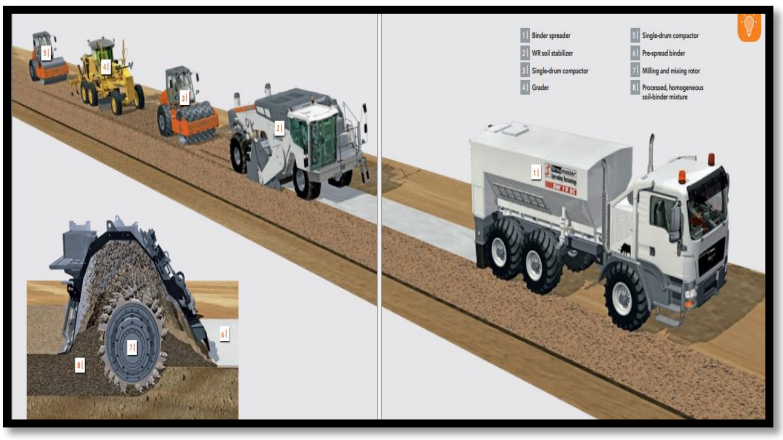
Road Construction and Maintenance

Level III

Based on September, 2023 Curriculum Version 2



Module Title: - Stabilizer Operations

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Addis Ababa, Ethiopia

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Acronym

TTLM	Teachers Training Learning Materials
HELVETAS	Swiss Inter-cooperation
B2P	Bridge to Property
MoLS	Ministry of Labour and Skill
WR	Writgen
PFA	pulverized fly ash
PI	Plasticity Index
PH	Potential of hydrogen
µm	Micrometer
EC	Electrical conductivity
CEC	Cation exchange capacity
CO_2	Carbon dioxide

Contents

Introduction to module

This module is designed to meet the industry requirement under the Road Construction and Maintenance Level III occupational standard, particularly for the unit of competency: Conducting and Monitor Stabilizer Operations. It includes. It includes Plan and prepare, Checks stabilizer pre-operation, Operate stabilizer, Relocate stabilizer, Check equipment performance, Clean up.

Soil stabilization is the process of improving the engineering properties of the soil and thus makes it more stable. It is required when the soil available for construction is not suitable for the intended purpose. In its broadest sense, stablisation includes compaction, preconsolidation, drainage and many other such processess. However the term stablisation is generally restricted to the process which alter the soil material itself for improvement of its properties. A cementing material or chemical is added to a natural soil for the purpose of stablisati

This module covers the units:

- Requirements of stabilization
- Stabilizer pre-operation
- Operate stabilizer and clean up
- Relocate stabilizer
- Equipment performance

Learning Objective of the Module

- Requirements of stabilization
- Checks stabilizer pre-operation
- Operate stabilizer clean up
- Relocate stabilizer
- Check equipment performance

Module Instruction

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

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one:	Requirements of stabilization

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

- Compliance documentation.
- Relevant drawings and specifications
- Safety requirement and Signage
- Plant, tools equipment and materials
- Work materials and quantity
- Environmental protection

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:

- Access, interpret and apply compliance documentation
- Identify and Apply relevant drawings and specifications
- Apply Safety requirement
- Identify, obtain and implement Signage implementation
- Select, check and use of plant, tools and equipment
- Handle and lay work materials
- Identify environmental protection
- Calculate material quantity

1.1 Compliance Documentation

In Ethiopia, stabilizer operations are subject to strict compliance documentation, which includes legislative, organizational, and site requirements and procedures. These documents outline the safety, environmental protection, and overall compliance of stabilizer operations. They help operators make informed decisions and execute operations in line with legal requirements. Organizational and site requirements outline specific protocols for safe and efficient operations. Manufacturer's guidelines and specifications provide detailed instructions on operating and maintaining stabilizer equipment, ensuring operators follow manufacturer's recommended guidelines for optimal performance and longevity.

Ethiopian standards are established by regulatory bodies and industry associations to ensure uniformity, quality, and safety across the sector. Employment and workplace relations legislation govern aspects such as working hours, wages, and occupational health and safety, and employee rights. Operators must ensure compliance with these regulations to foster a safe and fair working environment for employees. Equal Employment Opportunity and Disability Discrimination legislation promote equitable treatment of employees without bias or discrimination based on factors such as gender, race, age, disability, and religion. In conclusion, compliance documentation in Ethiopian stabilizer operations includes legislative requirements, organizational procedures, manufacturer's guidelines, Ethiopian standards, employment regulations, and Equal Employment Opportunity and Disability Discrimination legislation. Operators must access, interpret, and apply these documents to ensure safe, efficient, and legally compliant execution.

1.2 Drawings and job specifications

1.2.1 Drawings

This section explains how to use roadway engineering views for revegetation planning, including determining the vegetation zones that begin where the pavement ends. A glossary with illustrations is provided in order to understand technical concepts and terminology for effective communication with others involved in road design and construction. This section explains how to read and interpret:

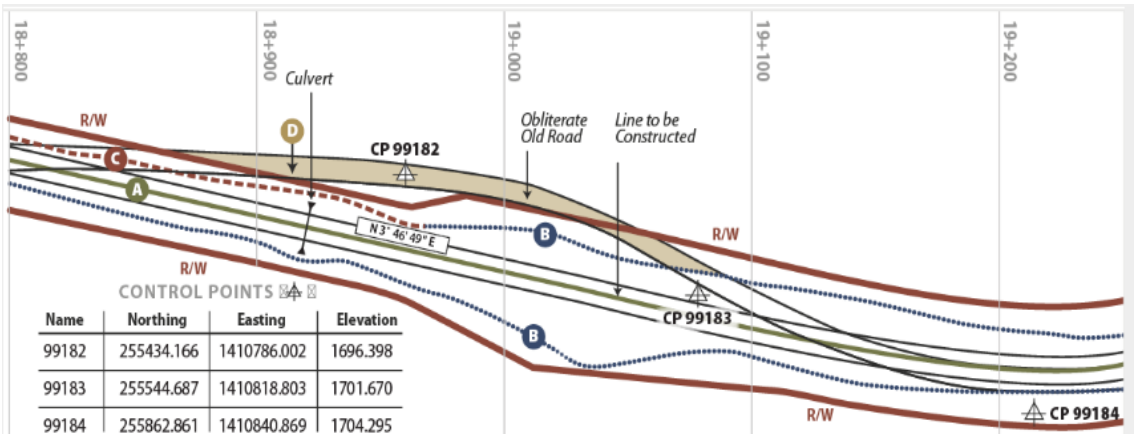
- Plan views
- Profile views
- Cross-section views
- Typical views
- Summary of quantities tables

The plan set consists of construction drawings and specifications for each section of road or project. The four most common views of plans utilized by the designer are plan views, cross-section views, profile views, and typical views. Each of these is defined in Table 2-1. Examples and descriptions for interpreting each of these views are provided below.

View	Definition
Plan	A drawing depicting a portion of the road project from a bird's eye view.
Profile	A drawing depicting the vertical plane section along the longitudinal centerline of the road, expressed in elevation or gradient.
Cross-section	A drawing depicting a horizontal section of the road viewed vertically, as if cut across the width of the road.
Detail	A drawing depicting features of a particular design, installation, construction or methodology.

