given 60 minutes to finish each task.

2.) Request your teacher for evaluation and feedback.

Perform the following task

Task 1:-Sample bitumen for penetration testing.

Task 2:- Sample bitumen for Ductility testing

Task 3:- Sample bitumen for viscosity testing.

Task 4:- Sample Concrete for compression test

Task 5:- Sample reinforcement bar for tensile test

3 Unit three: MATERIAL TESTING

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Material testing Equipment
- Laboratory Test
- Clean up

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Operate techniques of testing equipment
- Operate laboratory tests
- Clean up

3.1 Material Testing Equipment

Material testing equipment (machine) used in materials science to determine the properties of a material. Machines have been devised to measure tensile strength, strength in compression, shear, and bending (see strength of materials), ductility, hardness, impact strength (see impact test), fracture toughness, creep, and fatigue

Material testing machine offers advanced solutions for onsite and laboratory tests on concrete, cement, mortar, bitumen, asphalt, soil, aggregates, rocks, and steel, representing **t**he ideal partner for anyone working in building and civil engineering industries.

3.1.1Concrete Testing Equipment

Concrete is one of the most used materials in the construction industry. Several variables contribute to define the quality of the concrete utilized for a structure: workability, consistency, setting time and air content are only few examples.

Matest offers a wide range of testing equipment and high stiffness compression machines (manual, semiautomatic or automatic) which allow to test concrete cubes, cylinders and blocks and satisfy the EN and other International Standards. Each machine has its own kN capacity and control unit to perform tests on materials with different strength and composition.

- **A compression testing machine**/ Equipment to test cement, brick and concrete is offered by us. The range we offer includes Manually (Hand) Operated, Semiautomatic Compression Testing Equipment, Electrically Cum Manually Operated equipment and more. These strength testing equipment are extremely handy and are easy to use for testing cement, concrete and mortar cubes.

Figure 3-1compression testing machine

- **Tensile test machines**, also known as tension test machines, are universal testing machines specially configured to evaluate the tensile strength of specimens. Our tensile testers will measure characteristics such as ultimate tensile strength, yield strength, elongation, and modulus. Each tensile test machine is **configured to your testing needs** by our application engineers with the correct controller, grips, and accessories.

Figure 3-2tensile test machines

3.1.2Bitumen Testing Equipment

Bituminous mixture, also known as asphalt mixture, is mainly composed by aggregates and bitumen, an infinite variety of mixtures being possible.

The equipment required for bitumen testing, including machines to study the rheological properties of bitumen as well as the features of bituminous emulsion. It includes solutions to perform laboratory test on road surface.

- **Bitumen Penetration test equipment** The Penetration is the consistency of a bituminous material expressed as the distance in tenths of a millimetre that a standard needle vertically penetrates a sample of the material under known conditions of loading, time, and temperature. The penetration is measured with a penetrometer by means of which a standard needle is applied to the sample under specific conditions.

  The penetration test is used as a measure of consistency. Higher values of penetration indicate softer consistency. The value of penetration obtained is also used to classify the bitumen in a range of penetration grade.

Figure 3-3Bitumen Penetration test equipment

- **Bitumen ductility test equipment** Different bitumen properties can be analyzed thanks to the use of a Ductilo meter, a machine capable of applying a sample elongation at a fixed speed.
- **Ductility:** The ductility is a measure of tensile properties of bituminous materials.

  It is measured by the distance to which a bituminous material will elongate before breaking when two ends of a briquette specimen of the material are pulled apart at a specified speed and at a specified temperature. The specimen will be continuously immersed in water, while the two clips are pulled apart at a uniform speed.

  2) Elastic Recovery: The elastic recovery of a bitumen is expressed as a percentage of the distance between the ends of the half-threads, which has developed 30 min after the division relative to the elongation length of 200 mm.

  A bitumen specimen is stretched at a temperature of 25 °C and a constant rate of 50 mm/min to a predetermined elongation (200 mm). The bitumen thread thus produced is cut in the middle to obtain two halves of thread. After a predetermined time for recovery has elapsed, the shortening of the half threads is measured and expressed as the percentage of the elongation length. This value is especially applicable to bituminous binders modified with thermoplastic elastomers.

  3) Deformation Energy: The deformation energy is the energy supplied by test pieces, until a certain displacement of the moving element is achieved. For each test specimen, the energy calculation is accomplished from the computerized data of couples force/elongation.

Appropriate ductile meter permits the following measurements to be made:

- Tensile force exerted on the specimen, by calibrated load cells;
- Elongation of the specimen, by following the movement of the attachment points.

Figure 3-4ductile meter

- **Bitumen viscosity test equipment** Based on absolute or kinematic viscosity requirement, the bitumen viscosity can be measured by a variety of devices. The specifications kept for measurement is the absolute viscosity at 60 degree Celsius and a Kinematic viscosity at 135 degree Celsius.

  Bitumen tends to soften, when subjected to a temperature rise and will harden when the temperature falls.

  The vacuum capillary tube viscometer is used to find absolute viscosity. Atmospheric capillary tube viscometer is employed to measure the kinematic viscosity.

  Another method to measure the viscosity is the use of a rotational viscometer where a torque required to rotate a spindle at constant speed while immersed in the sample fluid. Dynamic viscosity is proportional to this measured torque.

Figure 3-5 Dynamic viscosity machine

3.2 Laboratory testing

Our laboratory construction materials tests form the backbone of our materials testing lab and are the majority of the tests we perform in the lab. Most of the material properties we (or the client) need can be obtained through performing a combination of the tests listed below.

In order to obtain accurate material information, it is important to obtain representative samples of the materials being tested. There are various standards that describe the sampling process in detail.

3.2.1 Concrete test

Compressive strength is the capacity of material or structure to resist or withstand under compression. The Compressive strength of a material is determined by the ability of the material to resist failure in the form cracks and fissure.

In this test, the push force applied on the both faces of concrete specimen and the maximum compression that concrete bears without failure is noted.

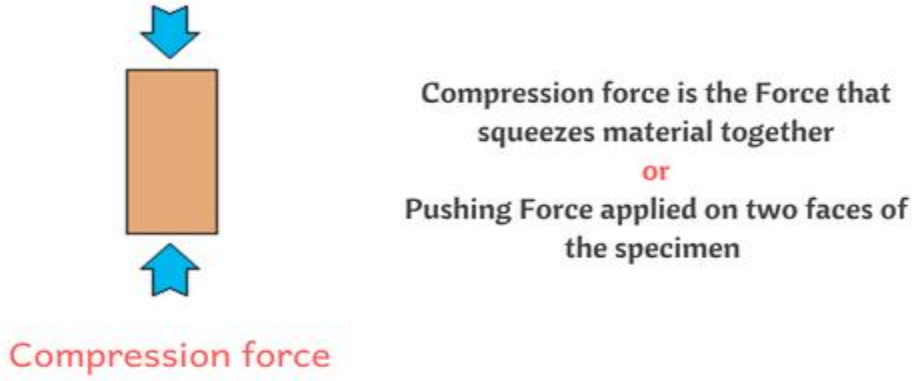


Figure 3-6Compressive strength

Compressive strength test is considered as the most popular test performed on concrete in construction as it gives a general idea on the all the characteristics of concrete. Based on this test, one can either accept or reject a concrete work.

Compressive strength as a concrete property depends on several factors related to quality of used materials, mix design and quality control during concrete production.

Depending on the applied code, the test sample may be cylinder [15 cm x 30 cm is common] or cube [15 cm x 15cm x 15 cm is the most common]. For example, as per ASTM C39, a standard test method is given to get the compressive strength of concrete cylinders.

Compressive Strength Test Idea:

1- Concrete is poured in the mold and compacted properly to reduce the amount of voids.

2- After 24 hours, molds are removed and test specimens are then placed in water for curing.

3- After the specified curing period [3, 7, 28, 56, or 91 days], specimens are tested by the compression testing machine.

4- Load is applied gradually until specimen failure.

5- Divide failure load by cross-sectional area of specimen to get the compressive strength of concrete.

Compressive Strength Test Procedure:

Tools/apparatus: Compression test machine, molds, mixer, trowel, tamping rod (steel bar 16 mm diameter and 60 cm long)

Sample preparation : Samples are taken from the concrete patches used in site or prepared with the same mixture as used in the field.

Specimen size: 3 cylinders [15 cm x 30 cm] or 3 cubes [15 cm x 15cm x 15 cm]

Figure 3-7steel cone

Guidance

The following table gives the strength of concrete at different ages as a percentage of the strength at 28 days in order to accept the test result.

