የሥራ እና ክህሎት ሚኒስቴር
MINISTRY OF LABOR AND SKILLS

ROAD CONSTRUCTION AND MAINTENANCE

LEVEL – III

Based on September, 2023 Curriculum Version II

Module Title: Construction of Flexible Pavement

Module Code: EIS RCM3 10 0923

Nominal duration: 50 hours

Prepared By: Ministry of Lobar and Skill

September, 2023

Addis Ababa, Ethiopia

Bridges to Prosperity

HELVETAS Swiss Intercooperation

Table of Contents

ACKNOWLEDGMENT

The **Ministry of Labor and skill, HELVETAS, and Bridge to Prosperity (B2P) Ethiopia wish** to thank MoLS experts, **HELVETAS** Leaders & experts, regional labor and skill bureaus, TVT trainers, university lecturers and industry experts who contribute their time and professional experience to the development of this **Training module** for Conduct and Monitor Construction of Flexible Pavement.

We would like to express our appreciation to the **Ministry of Labor and skill, HELVETAS and,** Bridge to Property (B2P **Ethiopia for** their technical and financial support and workshop facilitation of this training module development.

LIST OF ACRONYMS

RC –	RAPID CURING
MC –	MEDIUM CURING
PPE -	PERSONAL PROTECTIVE EQUIPMENT
AASHTO -	AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
CRS-	CATIONIC RAPID SETTING
AC -	ASPHALT CEMENT
ASTM -	AMERICAN SOCIETY FOR TESTING AND MATERIALS
CLFP-	CONVENTIONAL LAYER FLEXIBLE PAVEMENT
FDAP -	FULL – DEPTH ASPHALT CEMENT
HCA -	HOT COMPRESSED AIR
HAVS-	HAND-ARM VIBRATION SYNDROME
CRAM -	CONTAINED ROCK ASPHALT MAT
FWD-	FALLING WEIGHT DEFLECT METER
GPR-	GROUND PENETRATING RADAR
HMA-	HOT MIX ASPHALT
CBR –	CALIFORNIA BEARING RATIO
NDT -	NON-DESTRUCTIVE TESTING
ERA-	ETHIOPIAN ROAD AUTHOR
MTV-	MATERIAL TRANSFER VEHICLES

Introduction to this module

This module deals with the skills and knowledge and Attitude of construction of Flexible Pavement (Plan and prepare work ,Identify types of Flexible Pavement ,Conduct pre paving inspection, Place spread and compact materials and clean up

Flexible Pavement will transmit wheel load stresses to the lower layers by grain-to-grain transfer through the points of contact in the granular structure. The wheel load acting on the pavement will be distributed to a wider area, and the stress decreases with the depth. Taking advantage of these stress distribution characteristic flexible pavements normally has many layers. Hence, the design of flexible pavement uses the concept of layered system. Based on this, flexible pavement may be constructed in a number of layers and the top layer has to be of best quality to sustain maximum compressive stress, in addition to wear and tear.

This module covers the units:

- Planning and preparation work
- Types of Flexible Pavement
- pre -paving inspection
- Placing, spreading and compaction materials

Learning objectives of the Module

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

- plan and Prepare work
- Identify types of Flexible Pavement
- Conduct pre paving inspection
- Place, spread and compact materials

Module Instructions:

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the specific objectives of this unit.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

UNIT ONE: PLANNING AND PREPARATION WORK

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics

- Basic concept of Flexible Pavement
- Compliance Documentation
- Worksite instructions
- Material quantity requirements
- Safety and Signs t requirements
- Plant ,Tools And Equipment
- Environmental Protection Requirements

This unit 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 the basic concept of flexible pavement
- Identify compliance documentation
- Apply worksite instructions
- Identify material quantity requirements
- Identify Safety and Signs t requirements
- Select plant ,tools and equipment
- Identify Environmental protection requirements

1.1 Basic concept of Flexible Pavement

A flexible pavement is a type of road pavement that is made up of several layers of materials that are flexible and can deform under load. The top layer is typically made of asphalt concrete, which is a mixture of asphalt binder and aggregates. The bottom layers are typically made of granular materials, such as gravel or crushed stone.

The flexible pavement structure is designed to distribute the load from traffic over a wider area, so that the stresses on the sub grade are not too high. The sub grade is the natural soil or rock that supports the pavement.

The flexible pavement is able to deform under load because the asphalt concrete is a viscose elastic material. This means that it has both elastic and viscous properties. The elastic properties allow the asphalt concrete to return to its original shape after the load is removed. The viscous properties allow the asphalt concrete to flow under sustained load.

The flexible pavement is a popular type of pavement because it is relatively inexpensive to construct and maintain. It is also relatively easy to repair. However, flexible pavements are not as durable as rigid pavements, such as concrete pavements.

1.2 Compliance Documentation

1.2.1 Standard Document procedures

Important characteristics in determining the cause and effect relationship on why pavements perform as they do include the following:

- The strength of the pavement structure.
- The thickness and types of materials in the pavement structure.
- The strength, elastic, and plastic properties of the pavement materials.
- The magnitude and volume of wheel loads applied to the pavement. o The response of the pavement structure to load.
- The climate characteristics at the site.
- The condition of a pavement as a function of its roughness and features related to fracture, distortion, and disintegration of the surface materials.

Documented during ambient monitoring & following details:

A. Location of sampling station
B. Records of meteorological conditions
C. Use of recommended sampling equipment
D. Careful determination of gas flow rate and sample time
E. Noting of any unusual conditions which may affect sample
F. Proper handling of the collected sample and recording of container and filter numbers.

1.2.2 Labor laws and regulations

A. Employment policy

One of the aims of the government of Ethiopia is to fully involve local people in the construction, rehabilitation and maintenance of construction works as cost effectively as possible. Temporary laborers and some skilled labor required for the construction works will therefore be recruited from the locality of the site.

When construction, rehabilitation or maintenance of a road, section of road, is completed, the work site will move to another location and the causal labour force will be discharged. New causal laborers will be recruited at each work site.

This policy will spread the temporary employment opportunities to as many people as possible. Women will be offered equal opportunities as men for employment, and the recruitment process must clearly demonstrate this.

B. Laws and regulations

Laws and regulations apply to flexible pavement work:

Building codes: typically standards for the construction of pavements and structures. These codes requirements for the materials used the thickness of the pavement, and the methods of construction.

Environmental regulations: restrict the use of certain materials in pavement construction, such as materials that contain hazardous substances. Require the construction of certain features, such as storm water management systems, to minimize the impact of pavement construction on the environment.

Labor laws: wages and working conditions for workers involved in pavement construction. They require employers to provide workers with safety training and equipment.

Contracting laws: typically govern the process of awarding contracts for pavement construction. These laws may require that contracts be awarded through a competitive bidding process and that the contracts be in writing.

Inspection laws: require that pavement construction be inspected by a qualified inspector to ensure that it meets the required standards.

laws and regulations applicable as follows:

- Equality
- Freedom from forced labor
- Freedom of association
- Minimum age
- Minimum wage
- Protection of wage
- Safety and health

1.3 Work instructions

Work instructions are integral parts of constructing and monitoring flexible pavement projects. The processes involved dictate the overall operational efficiency and quality standard compliance of the project.

Instructions can be detailed in construction plan layouts, drafted specifications, design models, and operating procedures. Once these instructions are procured, the team needs to confirm those, ensuring they are coherent, achievable, relevant, and align with the project's scope and objectives.

Work instructions are key documents to reference when internal or external non conformances are identified. Make the review of the work instructions part of the corrective action process. Ask if the supporting instruction properly defines the process, then and it the instruction to confirm proper definition. Construction planning as they relate to construction productivity and closure windows:

1. Selection of the construction closures and windows
2. Sequence of construction activities
3. Preliminary estimation rates
4. Job specific constraints

Confirming Work Instructions- once work instructions are obtained, it is imperative to confirm their accuracy and relevance. Obtain the project plans, specifications, and quality requirements. This will ensure that everyone involved in the project is on the same page and that the work is done to the required standards.

Obtaining Work Instructions- Before commencing any construction project, it is crucial to obtain comprehensive work instructions. These instructions serve as a roadmap for the construction process, outlining the necessary steps and procedures. Work instructions can be obtained from various sources, project managers, engineers, or relevant authorities.

Applying Work Instructions After confirming the accuracy of work instructions, it is time to apply them during the construction process.

Work site instructions, day works & variation orders

Work Site instructions: Site instructions are written documents that provide specific instructions to the contractor on how to perform the work. They are typically issued by the project engineer or superintendent and should be clear, concise, and easy to understand.

Day works: Day works are a type of payment arrangement in which the contractor is paid for the actual time and materials used to complete the work. They are typically used for small, unplanned tasks or for work that is outside of the scope of the original contract.

Variation orders: Variation orders are written documents that authorize the contractor to deviate from the original contract. They can be issued by the project owner or engineer for a variety of reasons, such as changes in the scope of work, unforeseen conditions, or delays.

1.3.1 Worksite inspection

Purpose of Pavement Inspection Pavement Inspection has the following four (4) purposes;

1. To obtain required information promptly from the site for maintain smooth and safe traffic by adequate maintenance.
2. To know the pavement surface condition and identify the portion requiring maintenance
3. To find locations of serious potholes in order to prevent accident of the road user and third party.
4. To evaluate severity of the distress of the pavement, to prioritize the repair plan and to select the most urgent section to repair.

Flexible Paving Inspection

Flexible inspection is a team effort that consists of the following jobs:

Inspection of aggregate production and stockpiling

- Pre paving grade inspection
- Prime and/or tack inspection
- Plant Inspection

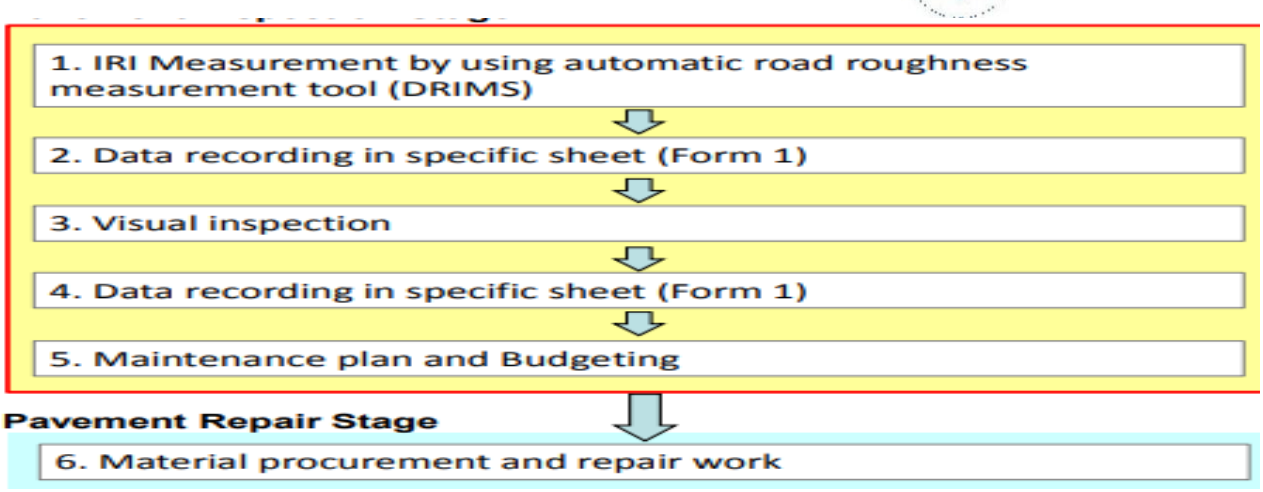
- Lay down inspection
- Materials testing
- Density Testing
- Traffic control inspection

Responsibilities of the Inspector

- Know the plans and specifications for the pay items you are inspecting, including specifications specific to the project (special provisions, etc.)
- Be alert for any potentially unsafe conditions or any situations that may delay construction and report them to your supervisor.
- Identify nonconforming work or materials as early as possible; anticipate problems where possible. Notify the Contractor immediately and make a record of it. Follow up on corrective work and make a record of it too. If the Contractor can't or won't fix the problem, notify your supervisor.
- Avoid any inspection, testing, or other activity that could be construed as the Contractor's responsibility. If you don't, the Contractor may not be held accountable for his work if there is a claim or other contract dispute.
- Be prepared to make inspections and tests promptly. Do not make hasty or premature decisions. The Contractor is expected to give you adequate notice of when he will be ready for inspection and testing.
- If specifications don't cover a particular situation or tolerances seem unrealistic, contact your supervisor for guidance. Report problems you can't handle and see that they get resolved before an expensive and time-consuming correction is required.