A) Plan View

The plan view shows the existing and proposed road locations from a bird's eye view. It is important to note that plan sets, in particular road plans, historically displayed distances in meters.



Name	Northing	Easting	Elevation
99182	255434.166	1410786.002	1696.398
99183	255544.687	1410818.803	1701.670
99184	255862.861	1410840.869	1704.295

Fig1-1 Plan view of the existing and proposed road

B) Profile view

The profile view is a trace of a vertical plane intersecting a particular surface of the proposed road construction. It corresponds to the longitudinal centerline of the road bed in the plans. Profile grade means either elevation or gradient of the trace, depending on the context.

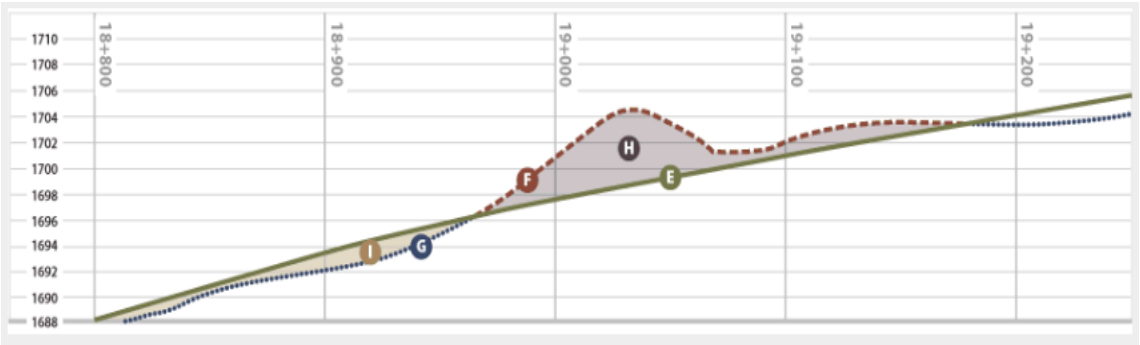


Fig 1-2 Profile view vertical plane intersecting a particular surface

C) Cross-section View

Cross-sections are views of the slopes perpendicular to the direction of the road. They display a vertical section of the ground or structure at right angles to the centerline or baseline of the roadway. Depending on the length and topographic complexity of the road, there can be hundreds of cross-sections. Each cross-section is referenced back to a station.

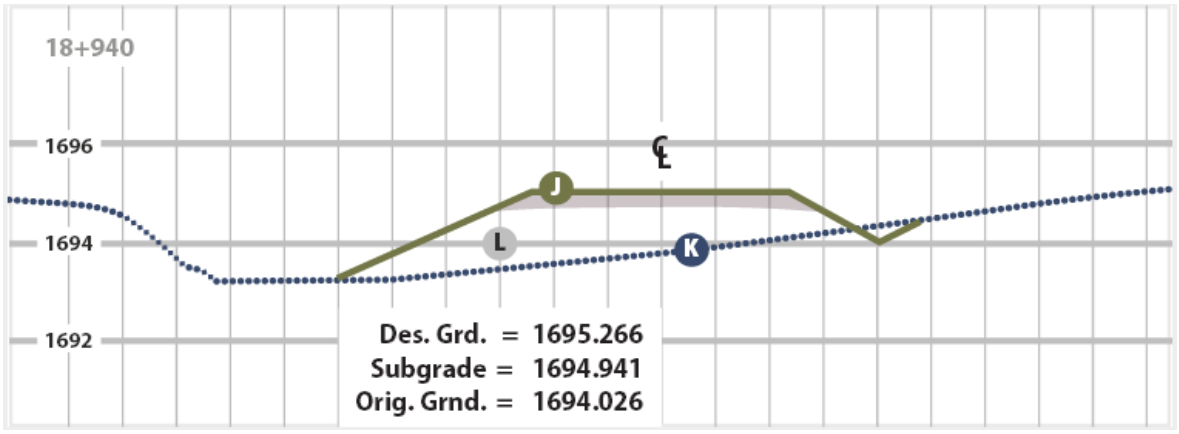


Fig 1-3 Cross-sections of the cut slopes perpendicular to the direction of the road

Cross-section and plan views are used together to view the proposed road three-dimensionally. From these views, a more detailed revegetation plan can be developed. Each cross-section can be reviewed and a set of revegetation criteria can be developed for similar cross-sections throughout the project.

Cross- sections show the proposed slope gradients for cut and fill slopes and provide the designer a means to determine slope steepness. Like stationing, the method of depicting slopes has changed over the years. Older plan sets often depicted slopes as a ratio of one unit horizontal to one unit vertical.

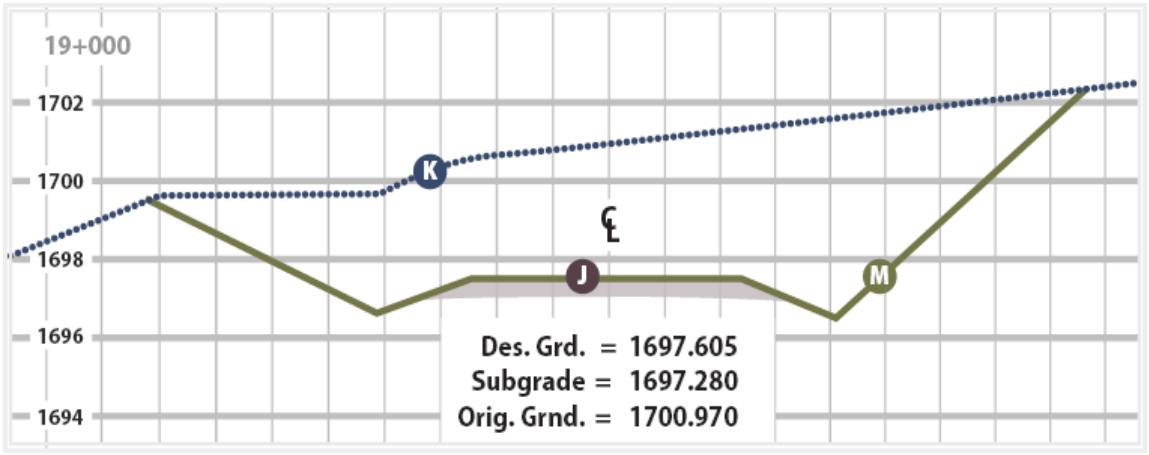


Fig 1-4 Cross-sections of the fill slopes perpendicular to the direction of the road

D) Specifications

Specifications describe the nature and the class of the work; materials to be used in the work, workmanship etc. and are very important for the execution of the work. The cost of a work depends much on the specifications. Specifications should be clear.

Specifications describe the materials and workmanship required for a development. They do not include cost, quantity or drawn information, and so need to be read alongside other information such as quantities, schedules and drawings.

Specifications should be developed alongside the design, increasing in level of detail as the design progresses.

They should not be left until the preparation of production information.

By tender they should describe every aspect of the building in such a way that there is no uncertainty about what the Contractor is pricing.

Specifications are of two types:

- General or Brief specifications
- Detail specifications

General or Brief specification:

- It is a short description of different parts of the work specifying materials, proportions, qualities etc.