Table3.1perecentage of strength at maximum date

Age	**% of 28 day Strength**
1 day	16%
3 days	40%
7 days	65%
14 days	90%
28 days	100%

Table 3-1Compressive Strength of Different Grades of Concrete at 7, 14, 21 and 28 Days

Concrete grade	Comp. strength N/mm at 3 days	Comp. strength N/mm at 7 days	Comp. strength N/mm at 14 days	Comp. strength N/mm² at 28 days

M10	4	6.5	9	10
M15	6	9.75	13.5	15
M20	8	13	18	20
M25	10	16.25	22.5	25
M30	12	19.5	27	30
M35	14	22.75	31.5	35
M40	16	26	36	40
M45	18	29.25	40.5	45
M50	20	32.5	45	50

The test includes following steps:

Preparing of material for Cube test:

All the material must be brought and stored to an approximate temperature of 27 ±3 degree Celsius. Cement must be uniformly mixed with a trowel in order there exist no lumps.

Mixing of concrete:

Machine mixing: The ingredient must not be rotated for more than 2 minutes and the following pattern must be followed

1>Calculated water,**2**>50% coarse aggregates,**3**>fine aggregates,**4**>cement,**5**>50% coarse aggregates.

Hand mixing: The process must be done on the rectangular pan until a homogenous mix is obtained.

Dry mixing of fine aggregates and cement>addition of coarse aggregate with the even distribution>addition of calculated water in batch till consistency is achieved.

Casting of specimen

The casting molds are chosen to be made of cast iron and must be rubbed with grease on inner side for easy removal of cubes. The specimen must be cast in 3 layers (5cm each) and properly compacted in order that honeycombing formation does not take place.

Compaction

In compacting through tamping bar, 35 strokes must be done in all parts of a cube for proper compacting. This tamping bar has the dimension of diameter 16mm and length of 0.6m.

Age of test

The cube test for Compressive strength can be done on 1,3, 7, 14 and 28 days. In some cases, the strength of greater ages is required which is performed from 13 to 52 weeks.

Number of specimens

It is mandatory to have at least 3 specimens for testing from different batches. The mean of compressive strength achieved by this specimen is used to determine actual strength of the batch.

Procedure for Compressive strength of concrete or Cube test:-

1. Place the prepared concrete mix in the steel cube mold for casting.
2. Once it sets, after 24 hours remove the concrete cube from the mold.
3. Keep the test specimens submerged underwater for stipulated time.
4. As mentioned the specimen must be kept in water for 7 or 14 or 28 days and for every 7 days the water is changed.

Figure 3-8compressive strength cube test curing

5. Ensure that concrete specimen must be well dried before placing it on the UTM.
6. Weight of samples is noted in order to proceed with testing and it must not be less than 8.1Kg.
7. Testing specimens are placed in the space between bearing surfaces.
8. Care must be taken to prevent the existence of any loose material or grit on the metal plates of machine or specimen block.

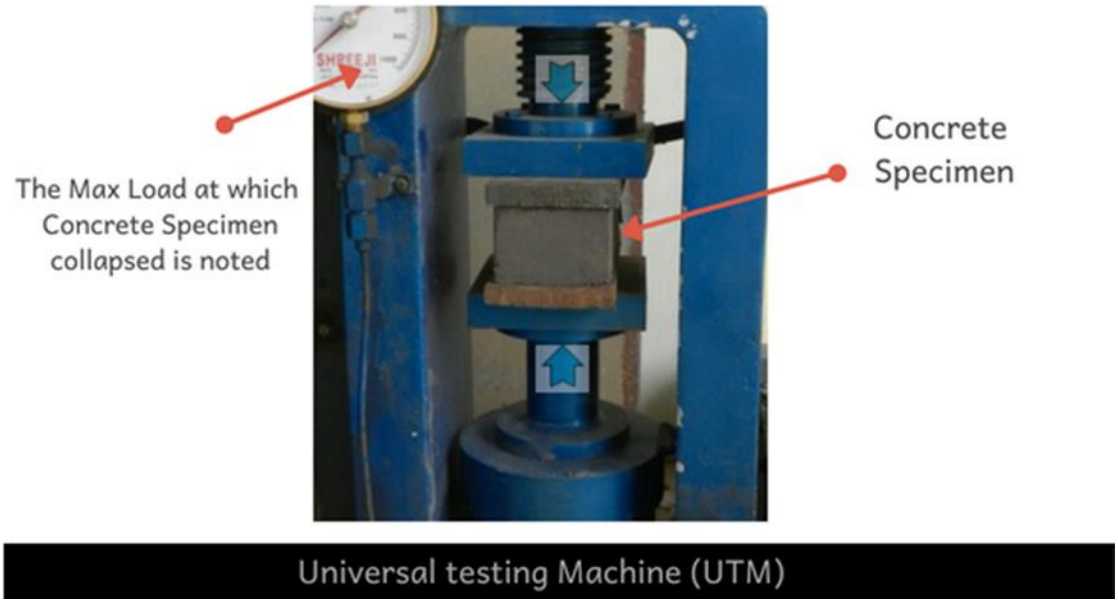
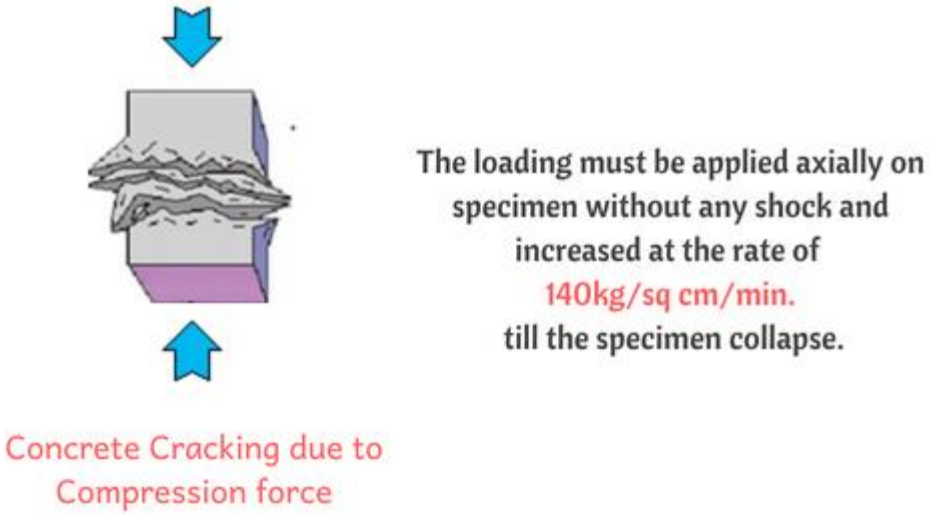


Figure 3-9max load application on specimen

9. The concrete cubes are placed on bearing plate and aligned properly with the center of thrust in the testing machine plates.
10. The loading must be applied axially on specimen without any shock and increased at the rate of 140kg/sq cm/min. till the specimen collapse.
11. Due to the constant application of load, the specimen starts cracking at a point & final breakdown of the specimen must be noted.



Calculations

Compressive strength of Concrete Formula:

The Compressive strength of specimen can be calculated by dividing maximum load carried by the specimen by cross-sectional area of the specimen cubes.

$$\text{Compressive Strength of Concrete} = \frac{\text{Max Load Carried by Specimen}}{\text{Top Surface Area of Specimen}}$$

The surface area of specimen: = 150 x 150 = 22500mm² = 225cm²

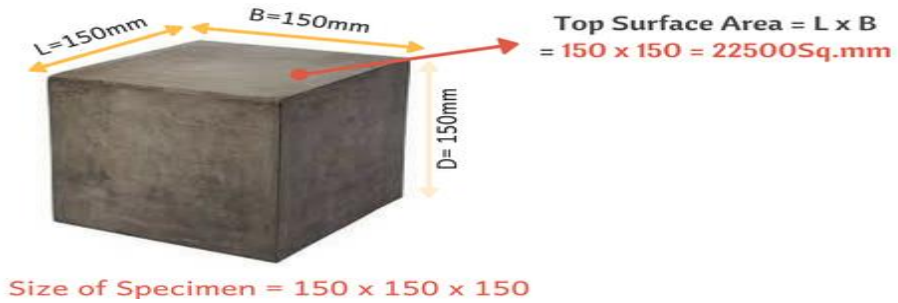


Figure 3-10surface area of cube

Assume, The Max compression load is 450KN
1KN = 1000N ; 450Kn = 450×100 = 450000N
Compressive strength of concrete = Max Load by Specimen
Top surface Area of specimen

Compressive strength of concrete = 450000/20N/mm²/cm²

Figure 3-11 calculation is done for the specimen at different ages as stated below

Detail		Specimen	
	Specimen 1@ 7 days	Specimen 2@14days	Specimen 3 @28 days
Max load	310KN	408KN	445KN
Compressive Strength in N/mm^2	310000/22500 13.7N/mm^2	408000/2250 18.13N/mm^2	448000/2250 19.9N/mm^2

As we assumed M20 grade concrete mix which bear a max load up to 20N/mm^2			
Minimum Strength to be achieved at different days	65% @7 days	90% @14 days	99% @28 days
Percentage of Concrete gain(test results)	(13.7x100)/20 = 8.5%>65%	(18.13x100)/20 = 90.6%>90%	(19.9x100)/20 = 99.1%>99%

A good concrete should not show less than the minimum Compressive strength at respective days. Hence concrete is safe to use.