Pavement Inspection Flow

The steps of the pavement inspection are illustrated in the following flow chart.



1.4 Material quantity requirements

The material quantity requirements for the construction of a flexible pavement will vary depending on the specific project. The material quantity requirements for the construction of a flexible pavement are an important part of the planning and preparation for the project. By accurately calculating the material requirements, the project can be completed on time and within budget. The most common materials used in flexible pavement construction and their typical quantities are as follows:

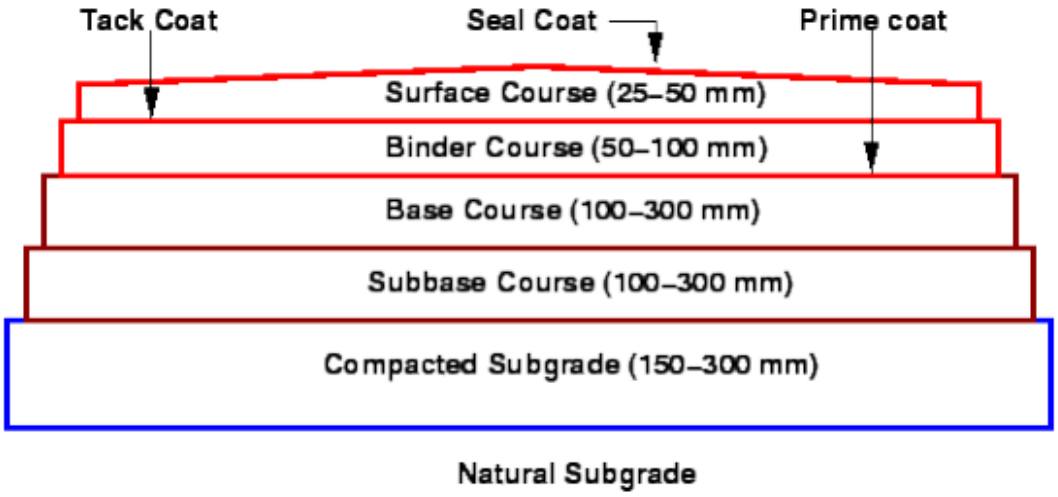


Fig1.1 Components of a flexible pavement

Asphalt concrete: Asphalt concrete is the most common material used in flexible pavement construction. It is made from a mixture of asphalt binder, aggregate, and water. The typical thickness of an asphalt concrete pavement is 10cm to 30 cm.

Base course: The base course is the layer of material that supports the asphalt concrete pavement. It is typically made from crushed stone or gravel. The thickness of the base course depends on the traffic

loading and the type of sub grade. Typical base course thickness ranges from 100 to 150mm. The base course of road serves as the essential basic segment of the adaptable asphalt.

The materials making the base course are select hard and tough totals, which generally fall into two

1. Fundamental classes
2. Balanced out and granular

Sub grade: The sub grade is the natural soil or rock that underlies the pavement. It is important to have a strong and stable sub grade to support the pavement.

Bituminous material: Bituminous material is used to bind the aggregate particles in the asphalt concrete. It is typically made from asphalt cement, which is a sticky, black liquid.

Water: Water is used to mix the asphalt concrete. The amount of water required depends on the type of asphalt cement used.

Aggregate: Aggregate is the inert material that makes up the bulk of the asphalt concrete. It is typically made from crushed stone or gravel.

Calculating material quantity requirements

Quantity of material = Volume of layer * Density of material * (1 + Waste factor)

Where:

Quantity of material: The amount of material required for the project.

Volume of layer: The thickness of the layer multiplied by the area of the pavement.

Density of material: The weight of the material per unit volume.

Waste factor: A factor that is added to the calculated quantity to account for material that is lost during construction.

Example1

Construct a flexible pavement with a 10-cm asphalt concrete layer and a 15-cm base course layer. The area of the pavement is 100 square meters, the density of asphalt concrete is 2,400 kilograms per cubic meter, and the density of base course is 2,000 kilograms per cubic meter. The waste factor is 5%.

Steps to calculate the material quantity requirements:

1. Convert the thickness of the layers from centimeters to meters:10 cm = 0.1 m and 15 cm = 0.15 m
2. Calculate the volume of the asphalt concrete layer: 100 square meters * 0.1 m = 10 cubic meters
3. Calculate the volume of the base course layer: 100 square meters * 0.15 m = 15 cubic meters
4. Calculate the quantity of asphalt concrete: 10 cubic meters / 2,400 kilograms per cubic meter = 41.67 kilograms
5. Calculate the quantity of base course: 15 cubic meters / 2,000 kilograms per cubic meter = 7.5

kilograms

6. Calculate the total quantity of materials required: 41.67 kilograms + 7.5 kilograms = 49.17 kilograms
7. Add the waste factor: 49.17 kilograms * 1.05 = 51.62 kilograms

1.5 Safety and Signs requirements

The construction of a flexible pavement is a complex and hazardous undertaking. There are many potential hazards associated with this type of construction, traffic accidents, falls, struck-by objects, and exposure to hazardous materials. To protect workers and the public, it is essential to implement appropriate safety and signs requirements.

Traffic control: Traffic control is essential to ensure the safety of motorists, workers, and pedestrians. Traffic cones, barricades, and signs should be used to warn motorists of the construction zone and to direct traffic around the work area.

Personal protective equipment (PPE): All workers should wear appropriate PPE, such as hard hats, safety glasses, gloves, and steel-toed boots. This will help to protect them from injury in the event of an accident.

Excavation and trenching: When excavating or trenching, it is important to ensure that the edges of the excavation are properly sloped and that there are adequate barricades to prevent people from falling in.

Asphalt concrete paving: When paving with asphalt concrete, it is important to take precautions to avoid slips and falls. This includes using non-slip shoes and walkways, and keeping the work area clean and free of debris.

Workers: All workers should be trained in the safe operation of equipment and the specific safety requirements for the construction of a flexible pavement.

Signage: Proper signage should be used to warn motorists and pedestrians of the construction zone and to direct traffic around the work area. Signs should be placed in a timely manner and should be clearly visible to motorists and pedestrians.

All equipment operators must be trained in the use of their equipment (trucks, rollers, concrete mixers, quarrying and construction hand-tools). Equipment must be maintained in good condition and workers must be aware of that safety covers should be used over moving parts on machinery.

Employers must:

- Make ‘assessments of risk’ to the health and safety of the workforce, and to act upon risks they identify

- Appoint competent persons to oversee workplace health and safety
- Provide workers with information and training on occupational health and safety
- Operate a written health and safety policy

1.5.1 Signage application

1. Traffic sign a device mounted on a fixed or portable support whereby a specific message is conveyed by means of words or symbols, officially erected for the purpose of regulating warning, or guiding traffic.
2. Traffic signal a power-oriented traffic control device by which traffic is regulated, warned, or alternately directed to take specific actions.

As a road work contractor you are directly responsible for the safety of your workers and the road users. Whenever work is being carried out on or close to the carriageway, adequate measures have to be taken to warn and protect both road users and your workers by ensuring that:-

- The necessary temporary traffic signs and protection are provided and correctly located on site for the duration of the work,
- All equipment and vehicles are parked off the carriageway or behind protective barriers and signs, when not in use,
- No material is to be left in a dangerous location and that the road adjacent to the work site is kept clean and swept of any debris arising from the work,
- All excavations are protected for the benefit of all road users, equipment and workers,
- All operators are trained in the operation of their equipment,
- Operators and labourers are informed of the potential risks of and procedures for working with or close to machinery,
- Traffic control operations are carried out properly and that road users are not unnecessarily delayed,
- Where work on the carriageway or shoulder remains unfinished overnight, then proper warning lights re to be arranged and, if necessary protected,
- All sites are to be left tidy and cleared of debris when the work is completed.

1.5.2 Signs and Safety Equipment

When working on the roadside or carriageway, traffic from both directions must be alerted. The following signs and barriers are useful for this purpose:

- Reversible ‘Stop / Go’ Signs

- Speed Limit Signs (30 Km/Hr)
- 'Men Working' Signs
- 'No Overtaking' Signs
- 'Road Narrows' Sign
- 'End of Restriction' Signs
- Lane Closure Barriers And
- Traffic Cones

Standard signs the following signs should be available for traffic control on site:

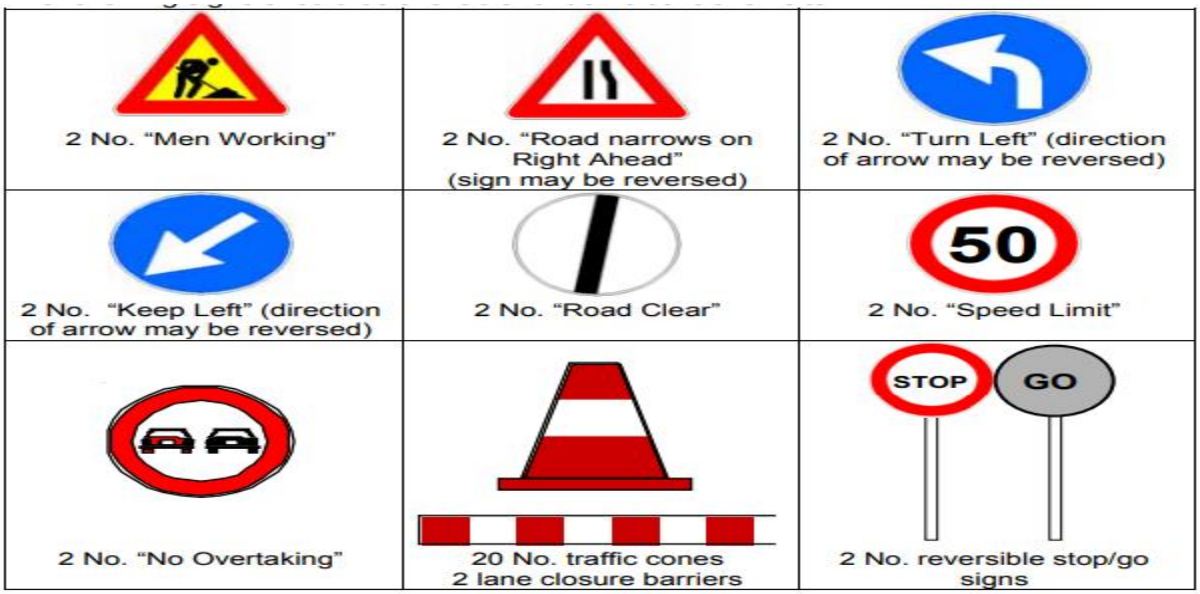


Figure1.2. Road signs used in Flexible Pavement works

These signs should be available as many as required. In addition to reflective vests, workers should be issued with considering personal protective equipment depending on the work being undertaken such as

- Gloves
- Helmets
- Safety shoes
- Safety suit
- Dust Masks
- Goggles And
- Ear Muffs

Fig 1.3 Safety equipment

1.6 Tools, Plant and equipment

1.6.1 Road excavating equipment

The process of cutting or loosing and removing earth from its original position, transport and improve it as a fill or spoil bank is known as excavation. For any type of soil such as soil, soft rock or even hard rock before preparing the sub grade excavation is needed. The reservation will also be required for the construction of side drains. Choice of suitable equipment will only depend on the nature of soil to be excavated.

These are intermittent types of equipments. Tractors, power shovels, draglines, Clam shells, bulldozer, angle dozer, scrapers, back hoes, dredger, ripper, motor grader, etc are the earth excavating equipments.

Tractor

This equipment is a self propelled machine which is used mainly to exert a powerful attractive force for pulling other machines. When the tractor is not required for hauling other machines, it can be easily converted to serve as bulldozer, angle dozer, etc when tractors are equipped with shovels, they can even be used for the mining operations

Bulldozer

Bulldozer is very useful equipment and it can be used on the construction work for the following purposes:

- To clear the site of work,
- To make the land level,
- To prepare for pilot roads through mountains and hard ground and,
- To excavate material and howl for distance of about 100 meters.