Detail Specification:

- The detail specifications of different items of work are prepared separately, and describe what the work should be and how they shall be executed and constructed.
- The detail specifications form an important part of contract document.

1.3 Safety requirement and signage

1.3.1 Health and safety and environment

Soil stabilizing products react with water and workers need to protect their skin and eyes from contact with unreacted materials. Be aware and stay clear of drift and do not breathe dusts or touch raw materials on the ground.

A) Plant/Person Interface Safe Zones

As with all construction operations, the interface between plant and people is of greatest importance. Whilst the process is relatively slow-paced, there are a number of operations being carried out simultaneously, sometimes within a relatively small area. Those operating machinery must actively look for and see people on the ground. All site personnel should be briefed on plant/people interfaces and on the need to be seen by other site operatives.

Safety briefings must be carried out prior to the commencement of any works; and all personnel must have the relevant training/qualifications for their element of the works.

Binder manufacturers and suppliers must be able to provide data sheets for their products. This must include safety and environmental information for the end-user. Anyone who comes in to direct and secondary contact with binders should either wear, or be issued with the following:

- Dust masks to FFP3 – goggles or close-fitting glasses – gloves (if handling binder) – disposable coveralls.
- Eye wash bottles and clean water should be available in all plant.

B) Environment

To minimize environmental impact, the following should be considered:

- Control of run off
  - Before addition of binders – general earthworks good practice and interface with other/main contractor(s)
  - After addition of binders – ensure fully mixed, fully compacted and curing protection applied

- Dust – note wind-blown risk and option for integrated spreader. Ensure that mixing closely follows the spreading operation
- Change in material properties due to an increase in pH of stabilized soils. The pH is likely to remain elevated and this should be considered when proposing landscaping and planting

1.3.2 Signage

The purpose of these guidelines is to inform, warn and guide the road users safely past the works area and in that way protecting the road users and the workforce.

All road works, no matter how small, must be properly signed. To keep the respect of the road users for the signing of road works, and with it the road safety, it is also important to continuously maintain and adjust the signing to the current work situation. If some or all of the signing are no longer needed, it must be removed.

Contractors and supervising engineers have an important responsibility to make sure, that road works are safe. These guidelines are intended to assist in ensuring the road safety when works are being carried out.

Road work signs must be standard traffic signs - don't design your own. All signs must be reflective. Make sure to place the signs in a visible place for the drivers. On dual carriageway roads the warning signs must be duplic. The most important traffic signs used at road works are acted on the central reservation.

Signs and guarding equipment must be secured against being blown over or out of position by the wind or passing traffic. For this purpose, use sandbags or – alternatively - equipment having ballasting as a part of its construction.

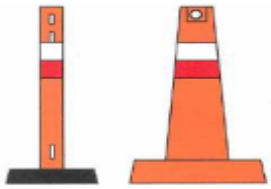
The most important traffic signs used at road works are:

"Road narrows on right"
Use this sign to warn the road users if the road narrows on their right.
Add a "Traffic control" sign when appropriate. Place it about 100 m before the lead-in taper. Length of the triangle sides = 90 cm.

Turn left

Sharp deviation of route to left" (right if chevrons reversed) Use this sign as a barrier across the carriageway only when the road user has to make an essential change of direction
(turn left or right).Height = 50 cm.
Width = 250 cm.

"Lane closed"
Use this sign as a barrier across the carriageway to close a lane.
Height = 50 cm. Width = 250 cm.



"Traffic cones"
Use the cones to mark the lead-in taper and along the works area, when the road works are of short duration.
When using traffic cones to mark the road works, they must be complemented with "keep left" and "keep right" signs.
Height = about 100 cm.

"Road narrows on left"
Use this sign to warn the road users if the road narrows on their left.
Add a "Traffic control" sign when appropriate.
Place it about 100 m before the lead-in taper.
Length of the triangle sides = 90 cm.

"Road narrows on right"
Use this sign to warn the road users if the road narrows on their right.
Add a "Traffic control" sign when appropriate.
Place it about 100 m before the lead-in taper.
Length of the triangle sides = 90 cm.

"Maximum speed"
Introduce a mandatory speed limit during the working period, typically 30, 40 or 50 km/h.
Place it with the road works sign and repeat it for every 500 m.
Diameter = 70 cm. *(90 cm on motorways)*

Pedestrians must be protected from both the works area and the moving traffic. If the footway has to be closed, a safe route for pedestrians must be provided and signed with the “footpath” sign (diameter = 50 cm) if not clear visible. Safe routes should always provide a minimum unobstructed width of 1, 0 m, increased wherever possible to 1, 5 m or more.

Pedestrians must be separated from the works by barrier planks in red and white.

Barrier plank

A) Traffic control

When there is insufficient width remaining to allow two-way traffic, reduce the available width to 3, 7 m and provide traffic control.

Traffic control by ‘Give and Take’ system can be used only when ALL of the following apply:

- The speed limit is < 50 km/h
- The length of the works from the start of the lead-in taper to the end of the exit Taper is < 50 m
- Drivers approaching from either direction can see 50 m beyond the end of works
- Two-way traffic flow is less than 20 vehicles counted over 3 minutes (400 veh/h)
- Less than 20 heavy goods vehicles pass the works per hour.

Manually operated Stop/Go boards or portable traffic signals must be used when the conditions for using ‘Give and Take’ system is not met.

When using traffic control by Stop/Go boards, the length of the works should not exceed 500 m. If the operators are not clear visible to each other, two-way radio control must be applied. At night the operators and their Stop/Go boards should be illuminated.