Important Note: As per IS: 516-1959 Minimum three specimens should be tested at each selected age (that means three specimens at 7 days, three specimens @ 14 days & 28 days) If strength of any specimen varies by more than 15% of average strength, such specimen should be rejected.

Results of cube test

Average Compressive strength at 7 days = _____N/mm²
The average Compressive strength at 28 days = _____N/mm²

3.2.2 Tensile test

A tensile test is used to determine the yield point or yield strength, tensile strength or ultimate tensile stress, and percentage elongation of a metal.

The tensile Testing method measures the force required to break a metallic, composite, or plastic specimen and the extent to which the specimen stretches or elongates to that breaking point

Importance of Tensile Test

Tensile testing *is the* most important mechanical test that is essential for all mechanical design & construction.

The test provides important data for material selection, evaluation, and quality assurance. The test helps to give critical input for material integrity assurance that it will meet the minimum required tensile/ yield strength and elongation for the product life.

All critical engineering design such as bridges, railroad, aerospace, and machinery where human life can be at risk, relies on the reliability of the data obtained by the tensile test.

In these applications, tensile test roles are highly important. A wrong result or not complying with the design standards can put both financial and human life at risk.

The financial expense of such fatal incidents caused due to substandard material selection is much higher than the cost of performing the usual tensile testing of the materials.

Tensile Testing Standards & Specification

The main tensile testing standards and specifications are listed below. These standards are applicable for material and weld joint testing.

1. **ASTM E8/E8M** – Tensile Testing of Metallic Materials
2. **BS EN ISO 4136**: Destructive tests on welds in metallic materials. Transverse tensile test
3. **BS EN 895:** Destructive tests on welds in metallic materials. Transverse tensile test
4. **ISO 6892** – Tensile Testing of Metallic Materials
5. **ASTM D412** – Tensile Testing of Elastomers
6. **ISO 37** – Tensile Testing of Elastomers
7. **ASTM D638** – Tensile Testing of Plastics
8. **ISO 527-2** – Tensile Testing of Plastics
9. **ASTM A370 –** Standard Test Methods and Definitions for Mechanical Testing of Steel Products

The Tensile Test Process

Material strength testing, using the tensile or tension test method, involves applying an ever-increasing load to a test sample up to the point of failure. The process creates a stress/strain curve showing how the material reacts throughout the tensile test. The data generated during tensile testing is used to determine mechanical properties of materials and provides the following quantitative measurements:

- **Tensile strength, also known as Ultimate Tensile Strength (UTS),** is the maximum tensile stress carried by the specimen, defined as the maximum load divided by the original cross-sectional area of the test sample.
- **Yield strength** is the stress at which time permanent (plastic) deformation or yielding is observed to begin.

- **Ductility measurements** are typically elongation, defined as the strain at, or after, the point of fracture, and reduction of area after the fracture of the test sample.

The test sample is securely held by top and bottom grips attached to the tensile or universal testing machine. During the tension test, the grips are moved apart at a constant rate to pull and stretch the specimen. The force on the specimen and its displacement is continuously monitored and plotted on a stress-strain curve until failure.

The measurements, tensile strength, yield strength and ductility, are calculated by the technician after the tensile test specimen has broken. The test specimen is put back together to measure the final length, then this measurement is compared to the pre-test or original length to obtain elongation. The original cross section measurement is also compared to the final cross section to obtain reduction in area.

Elevated Temperature Tensile Testing is a proven method of evaluating the behavior of materials under a combination of heat and tension. When performing an elevated temperature tensile test, the specimen is placed inside a furnace on our test carousel, which is capable of processing up to three specimens at a time. Our computer-controlled system heats the specimen to the required temperature, then allows it to soak. Next, the specimen is loaded into the test frame, where an extensometer in the latest design measures the strain on the specimen as the load is increased.

Stress

Stress (σ) – the force per unit cross sectional area applied to an object.

From this definition we have the following equation:

$$\sigma = \frac{F}{A}$$

Where F is the force applied in Newton (N) and A is the cross sectional area of the object before the force is applied in meter squared (m^2).

From the definition we know that the units for stress are Nm^{-2}, in SI units this is the same as Pascal (Pa).

The force can be compressive or tensile and must act **perpendicular** to the cross sectional area in order to change the length.

Strain

Strain (ε) – the extension (or compression) per unit length resulting from an applied stress.

The strain of an object can be calculated using the following equation:

$$\varepsilon = \frac{L - L_0}{L_0}$$

Where L is the stretched/compressed length of the object and L_0 is the original length of the object, both measured in meters (m).

As strain is calculated by dividing a length by a length the units cancel each other out and strain has no units.

NOTE: As long as all your lengths are in the same units, they don't have to be in meters – as they cancel each other out. For example, they could all be in inches. But if you had L in meters and L_0 in inches you would have to convert them to be the same.

3.2.3 Bitumen test

Determination of penetraton value of bitumen

Objective:

To determine consistency or the grade (mean penetration value) of bituminous material.

Theory:

Penetration is a measurement of hardness or consistency of bituminous material. The penetration of a bituminous material is the distance in tenths of a mm, that a standard needle would penetrate vertically, into a sample of the material under standard conditions of temperature load and time. This test is used for evaluating consistency of bituminous materials.

Apparatus:

i) Container: A flat bottomed cylindrical metallic dish 55 mm in diameter and 35 mm in depth is required. If the penetration is of the order of 225 or more deeper dish of 70 mm dia. And 45 mm depth is required.

ii) Needle: A straight, highly polished, cylindrical hard steel rod with standard dimension.

iii) Water bath: A water bath maintained at 25.0°C ± 0.1 °C containing not less than 10 litres of water, the sample being immersed to a depth not less than 100 mm from the top and

supported on a perforated shelf not less than 0 mm from the bottom of the bath.

iv) Transfer dish or tray: It should provide support to the container and should not block the container.

v) Penetration apparatus: It should be such that will allow the needle to penetrate without much friction and is accurately calibrated to give results in one tenth of a millimetre.

vi) Bath thermometer - Range 0 to 44^{o}C, Graduation 0.2^{o}C

vii)Time measuring device: With an accuracy of ± 0.1 s.

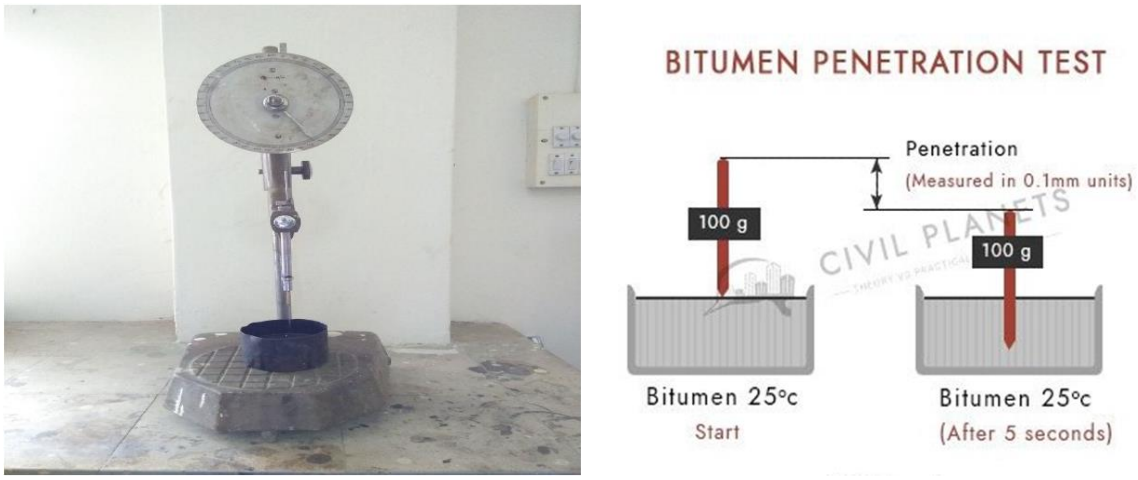


Figure 3-12bitumen penetration test

Procedure:

i) The bitumen above the softening point (between 75 and 100^{o}C) is softened. It is stirred thoroughly to remove air bubbles and water.

ii) It is poured into a container to a depth of at least 15mm in excess of the expected penetration.

iii) It is cooled at an atmospheric temperature of 15 to 30^{o}C for 1 hrs. Then it is placed in a transfer dish in the water bath at 25.0 ± 0.1^{o}C for 1 to 1.5 hrs.

iv) The container is kept on the stand of the penetration apparatus.

v) The needle is adjusted to make contact with the surface of the sample.

vi) Make the pointer of the dial gauge to read zero or note the initial dial readin

vii)With the help of the timer, the needle is released for exactly 5 seconds.

viii) The dial reading is recorded.

ix) Make at least 3 readings at points on the surface of the sample not less than 10 mm apart and not less than 10 mm from side of the dish.