Grader

Graders may be used in place of milling machines if the base course is dirt or gravel. They are vehicles with large blades that create a wide flat surface for asphalt to be placed on.

Figure 1.4: A grader preparing the sub grade on a project

Scraper:

This equipment consists of a large bucket called the scraper and it is attached to a tractor. Its capacity varies rum 3 m3 to 9 m3, the scraper has a cutting edge or blade at the tom and it is possible to dig earth to a depth of about 250 mm.

Excavators:

Excavator is the most used oldest type of machine used for the movement of the earth for road paver by doing its work of moving the earth while the main unit is stationary. Little effort is required to move the dead weight of the earth in a vertical plane. The lateral motion is in the horizontal plane and the effort required is primarily limited to acceleration and deceleration of the bucket in the plane.

1.6.2 Paving Equipment

Stabilizers/Re claimers

A stabilizer/re claimer is a vehicle with a dual purpose. These machines have a large rotor blade which may be used to cut and pulverize damaged or old pavement, but which also may be used to mix lime, fly ash, or cement into the sub base in order to stabilize poor soils.

Sweepers

Sweepers clean the surface of the road after it has been milled or graded. This is necessary because excessive dust and debris on the ground can prevent proper bonding between the asphalt and the base course. Large pieces of debris can also cause non-uniform compaction of the asphalt.

Figure 1.5: Sweeping machine.

Batch Plant

Batch plants, which produce asphalt in individual batches, are the older of the two types of asphalt production facilities; it was not until the 1970s that drum plants became a popular asphalt production option. Typical batch quantities range from 1.5 to 5 tons of asphalt and each batch can take 15 – 45 seconds to make.

Figure 1.6: Batch plant

Drum Plant

Drum plants, which produce HMA in a continuous manner, generally offer higher production rates than batch plants for comparable cost. Typical production rates for drum plants vary between about 100 tons/hr up to over 900 tons/hr depending upon drum design.

Figure1.7: drum plant.

Dump Trucks

Dump trucks move the hot asphalt from the plant to the jobsite. There are many kinds of dump trucks:

- End dump: unload their payload by raising the front end and letting the payload slide down the bottom of the bed and out the back through a tailgate.
- Bottom or belly dump: Bottom dump trucks unload their payload by opening gates on the bottom of the bed.
- Live bottom: Live bottom dump trucks have a conveyor system at the bottom of their bed to unload their payload.

Figure 1.8: End dump truck placing.

Material Transfer Vehicles

Material transfer vehicles (MTVs) are used to provide additional surge volume, which is advantageous because it allows the paver to operate continuously without stopping, minimizes truck waiting time at the paving site and may minimize aggregate segregation and temperature differentials.

Figure 1.9: Material transfer vehicle, or shuttle buggy.

Asphalt Pavers

The asphalt paver is a self-propelled formless lay down machine with a floating screed. This set of functions can be divided into two main systems:

- Tractor: The tractor contains the material feed system, moves it to the rear and spreads it out to the desired width in preparation for screed leveling and compaction.
- Screed: The most critical feature of the paver is the self-leveling screed unit, strikes it off at the correct thickness and provides initial mat compaction.

Figure 1.10: A typical asphalt paving machine.

Compactors/Rollers

There are three basic pieces of equipment available for asphalt compaction:

(1) The paver screed

(2) The steel wheeled roller and

(3) The pneumatic tire roller.

Each piece of compacts equipment the asphalt by two principal means:

1. By applying its weight to the asphalt surface and compressing the material underneath the ground contact area. Since this compression will be greater for longer periods of contact, lower equipment speeds will produce more compression. Obviously, higher equipment weight will also increase compression.
2. By creating a shear stress between the compressed material underneath the ground contact area and the adjacent uncompressed material. When combined with equipment speed, this produces a shear rate. Lowering equipment speed can decrease the shear rate, which increases the shearing stress. Higher shearing stresses are more capable of rearranging aggregate into more dense configurations.

These two means are of compacting asphalt are often referred to collectively as “comp active effort”.

1. Paver Screed

Approximately 75 to 85 percent of theoretical maximum density, or Rice density, will be obtained when the mix passes out from under the screed.

2. Steel Wheel Rollers

Steel wheel rollers are self-propelled compaction devices that use steel drums to compress the underlying asphalt. The drums can be either static or vibratory and usually range from 35 to 85 inches in width and 20 to 60 inches in diameter. Roller weight is typically between 1 and 20 tons.

As a general rule-of-thumb, a combination of speed and frequency that results in 10 – 12 impacts per foot is good. At 3000 vibrations/minute this results in a speed of 2.8 – 3.4 mph.

Figure 1.11: A steel wheel roller

Pneumatic Tire Rollers

Pneumatic tire rollers are self-propelled compaction devices that use pneumatic tires to compact the underlying asphalt. Pneumatic tire rollers employ a set of smooth (no tread) tires on each axle; typically four or five on one axle and five or six on the other. Which is typically set between 60 and 120 psi? In addition to a static compressive force, pneumatic tire rollers also develop a kneading action between the tires that tends to realign aggregate within the asphalt. Because asphalt binder tends to stick more to cold tires than hot tires, the tire area is often insulated with rubber matting or plywood to maintain the tires near mat temperature while rolling.

Figure 1.12: A pneumatic tire roller compacting chip seal.

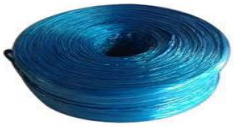
Followings are the type of Compacting equipment for road:

- Road rollers,
- Rubber-tired or pneumatic rollers,
- Sheep's foot rollers,
- Smooth wheeled rollers
- Vibratory Compactors
- Earth Rammers
- Jetting and pounding

Tools

- Tape Measures, (30 m and 5 m)
- String line & Club Hammer
- Wooden/ steel Pegs & Strings
- straight edged screenings
- tools (steel/aluminum)
- steel rakes
- concrete shovels
- Concrete finishing steel
- trowels
- mechanical concrete mixers
- Wheel barrows
- mechanical vibrator
- Camber board/ straight edge

Table: 8 Flexible Pavement tools

Tools	Definition	Picture
steel Rakes	Rakes are used in road works for raking out vegetation from loose soil. Commercially produced rakes have 10 to 16 teeth, each about 75 - 100mm long, with an overall length about 400 - 450mm.	
Sledge Hammer	A sledgehammer is a tool with a large, flat, often metal head, attached to a long handle. The long handle combined with a heavy head allows the sledgehammer	
Spirit Level	Spirit levels are available in all different sizes. For construction work robust and long spirit levels are ideal.	
Hoes	The hoe, in addition to being very useful in agriculture, is also a commonly used tool when using labour-based work methods for rural road works.	
Strings	Alignment string /mason line/, sometimes called, Fish line, is a rope used to transfer horizontal & vertical alignments or lines, i.e.,	
Tape Measure	A great variety of tape measures exist. The most common length of tape measure used for setting out is 30 meters.	

1.7 Environmental protection requirements

1.7.1 Environmental management plan

Environmental protection planning is an important component of overall planning and implementation of mega-projects. The primary purpose of this Environmental Management Planning is to establish the Environmental Protection Procedures to be implemented by staff, consultants and contractors.

The purpose of the Environmental Management Plan is to:

- Ensure that commitments to minimize environmental effects are met
- Document environmental concerns and appropriate protection measures;
- Provide contingency plans for accidental events;
- Communicate changes in the program through the revision process; and n Provide a reference to applicable legislative requirements.

1.7.2 Waste management Plan

The waste management plan for each project will usually be the responsibility of the main contractor, and from this plan, specifications can be developed for bid/contractor packages, outlining procedures for salvage, reuse and recycling. It can also be used to provide clients with details of actual reuse/ recycling and disposal of waste.

In most cases, subcontractors would operate to the main contractor's plan. Where subcontractors have sole responsibility for their waste, they should complete their own waste management plan.

- The type and quantities of waste generated during operation
- Procedures to collect and dispose of waste
- Measure that will be implemented to minimize waste generation associated with the development
- A program for monitoring the effectiveness of these measures

Establish goals and objectives

Set broad goals and objectives related to the following:

- Eliminate the generation of waste, as a priority.
- Recycle and reuse waste that is created on the job.
- Use construction methods that allow for deconstruction.
- Use products and materials that reduce waste.

Estimate waste amounts

Forecast the types and percentages of waste that will be produced. Start off with your usual waste percentages - if you have no basis for comparison, use the Ethiopian construction industry averages.

Set targets for reduction

Use resource routing calculator to determine what materials will be recycled. Set a target for each waste type; for example, reduce waste by 20% by the project's end.

Describe recycling/reuse methods

Identify the possibilities for reuse and recycling for each type of waste that is created and describe these where, how and when to handle waste materials.

Material use and handling

Use this section to identify any recycled and second-hand materials or materials with recycled content being used on the project.

Also identify any special handling or storage measure to protect reusable and recyclable materials from damage and to ensure materials are consistent with requirements for acceptance by designated facilities

Project review

At the end of the project, add your ideas about strengths, weaknesses and suggested actions. See Reviewing the Process for more information.

Noise

Noise is unwanted sound judged to be unpleasant, loud or disruptive to hearing. From a physics standpoint, noise is indistinguishable from sound, as both are vibrations through a medium, such as air or water. The difference arises when the brain receives and perceives a sound.

Acoustic noise is any sound in the acoustic domain, either deliberate (e.g., music or speech) or unintended. In contrast, noise in electronics may not be audible to the human ear and may require instruments for detection.

Vibration

Vibration in construction work Construction workers are at high risk of ill-health from using vibrating work tools. When using these tools vibration is transmitted into the worker’s hands and arms – causing hand-arm vibration.

Regular hand-arm vibration can result in a number of conditions collectively known as hand-arm vibration syndrome (HAVS).

Dust and clean-up management

When it comes to working in construction, you have to be ready to get dirty. Whether you're renovating a building or constructing a new house, dust and dirt are part of the job. When there is an excess of dust and dirt traveling through the air though, it can become dangerous for your workers' health.

SELF-CHECK 1	Written Test

TEST I: MULTIPLE CHOICE

Direction: Choose the best answer for the following question

1. What is the advantage of using performance-based specifications?

   A) It prescribes specific work methods and materials as well as the end result

   B) It eliminates the need for quality requirements for materials

   C) It allows for fully utilizing the experience and knowledge of the contractor

   D) It is less time-consuming

2. What is the purpose of flexible pavement inspection?

   A) To obtain required information promptly from the site for maintain smooth and safe traffic by adequate maintenance.

   B) To identify nonconforming work or materials

   C) To find locations of serious potholes in order to prevent accident of the road user and third party.

   D) To evaluate severity of the distress of the pavement

3. What is the purpose of stabilizers in the base course?

   A) To provide drainage

   B) To prevent cracking

   C) To transfer wheel load stresses to the sub grade

   D) To bind crushed or uncrushed aggregate

4. What is the required grade of the bituminous material for the project?

   A) Grade 150-170

   B) Grade 40-60

   C) Grade 120-150

   D) Grade 100-120

5. What should an inspector do if they are unsure of their duties during flexible paving inspection?

   A) Follow up on corrective work and make a record of it.

   B) Contact their supervisor to define their duties for them.

   C) Both B and

   D) Provide guidance to other team members.

TEST II: SAY TRUE OR FALSE

Direction: Answer the following question by writing TRUE or FALSE. Time allotted for each item is 1 minute and each Question carries 3 points.

1. _____Local people are not involved in the construction, rehabilitation and maintenance of construction works.
2. _____Is it necessary to have a sub-base when the pavement will only have foot traffic?
3. _____ is the sub-base course located above the base course layer?
4. _____Is grading and compaction necessary for sub-base course even if it is knowingly sufficient?
5. _____All sites are not required to be left tidy and cleared of debris when the work is completed.

Test III: Short Answer writing

Instruction: write short answer for the given question. You are provided 3 minutes for each question and each point has 5 Points.

1. What should be done if a worker has an accident on a construction site?
2. What types of signs are useful for alerting traffic when working on a roadside or carriageway?
3. What are the components of civil works projects described through?
4. What do road works drawings concentrate on?
5. What should be done if a worker has an accident on a construction site?