Fig 1-5 manually operated temporary STOP and signs

EXAMPLE

Lay out-1 work in roadway (single carriageway) speed limit to 80km/h

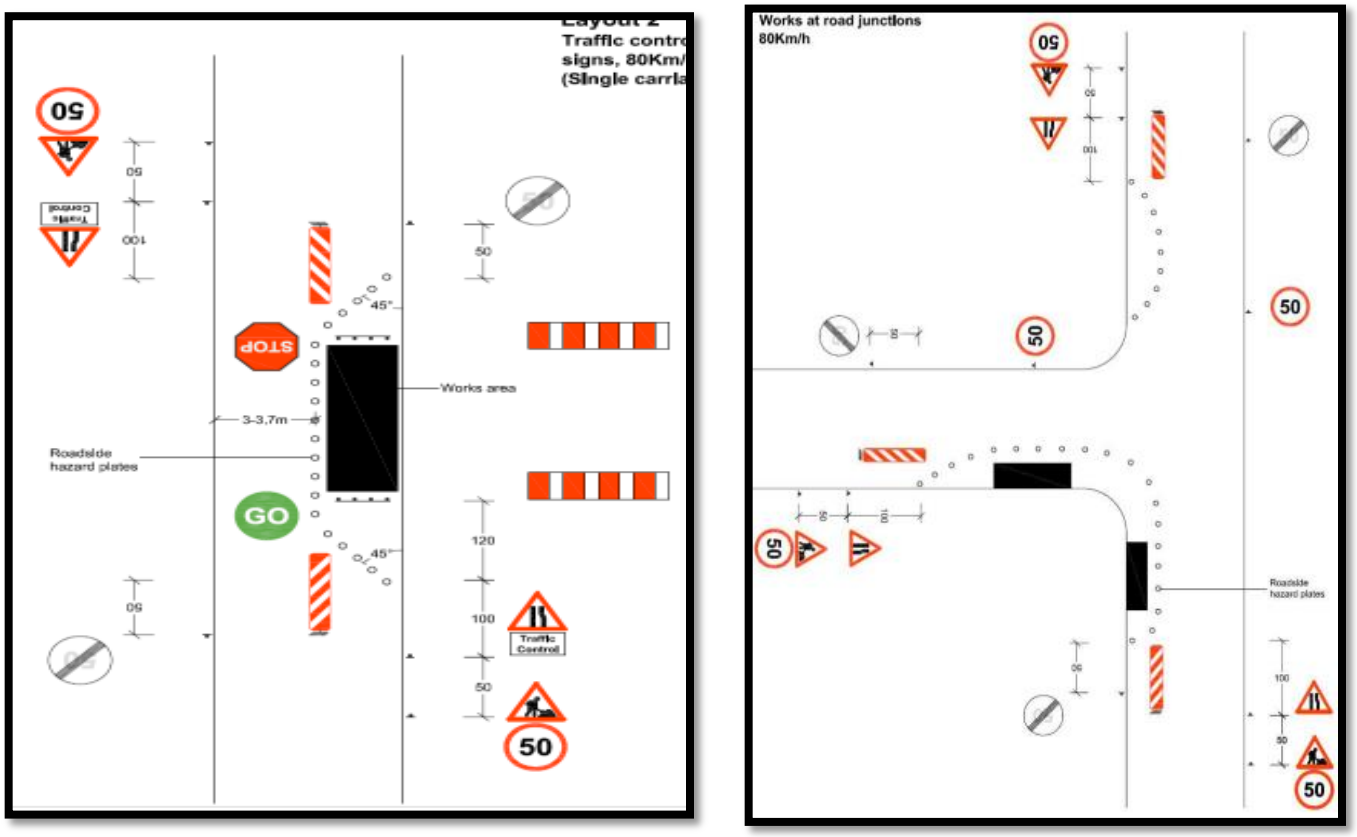


Fig 1-6 Signage lay out work in roadway

1.4 Plant, tools, equipment and materials

1.4.1 Hand Tools used in soil stabilization

Common Hand Tools for Road Maintenance Works:

- Shovel and spade
- Pick and mattock
- Hoe
- Rake and spreader
- Grass cutter or slasher

- Hand rammer
- Wheelbarrow

1.4.2 Soil Stabilization Equipment

Self-Propelled Stabilization Mixers (Writgen WR240i)

- With a working width of 2.40 m and a maximum working depth of 510 mm, the recycler is highly flexible when it comes to operations in soil stabilizing and cold recycling.
- When it comes to soil stabilizing, the ideal performance range is between 4,000 and 8,000 square meters a day.

Streumaster binding agent spreaders

- The Streumaster binding agent spreaders are an ideal complement to Wirtgen soil stabilizers and cold recycler's equipment.
- Spreading large quantities of binding agents while adhering to the specified accuracy at the same time is of paramount importance in both soil stabilization and cold recycling. The sophisticated binding agent spreaders from Streumaster meet these requirements with superior ease.

Features include:

- Attachment, trailers, built-up, or self-propelled units
- Excellent spreading and distribution of the binding agent
- Automatic functions
- Excellent productivity
- Easy maintenance
- Self levelling
- Used for soil homogenization and stabilization with lime and cements.

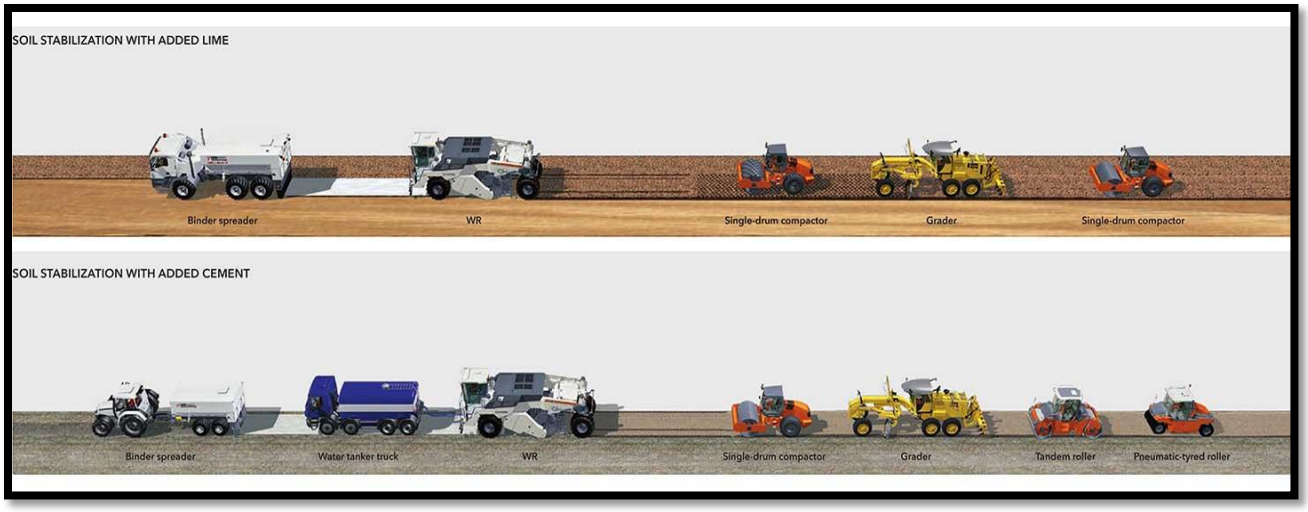
- Tractor Drawn Stabilization Mixers

- The WS 220 tractor-towed stabilizer is designed for efficient soil stabilization at a working width of 2.15m.
- Their range of applications covers both soil improvement and soil strengthening measures. In soil improvement, the tractor-towed stabilizers produce soils suitable for placing and compacting to create embankments, slopes, backfills or site haulage roads.
- In soil strengthening, they create load-bearing surfaces for the construction of parking lots, roads, sports grounds, track beds, harbour facilities, airports or industrial parks.