Precautions:

i) There should be no movement of the container while needle is penetrating into the sample.
ii) The sample should be free from any extraneous matter.
iii) The needle should be cleaned with benzene and dried before penetration.

	Test 1	Test 2	Test 3
Penetration dial reading a) Initial			
b) Final			
Penetration value			

Record of Observations:

Mean penetration value =

Interpretations of results:

Penetration test is a commonly adopted test to grade material in terms of its hardness. A 80/100 grade bitumen indicates that its penetration value lies in between 80 and 100. The grading of bitumen helps to assess its suitability for use in different climatic conditions and types of construction.

Questions for Discussion:

i) Which property of bitumen is related to penetration value ?
ii) The penetration value of a binder is 65; what is the distance in mm which the needle has penetrated through ?
iii) What variations are expected in the test results if:
   a) The time of penetration is increased ?
   b) The actual test temperature is below the test temperature ?

iv) What does a 80/100 grade bitumen indicate ?

Table3.2 penetration value recording

3.2.4 Determination of Ductility Bitumen test

Ductility is one of the important properties of bitumen that shows the capability of tolerating deflections that occur on the road. Consequently, the probability of cracking becomes lower, and the life span of asphalt is increased. Ductility is measured by the ductility test.

In this test, the cohesive strength of bitumen is obtained by applying stresses to it.

In this experiment, bitumen is poured into the tester and pulled with a speed of 5 cm/min at a temperature below its softening point. The length of bitumen stretched in centimeters before tearing apart is the bitumen ductility.

Ductility is usually within the range of 5 cm to over 100 cm. The acceptable value of bitumen ductility should be more than 50 cm. However, this value should be 100 cm or more for road construction.

A ductility test can measure the cohesive strength of bituminous products like oxidized and cutback bitumen.

Table 3-2Ductility value of viscosity bitumen grades based on IS 1208 method

Paving grades	Maximum value of ductility @25˚c
VG10	75cm
VG20	50cm
VG30	40cm
VG40	25cm

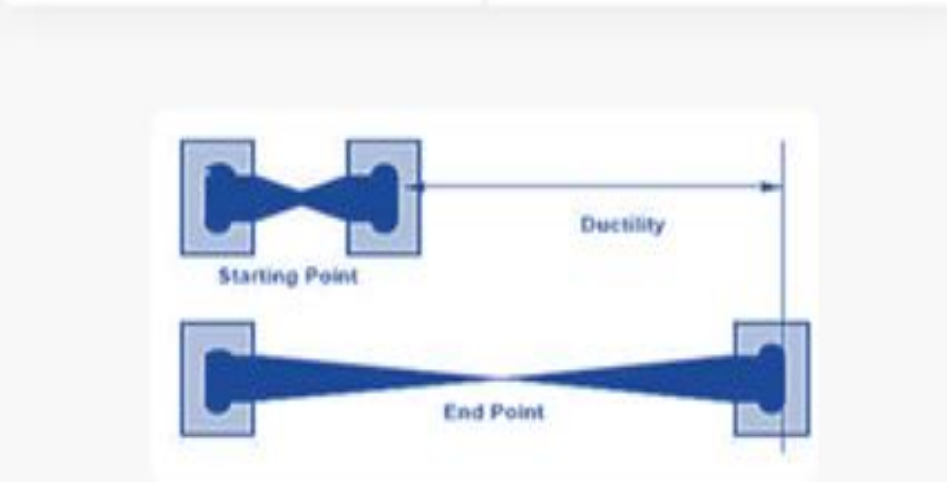


Figure 3-13ductility value of elongation

Ductility Test Methods of Bitumen in International Standards

Bitumen ductility test can be performed by following standard methods:

- ASTM D133
- ASTM D 6084
- AASHTO T51
- IS 1208
- EN 13589
- EN 13703

The ductility test based on the ASTM D113 method will be described as follows

Ductility Test Procedure

1. Melt the bituminous test material completely at a temperature of 75oC to 100oC above the Approximate softening point until it becomes thoroughly fluid
2. Strain the fluid through IS sieving 30.
3. After stirring the fluid, pour it in the mold assembly and place it on a brass plate
4. In order to prevent the material under test from sticking, coat the surface of the plate and interior surface of the sides of the mold with mercury or by a mixture of equal parts of glycerin and dextrin
5. After about 30 – 40 minutes, keep the plate assembly along with the sample in a water bath. Maintain the temperature of the water bath at 27oC for half an hour.
6. Remove the sample and mold assembly from the water bath and trim the specimen by leveling the surface using a hot knife.
7. Replace the mold assembly in water bath maintained at 27oC for 80 to 90 minutes
8. Remove the sides of the molds
9. Hook the clips carefully on the machine without causing any initial strain
10. Adjust the pointer to read zero
11. Start the machine and pull two clips horizontally at a speed of 50mm per minute
12. Note the distance at which the bitumen thread of specimen breaks.
13. Record the observations in the preformat and compute the ductility value report the mean of two observations, rounded to nearest whole number as the Ductility value

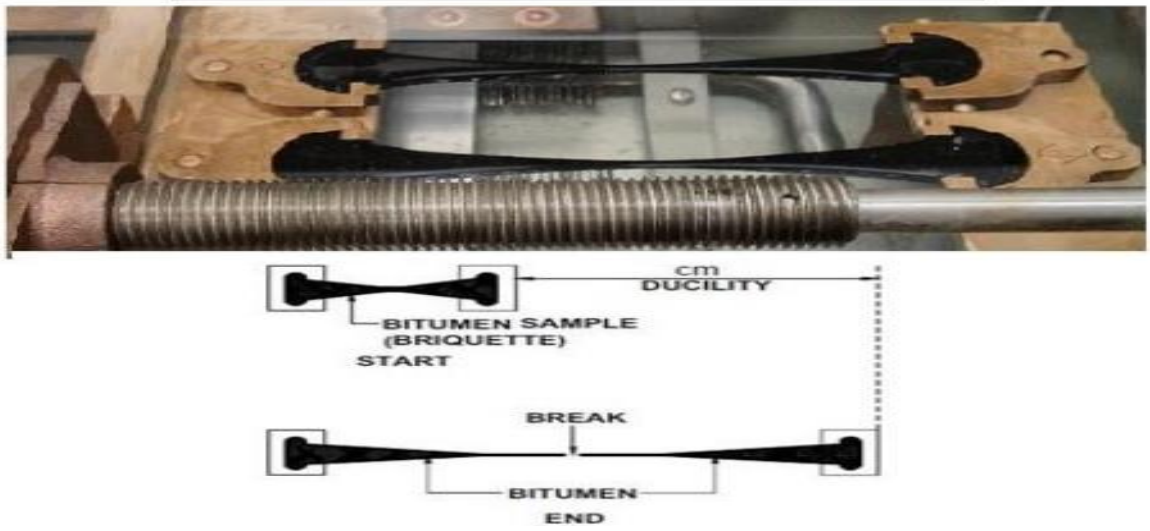


Figure 3-14ductility test methods

Record and Observations:
I. Bitumen grade = _
II. Pouring temperature o C =
III. Test temperature o C =
IV. Periods of cooling, minutes =
    a) In air =
    b) In water bath before trimming =
    c) In water bath after trimming =

Result:
The Ductility value of given bitumen is _____

3.2.5 Determination of viscosity bitumen test

The viscosity test of bitumen measures the bitumen viscosity. This property shows how easily bitumen flows.

The higher the viscosity of the bitumen, the harder it is to flow. Consequently, it behaves more like semi-solid matter. Bitumen viscosity is determined by viscometers. How rotary and capillary viscometers are used to measure dynamic (ASTM D4402) and kinematic (ASTM D2170 or IS 1206) viscosity of bitumen.

Table 3-3Viscosity value of viscosity Bitumen Grades

Paving Grades	Absolute viscosity @60˚c poises	Kinematic viscosity @135 ˚c Cst
VG10	800- 1200	250
VG20	1600-2400	300
VG30	2400-3600	350
VG40	3200-4800	400

Standard methods can be used to determine the viscosity of bitumen:

- **Industrial viscosity**

1. IS 1206 (I)
2. EN 12846-1
3. EN 12846-2

- **Absolute or dynamic viscosity**

1. ASTM D2171
2. ASTM D4402
3. AASHTO T202-03
4. AASHTO T316-06
5. EN 12596 dynamic at 60
6. EN 13302
7. IS 1206 (II)

- **Kinematic viscosity**

1. ASTM D2170
2. ASTM D2161
3. ASTM D445
4. AASHTO T201-03
5. EN 12595 kinematic at 135
6. IS 1206 (III)
7. IP 543

Viscosity is defined as inverse of fluidity. Viscosity thus defines the fluid property of bituminous material. The degree of fluidity at the application temperature greatly influences the ability of bituminous material to spread, penetrate into the voids and also coat the aggregates and hence affects the strength characteristics of the resulting paving mixes.