UNIT TWO: TYPES OF FLEXIBLE PAVEMENT

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

- Over view of flexible pavement
- Conventional Layer flexible pavement
- Full - depth asphalt pavement
- Contained rock asphalt mat

This unit 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 Over view of flexible pavement
- Undertaken Conventional Layer Flexible Pavement
- Construct full - depth asphalt pavement
- Construct contained rock asphalt mat

2.1 Over view of flexible pavement

Flexible pavement is constructed from the stress that is transmitted to the sub-grade through the lateral distribution of the applied load with depth and unbound or bituminous material.

This layer is composed of a surface course and bituminous material underlying base. The bituminous material is more often asphalt material whose viscous nature form allows significant plastic deformation.

Most asphalt surfaces are built on a gravel (aggregate) base, although sometimes the full depth of the asphalt surfaces are built directly layer on the sub grade. Depending on the temperature at which it is applied asphalt on the road, asphalt is categorized as hot mix asphalt (HMA) cold mix asphalt, warm mix asphalt.

Flexible pavements are commonly used in areas with moderate to heavy traffic, as they can withstand a lot of wear and tear.

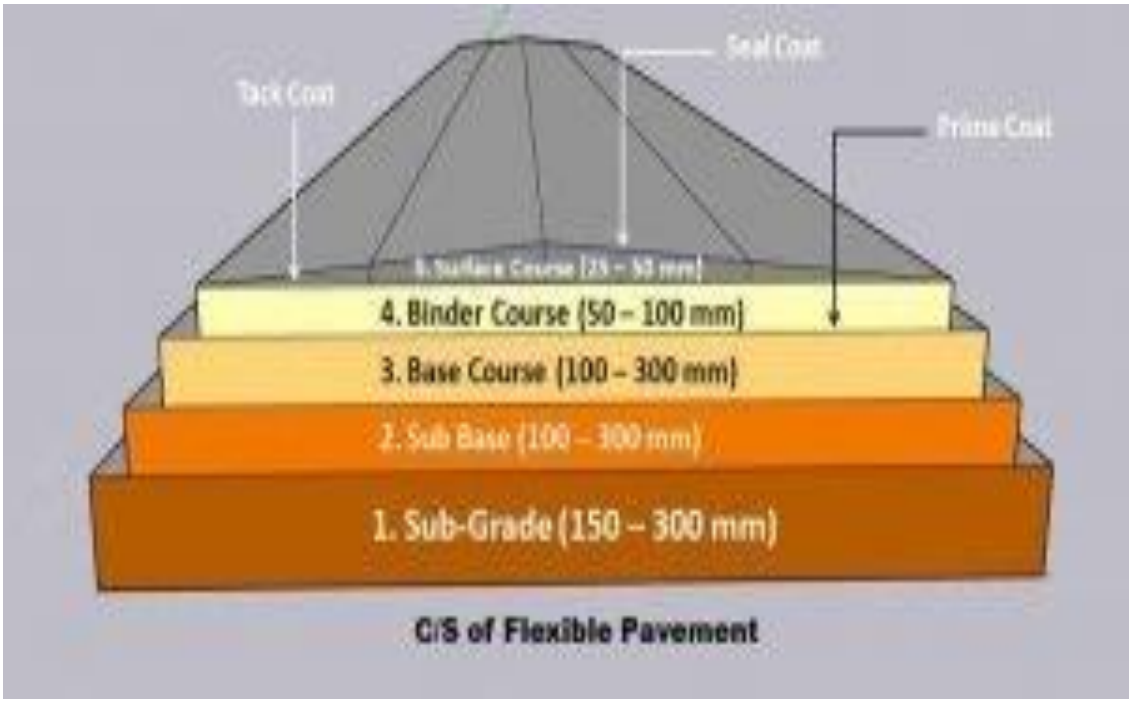


Figure1.12. Flexible pavement structure

They are so named as the pavement surface reflects the total deflection of all subsequent layers due to the vehicle load acting upon it. Their design is based on the load-distributing characteristics of a layered system.

It transmits the load to the combination of layers through a sub grade. Flexible pavement distributes the load over a sub grade beneath a relatively smaller area. The initial installation of a flexible

pavement cost is quite low which is why flexible pavement is more commonly seen universally.

Three main types, there are also a number of other types of flexible pavements, such as:

1. Bituminous surface treatment is a thin layer of asphalt concrete applied to an existing pavement to improve its surface condition.
2. Macadam pavement is a type of flexible pavement that consists of a layer of crushed stone or gravel bound together with asphalt or tar.
3. Water-bound macadam pavement is a type of macadam pavement that is compacted with water.

Stress distribution in flexible pavement

A valuable advantage of flexible pavement can be opened for traffic within 24 hrs after the completion of the road. Also, the maintenance and repair of flexible pavement are cost-effective and easy.

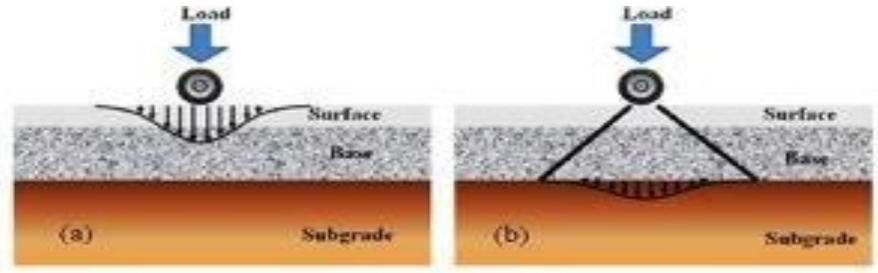


Figure1.13. Stress distribution

2.2 Conventional Layer flexible pavement (CLFP)

Conventional layered flexible pavement is a type of flexible pavement where high-quality materials are placed at the top of the pavement to resist the maximum stress which is coming from vehicular loads and low quality and cheap materials are used in the bottom part of the layers**.**

The thickness of each layer of a conventional layered flexible pavement will vary depending on the design traffic and the sub grade conditions. The sub grade must be properly prepared before the sub base course is placed. Removing soft or unstable material and compact the sub grade to the required density. The sub base course is then placed and compacted.

The base course is then placed and compacted. The asphalt concrete layer is then placed and compacted in lifts.

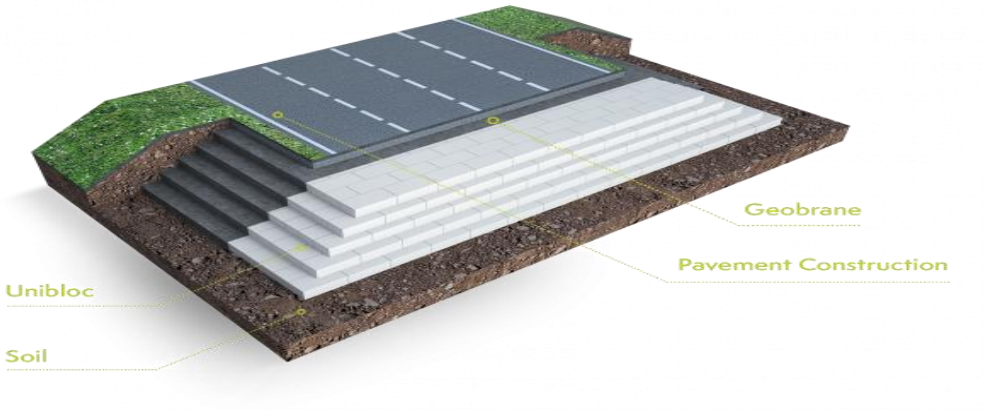


Figure1.14. Conventional layer flexible pavement

Conventional flexible pavements are installed by placing bituminous layers on top of a soil sub grade**.** The thickness of each layer depends on the traffic load**,** the material properties and the failure criteria. The top layer is called the surfacing and it provides a safe and comfortable riding surface, while the lower layer is called the road base and it spreads the load and adds stiffness to the pavement.

2.2.1 Typical conventional Layers flexible pavement

Typical conventional layers flexible pavement include tack coat, prime coat, base course, sub-base course, seal coat, surface course, compacted sub grade, binder course, and natural sub grade.

Seal Coat: This is a thin surface treatment to provide skid resistance and used to water-proof the surface.

Tack Coat: This is a very light application of asphalt, usually, asphalt emulsion meets with water. Tack coat provides proper bonding between two layers of must be thin and binder course, set very fast, and uniformly covering the entire surface.

Prime Coat: It is low viscous cutback bitumen to an absorbent surface like granular bases on which the binder layer is placed on the road layer. The prime coat provides bonding between two layers together. Unlike tack forms and coats a watertight surface.

Surface course: This layer directly in contact with generally contains superior quality materials and traffic loads. Surface layers are usually constructed with dense graded asphalt concrete.

The surface course provides characteristics such as smoothness, drainage, and friction, etc. Also, the surface course will prevent the entrance of excessive quantities of surface water into the sub-base and sub-grade, underlying base.

Surface courses must be tough to resist providing a smooth and skid- resistant riding surface and distortion under traffic.

Binder course: The Binder course layer provides the bulk of the asphalt concrete structure. The Binder course's chief purpose is to distribute the load to the base course. The binder course generally consists of aggregates that don't require quality as high as the surface course and less asphalt.

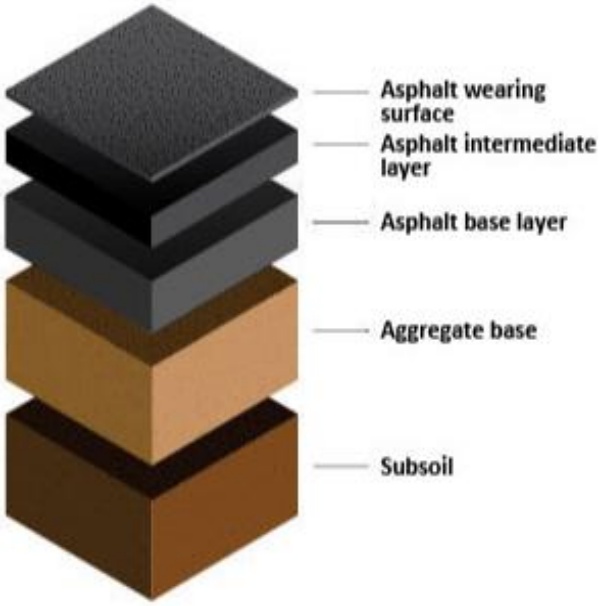


Figure1.15. conventional Layers flexible pavement

2.3 Full -depth asphalt pavement (FDAP)

Full-depth asphalt pavement (FDAP) is a pavement rehabilitation technique that involves milling or pulverizing the existing asphalt layer and mixing it with a new asphalt binder. The recycled material is then compacted to form a new, smooth surface.

Full - depth asphalt pavements are constructed by placing bituminous layers directly on the soil sub-grade.

Full depth asphalt pavement refers to a durable asphalt surface structure directly constructed on the treated or untreated soil foundation, which is a special form of permanent asphalt pavement.

The advantages of life cycle cost and other aspects are obvious, and it is an important technological innovation to realize the transformation of high energy-consumption roads to a new generation of green pavements and the periodic reconstruction to structural durability.

Benefits of full -depth asphalt pavement (FDAP)

Reduced costs: FDR is a more cost-effective way to rehabilitate an existing pavement than removal and replacement.

Environmentally friendly: FDAP reduces the amount of waste sent to landfills.

Quicker construction time: (FDAP) can be completed in a shorter amount of time than removal and replacement.

Improved ride quality: FDAR can improve the ride quality of an existing pavement.

Disadvantages of full -depth asphalt pavement (FDAR)

Not suitable for all pavements: FDAR is not suitable for all pavements. It is not recommended for pavements with severe structural damage.

Requires specialized equipment FDAR requires specialized equipment, such as a milling machine and a paver.

May require additional maintenance FDR may require additional maintenance, such as seal coating, over time.