Sheep foot roller

Single drum compactor

Grader



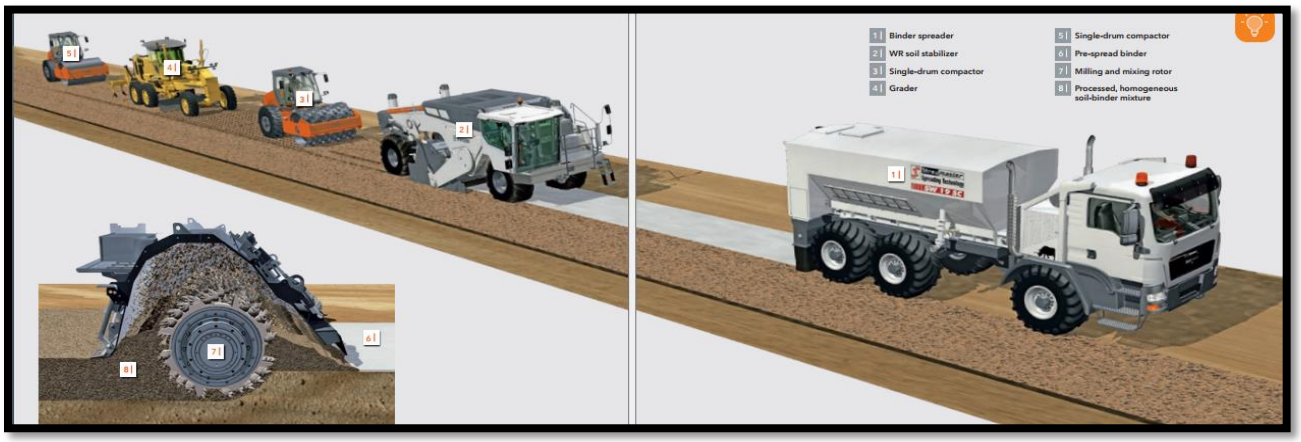


Fig 1-7 Stabilization equipment working together on job site

1.4.3 Materials

Soil stabilization involves the use of stabilizing agents (binder materials) in weak soils to improve its geotechnical properties such as compressibility, strength, permeability and durability. The components of stabilization technology include soils and or soil minerals and stabilizing agent or binders (cementations materials).

A) Cement

- Cement is the oldest binding agent since soil stabilization technology was invented in the 1960s. It is a primary stabilizing agent or hydraulic binder, as it can be used alone to stabilize a wide range of soils. Cement reaction is not dependent on soil minerals but on its reaction

with water, making it suitable for various soil types. There are various types of cement available, such as ordinary Portland, blast furnace, sulfate resistant, and high alumina cement. The hydration process occurs when cement is mixed with water and other components, resulting in hardening phenomena. This process does not change soil structure, but it is slow and can leave the center of the grains un-hydrated.

- presence of foreign matters or impurities
- water-cement ratio
- curing temperature
- presence of additives
- Specific surface of the mixture.

Depending on factor(s) involved, the ultimate effect on setting and gain in strength of cement stabilized soil may vary. Therefore, this should be taken into account during mix design in order to achieve the desired strength. Calcium silicates, C3S and C2S are the two main cementations properties of ordinary Portland cement responsible for strength development (Al-Tabbaa and Perera, 2005; Euro Soil Stab, 2002). Calcium hydroxide is another hydration product of Portland cement that further reacts with pozzolanic materials available in stabilized soil to produce further cementations material (Sherwood, 1993). Normally the amount of cement used is small but sufficient to improve the engineering properties of the soil and further improved cation exchange of clay. Cement stabilized soils have the following improved properties:

- Decreased cohesiveness (Plasticity)
- Decreased volume expansion or compressibility
- Increased strength (PCA-IS 411, 2003

Fig 1-9 A truck applies cement stabilizers to a roadway

Calculate material quantity

- **Quantity of cement:** A well graded soil requires about 5% cement, whereas a poorly graded, uniform sand may require about 9% cement. Non plastic soils require about 10% cement, whereas plastic clay may need about 13% cement.

- The actual quantity of cement required for a particular soil is ascertained by laboratory tests. For base course, samples are subjected to durability test determination of the quantity of cement required. It consists of 12 cycles of freezing and thawing or 12 cycles of wetting and drying. The maximum volume change (swelling plus shrinkage) of 2% is generally permitted.
- Sometimes, the quantity of cement is determined according to the minimum unconfined compressive strength of about 1500kg/m^2 for clay soils and of about 5500 kg/m^2 for sand soils is specified. High strength is obtained by decreasing the water-cement ratio. This is done by increasing the cement content for the same water content.

Example

Assume a given road, 276 m length * 9.5 m width is required to be established with 3% cement. If the materials are spread by bags, show how to estimate the quantity of bags required and how to spread them **(Note that 3% is calculated on the mass of dry soil when estimating on the mass of dry soil when estimating the quantity of bags required).**

Volume of road to receive stabilizer = 276*9.5*0.2 = 524.4 m3 (0.2 m thickness of subgrade)

Dry density of soil = 1970kg/m^3

Mass of soil = Density of soil*Volume of soil = 524.4 m^3 *1970kg/m^3 = 1033068kg.

Cement content = 3% of mass of soil = 3%*1033068kg = 30992.04 kg of cement required for the entire road.

Using 50kg bags, number of bags required = 30992.04/50 = 620 bags.

B) **Lime**

Lime provides an economical way of soil stabilization. Lime modification describes an increase in strength brought by cation exchange capacity rather than cementing effect brought by pozzolanic reaction (Sherwood, 1993). In soil modification, as clay particles flocculates, transforms natural plate like clays particles into needle like interlocking metal line structures. Clay soils turn drier and less susceptible to water content changes (Roger et al, 1993). Lime stabilization may refer to pozzolanic reaction in which pozzolana materials reacts with lime in presence of water to produce cementitious compounds (Sherwood, 1993, Euro Soil Stab, 2002). The effect can be brought by either quicklime, CaO or hydrated lime, Ca (OH) 2. Slurry lime also can be used in dry soils conditions where water may be required to achieve effective compaction (Hicks, 2002). Quicklime is the most commonly used lime; the followings are the advantages of quicklime over hydrated lime (Rogers et al, 1996).

- ✓ Higher available free lime content per unit mass
- ✓ Denser than hydrated lime (less storage space is required) and less dust
- ✓ Generates heat which accelerate strength gain and large reduction in moisture content according to the reaction equation below
    - $CaO + H\,2O \rightarrow Ca\,(OH)\,2 + Heat$.

Quicklime when mixed with wet soils, immediately takes up to 32% of its own weight of water from the surrounding soil to form hydrated lime; the generated heat accompanied by this reaction will further cause loss of water due to evaporation which in turn results into increased plastic limit of soil i.e. drying out and absorption (Euro Soil Stab, 2002; Sherwood, 1993). The effect can be explained from Figure 1 for soil at a moisture content of 35% and plastic limit 25%. Addition of 2% lime will change the plastic limit to 40% so that the moisture content of the soil will be 5% below plastic limit instead of 10% above plastic limit (Sherwood, 1993). Sherwood (1993) investigated the decrease in plasticity as brought about in first instance by cation exchange in which cations of sodium and hydrogen are replaced by calcium ions for which the clay mineral has a greater water affinity. Even in soils (e.g. calcareous soils) where, clay may be saturated with calcium ions, addition of lime will increase pH and hence increase the exchange capacity. Like cement, lime when reacts with wet clay minerals result into increased pH which favors solubility of siliceous and aluminous compounds. These compounds react with calcium to form calcium silica and calcium alumina hydrates, a cementitious product similar to those of cement paste. Natural pozzolanas materials containing silica

and alumina (e.g. clay minerals, pulverized fly ash, PFA, blast furnace slag) have great potential to react with lime.