Object: To determine the viscosity of bitumen by Tar Viscometer.

Apparatus: Tar Viscometer with 4nun and 10mm orifices -The apparatus consists of main parts like cup. valve, water bath, sleeves, stirrer, receiver and thermo meters etc.

Procedure:

The tar cup is properly leveled and water in the bath is heated to the temperature specified for the test and is maintained throughout the test. Stiffing is also continued .The sample material is heated at the temperature 20°c above the specified test temperature, and the material is allowed to cool. During this the material is continuously, stiffed. When material reaches slightly above test temperature, the same is poured in the tar cup, until the leveling peg on the valve rod is just immersed. In the graduated receiver (cylinder), 2Sml of mineral oil or one percent by weight solution of soft soap is poured. The receiver is placed under the orifice. \When the sample material reaches the specified testing temperature within +/- 0.1°c and is maintained for 5 minutes. the valve is opened. The stopwatch is started when cylinder records 25ml. The tune is recorded for flow up to a mark of 75ml (i.e., 50 ml of test sample to flow through the 01fice).

Results:

The time in seconds for 50ml of the test sample to flow through the orifice is defined as the viscosity at a given test temperature.

3.3 Clean up

The Construction cleanup is a massive process that involves the removal and disposal of debris, building materials, tools, equipment, furniture, appliances, etc. The scope can vary from project to project but generally includes cleanup of demolition, site preparation, grading/drainage,

excavation, backfill, landscaping, fencing, concrete work, painting, roofing, electrical installation, plumbing, drywall, floor covering etc.

The cost for post construction clean up varies depending on several factors including size of the job, location, number of trades involved in the project, type of property being worked on, the time frame required by each trade, level of experience among the team members, weather conditions during the course of the project, availability of sub-contractors or subcontractors, insurance coverage needed, and more.

In material testing, clean up refers to the process of removing any residue or debris from the test specimen or equipment after a testing procedure is completed. It is essential to ensure that the next test is not contaminated and that accurate results are obtained. Clean up typically involves removing any loose particles, cleaning surfaces with appropriate solvents, and ensuring that the equipment is properly calibrated and ready for the next test.

Process includes:

1. Proper storage: All testing materials should be stored in designated areas to prevent cross-contamination and ensure easy access when needed.
2. Cleaning instruments: Testing equipment, such as testing machines, fixtures, grips, and surfaces, should be regularly cleaned and maintained to remove any dirt, debris, or residues.
3. Disposal of waste: Proper disposal of waste generated during testing, such as samples, chemicals, solvents, and disposable materials, is essential. Follow local regulations and guidelines for handling and disposing of hazardous waste.
4. Surface cleaning: The testing area, workbenches, and countertops should be regularly cleaned and disinfected to ensure a clean environment for accurate testing. Use appropriate cleaning agents that do not interfere with the material being tested.
5. Personal hygiene: Testing personnel should adhere to good personal hygiene practices, such as washing hands before and after handling samples, wearing gloves, lab coats, and any necessary protective equipment.

6. Prevention of cross-contamination: Proper protocols should be followed to prevent cross-contamination between different samples or materials. This may include using separate tools or cleaning equipment between tests.

7. Quality control: Regular inspections and quality control checks should be performed to ensure that the testing environment meets required standards and is free from contamination.

By implementing thorough cleaning procedures and maintaining a clean testing environment, material testing accuracy can be preserved, and reliable results can be obtained.

Common material testing tools include:

1. Tensile testing machine: Used to determine the strength and elongation properties of materials by subjecting them to tension forces.

2. Hardness tester: Measures the resistance of a material to indentation or scratching, providing an indication of its hardness.

3. Impact tester: Determines the impact resistance and toughness of materials by subjecting them to a sudden force or impact.

4. Compression testing machine: Assess the compressive strength and deformation properties of materials by subjecting them to compressive forces.

5. Fatigue testing machine: Evaluates the fatigue strength and durability of materials by subjecting them to repeated or cyclic loading.

6. Microscope: Allows for the examination and analysis of materials at a microscopic level, helping to identify imperfections, grain structure, or phase composition.

7. Calipers and micrometers: Measure dimensional properties such as length, thickness, or diameter of materials with high precision.

8. Spectrophotometer: Determines the color, reflectance, and transmittance properties of materials, aiding in color matching and quality control.

9. Ductility tester: Measures the malleability and formability of materials, particularly metals, by subjecting them to tension to determine their ability to elongate before fracture.

Bitumen is a widely used material in the construction industry, particularly for road paving and roofing. To ensure the quality and performance of bitumen, various tests are conducted. Some common bitumen tests include:

1. Penetration Test: Determines the hardness or softness of bitumen by measuring the depth to which a standard needle penetrates the material under specified conditions.
2. Softening Point Test: Measures the temperature at which bitumen softens, providing an indication of its temperature susceptibility.
3. Ductility Test: Measures the elongation property of bitumen by quantifying the distance a briquette of bitumen can be stretched before breaking.
4. Flash and Fire Point Test: Determines the temperature at which bitumen generates vapors that can ignite momentarily or support continuous combustion.
5. Kinematic Viscosity Test: Measures the flow characteristics of bitumen at a specific temperature, which provides an indication of its viscosity or resistance to flow.
6. Solubility Test: Determines the solubility of bitumen in various solvents, helping identify its chemical composition and purity.
7. Thin-Film Oven Test (TFOT): Evaluates the effect of short-duration high-temperature exposure on bitumen, simulating the aging process to assess its long-term performance.
8. Marshall Stability Test: Measures the strength and stability of bituminous mixtures used for asphalt paving.

To clean up bitumen apart and material testing tools,

1. Remove any excess bitumen apart from the tools using a scraper or brush.
2. Wipe off any remaining bitumen apart using a cloth or absorbent material. Be careful not to spread the material further.
3. If the tools are still dirty, use a mild detergent or cleaning solution mixed with water to gently scrub the surfaces.
4. Rinse the tools with clean water to remove any residue from the cleaning solution.
5. Dry the tools thoroughly using a clean cloth or allowing them to air dry.
6. After cleaning, inspect the tools to ensure there is no visible bitumen residue left.

Self – check

Part one choose the best answer for the following questions

1. Which of the following is NOT a property that can be tested with material testing equipment?

A) Tensile strength

B) Solubility

C) Flexibility

D) Shear strength

2. What type of machine is used to measure various properties of a material in tension?

A) Compression testing machine

B) Tensile testing machine

C) Fatigue testing machine

D) Ductility testing machine

3. What does the bitumen penetration test measure?

A) The ability of bitumen to resist shear stress

B) The temperature at which bitumen melts

C) The hardness of bituminous material

D) The distance a needle can penetrate bituminous material

4. What are the characteristics measured by a tensile test machine?

A) None of the above

B) Ultimate tensile strength, yield strength, elongation, and modulus

C) Viscosity, tension, and elongation

D) Solubility, elasticity, and durability

5. At what age are the test specimens submerged underwater for a stipulated time before conducting the compressive strength test?

A) 3 days

B) 28 days

C) 7 days

D) 1 day

Part two say true or false

1. The Compressive Strength Test Procedure involves casting specimens in the shape of a rectangular prism or a cylinder?

2. A wrong result or not complying with the design standards of tensile testing can pose risks for financial and human life?

3. The ASTM D2170 method is used to determine industrial viscosity of bitumen?

2. The time for 50 ml of the test sample to flow through the orifice is defined as the viscosity at a given test temperature for the Tar Viscometer test?

3. The acceptable value of bitumen ductility for road construction is less than 50 cm?

Part three define the following questions

1. What is the significance of the penetration value of a bitumen binder?
2. What are the viscosity values for VG10 and VG40 paving grades of bitumen at 60°C according to IS 1206 (I)?
3. What is the acceptable value of bitumen ductility for road construction?
4. What is the significance of a tensile test?
5. What is the minimum strength to be achieved for M20 grade concrete mix at different days?

Operation sheet

Operation Title: Bitumen ductility test

Instruction: The ductility of a bituminous material is measured by the distance in cm to which it will elongate before breaking when a standard briquette specimen of the material is pulled apart at a specified speed and a specified temperature.

Purpose: To determine the ductility of distillation residue of cutback bitumen, blown type bitumen and other bituminous products as per IS: 1208 - 1978

Required tools:

1. Standard mold
2. Water bath
3. Testing machine
4. Thermometer - Range 0 to 44oC, Graduation 0.2oC

Figure 3-15Testing machine

PROCEDURE

1. The bituminous material is tested is completely melt by heating it to a temperature of 75 to 100oC above the approximate softening point until it becomes thoroughly fluid.