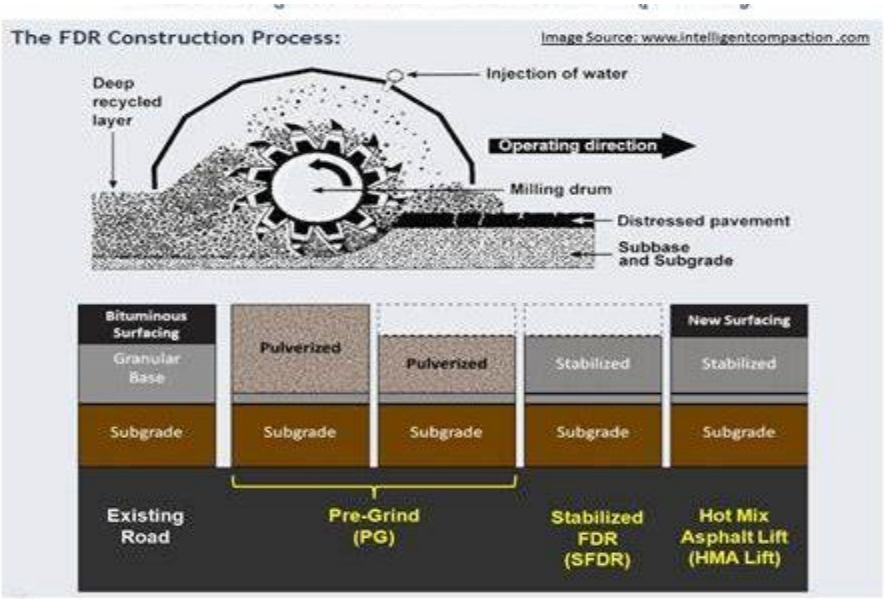


Figure1.16. Full - depth asphalt

2.4 Contained rock asphalt mat (CRAM)

A contained rock asphalt mat (CRAM) is a type of flexible pavement that is made of asphalt binder, aggregate, and rock. The rock is contained within the asphalt binder by a geo textile fabric.

Contained rock asphalt mats are constructed by placing dense/open graded aggregate layers in between two asphalt layers. Modified dense graded asphalt concrete is placed above the sub-grade will significantly reduce the vertical compressive strain on soil sub-grade and protect from surface water.

CRAMs are typically used on low- to medium-traffic roads. They are also used on roads where the sub grade is not strong enough to support a conventional asphalt pavement.

The three layers of a Contained rock asphalt mats (CRAM) are:

1. **Base layer:** This is the bottom layer of asphalt concrete. It is typically 2-3 inches thick and is designed to provide a smooth, stable surface for the next layer.
2. **Rock layer:** This is the middle layer of crushed rock. It is typically 4-6 inches thick and helps to distribute the weight of traffic more evenly.
3. **Surface layer:** This is the top layer of asphalt concrete. It is typically 1-2 inches thick and provides a smooth, wear-resistant surface.

Advantages of Contained rock asphalt mats (CRAM)

- They are more durable and can withstand heavier traffic loads.
- They are less likely to crack or rut.
- They can be used in areas with poor sub grade conditions.
- They are less expensive than other types of asphalt pavements.

Disadvantages Contained rock asphalt mats (CRAM)

- They require more maintenance than other types of asphalt pavements.
- They are not as aesthetically pleasing as other types of pavements.
- They can be more difficult to install.

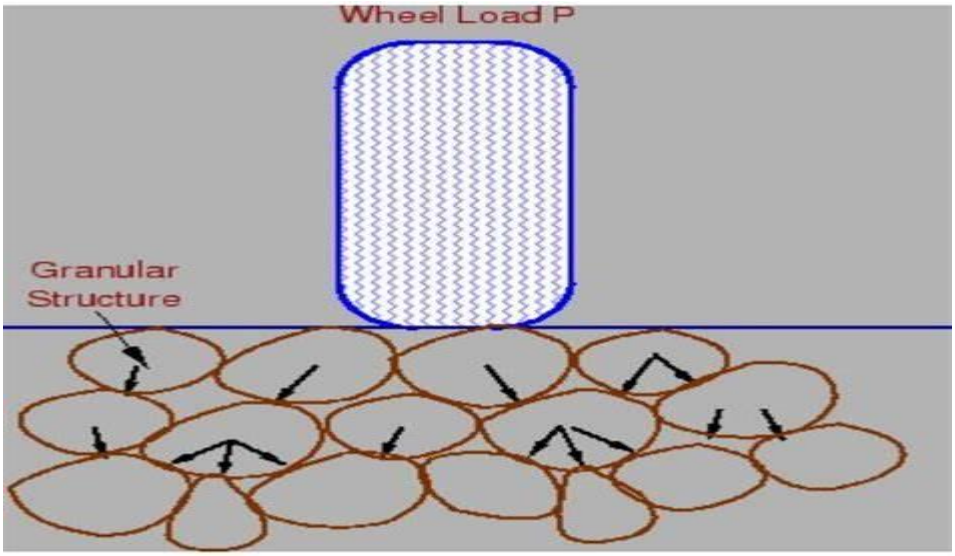


Figure1.17. Contained rock asphalt mats

SELF-CHECK -2 WRITTEN TEST

TEST I: MULTIPLE CHOICE

Directions: Choose correct answer for the following Questions. Use the Answer sheet provided in the following

1. What type of material is the bituminous layer made of in flexible pavement?

A) Asphalt

B) Concrete

C) Sand

D) Tar

2. Which of the following is NOT a type of flexible pavement mentioned in the context?

A) Conventional layered flexible pavement

B) Water-bound macadam pavement

C) Rigid pavement

D) Macadam pavement

3. What are some mat defects in asphalt?

A) Surface waves, tearing, and shoving and rutting

B) Checking, poor compaction, and alligator cracking

C) None of the above

D) All of the above

4. What is full-depth asphalt pavement?

A) Asphalt layers placed on top of existing pavement

B) Asphalt layers placed directly on soil sub-grade

C) Concrete layers placed directly on soil sub-grade

D) Asphalt layers placed on top of concrete

5. What are the advantages of full-depth asphalt pavement compared to traditional semi-rigid base pavement structures?

A) Higher shrinkage coefficients

B) All of the above

C) Lower moisture channel formation

D) Lower formation of reflective cracks

TEST II: TRUE OR FALSE

Direction: Answer the following question by writing TRUE or FALSE. Use the Answer sheet provided in the following

1. _____Flexible pavement is constructed by transmitting stress to the sub-grade through the lateral distribution of applied load.
2. _____The surface course of a flexible pavement provides characteristics such as smoothness, drainage, and friction.
3. _____Before pulverization in full-depth reclamation, the pavement must be adequately prepared.
4. _____Controlling moisture content during pulverization is not an important aspect of achieving FDAP with reclamation.
5. _____The layer under asphalt is called sub-grade and helps to prevent the pavement from sinking.

TEST III: SHORT ANSWER WRITING

Instruction: write short answer for the given question. You are provided 3 minutes for each question and each point has 5 Points.

1. What are the different types of asphalt used in flexible pavement?
2. What is the function of seal coat in flexible pavement?
3. How long should the reclaimed surface cure before it is opened for traffic in full depth asphalt pavement?
4. What are the advantages of using a contained rock asphalt mat (CRAM) for pavement construction?

OPERATION SHEET 1	Full -depth asphalt pavement

Operation Title: Full -depth asphalt pavement

Instruction: Using the necessary tool, equipment and materials Full -depth asphalt pavement according to drawing

Required tools and equipment:

- Asphalt pavers
- Non-destructive testing (NDT)
- Screeds
- Cutters
- Crack sealers
- Sealcoats
- Rollers:

Precautions: - Always put on helmets, seat belts and safety equipment before starting work

- Never use mobile phones or ear phone while work always remember

Procedures:-

Step1. Conduct a visual inspection.

Step2. Use non-destructive testing (NDT) techniques.

2.1. Asphalt Core Drilling

2.2. Falling Weight Deflect meter (FWD):

2.3. Ground Penetrating Radar (GPR):

Step3. Develop a pavement management plan

Step4. Establish a maintenance schedule

Step5. Document your findings

Quality Criteria:

- Use high-quality materials and construction practices.
- Inspect the pavement regularly for signs of damage.
- Make repairs as soon as possible to prevent small problems from becoming big ones.
- Use a qualified contractor who has experience with full-depth asphalt pavement construction.

LAP TEST 1	Practical demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: As shown the Figure and detail below, you required to prepare Full -depth asphalt pavement. Use necessary templates, workshop, tools and materials you are required to perform the following tasks within 3 hours.

Task1. Perform non-destructive testing (NDT) techniques

Task2. Conduct a visual inspection

Task3. Develop a pavement management plan

UNIT THREE: PRE- PAVING INSPECTION

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

- Overview of pre-paving inspection
- Checking base course stability
- Establishing offset pegs/profiles

This unit 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 overview of pre-paving inspection
- Identify base course stability
- Apply eestablish offset pegs/profiles

3.1 Overview of pre-paving inspection

The pre-paving inspection is important because it can help to identify any defects in the existing pavement that could affect the performance of the new asphalt. If any defects are found, they can be repaired before the new asphalt is placed.

Pre-paving inspection: is a visual inspection of a flexible pavement that is performed before new asphalt is placed. The purpose of the inspection is to identify any defects in the existing pavement that could affect the performance of the new asphalt.

Construction flexible pavement: is a type of road pavement that is made of materials that can deform under load. The most common type of construction flexible pavement is asphalt concrete, which is a mixture of asphalt binder and aggregate.

3.2 Checking base course stability

Base course stability is an important factor to consider during a pre-paving inspection of construction flexible pavement. The base course is the layer of material that is placed beneath the asphalt concrete. It is important for the base course to be stable so that it can support the weight of the asphalt concrete and prevent it from sinking or shifting.

During a pre-paving inspection to assess the stability of the base course

Condition of the sub grade: The sub grade is the soil or rock that underlies the base course. It is important for the sub grade to be stable and free of soft spots or voids.

Thickness of the base course: The base course should be thick enough to support the weight of the asphalt concrete.

Compaction of the base course: The base course should be compacted to the proper density.

Drainage of the base course: The base course should be well-drained to prevent water from pooling and causing the base course to become saturated.

Presence of any defects: The base course should be free of any defects, such as cracks, potholes, or voids.

3.2.1 Sub grade Improvement and Strengthening

Stabilization provides an alternate method to improve the structural support of the foundation for many of the sub grade conditions presented in the previous section. In all cases, the provision for a uniform soil relative to textural classification, moisture, and density in the upper portion of the sub

grade cannot be over-emphasized.

A. Soil Stabilization

Soils that is highly susceptible to volume and strength changes can cause severe roughness and accelerate the deterioration of the pavement structure in the form of increased cracking and decreased ride quality when combined with truck traffic. Stabilization of soils is usually performed for three reasons:

1. As a construction platform to dry very wet soils and facilitate compaction of the upper layers-for this case, the stabilized soil is usually not considered as a structural layer in the pavement design process.
2. To strengthen a weak soil and restrict the volume change potential of a highly plastic or compressible soil-for this case, the modified soil is usually given some structural value or credit in the pavement design process.
3. To reduce moisture susceptibility of fine grain soils.

B. Thick Granular Layers

Thick granular layer is an important feature in pavement design and performance. Thick granular layers provide several. Benefits of thick granular layers,

- Increased load-bearing capacity
- Frost protection
- Improved drainage

3.2.2 Asphalt Stabilization

Asphalt stabilization is a process of improving the strength and durability of asphalt pavements. It is done by adding a stabilizing agent to the asphalt mix, which helps to bind the aggregate particles together and reduces the amount of voids in the mix.

There are two main types of asphalt stabilization:

Chemical stabilization: This involves adding a chemical agent to the asphalt mix, such as lime or cement. The chemical agent reacts with the aggregate particles and forms a bond that helps to hold them together.

Mechanical stabilization: This involves compact the asphalt mix to a very high density. This reduces the amount of voids in the mix and makes it more stable.

Asphalt stabilization can be used to improve the performance of asphalt pavements in a number of ways:

- It can increase the strength and durability of the pavement, making it less likely to crack or rut.
- It can improve the drainage of the pavement, reducing the risk of water damage.
- It can extend the lifespan of the pavement, making it more cost-effective in the long run.

Table9. Asphalt-Stabilized Methods for Pavements

Stabilization Method	Item	Requirement
Asphalt-Stabilized	Gradation of material	AASHTO No. 67 stone, preheat at 135o - 160°C (275o - 320°F).
	Amount of asphalt	2 - 2.5% by weight, using harder asphalt like AC 40 or AR 8000.
	Temperature of mix	Lay at 90o - 120°C (195o - 250°F) and seal with one pass of a 7.2 - 10.9 metric ton (8 - 12 ton) smooth wheel roller. Start compaction rolling after the temperature reaches 65°C (150°F), but before it drops to 38°C (100°F).