Lime stabilizations technology is mostly widely used in geotechnical and environmental applications. Some of applications include encapsulation of contaminants, rendering of backfill (e.g. wet cohesive soil), highway capping, slope stabilization and foundation improvement such as in use of lime pile or lime-stabilized soil columns (Ingles and Metcalf, 1972). However, presence of sulphur and organic materials may inhibit the lime stabilization process.

Sulphate (e.g. gypsum) will react with lime and swell, which may have effect on soil strength

Fig 1-10 A truck applies chemical stabilizers to a roadway for dust suppression

The amount of lime required for stabilizations varies between 2 to 0% of the soil. However, if the lime is used only to modify some of the physico-chemical characters tics of the soil, the amount of lime is about 1 to 3%.

The following amount may be used as rough guide.

- 2 to 5% for clay gravel material having less than 50% of silt clay friction.
- 5 to 10% for soils with more than 50% of silt clay friction.
- For soil having particle size intermediate between (i) and (ii) above, the quantity of lime required is between 3 to 7%.
- About 10% heavy clays used as bases and sub-bases.

Lime stabilization is not effective for sandy soils. However the soil can be established in combination with clay, fly ash or other pozzolanic materials, which serve as hydraulically reactive ingredients. The ratio of fly ash to lime generally varies between 3 to 5%. The fly ash is used about 10 to 20% of the soil weight.

Example: refer the above example.

C) Bitumen

Stabilization of soils and aggregates with asphalt differs greatly from cement and lime stabilization. The basic mechanism involved in asphalt stabilization of fine-grained soils is a waterproofing phenomenon. Soil particles or soil agglomerates are coated with asphalt that prevents or slows the penetration of water which could normally result in a decrease in soil strength. In addition, asphalt stabilization can improve durability characteristics by making the soil resistant to the detrimental effects of water such as volume. In non-cohesive materials, such as sands and gravel, crushed gravel, and crushed stone, two basic mechanisms are active: waterproofing and adhesion. The asphalt coating on the cohesion less materials provides a membrane which

Prevents or hinders the penetration of water and thereby reduces the tendency of the material to lose strength in the presence of water. The second mechanism has been identified as adhesion. The aggregate particles adhere to the asphalt and the asphalt acts as a binder or cement. The cementing effect thus increases shear strength by increasing cohesion. Criteria for design of bituminous stabilized soils and aggregates are based almost entirely on stability and graduation requirements. Freeze-thaw and wet-dry durability tests are not applicable for asphalt stabilized mixtures.

- **Types of bituminous stabilized soils.**
  - **Sand bitumen.** A mixture of sand and bitumen in which the sand particles are cemented together to provide a material of increased stability.
  - **Gravel or crushed aggregate bitumen.** A mixture of bitumen and a well-graded gravel or crushed aggregate that, after compaction, provides a highly stable waterproof mass of sub base or base course quality.
  - **Bitumen lime.** A mixture of soil, lime, and bitumen that, after compaction, may exhibit the characteristics of any of the bitumen-treated materials indicated above. Lime is used with material that has a high PI, i.e. above 10.

- **Types of bitumen.**

  Bituminous stabilization is generally accomplished using asphalt cement, cutback asphalt, or asphalt emulsions. The type of bitumen to be used depends upon the type of soil to be stabilized,

method of construction, and weather conditions. In frost areas, the use of tar as a binder should be avoided because of its high temperature susceptibility. Asphalts are affected to a lesser extent by temperature changes, but a grade of asphalt suitable to the prevailing climate should be selected. As a general rule, the most satisfactory results are obtained when the most viscous liquid asphalt that can be readily mixed into the soil is used. For higher quality mixes in which a central plant is used, viscosity-grade asphalt cements should be used. Much bituminous stabilization is performed in place with the bitumen being applied directly on the soil or soil aggregate system and the mixing and compaction operations being conducted immediately thereafter. For this type of construction, liquid asphalts, i.e., cutbacks and emulsions, are used. Emulsions are preferred over cutbacks because of energy constraints and pollution control efforts. The specific type and grade of bitumen will depend on the characteristics of the aggregate, the type of construction equipment, and climatic conditions. Generally, the following types of bituminous materials will be used for the soil gradation indicated.

Fig 1-11A truck applies Bitumen stabilizers to a roadway

D) Aggregate

- **Soil aggregate stability** is a measure of the ability of soil aggregates—soil particles that bind together—to resist breaking apart when exposed to external forces such as water erosion and wind erosion, shrinking and swelling processes, and tillage. Soil aggregate stability is a measure of soil structure and can be affected by soil management.

➢ **Factors Affecting Aggregate Formation**

Soil aggregates are formed due to flocculation and cementation processes, and are enhanced by physical and biological processes. Primary soil particles (sand, silt, and clay) are subjected to these

processes, and can stick together to form larger sub-micro aggregates (< 250 μm), micro aggregates, and macro aggregates (> 250 μm). It has been suggested that soil aggregates form hierarchically, meaning larger less dense aggregates are composed of smaller more dense aggregates.

- **Flocculation**

Flocculation refers to a state when primary soil particles (sand, silt, and clay) are drawn to each other by inter-particle forces to create microscopic floccules (or clumps). Inter-particle forces include: van der Waals forces, electrostatic forces, and hydrogen bonding. This is the opposite of dispersion, which occurs when individual primary soil particles are held apart. Soil particle dispersion and flocculation are mainly controlled by the soil pH,[10] electrical conductivity (EC), and sodium content.

- **Cementation**

Microscopic floccules, will become aggregates once they are stabilized through cementation by one or several cementing agents such as carbonates, gypsum, sesquioxides, clay particles, and organic matter.

- **Carbonates and Gypsum**

Calcium carbonate (CaCO3), magnesium carbonate (MgCO3), and gypsum (CaSO4.2H2O) can enhance soil aggregation when associated with clay minerals. The calcium ion (Ca2+), through its cationic bridging effect on flocculation of clay and organic matter compounds, has a crucial role in the formation and stability of soil aggregates. Calcium can exchange with sodium on exchange sites. This, in turn, reduces soil particle dispersion, surface crusting, and aggregate slaking associated with sodic soils and indirectly increases aggregate stability.

- **Clay Particles**

Soil clay particles have varying effects on aggregate formation, depending on its type. Soil with 2:1 type of phyllosilicate clay minerals (e.g., montmoriollinite) typically have high cation exchange capacity (CEC), which allows them to bind with polyvalently charged organic matter complexes to form micro aggregates (Amézketa, 1999). Soil organic matter is therefore the main binding agent in these soils (Six et al., 2000. On the other hand, in soils with oxides and 1:1 type of phyllosiliacte clay minerals (e.g., kaolinite), soil organic matter is not the only binding agent and aggregate formation is also due to electrostatic charges between and among oxides and kaolinite particles.

- **Soil Organic Matter**

Soil organic matter can increase aggregate stability in soil and form a soil carbon sponge.

Physical Processes

- **Wetting and Drying**

Oil wetting and drying cycles can have both a beneficial effect on soil aggregation (Utomo and Dexter, 1982; Dexter et al., 1988, and a negative effect on soil aggregation (Soulides and Allison, 1961; Tisdall et al., 1978. To help explain these contradictory results, it was hypothesized that soils will maintain a state of aggregate stability equilibrium. If soils have certain properties, a threshold level will be reached where a period of wetting and drying will lead to increases or decreases in aggregate stability depending on the aggregate stability of the soil at that point in time.