2. The mold is assembled on a brass plate and in order the material is prevented under test from sticking, thoroughly coat the surface of the plate and the interior surfaces of the sides of the mold with a mixture of equal parts of glycerin and dextrin.

3. While filling, the material is poured in a thin stream back and forth from end to end of the mold until it is more than level full. It is leaved to cool at room temperature for 30 to 40 minutes and then it is placed in a water bath maintained at the specified temperature for 30 minutes, after which cut off the

excess bitumen by means of a hot, straight-edged putty knife or spatula, so that the mold is just level full.

4. The brass plate and mold is placed with briquette specimen in the water bath and it is kept at the specified temperature for about 85 to 95 minutes. The briquette is removed from the plate; detach the side pieces and the briquette immediately.

5. The rings are attached at each end of the two clips to the pins or hooks in the testing machine and the two clips are pulled apart horizontally at a uniform speed, as specified, until the briquette ruptures.

6. The distance is measured in cm through which the clips have been pulled to produce rupture.

7. While the test is being done, the specimen both above and below by at least 25mm is covered with water in the tank of the testing machine and the temperature is maintained continuously within ± 0.5oC of the specified temperature.

Precautions:

1. The plate assembly upon which the mold is placed shall be perfectly flat and level so that the bottom surface of the mold touches it throughout.
2. In filling the mold, care should be taken not to distort the briquette and to see that no air pocket is within the molded sample.

Quality criteria:

1. Identification of material defects or weaknesses.
2. Determination of material properties such as elongation and reduction in area.
3. Quality control in your manufacturing processes.
4. Ensuring compliance with industry standards and regulations.

LAP Test	

Name: _____ Date: _____

Time started: _____ Time finished: ----------

Instruction I:

1. Apply safety rules
2. Access tools appropriate to the operation
3. Take appropriate procedures for resolution/reconfirm

Time allowed: 6houre

Task 1: Determine the grade of bitumen
Task 2: Measure the resistance of flow
Task 3: Determine the viscosity of bitumen by Tar Viscometer.

4 Unit Four: Documentation and Customer Service

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Logging Samples
- Customer Service

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Log samples
- Address customer service issues

4.1 Logging Samples

4.1.1 Recording, Checking, and Matching Sampling Date

Recording construction material sampling dates refers to keeping a record of when samples of construction materials, such as concrete, soil, asphalt, or steel, were collected for testing and analysis.

This record helps in tracking the quality and performance of these materials throughout the construction process. The sampling dates are typically noted in a logbook or database and may information like the location of sampling, name of the material, testing standards followed, and any specific instructions given for the sampling process. This data is important for monitoring the strength, durability, and suitability of construction materials, as well as for evaluating compliance with regulatory requirements and project specifications.

Checking sampling date refers to the process of verifying the date on which a sample was collected or taken for analysis or testing purposes. This is done to ensure that the sample is representative of the desired time frame or specific point in time, and that it is not outdated or contaminated. The checking of sampling date is important in various industries where accurate and up-to-date sampling is crucial for reliable results and decision-making.

To check the recorded construction material sampling date, you can follow these steps:

- Identify the construction material that was sampled. It could be concrete, soil, asphalt, etc.
- Locate the relevant documentation related to the construction project. This could construction plans, material testing reports, or other project records.
- Review the material testing reports or laboratory test results. These reports typically information about when the materials were collected and sampled.
- Look for a section in the report that details the sampling date and time. It may be titled "Sampling Date," "Date Collected," or something similar.
- Take note of the recorded sampling date and time for the specific construction material you are interested in.

It's important to note that the availability and format of the records may vary depending on the project and the jurisdiction. If you are unable to find the information in the project documentation or test reports, you may need to contact the construction project manager, material testing lab, or relevant regulatory authorities for further assistance.

Matching sampling date refers to the process of selecting a control group that matches the characteristics and timing of the sample in a construction material testing. To match recorded construction material sampling dates, follow this procedure:

- Review the recorded construction material sampling records: Gather all the relevant documents, such as test reports, laboratory certificates, or sampling logs, that contain the recorded dates of the samples.
- Establish a reference point: Determine a reference point against which you can match the recorded sampling dates. This could be the date of a significant construction event, such as the start or completion of a specific phase of the project.
- Compare the dates: Go through the recorded sampling dates and compare them with the reference point established. Note any discrepancies or outliers that may need further investigation.
- Analyze the context: Consider any relevant information regarding the construction project timeline. This could the expected duration of construction phases, any delays or extensions, or any specific events that could have affected the sampling process.
- Verify accuracy: Cross-check the recorded sampling dates with any other available sources, such as emails, photos, or field notes. Ensure that the recorded information is consistent and accurate.
- Consult project stakeholders: If there are still discrepancies or doubts regarding the construction material sampling dates, consult with relevant project stakeholders, such as the construction manager, materials engineer, or site supervisor. They may provide additional context or help in resolving any discrepancies.
- Document and report findings: Once you have matched the recorded sampling dates, document your findings in a clear and concise manner. If there were any discrepancies or issues during the matching process, an explanation or recommendation for further investigation if necessary.

Remember that accuracy and attention to detail are crucial when matching recorded construction material sampling dates. Double-check all information and consult with professionals if needed to ensure the reliability of the data.

4.1.2 Laboratory Information Management System (LIMS)

A laboratory information management system is a computer-based application software product that is used in the. Laboratory to manage analysis and standard samples, test results, laboratory staff, and analytic equipment, as well as for the. Purpose of generating commercial reports and other functions. A laboratory information management system allows you to effectively manage the flow of samples and associated data to improve lab efficiency. A LIMS helps standardize workflows, tests and procedures while providing accurate controls of the process. Instruments may be integrated into the LIMS to automate the collection of test data, ensuring they are properly calibrated and operated by trained staff only. Today's laboratories generate vast amounts of valuable data. Tracking samples and associated test data through the laboratory, and using that data to generate certificates of analysis, management reports and other information-based insights is important in managing and optimizing the laboratory and the business it supports. Laboratory information management systems have evolved to manage the laboratory workflow, organize the data efficiently and support the business of the laboratory. In addition, they can drive and support regulatory and standards compliance.

The workflows and data points that a LIMS organizes:

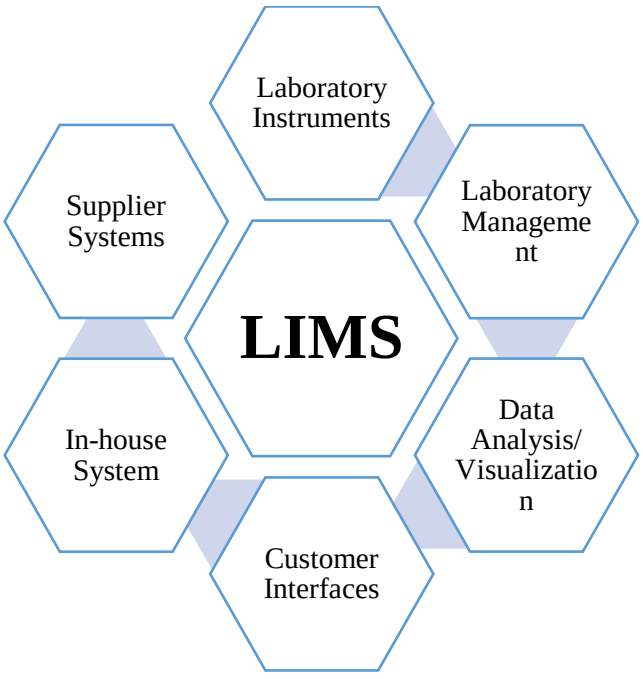


Figure 4-1 Laboratory Information Management Systems

The key advantages of LIMS:

- Defining and enforcing standard workflows – ensuring procedures are always followed
- Eliminating transcription errors through instrument integration
- Integrating with other systems to increase process efficiency
- Reducing the management and reporting overhead of the laboratory - a single electronic repository for all operational data; making the paperless laboratory a reality
- Reducing costs and increasing productivity through more efficient working
- Supporting regulatory compliance including ISO17025

While not all organizations have to work to specific regulatory guidelines or standards many LIMS features designed to support compliance are relevant to the majority of laboratories. These:

- Enforcing standard operating procedures to ensure repeatability.
- Managing staff training and competency.
- Maintaining and calibrating instruments appropriately.
- Managing inventory and supplies.
- Tracking and managing the location of samples.
- Managing corrective and preventative actions (CAPA) as part of the quality improvement cycle.