3.3 Establishing offset pegs/profiles

Offset pegs and profiles are used in pre-paving inspection to establish the alignment and elevation of the pavement. They are typically made of wood or metal and are placed at regular intervals along the length of the pavement.

They are placed at a set distance from the edge of the pavement, and the distance between the pegs is equal to the width of the pavement.

The profiles are used to establish the elevation of the pavement. They are placed at a set elevation, and the elevation of the profiles is equal to the elevation of the finished pavement.

The steps on how to establish offset pegs/profiles of Pre- paving inspection:

1. Measure the width of the pavement and mark the location of the offset pegs at this distance from the edge of the pavement.

2. Drive the offset pegs into the ground at the marked locations.
3. Measure the elevation of the finished pavement and mark the location of the profiles at this elevation.
4. Drive the profiles into the ground at the marked locations.
5. Use a theodolite or total station to create a survey map of the pavement.

The steps on how to conduct a pre-paving inspection to ensure that the offset pegs/profiles are established to line and level as specified:

1. **Inspect the offset pegs/profiles:** Check to see if the offset pegs/profiles are in the correct location and are at the correct elevation.
2. **Measure the distance between the offset pegs:** The distance between the offset pegs should be equal to the width of the pavement. If the distance is not correct, the offset pegs should be moved.
3. **Measure the elevation of the profiles:** The elevation of the profiles should be equal to the elevation of the finished pavement. If the elevation is not correct, the profiles should be moved.
4. Use a theodolite or total station to check the alignment and elevation of the offset pegs/profiles: A theodolite or total station is a surveying instrument that can be used to measure angles and distances. Using this instrument, you can check to see if the offset pegs/profiles are aligned and are at the correct elevation.
5. **Make any necessary adjustments to the offset pegs/profiles:** If the offset pegs/profiles are not aligned or are not at the correct elevation, you will need to make adjustments. This can be done by moving the offset pegs/profiles or by adding or removing material from the ground around the offset pegs/profiles.

The following instruments are required for measurements with chain and tape:

(i)Arrows
(ii) Pegs
(iii) Ranging rods and ranging poles
(iv) offset rods
(v) Laths
(vi) Whites
(Vii) Plumb bobs
(viii) Line ranger

Arrows

when the length of the line to be measured is more than a chain length, there is needed to mark the end of the chain length. Arrows are used for this purpose. A typical arrow is shown in Fig. 12.5. Arrows are made up of 4 mm diameter steel wire with one end sharpened and other end bent into a loop. Length of an arrow is approximately 400 mm.

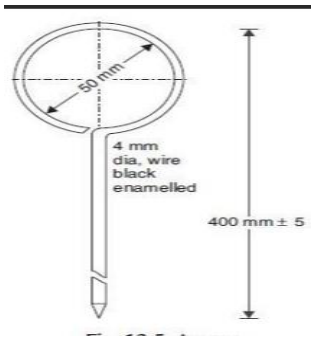


Figure1.18. Arrows line

Pegs

Wooden pegs are used in measuring a length of a line to mark the end points of the line. The pegs are made of hard wood of 25 mm Ã— 25 mm section, 150 mm long with one end tapered as shown in Fig. 9. When driven in ground to mark station points they project about 40 mm.

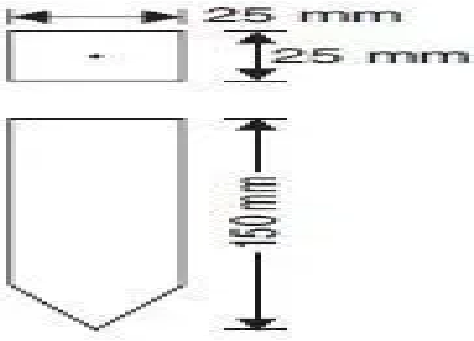


Figure1.19. Pegs

Ranging Rods and Ranging Poles

for ranging intermediate points along the line to be measured, ranging rods and ranging poles are used. Ranging rods are 2 to 3 m long and are made of hard wood. They are usually circular in section with 30 mm diameter and are painted with 200 mm colour bands of red and white or with black and white. If distance is more than 200 m, for clear visibility they may be provided with multi colored flags at their top. The ranging rods are occasionally used to measure short distances since they are painted with alternate colour of band 200 mm.

Ranging poles are similar to ranging rods except that they are longer. Their length varies from 4 m to

8 m and diameter from 60 mm to 100 mm. They are made of hard wood or steel. They are fixed in the ground by making 0.5 m holes and then packed to keep them vertical.

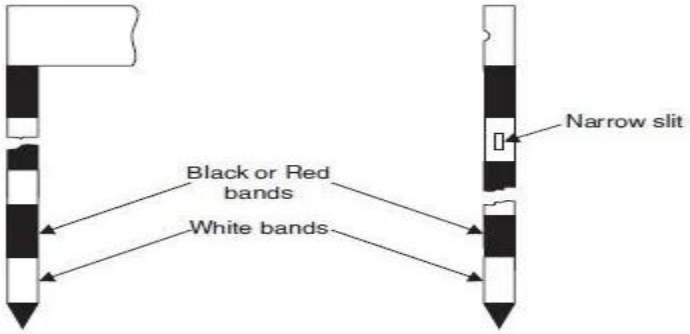


Figure1.20. Ranging Poles

Offset Rods

These rods are also similar to ranging rods and they are 3 m long. They are made up of hard wood and are provided with iron shoe at one end. A hook or a notch is provided at other end. At height of eye, two narrow slits at right angles to each other are also provided for using it for setting right angles.

Line Ranger

It is an optical instrument used for locating a point on a line and hence useful for ranging. It consists of two isosceles prisms placed one over the other and fixed in an instrument with handle. The diagonals of the prisms are silvered so as to reflect the rays.

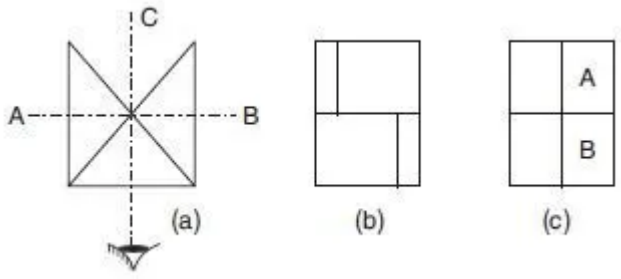


Figure1.21. Line Ranger

3.3.1 Construction Peg Set Out

Clearing Vegetation & Limits of Clearing

- The limits of vegetation clearing; shall mean the clearing footprint to be communicated to the contractor. The limits of vegetation clearing shall be in accordance with the definition of designated and other areas required to undertake works under the contract.
- The Contractor shall receive the limits of vegetation clearing from the Superintendent in a shape file and/or in nominated drawings.
- The Contractor shall confirm receipt of the clearing line data to the Superintendent if required.
- The clearing line shall be pegged in accordance with the Pegging and Flagging Clearing Lines Principal Environmental Management Requirements. (D19#260830).
- All vegetation proposed to be cleared will be demarcated by PINK flagging tape on site prior to the commencement of project activities.
- Any vegetation or trees that are to be retained will be marked by WHITE flagging tape.
- Pegging is done by either stakeout from digital design model using RTK GNSS, string line radiation, offsetting from previously set out string lines, scaling and measuring from the plan using established features such as fences, edge of road, cadastral boundary etc.
- Accuracy required for this work is generally 0.5m or as specified by the contract documents or the project engineer.
- The pegged vegetation clearing line shall be sent to the Superintendent. The Superintendent will send this to the relevant Environmental officer. The Environmental officer will confirm that the pegged vegetation clearing line is within the “approved” clearing area.
- The format of the pegged vegetation clearing line shall be detailed in Spec 301.
- The as constructed vegetation shall mean the final clearing area that occurred over the duration of the contract.
- Vegetation outside the approved clearing area shall not be disturbed. The contractor shall take all necessary precautions to protect all tagged declared rare flora and nominated vegetation to be retained within the limits of clearing.

Formation

The edge of formation is set out using the verge or shoulder strings and is placed by either stakeout from digital design model, string line radiation from the cross section reports or by offset from the existing centre line pegging.

The shoulder string is usually offset by 0.3 – 1.0m to allow compacting machinery to operate to the edge of the formation. If the verge string is set out, no offsetting is usually required.

These string lines form the basis of horizontal and vertical control for the pavement construction. It is the surveyor's responsibility to maintain a continuous control on alignment and levels.

The pegging interval for sub-grade should be no more than 20 meters and every 10 meters for sub-base and base-course.

Priming, Sealing Edge

Usually only one edge of the pavement requires marking out for the primer seal edge to ensure that spray run is on correct alignment and uniform.

The alignment should be nailed every 10m with spring head nails and flagging under the nail for better visibility. Paint can also be used for better visual affect.

Flexible Pavement, Lane Marking

Before asphalt paving can proceed, the proposed lane marking has to be established in order for the asphalt joins to coincide with the line markings.

3.3.2 Construction Peg Offsets and Intervals

The construction peg offsets and intervals of pre-paving inspection of flexible pavement vary depending on the project common guidelines are as follows:

- The offset pegs should be placed at a distance from the edge of the pavement that is equal to the width of the pavement.
- The profiles should be placed at regular intervals along the length of the pavement, typically every 10 to 20 feet.
- The specific offset peg offsets and intervals will vary depending on the size of the project and the desired accuracy of the inspection.

The factors affect the offset peg offsets and intervals:

Width of the pavement: The wider the pavement, the greater the offset peg offsets will need to be.

Desired accuracy of the inspection: The more accurate the inspection needs to be, the closer together the offset peg offsets and intervals will need to be.

3.3.3 Checking Elevation

Elevation checking is a critical part of the pre-paving inspection process. It involves checking the elevation of the existing pavement to ensure that it is level and within the specified tolerances.

There are a few different ways to check the elevation of the existing pavement. the specific method that is used to check the elevation of the existing pavement will depend on the size and complexity of the project.

To check during elevation checking of pre-paving inspection:

- The elevation of the existing pavement should be checked at regular intervals to ensure that it is level.
- The elevation of the pavement should be checked at all of the joints and cracks to ensure that they are properly aligned.
- The elevation of the pavement should be checked at the edges to ensure that it is sloped away from the road.
- The elevation of the pavement should be checked in areas where there is drainage to ensure that the water will flow away from the road.

SELF-CHECK -3 WRITTEN TEST

TEST I: MULTIPLE CHOICE

Directions: Chose correct answer for the following Questions. Use the Answer sheet provided in the following

1. What is the purpose of documenting the pre-paving inspection results?

A) To satisfy legal requirements

B) To develop a plan for repairing existing pavement defects and determine new pavement requirements

C) To increase construction costs

D) None of the above

2. What is sub grade stabilization?

A) The process of making the sub grade harder to compact

B) The process of adding more soil to the sub grade

C) The process of improving the structural support of the foundation

D) None of the above

3. What is the sub grade layer of pavement?

A) The layer of gravel

B) The layer of sand

C) None of the above

D) The layer of soil or rock that lies beneath the pavement

4 What does the Environmental officer do after receiving the pegged vegetation clearing line?

A) Confirm that the pegged vegetation clearing line is within the "approved" area

B) Approve the clearing line

C) Suggest a different location for the clearing

D) Provide details of the flora and fauna found in the clearing area

TEST II: TRUE OR FALSE

Direction: Answer the following question by writing TRUE or FALSE

. Use the Answer sheet provided in the following

1. A pre-paving inspection should only be conducted by a qualified engineer.
2. All cracks in the existing pavement should be repaired before the new pavement is installed.
3. Soils that are highly susceptible to volume and strength changes can accelerate the deterioration of the pavement structure
4. The Superintendent will provide the clearing line data to the contractor in a word document..
5. The pegging and flagging of clearing lines should follow the Principal Environmental Management Requirements.

Test III: Short Answer writing

Instruction: write short answer for the given question. You are provided 3 minutes for each question and each point has 5 Points.