- **Shrinking and Swelling**

Shrinking and swelling cycles of soil are closely linked with wetting and drying cycles; however, they are also dependent on the type of clay phyllosilicate minerals present. Soils with higher content of 2:1 types of phyllosilicate minerals (such as montmorillonite), have a stronger cementation force acting during repeated wetting and drying cycles, which can increase soil aggregate stability. This is because 2:1 type phyllosilicate minerals swell and increase their volume with changing water content; meaning these soils expand when wet, and contract as they dry out.

- **Freezing and Thawing**

When soils freeze and thaw, they undergo expansion and contraction. It was found that with higher water content in the soil at the time of freezing had a reducing effect on aggregate stability overall. The water expands in these soils and breaks apart the aggregates into smaller aggregates, while pores created by the freezing collapse once soils thaw (Amézketa, 1999).

➢ **Chemical Stabilization**

Chemical stabilizers, also known as soil binders or soil palliatives, provide temporary soil stabilization. They are readily applicable to the surface of the soil, can stabilize areas that cannot establish vegetation, and provide effective protection from wind and storm water erosion. Categories of chemical stabilizers are as follows:

- Water with surfactant

- Water-absorbing
- Organic non-petroleum
- Organic petroleum
- Synthetic polymer emulsion
- Concentrated liquid stabilizer and clay additive (Jones, 2017).

Fig 1-12 A truck applies chemical stabilizers to a roadway for dust suppression

1.5 Environmental Protection

Environmental protection is the practice of protecting the natural environment by individuals, groups and governments. Its objectives are to conserve natural resources and the existing natural environment and, where it is possible, to repair damage and reverse trends.

1.5.1 Organizational/project environmental management plan

A) Waste Management

- **The issue**

Construction and maintenance activities generally produce various types of waste, including waste from work camps. Waste materials require proper disposal to avoid pollution, hazards, and visual blight.

- **The aim**

Minimize environmental degradation by properly disposing of waste.

- **The practice**
  - ✓ Identify waste products from road activities and plan correct disposal.
  - ✓ Identify suitable areas for disposal of spoil from road works.

- ✓ Dispose of waste that could cause environmental degradation in areas determined as suitable.
- ✓ Ensure workers are aware of proper disposal.

- **Organizations for advice:**
  - ✓ Department of Environment and Conservation
  - ✓ Local Government Association
  - ✓ Main Roads

Fig 1-13 Waste materials require proper disposal to avoid pollution, hazards, and visual blight

B) Water quality protection

- **The issue**

Runoff from road construction and maintenance sites can contain pollutants and affect the quality of receiving waters such as wetlands, watercourses, ground water, and drinking water supply. Pollutants can include hydrocarbons such as oils, zinc and other metals especially in urban areas, and sediment. Large volumes of runoff from cleared areas can cause significant erosion and general land degradation.

- **The aim**

Maintain water quality in wetlands, waterways and drinking water catchment areas that adjoin roads. Control erosion from cleared areas to avoid erosion and siltation of watercourses.

- **The practice**
  - ➢ Limit disturbance and clearing of sites.
  - ➢ Implement actions where necessary to control erosion and runoff from construction sites.

- Use and store any hazardous substances appropriately.
- Dispose of wastes appropriately.
- Control discharge flows and sedimentation caused by dewatering operations.
- Minimize surplus wastewater from activities such as brick and pavement cutting, and avoid runoff to environmentally sensitive areas.
- Locate wash down of vehicles and other equipment away from environmentally sensitive areas.
- Clean out sediment from detention basins as appropriate and dispose at approved disposal site.

- **Organizations for advice:**
  - Department of Environment and Conservation Main Roads

C) Noise and Vibration

- **The issue**

Noise and vibration from road construction and maintenance activity can cause a nuisance to people nearby. The degree of nuisance can depend on the time of occurrence, duration and intensities. In some instances vibration can cause damage to buildings. The common source of noise and vibration is equipment, and on occasion, blasting.

- **The aim**

Minimize noise and vibration to prevent damage to buildings and maintain amenity in sensitive adjoining areas.

- **The practice**
  - Notify the public that proposed works will create noise and/or vibrations especially if these works will occur outside normal working hours.
  - Obtain any necessary approval to undertake work outside normal working hours.
  - Implement special noise control where necessary, e.g. temporary barriers or enclosures.
  - Plan site activity to minimize noise impacts.
  - Use equipment with low noise levels, and maintain noise control devices on equipment.

- Take precautionary measures to avoid vibration damage to buildings near work sites.

- **Organizations for advice**:
  - ✓ Department of Environment and Conservation

Fig 1-14 Noise and vibration from road construction and maintenance activity can be a nuisance and cause damage to buildings.

D) Dust

- **The issue**

Road construction and maintenance activities often generate some amount of dust, especially in very dry conditions. Dust is a nuisance in the environment and can decrease amenity values. It can also be a health hazard causing respiratory problems and can pose a risk to traffic safety by reducing visibility.

Fig 1-15 Road construction and maintenance activities often generate some amount of dust.

- **The aim**

Control dust emissions for the benefit of nearby residents and to limit the effect on native vegetation.

- **The practice**
  - Clear vegetation only when necessary.
  - Control dust by spraying soil with water as required.
  - Treat areas due for soil stabilization as soon as practical.
  - Use dust suppressants as appropriate, that are suitable to the environment and in accordance with the manufacturer's recommendations.

Self-Check 1	Written test

Name…… ID…… Date…….

Part I: True or False question

I. Instruction: Say true if the statement is correct and false if the statement is incorrect.

1. Ethiopian Standards are used to maintaining quality operation of stabilizers and compatibility.

2. The profile view is a views of the slopes perpendicular to the direction of the road.

3. Soil stabilizing products have no effect to skin and eyes.

4. Self-Propelled Stabilization equipment is an equipment used to spread the material.

5. The use of stabilizing agents or binder materials in weak soils is to improve its geotechnical properties.

6. The aim of environmental protection in soil stabilization is to minimize environmental degradation by properly disposing of waste.

Part II: Matching

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

	A		B
1	Provides information on applicable laws and regulations	**A)**	To avoid pollution, hazards, and visual blight.
2	Describe the nature and the class of the work; materials to be used in the work, workmanship etc.	**B)**	Stabilization equipment
3	Streumaster binding agent spreaders	**C)**	Specifications
4	Part of environmental protection management	**D)**	Compliance document

Part III: Short Answer Questions

1. What is the impotency of compliance document with respect to soil stabilization?
2. List the construction drawings and specifications for road project.
3. List the tools and equipment that are used for soil stabilization.
4. What are the objectives of environmental protection?
5. List the materials that are used for soil stabilization.

Unit Two: stabilizer pre-operation

This unit to provide you the necessary information regarding the following content coverage and topics:

- Pre-start, start-up, park and shutdown procedures.
- Stabilizer controls and functions

Overview

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

- Pre-start, start-up, park and shutdown procedures.
- Stabilizer controls and functions

2.1 Pre-start, start-up, park and shutdown procedures.

Here are the pre-start, start, and shut down procedures for soil stabilization equipment:

2.1.1 Pre-start procedures

- Check the equipment for any damage or wear and tear.
- Make sure that all the safety guards are in place and functioning properly.
- Fill the fuel tank and check the oil level.
- Inspect the tires and make sure that they are properly inflated.
- Familiarize yourself with the operation of the equipment.