4.1.3 Document Tracking Mechanisms

Document tracking is a feature which tracks different attributes and locations of documents. Through document tracking you can control who can view a document, check to see who has accessed the document, who has made changes to it, and who the document has been sent to. Document tracking enables organizations to monitor when a document was created, opened, edited or printed, by who and when. This is vital for businesses who are regularly audited. It also provides a way to ensure a document has been seen by the recipient and not just simply delivered.

There are several document tracking mechanisms that can be used to monitor the movement and status of documents within an organization. Some common mechanisms:

- Barcodes/QR codes: Documents can be labeled with unique barcodes or QR codes, which are then scanned and tracked at various points throughout their lifecycle. This helps in keeping a record of the document's movement and location.
- Document Management Systems (DMS): DMS software allows organizations to centralize their documents and track their movement electronically. It provides features like version control, access controls, audit trails, and notifications to keep track of document activities.
- Electronic Signatures: By incorporating electronic signatures, organizations can track when and by whom the documents were signed. This helps in monitoring the progress of approvals and identifying bottlenecks in the document workflow.
- Document Tracking Software: There are various software solutions available specifically designed for tracking documents. These tools provide features like document search, metadata tracking, document histories, and real-time notifications, making it easier to monitor and locate documents.
- Radio Frequency Identification (RFID): RFID tags can be attached to physical documents, and their movement can be tracked using RFID readers. This mechanism enables real-time tracking and provides accurate information about the document's location.
- Document Log Sheets: For organizations that still rely on physical document tracking, log sheets can be used. These sheets capture details such as document name, location, date, and person in charge, allowing for manual tracking and accountability.
- Document Tracking Apps: Mobile apps with built-in document tracking capabilities can be used to track documents on the go. These apps often integrate with other systems, such as DMS or email, to provide a seamless tracking experience.

Document tracking mechanisms help organizations maintain control, improve efficiency, and ensure compliance with regulations by keeping a close eye on the movement and status of their important documents.

4.1.4 'Urgent' Test Request Process

An "urgent test request" is a term used in various industries to indicate the need for a test to be conducted or results to be provided quickly. It typically means that there is a time-sensitive situation

or critical condition that requires immediate attention and action. Urgent test requests are often prioritized over routine tests.

The urgent test request process typically involves the following steps:

- Identify the urgency: Determine if the test request is truly urgent and requires immediate attention.
- Notify the laboratory: Contact the laboratory or testing facility to inform them about the urgent test request. Provide all the necessary details, including sample type, the type of test required, and the reason for urgency.
- Expedite the request: Request the material testing to prioritize the test request and expedite the processing time. Some material testing may have specific protocols for urgent tests that need to be followed.
- Provide supporting documentation: In many cases, providing supporting documentation can help reinforce the urgency of the request.
- Communicate with the concerned persons: Inform the relevant concerned persons about the urgent test request. This helps ensure that everyone is aware of the urgency and can act accordingly.
- Follow-up and track progress: Regularly check the progress of the material test request and communicate with the construction laboratory to ensure that it is being processed expediently. If there are any delays or issues, escalate the matter to appropriate authorities.

It is important to note that specific organizations may have their unique urgent construction material test request processes, so it is advisable to consult the relevant policies and procedures for detailed instructions.

4.1.5 Security and Traceability of Information, Laboratory Data and Records

The security and traceability of information, laboratory data, and records is crucial in ensuring the integrity and reliability of experiments, and regulatory compliance. Key points related to their security and traceability:

- Data Security: It is vital to implement robust measures to protect information, laboratory data, and records from unauthorized access, tampering, loss, or damage. This may involve using

secure authentication methods, encryption techniques, firewalls, antivirus software, and regular backups.

- Access Control: Strict access controls should be in place to ensure that only authorized personnel have access to sensitive information. This can be achieved through user authentication mechanisms, role-based access control, and regular review of user privileges.
- Data Integrity: Data integrity measures help ensure that information and laboratory data remain accurate, complete, and reliable throughout their lifecycle. This may involve implementing data validation checks, maintaining an audit trail of all data modifications, and using checksums or digital signatures to verify data integrity.
- Data Encryption: Encrypting sensitive data, both while in transit and at rest, provides an additional layer of protection against unauthorized access. Strong encryption algorithms and secure key management practices should be employed to safeguard the confidentiality and integrity of the data.
- Backup and Disaster Recovery: Regularly backing up information, laboratory data, and records is essential to prevent data loss. Backup storage should be secure, and procedures for timely data restoration and disaster recovery should be established and tested.
- Audit Trail: Maintaining an audit trail helps track all activities related to information, laboratory data, and records. It provides a traceable history of who accessed, modified, or deleted data and when those actions occurred. Audit logs should be protected against tampering and reviewed periodically to detect any suspicious activities.
- Data Retention and Archiving: Establishing proper data retention and archiving policies ensures that laboratory data and records are stored for the appropriate duration, in compliance with regulatory requirements. These policies should consider factors like the type of data, legal obligations, and scientific significance.
- Regulatory Compliance: Depending on the industry and jurisdiction, specific regulations and standards may govern the security and traceability of information, laboratory data, and records. Organizations should stay updated with applicable regulatory requirements and implement necessary controls to achieve compliance.

By implementing robust security measures, strict access controls, data integrity checks, and appropriate data retention policies, organizations can enhance the security and traceability of their information, laboratory data, and records, thus ensuring the reliability and trustworthiness of their scientific work and compliance with regulatory obligations.

4.2 Customer Service

Customer service issues refer to problems or concerns faced by customers when they interact with a company's customer service department. These issues can arise from various factors such as long wait times, unhelpful or rude representatives, difficulty in reaching a live person, lack of knowledge or understanding, unresolved complaints or disputes, billing errors, inaccessible contact information, poor communication, and inadequate or incorrect information provided by the company. Customer service issues that customers often encounter:

- Difficulty in reaching customer service: Customers may face challenges in finding the contact information or reaching a live person for assistance. Automated phone systems or lengthy wait times can frustrate customers.
- Unhelpful or rude representatives: Customers may interact with untrained or uncooperative representatives who are unable or unwilling to assist them effectively. Rude or dismissive behavior can leave customers feeling dissatisfied.
- Lack of knowledge or understanding: Representatives may lack the knowledge or understanding required to address customers' concerns adequately. This can result in incorrect or incomplete information being provided, leading to further frustration for customers.
- Unresolved complaints or disputes: When customers have complaints or disputes, they expect a prompt and satisfactory resolution. If their concerns are not adequately addressed or remain unresolved, it can severely damage their perception of the company's customer service.
- Billing errors: Customers may be billed incorrectly due to mistakes made by the company or its representatives. Resolving billing errors promptly is crucial to maintaining customer trust and satisfaction.
- Poor communication: Customers appreciate clear and concise communication from customer service representatives. Communication breakdowns, ambiguous explanations, or language barriers can further exacerbate customer service issues.

To overcome these issues, companies should invest in comprehensive customer service training, efficient communication channels, knowledgeable and empathetic representatives, and effective complaint resolution processes. Regularly gathering customer feedback and addressing concerns promptly can also help in improving the overall customer service experience.

4.2.1 Referring Client

Referring a client involves recommending them to another individual or company for their services. It typically happens when the referring person believes the client's needs can be better met by another party. The referral could be made due to various reasons such as expertise, cost-effectiveness, or personal preference. When referring a client, it is important to provide relevant information and communicate the client's requirements and expectations effectively to ensure a successful transition. When faced with samples and request forms that do not comply with enterprise requirements, it is important to handle the situation professionally and provide clear guidance to the client.

- Review the requirements: Thoroughly go through the enterprise requirements to ensure there are no misunderstandings or miscommunications. Make a note of the specific points where the samples or request forms fall short.
- Communicate with the client: Reach out to the client and explain that the samples or request forms do not meet the enterprise requirements. Clearly outline the specific areas that need improvement or modification.
- Provide guidance: Offer guidance to the client on how they can amend the samples or request forms to comply with the enterprise requirements. This may involve providing specific instructions, templates, or examples they can refer to.
- Offer support: If the client is unsure about how to make the necessary changes, offer your assistance. This can set up a meeting or call to discuss the required modifications in more detail or providing additional resources for them to utilize.
- Clarify the benefits: Explain to the client the benefits of complying with the enterprise requirements. Emphasize how adherence to these requirements can streamline processes, enhance communication, and ensure consistency across different clients or projects.

- Follow up: Keep track of the progress made by the client in modifying the samples or request forms. Follow up with them regularly to provide any further guidance or support needed until compliance is achieved.
- Escalation: If the client continues to disregard the enterprise requirements, it may be necessary to escalate the issue to a higher authority within your organization. This should be a last resort option, used only when all attempts at resolution have been exhausted.

Remember to approach the situation with patience, professionalism, and a willingness to assist the client in meeting the enterprise requirements.