1. What is a pre-paving inspection?
2. What are the things that should be checked during a pre-paving inspection?
3. What are the objectives of soil stabilization?
4. What is the demarcation process for vegetation proposed to be cleared and retained?
5. What methods are used for pegging the clearing line?

OPERATION SHEET 1	Construction Peg Set Out in Pre-Pavement Inspection

Operation Title: Construction Peg Set Out in Pre-Pavement Inspection

Instruction: Using the necessary tool, equipment and materials to set out the location of construction pegs in preparation for pavement installation according to drawing

Required tools and equipment:

- Tape measure
- Level
- Stakes
- Hammer
- Paint

Precautions: - Wear safety glasses to protect your eyes from flying debris.

-Be aware of your surroundings and watch out for traffic.

-Use caution when driving stakes into the ground to avoid hitting any underground utilities.

Procedures:-

Step1. The first step is to mark the location of the pavement edge on the ground. This can be done by using a tape measure and a level.

Step2. The pavement edge has been marked.

Step3. Drive stakes into the ground at regular intervals along the edge. The spacing of the stakes will depend on the width of the pavement.

Step4. Finally, the stakes are painted to make them visible

Quality Criteria:

- The construction peg set out should be checked to ensure that it is accurate.
- To should verify that the stakes are located at the correct intervals and that they are painted in a visible manner.

LAP TEST- 1	Practical demonstration

Name: _____ Date: _____

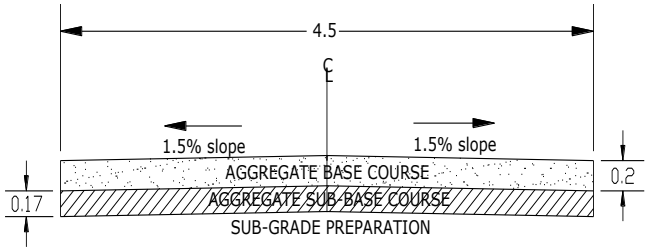
Time started: _____ Time finished: _____

Instructions: As shown the Figure and detail below, you required to prepare the Setting-out of Base/Sub-base. The slope in the elevation is depending on the area as per instruction of the trainer. Use necessary templates, workshop, tools and materials you are required to perform the following tasks within 3 hours.

Task1. Perform offset pegs/profiles

Task2. Monitor base/sub-base make sure the construction drawing

Figure Exercise:



Note:

1. The length is equal 1.5 meter
2. The dimension is all in meter

UNIT FOUR: PLACING,SPREADING AND COMPACTION MATERIALS

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

- Road pavement layer and depth of spread materials
- Trucks load placement
- Check moisture content and adjust uniformly.
- Road Pavement compaction and Roller operators
- Check pavement trimming and Finishing levels

This unit 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:

- Determine road pavement layer and depth of spread materials
- Specified trucks load placement
- Checking moisture content and adjust uniformly.
- Informed pavement compaction and roller operators
- Checking pavement trimming and finishing levels

4.1 Road pavement layer and depth of spread materials

The road pavement layer is made up of several layers of materials, each of which serves a specific

purpose. The thickness of each layer depends on the type of material being used, the desired compaction, and the sub grade conditions.

The common layers of a road pavement:

Sub grade: The sub grade is the natural soil or rock that supports the pavement. It is important to have a strong and stable sub grade in order to support the weight of the pavement and the traffic that will be using it. The sub grade should be compacted to the required density before the pavement is constructed.

Base course: The base course is the layer of material that is placed on top of the sub grade. It provides a smooth and stable surface for the wearing course and helps to distribute the weight of the pavement and the traffic. The base course is typically made of gravel, crushed stone, or concrete.

Wearing course: The wearing course is the top layer of the pavement. It is the layer that is exposed to the elements and the traffic. The wearing course is typically made of asphalt concrete or concrete.

Layer depth of spread materials depends on the following factors:

Type of material: The type of material being used will determine the desired thickness of the spread material. For example, asphalt concrete typically requires a layer depth of 2 to 4 inches, while gravel requires a layer depth of 4 to 6 inches.

Desired compaction: The desired compaction of the spread material will also affect the layer depth. The more compacted the spread material, the thicker the layer depth will need to be.

Sub grade conditions: The condition of the sub grade will also affect the layer depth. If the sub grade is soft or uneven, the layer depth will need to be thicker to compensate.

Traffic: The amount of traffic that the spread material will be subjected to will also affect the layer depth. Heavier traffic will require a thicker layer of spread material.

Budget: The cost of materials and labor may affect the decision of how thick to make the spread material.

The layer depths of spread materials

- Gravel: 10 to 15 cm
- Crushed stone: 10 to 15 cm
- Asphalt concrete: 5 to 10 cm
- Concrete: 15 to 20 cm

The methods of place and spread materials in flexible pavement construction:

Manual spreading: This method is typically used for small projects or for areas with limited access. The materials are spread by hand or with a shovel.

Mechanical spreading: This method is typically used for larger projects or for areas with easy access. The materials are spread by a machine, such as a grader or a bulldozer.

Pneumatic spreading: This method is used to spread materials that are too fine to be spread by other methods.

The steps involved in placing and spreading materials in flexible pavement construction:

1. Prepare the sub grade: The sub grade must be prepared to ensure that it is level and free of debris. This may involve removing existing pavement, excavating the sub grade, and compacting it
2. Place the sub base: The sub base is typically placed in a layer of 150 mm (6 inches) thickness. The sub base material should be spread evenly and compacted to the specified density.
3. Place the base course: The base course is typically placed in a layer of 100 mm (4 inches) thickness. The base course material should be spread evenly and compacted to the specified density.
4. Place the asphalt concrete (AC) pavement: The AC pavement is typically placed in two layers, with a thicker layer at the bottom and a thinner layer at the top. The AC pavement material should be spread evenly and compacted to the specified density.

4.2 Trucks load placement

The trucks should be placed in a way that minimizes the amount of disturbance to the sub grade. The trucks should also be spaced evenly to ensure that the materials are spread evenly.

Truck loading and placement are important steps in the construction of a road pavement. The trucks should be loaded evenly to prevent the materials from shifting during transportation.

Trucks loading for place and spread material

Truck size and capacity: The size and capacity of the trucks will determine how much material they can carry. It is important to use trucks that are the right size for the job in order to avoid overloading them.

Truck weight: The weight of the trucks will also need to be considered. Overweight trucks can damage the road surface and make it difficult to spread the materials evenly.

Truck loading: The trucks should be loaded evenly to prevent the materials from shifting during transportation.

Truck placement: The trucks should be placed in a way that minimizes the amount of disturbance to the sub grade. The trucks should also be spaced evenly to ensure that the materials are spread evenly.

Material spread: The materials should be spread evenly to achieve the desired thickness and

compaction. The materials should also be spread in a way that minimizes the amount of waste.

Compaction: The materials should be compacted to the required density to ensure that the pavement is strong and durable.

4.3 Check moisture content and adjust uniformly

Moisture content is the amount of water in a material. It is important to check the moisture content of the materials used in road construction to ensure that it is within the desired range. The moisture content of the materials affects their ability to be compacted and their durability.

The moisture content of the materials can be checked using a variety of methods, including:

Moisture meter: is a device that measures the electrical conductivity of the materials. The higher the moisture content, the higher the electrical conductivity.

Oven drying: The materials can be dried in an oven and the weight loss can be used to determine the moisture content.

Pycnometer: is a device that measures the density of the materials. The moisture content can be calculated from the density and the weight of the materials.

4.3.1 Checking moisture content

The moisture content affects the ability of the materials to be compacted. If the moisture content is too low, the materials will be difficult to compact. If the moisture content is too high, the materials will be weak and prone to cracking.

The moisture content affects the durability of the pavement. A pavement with high moisture content is more likely to crack and deteriorate over time.

The moisture content affects the weight of the pavement. A pavement with high moisture content will be heavier than a pavement with low moisture content. This can affect the design of the pavement and the amount of materials needed.

4.4 Road pavement compaction and roller operators

Placing and compacting materials is a common construction activity that is used to create a stable, uniform surface. The materials that are placed and compacted can vary depending on the application, but they typically include soil, gravel, sand, asphalt, or concrete.

The process of placing and compacting materials typically involves the following steps:

1. Prepare the sub grade: The sub grade is the surface on which the materials will be placed. It must be clean, dry, and free of debris.
2. Place the materials: The materials are placed in layers, with each layer being compacted before the next layer is placed.
3. Compact the materials: The materials are compacted using a variety of methods, such as rollers, tamping machines, or vibrating plates.
4. Inspect the materials: The materials are inspected to ensure that they have been placed and compacted properly.

4.4.1 Roller operator

A roller operator is a skilled worker who operates a roller machine to compact soil, asphalt, or concrete surfaces. They are responsible for ensuring that the surfaces are properly compacted to meet the required specifications. Roller operators typically work in construction or industrial settings.

Duties of a roller operator:

- Operating a roller machine to compact soil, asphalt, or concrete surfaces
- Determining the correct speed and pressure for compaction
- Monitoring the progress of compaction and adjusting the machine as needed
- Inspecting the compacted surfaces for defects
- Maintaining the roller machine in good condition

The number of passes required by a roller operator to compact materials depends on the following factors:

Desired compaction: the desired compaction level will also affect the number of passes required. The more compacted the materials, the more passes will be required.

Thickness of the material: the thickness of the material will also affect the number of passes required. Thicker materials require more passes than thinner materials.

A. Determine the Number of Passes and Lift Thickness for the Compaction of Soil

The calculation of the number of passes for compactors and lift (soil layer) thickness for soil is critical to attain the required degree of compaction. Generally, the lift thickness varies between 15-30cm based on soil type, and the majority of compaction is achieved through the first five passes.

Table-10: Lift Thickness and Number of Passes of Different Compactors for Various Types of Soil

Type of compactor	Types of soil	Lift thickness, cm	Number of passes
Sheep's foot roller	Fine-grained soil	15	4-6
Sheep's foot roller	Dirty coarse-grained soil with more than 20% passing sieve No. 200	15	6-8
Rubber tire roller	Clean coarse-grained soil with 4-8% passing sieve No. 200	25	3-5
Rubber tire roller	Fine-grained soil or well-graded dirty coarse-grained soil with more than 8% passing sieve No. 200	15-20	4-6
Smooth wheel roller	Well-graded sand-gravel mixtures	20-30	4
Smooth wheel roller	Fine-grained soils except in earth dams	15-20	6
Vibrating base plate compactor	coarse-grained soil with less than 12% passing sieve No. 200, Material with 4-8% passing sieve No. 200 placed thoroughly wet	20-25	3
Crawler tractor	Coarse-grained soils with less than 4-8% passing sieve No. 200 placed thoroughly wet	25-30	3-4
Power tamper or rammer	Silt or clay	10-15	2
Power tamper or rammer	Coarse-grained soils	15	2

B. Roller compaction for placing and compacting materials

Roller operators are required to conduct and monitor the compaction of earth, sub grade, and sub-base asphalt surfaces in the construction of highways and streets. They use a variety of rollers, including

smooth drum rollers, pneumatic-tired rollers, and sheep's foot rollers, to achieve the desired level of compaction.

To conduct compaction, roller operators must first set up the roller properly. This includes adjusting the roller's weight, speed, and pattern. They must also ensure that the roller is properly aligned with the work area.

Roller operators must be aware of the safety hazards associated with their work. They must wear appropriate safety gear, such as hard hats, safety glasses, and gloves. They must also be aware of the traffic patterns in the work area and take precautions to avoid accidents.

The specific tasks that a roller operator may be responsible for:

- Setting up the roller properly
- Adjusting the roller's weight, speed, and pattern
- Ensuring that the roller is properly aligned with the work area
- Compacting the material to the desired level
- Monitoring the material's moisture content and density
- Adjusting the roller's settings as needed
- Monitoring the progress of compaction to ensure that it is uniform
- Looking for signs of rutting, cracking, or other defects
- Stopping the compaction process if necessary
- Correcting any defects that are found
- Wearing appropriate safety gear
- Being aware of the traffic patterns in the work area
- Taking precautions to avoid accidents

4.5 Checking pavement trimming and finishing levels

Pavement trimming is the process of leveling and shaping the pavement to ensure that it is smooth and even. It is important to check the pavement trimming of place and compact materials to ensure that the desired smoothness and evenness are achieved.

The pavement trimming should be checked to ensure that the following criteria are met:

- Smoothness: The pavement should be smooth and free of bumps or ridges.
- Evenness: The pavement should be even from one end to the other.
- Grade: The pavement should be graded to ensure that it slopes away from the road edges.
- Camber: The pavement should have a slight camber to ensure that water drains away from the road surface.

The pavement trimming should be done in a way that minimizes the damage to the materials. The materials should also be trimmed in a way that minimizes the amount of waste.

4.5.1 Finishing levels

The pavement materials must be compacted to the required density in order to provide a smooth; even surface that is resistant to cracking and rutting. If the pavement materials are not compacted properly, they will be more likely to deform under traffic loading, which can lead to premature failure of the pavement.

- Improper compaction: If the pavement materials are not compacted properly, they will be more likely to deform under traffic loading.
- Poor-quality materials: If the pavement materials are of poor quality, they will be more likely to crack and rut.
- Inadequate drainage: If the pavement does not have adequate drainage, water can pool on the surface, which can lead to rusting and deterioration of the pavement materials.
- Heavy traffic: Heavy traffic can put a lot of stress on the pavement, which can lead to premature failure.
- Extreme weather conditions: Extreme weather conditions, such as freezing and thawing, can also damage the pavement.

To ensure that finish levels in flexible pavements hold up, it is important to use high-quality materials and to properly compact the pavement. It is also important to design the pavement to be able to withstand the anticipated traffic and weather conditions.

The steps of placing and compacting materials to achieve the desired finishing levels:

1. Prepare the sub grade by grading it to the desired elevation and removing any debris.
2. Place the materials in layers, following the desired thickness and compaction requirements.
3. Compact each layer of material using the appropriate equipment.

4. Inspect the finished surface for any defects and make any necessary adjustments.

The specific steps involved will vary depending on the type of materials being used, the desired finishing levels, and the sub grade conditions. It is always best to consult with a qualified engineer or contractor to ensure that the materials are placed and compacted properly.

4.5.2 Clean Up

A. Work area is cleared and materials disposed.

The work area can be cleared and materials disposed of in compliance with regulations and safety requirements. The steps on how to clear and dispose of materials from a work area:

1. Clear the work area of all debris and loose material. This can be done using a broom, shovel, or vacuum.
2. Break up the materials using a paving saw, hydraulic breaker, impact hammer, or pneumatic drills.
3. Remove the broken-up materials and dispose of them properly. The disposal method will vary depending on the local regulations.
4. Inspect the work area carefully to ensure that all debris has been removed.

The safety precautions to take when clearing and disposing of materials:

- Always wear safety gear, such as hardhat, safety glasses, and gloves.
- Be aware of your surroundings and watch out for traffic.
- Do not operate any equipment if you are not trained to do so.
- Follow all safety instructions provided by the equipment manufacturer.
- Dispose of the broken-up materials in accordance with local regulations.

Clearing and disposing of materials:

- The size and thickness of the materials will affect the amount of time and effort required to clear and dispose of them.
- The location of the work area will also affect the disposal method that can be used. For example, if the work area is located near a waterway, the broken-up materials may need to be disposed of in a landfill.
- The local regulations will also affect the disposal method that can be used. It is important to check with the local authorities to determine the proper disposal method for the materials.

B. Cleaning, checking, maintaining and stored of Plant, tools and equipment

They ensure the safety of workers and the longevity of the equipment.

- **Cleaning:** Equipment should be cleaned regularly to remove dirt, debris, and other materials that can damage the equipment or cause safety hazards. This includes cleaning the exterior of the equipment as well as the interior components.
- **Checking:** Equipment should be checked regularly for any signs of wear and tear. This includes checking the tires, brakes, belts, and other moving parts. Any problems should be repaired or replaced immediately to avoid further damage.
- **Maintaining:** Equipment should be properly maintained to keep it in good working condition. This includes changing the oil and fluids, greasing the moving parts, and inspecting the electrical system.
- **Storing:** Equipment should be stored in a safe and dry place when not in use. This will help to prevent damage from the elements and from unauthorized use.

Procedures common plant, tools, and equipment used in flexible pavement work:

- **Asphalt paver:** Clean the paver with a pressure washer. Check the augers and blades for wear and damage. Lubricate the paver according to the manufacturer's instructions. Store the paver in a clean, dry place.
- **Roller:** Clean the roller with a brush. Check the tires and bearings for wear and damage. Lubricate the roller according to the manufacturer's instructions. Store the roller in a clean, dry place.
- **Vibratory screed:** Clean the screed with a brush. Check the blades for wear and damage. Lubricate the screed according to the manufacturer's instructions. Store the screed in a clean, dry place.
- **Tamper:** Clean the tamper with a brush. Check the tamper head for wear and damage. Lubricate the tamper according to the manufacturer's instructions. Store the tamper in a clean, dry place.
- **Plate compactor**: Clean the plate compactor with a brush. Check the plates for wear and damage. Lubricate the plate compactor according to the manufacturer's instructions.

SELF-CHECK -4 WRITTEN TEST

TEST I: MULTIPLE CHOICE

Directions: Chose correct answer for the following Questions. Use the Answer sheet provided in the following

1. What are some common materials used in placing and compacting?

A) Glass and concrete

B) Wood and paper

C) Soil and gravel

D) Metal and plastic

2. How can to number of passes require for compaction be calculated?

A) By performing a soil test

B) By referring to a chart or data table

C) By using scissors

D) By guessing

3. Which method is typically used for small projects or for areas with limited access?

A) Pneumatic spreading

B) Gravity spreading

C) Mechanical spreading

D) Manual spreading

4. What is the purpose of spreading materials evenly and uniformly in flexible pavement construction?

A) To dilute the asphalt cement with kerosene

B) To protect the material from waste material

C) To ensure that the pavement is constructed to the correct cross-section

D) To improve the adhesion between the existing surface and the mixture material

5. What is the purpose of covering the container during transporting of the mixture material?

A) To dilute the asphalt cement with kerosene

B) To clean the existing surface of loose material

C) To protect the material from waste material

D) To retain the heat of the mix and protect the material from the weather

TEST II: TRUE OR FALSE

Direction: Direction: In circle Correct Answer. Use the Answer sheet provided in the following

1._____ Placing and compacting materials always involve the same steps regardless of the type of materials being used.

2. _____The materials that are commonly used in placing and compacting include soil, gravel, sand, asphalt, and concrete.

3. _____The container hauling the mixture from central plant to the work site does not need to be covered with canvas to retain the heat of the mix and protect the material from the weather and to prevent contamination from waste material.

4. _____The layer depth of spread materials for flexible pavement construction can vary depending on the specific project.

5. _____The bituminous Tack Coat and or Prime Coat shall be either AC-10 grade (80/100 Pen.) or AC-20 (60/70 Pen) diluted with water.

TEST III: SHORT ANSWER WRITING

Instruction: write short answer for the given question. You are provided 3 minutes for each question and each point has 5 Points.

1. What is the purpose of determining the number of passes for compactors in soil compaction?
2. What information can be found in Table-10 related to soil compaction?
3. Why is it important for roller operators to adjust the roller's settings during pavement compaction?
4. How does moisture content affect the number of passes required for pavement compaction?
5. What factors determine the layer depth of spread materials in flexible pavement construction?

OPERATION SHEET - 1	Place Spread and Materials

Operation Title: Placing Spread and Materials

Instruction: Using the necessary tool, equipment and materials To place the specified spread and materials in accordance with the approved plans and specifications.

Applies to the placement of all types of spread and materials, including but not limited to:

- Asphalt concrete
- Concrete
- Gravel
- Sand
- Soil

Required tools and equipment:

- Spreader
- Roller
- Rake
- Dump truck
- Tamping machine
- Level

Precautions: Wear safety glasses to protect your eyes from flying debris.

Be aware of your surroundings and watch out for traffic.

Use caution when operating heavy machinery.

Follow all safety procedures as outlined in the project safety plan

Procedures:-

Step1. The first step is to prepare the sub grade.

Step2. The sub grade prepared to place the spread

Step3. The spread should be placed in a uniform layer to the specified thickness.

Step4. Once the spread is placed, it should be compacted to the specified density

Step5. The surface of the spread should be finished to the required smoothness

Quality Criteria:

- Checking to ensure that it is to the specified standards.
- The spread is placed to the correct thickness and that it is compacted to the specified density.

LAP TEST -1	Practical demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Performed by applying a known amount of material to a clean, flat surface using a specified spreading tool. The spread of the material is then compared to a reference material, such as a piece of paper. to perform the following tasks within 3 hours.

Task1. Prepare the test surface

Task2. Apply the material.

Task4. Apply the reference material

Task5. Allow the materials to dry

Task6. Compare the spread of the materials.

REFERENCE BOOKS

1. American Society for Testing and Materials. (2017). Standard specification for materials and construction of flexible pavements. ASTM D6931-17. West Conshohocken, PA: ASTM International. doi:10.1520/D6931-17
2. American Association of State Highway and Transportation Officials. (2018). AASHTO guide for design of flexible pavements. Washington, DC: AASHTO.
3. British Standards Institution. (2015). Code of practice for flexible pavements. BS 5949-1:2015. London: BSI.
4. Canadian Standards Association. (2014). Design and construction of flexible pavements. CSA A23.2-14. Mississauga, ON: CSA.
5. Federal Highway Administration. (2016). Flexible pavement design guide. Washington, DC: FHWA.
6. French, R. J., & Inyang, H. I. (2010). Flexible pavement design and analysis. Hoboken, NJ: Wiley.
7. Hall, J. D. (2012). Flexible pavements: An introduction to design, construction, and maintenance. Boca Raton, FL:
8. Huang, Y. H. (2013). Pavement analysis and design. Boca Raton, FL: CRC Press.
9. Mohamed, A. A. (2015). Flexible pavements: Theory, design, and analysis. Boca Raton, FL:
10. Pavement Research Center. (2019). Flexible pavement design and construction. Madison, WI: University of Wisconsin-Madison.
11. Roesler, J. R. (2009). Flexible pavements: Materials, design, and construction. Upper Saddle River, NJ: Prentice Hall.
12. Sayers, M., & Scullion, R. (2014). Flexible pavement design. London: Thomas Telford.
13. Sinha, K. (2016). Flexible pavement design and analysis. New York, NY: McGraw-Hill.
14. Subramanian, K. (2017). Flexible pavement analysis and design. Boca Raton, FL: CRC Press.
15. Thomas, B. J. (2014). Pavement engineering: Principles and practice. Hoboken, NJ: Wiley.
16. Transportation Research Board. (2014). Guide for flexible pavement design. NCHRP Report 672. Washington, DC: TRB.

የሥራ እና ክህሎት ሚኒስቴር
MINISTRY OF LABOR AND SKILLS

Participants of this Module (training material) prepare

No	Name	Qualification (Level)	Field of Study	Institution	Mobile number	E-mail
1	ASHAGRE BIBISO	B	Road construction(B.sc)	Wolaita sodo PTC	0912304708	Ashagrebibiso695@gmail.com
2	BEKALU YIBELTAL	A	Structural engineer(M.sc) Civil engineering (B.sc)	FTVTI	0911271096	fikruyibetal@gmail.com
3	BELETE AWEKE	B	Road construction(B.sc)	Bahirdar PTC	0910974355	beleteyc@gmail.com
4	HABIB SURUR	B	Road construction	Hawasa P.T.C	0979798778/ 0909669919	habibsurur0@gmail.com
5	MOHAMMED SEID	A	Surveying (B.sc) COTM(M.sc)	FTVTI	0914053274	Muha.seid@gmail.com
6	NIGUSSIE TESHOME	A	Geotechnical enginer(M.sc) Civil engineering (B.sc)	Arbaminch PTC	0913767770	teshomeng@gmail.com
7	WONDWESN GIRMA	A	COTM(M.sc) Civil engineering (B.sc)	Harar polytechnic College	0912778365 0703608365	wondwesngirma@gmail.com

Bridges to Prosperity

HELVETAS Swiss Intercooperation

የሥራ እና ክህሎት ሚኒስቴር
MINISTRY OF LABOR AND SKILLS

Bridges to Prosperity

HELVETAS
Swiss Intercooperation