4.2.2 Inappropriateness of 'Return to Source' Supervision

In cases where "return to source" is inappropriate or not possible, a supervisor should intervene and guide the employee accordingly. Scenarios where "return to source" not be applicable:

- Confidentiality: If the information or instruction received is of a sensitive nature or involves confidentiality, it may not be appropriate to return to the source. In such cases, the supervisor should advise the employee on the appropriate handling of the situation, ensuring confidentiality is maintained.
- Time-sensitive issues: If the instruction requires immediate action or a quick decision, it might not be practical to seek confirmation from the source. In such instances, the supervisor should help the employee make an informed decision based on available resources and expertise.
- Lack of accessibility: If the source of the instruction is inaccessible or not readily available, returning to the source may not be possible. The supervisor should provide alternative solutions or suggest seeking advice from a different reliable source.
- Emergency situations: During emergencies or critical incidents, returning to the source may not be feasible. In these cases, supervisors should empower employees to make decisions independently while highlighting the importance of following established emergency protocols.
- Language or communication barriers: If the source of the instruction doesn't speak the same language or faces communication challenges, it may be difficult to achieve clarity through a

simple return to the source. The supervisor should assist in finding alternative methods of communication or provide necessary support for effective understanding.

In each of these situations, the supervisor's role is crucial. They should conduct regular training sessions to equip employees with decision-making skills, provide clear guidelines on when "return to source" is not possible, and encourage critical thinking to handle such scenarios effectively.

4.2.3 Confidentiality of Client Data and Information

Confidentiality of client (enterprise) data and information is of utmost importance in order to protect sensitive information from unauthorized access, use, or disclosure. It refers to the practice of keeping data and information secure, ensuring that only authorized individuals have access to it. There are several measures that can be taken to maintain confidentiality:

- Access control: Implementing strong authentication methods, such as passwords and two-factor authentication, to control who has access to the data. This helps ensure that only authorized individuals can view and manipulate the information.
- Encryption: Encrypting data both at rest and in transit helps to protect it from being intercepted or accessed by unauthorized parties. This involves encoding the information in a way that can only be decrypted by authorized users with the encryption key.
- Secure storage: Storing data in secure locations, such as encrypted databases or cloud storage with appropriate security measures, to prevent unauthorized access or physical theft.
- Confidentiality agreements: Implementing confidentiality agreements with employees, contractors, or third-party vendors who have access to the data. These agreements outline the responsibilities and obligations of all parties to maintain the confidentiality of the information.
- Regular security assessments: Conducting regular security assessments and audits to identify vulnerabilities and mitigate any potential risks to the confidentiality of data.
- Employee training: Providing training and awareness programs to educate employees about the importance of confidentiality and how to handle sensitive data securely, such as avoiding sharing passwords, practicing safe browsing habits, and recognizing phishing attempts.

Overall, maintaining the confidentiality of client (enterprise) data and information requires implementing a combination of technical, physical, and administrative controls to ensure that unauthorized access or disclosure does not occur.

4.2.4 Information to Customers

To ensure that the information provided to customers is accurate, relevant, and authorized for release, businesses should follow these best practices:

- Training and Knowledge: Businesses should invest in training their customer service representatives or any employees who communicate directly with customers. They should have a thorough understanding of the products, services, policies, and procedures to provide accurate information.
- Fact-checking and Verification: Before providing information to customers, it is essential to verify the accuracy and relevance of the information. Customers rely on the businesses to provide correct details, so fact-checking is crucial to build trust.
- Internal Communication: Establish effective communication channels within the organization to ensure that employees have access to the updated and authorized information. Encourage employees to ask questions or seek clarification if they are unsure about any information.
- Authorized Sources: Clearly define the authorized sources of information within the organization. This can official documents, databases, frequently asked questions (FAQs), or internal resources. Employees should be aware of these sources and only provide information that is sourced from these authorized channels.
- Regular Updates: Ensure that the information provided to customers is regularly updated. This will help in maintaining accuracy and relevance. Any changes in policies, products, or services should be communicated promptly to the frontline employees.
- Documentation and Standard Operating Procedures (SOPs): Document the accurate information in the form of SOPs or knowledge bases. These documents should be easily accessible to employees and regularly reviewed and updated.

- Quality Assurance: Establish a quality assurance process to monitor and review the information provided to customers. This can involve periodic checks, audits, or manager feedback to ensure that information is accurate and relevant.
- Customer Feedback and Complaints: Encourage customers to provide feedback on the accuracy and relevancy of the information they receive. This feedback can help identify areas for improvement and address any gaps in knowledge.
- Legal and Regulatory Compliance: Ensure that the information provided complies with all legal and regulatory requirements. Depending on the industry, there might be restrictions on what information can be shared with customers, so businesses should be aware of and follow these guidelines.

By implementing these practices, businesses can provide accurate, relevant, and authorized information to customers, enhancing their trust, satisfaction, and overall experience.

4.2.5 Dealing with Customers Politely and Efficiently

Dealing with customers politely and efficiently is essential for providing excellent customer service. Tips to help you create positive interactions:

- Maintain a positive attitude: Approach each customer interaction with a friendly and positive attitude, regardless of their demeanor. Your positive energy can help diffuse any tension and create a more pleasant experience.
- Use active listening: Demonstrate that you genuinely care about the customer's concerns by actively listening to them. Pay full attention to their words, maintain eye contact, and provide verbal and non-verbal cues to show that you are engaged in the conversation.
- Practice effective communication: Clearly convey information to customers using language they can understand. Communicate in a friendly and concise manner, avoiding jargon or technical terms that may confuse them. Ask clarifying questions to ensure you understand their needs fully.
- Show empathy and understanding: Put yourself in the customer's shoes, understand their frustrations or concerns, and respond with compassion. Validate their feelings, apologize when necessary, and assure them that you're committed to resolving their issues.

- Be patient and calm: Stay calm and patient, even when dealing with difficult or irate customers. Avoid getting defensive or reacting emotionally. Focus on finding a solution or offering alternatives that meet their needs.
- Provide timely and accurate information: Customers appreciate getting accurate and timely information. If you don't have an immediate answer, let them know that you will find the information and follow up accordingly. Avoid making commitments you can't fulfill.
- Take ownership of the problem: Customers value individuals who take responsibility and show initiative to resolve their issues. Avoid passing customers from one department or person to another excessively. Take ownership of their concerns and see it through until the problem is resolved.
- Offer options and solutions: Present customers with viable options and creative solutions to address their needs. This can offer alternatives, suggesting add-ons or upgrades, or connecting them with relevant resources.
- Practice time management: Be aware of the time customers spend waiting for assistance and try to minimize it. Efficiently manage your tasks, prioritize customer needs, and avoid unnecessary delays.
- Follow up: After resolving a customer's issue or fulfilling their request, follow up to ensure their satisfaction. This can be done through a phone call, email, or any preferred communication method. Show gratitude for their patience and thank them for their business.

Providing excellent customer service requires ongoing practice and a genuine desire to serve. By following these tips, you can build strong customer relationships and enhance your reputation as a polite and efficient customer service representative.

Self-Check-1

Part I: Multiple Choice

Instruction: Choose the best from the given alternatives.

1. What are some measures to protect laboratory data and records?
    a. Regular backups and antivirus software
    b. Firewalls and secure authentication methods
    c. Secure authentication methods and encryption techniques
    d. Encryption techniques and regular backups
2. Why is it important to record construction material sampling dates?
    a. To schedule construction activities
    b. To identify potential hazards on construction sites
    c. To determine the cost of construction materials
    d. To track the quality and performance of materials
3. What is the benefit of using a laboratory information management system (LIMS)?
    a. To generate certificates of analysis
    b. To improve lab efficiency and standardize workflows
    c. To ensure proper calibration of instruments
    d. To track the flow of samples in the laboratory
4. What is an 'urgent test request'?
    a. A request for a test to be repeated for verification
    b. A request for a test to be conducted on a specific sample
    c. A request for a test to be completed within a specific time frame
    d. A request for a test to be performed by a specific laboratory
5. What is document tracking used for?
    a. To prioritize urgent test requests
    b. To track document access and changes
    c. To protect laboratory data and records
    d. To monitor when a document was created

Part II: Matching

Instruction: Match Terms in column A with its meanings in column B.

A	B
_____ 1. Active listening	A. Politely and effectively
_____ 2. Dealing with customers	B. Pay full attention to customer
_____ 3. Customer service issues	C. Protect sensitive information from unauthorized access
_____ 4. Confidentiality	D. Concerns faced by customers
_____ 5. Referring a client	E. Recommending customer to another individual

Part III: Short Answer Questions

Instructions: Answer all the following questions accordingly.

1. What is the significance of recording construction material sampling dates?
2. Why is it crucial to check the sampling date in different industries?
3. How does a laboratory information management system (LIMS) enhance lab efficiency?
4. In what ways can document tracking benefit organizations?
5. What defines an urgent test request and why are they given priority?

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