2.1.2 Start-up procedures

- Start the engine and let it warm up for a few minutes.
- Adjust the controls to the desired settings.
- Slowly engage the drive system.

Shut down procedures

- Allow the engine to cool down before shutting it off.
- Engage the parking brake.
- Lower the equipment to the ground.
- Secure the equipment and remove the keys.

Here are some additional safety tips to keep in mind when operating soil stabilization equipment:

- Always wear personal protective equipment (PPE), such as hard hat, safety glasses, gloves, and boots.
- Be aware of your surroundings and watch for other workers and traffic.
- Do not operate the equipment if you are tired or under the influence of drugs or alcohol.
- Follow the manufacturer's instructions carefully.
- By following these procedures, you can help to ensure the safe operation of soil stabilization equipment.

2.1.3 Shutdown procedures

The shutdown procedures for soil stabilizer equipment will vary depending on the specific type of equipment, but there are some general steps that should be followed.

- Turn off the power to the equipment.
- Close the valves on the supply lines.
- Drain the water or other fluids from the system.
- Disconnect the hoses and other attachments.
- Clean the equipment and store it in a safe place.

Here are some additional tips for safe shutdown of soil stabilizer equipment:

- Always follow the manufacturer's instructions.
- Be sure to wear personal protective equipment (PPE) when working with soil stabilizer equipment.
- Dispose of any hazardous materials properly.

Here are the specific shutdown procedures for a few common types of soil stabilizer equipment:

Rotary drum stabilizer:

- Turn off the power to the machine and allow it to cool down.
- Then, open the valves on the supply lines and drain the water or other fluids from the system.
- Disconnect the hoses and other attachments, and clean the machine.

Static mixer stabilizer:

- Turn off the power to the machine and allow it to cool down.
- Then, close the valves on the supply lines and drain the water or other fluids from the system.
- Disconnect the hoses and other attachments, and clean the machine.

Chemical stabilizer:

- Follow the manufacturer's instructions for safe shutdown of the equipment.
- This may involve neutralizing the chemicals, draining the system, and cleaning the equipment.

2.2 Stabilizer controls and functions

The text discusses the use of cement, lime, lime-fly ash, and asphalt in soil stabilization for pavement building, emphasizing the importance of quality control to ensure the final product meets intended purpose and contractor compliance with plans and specifications.

2.1.1 Pulverization

Pulverization in cement construction is not a problem unless clayey or silty soils are stabilized. The No. 4 sieve is used for pulverization control, and moisture management is essential. Cement content is measured in volume or dry weight, and the correct amount is known by field staff. Moisture content is calculated in the laboratory and in situ, and nuclear technologies are used for field control. Mixing uniformity is ensured through visual assessments and testing across the pavement's width and treatment depth.

Building begins with ideal laboratory moisture content, followed by in situ soil moisture. Field control involves determining optimum moisture content and maximum density. Mixing uniformity is ensured through visual assessment and testing across pavement width and depth. Nuclear technologies can determine moisture content before construction and throughout processing.

2.1.2 Compaction

A good pavement mix has a consistent hue, while a streaked one indicates a bad mix. Compaction is the process of compacting soil, reliant on the soil type and using methods like sand-cone, balloon, oil, and nuclear. The depth of compaction is determined, with special attention to edges. Curing is crucial, with a bituminous membrane over large areas. Critical aspects during soil-lime construction include pulverization and scarification, lime content, regular mixing, time sequence, and curing. Pretreatment with lime is best for heavy clays.

2.1.3 Lime Stabilization of Soil for Pavements

Lime dissemination on pulverized soil can be estimated by laying a canvas and weighing it. Field personnel can use charts to assess the appropriate rate of application for the lime content. The slurry composition is crucial for determining the required amount of lime solids. Maintaining consistent

lime content throughout the treated soil is crucial, but controlling this can be challenging. A phenolphthalein indicator solution can indicate the minimum lime content required for soil treatment.

2.1.4 Bituminous stabilization

The most critical aspects to control during construction using bituminous stabilization include surface moisture content, asphalt viscosity, consistency of mixing, aeration, compaction, and curing. Surface wetness is a concern, and traditional methods can determine it. Aggregate gradation is important, as high moisture levels cause longer compressibility. Cold-mix construction should not be below 50 degrees Fahrenheit, and the amount of asphalt in the mixture should be calculated to make informed decisions.

2.2.5 Choosing the right soil stabilizer

With so many stabilization categories and subcategories, choosing the right methods of soil stabilization can be challenging. It is important to remember that there is not a gold standard regarding soil stabilization, meaning that every project and soil type will have different requirements and needs for soil stabilization. It is beneficial to know about the different methods and products that are available. To choose the best method of soil stabilization for your project, consider the following:

- The type of soil.
- The project type (road, erosion control, etc.)
- Longevity of the project. How long should it last?
- What is your budget?
- Are there any environmental concerns?

Self-Check 2	Written test

Name…… ID…… Date…….

Part I: True or False question

I. Instruction: Say true if the statement is correct and false if the statement is incorrect.

1. Shutdown procedure of the soil stabilizer equipment is different with the type of equipment.

2. Adjusting the controls to the desired settings of equipment is grouped under the Pre-start procedures.

3. Field control in soil stabilization involves determining optimum moisture content and maximum density.

4. The depth of compaction in soil stabilization is determined with special attention to edges.

5. Curing is not required for soil stabilization.

Part II: Matching

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

	A	B
1	Pre-start procedures	A) Secure the equipment and remove the keys
2	Start-up procedures	B) The type of soil
3	Shut down procedures	C) Adjust the controls to the desired settings
4	Choosing the right soil stabilizer	D) Check the equipment for any damage or wear and tear

Part III: Short Answer Questions

1. Write down the pre-start procedures for soil stabilizer equipment.
2. What criteria we should consider to choose the best method of soil stabilization?

Unit Three: stabilizer and clean up

This unit to provide you the necessary information regarding the following content coverage and topics:

- Stabilizer site hazard.
- Stabilizer operation techniques
- Operate stabilizer.
- Additive mixing material

Overview

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

- Identify stabilizer site hazard.
- Identify and apply stabilizer operation techniques
- Operate stabilizer.
- Operate and use additive mixing material

3.1 Stabilizer site hazard

Several hazards are associated with excavation work. Being aware of these risks is crucial to implement the necessary safety measures to protect workers and prevent accidents.

3.1.1 Types of Stabilizer site hazard

- Cave-ins and soil collapse
- Damage to underground facilities
- Accidents involving Personnel, Vehicles, Equipment, and Materials
- Injuries due to Proximity of Workers
- Detection of Underground Facilities
- Adapting Soil Protection Methods
- Implementing Shoring or Sheeting for Deep Excavations
- Providing Adequate Barricades and Signage
- Remixing Hazards

3.2 Stabilizer operation techniques

3.2.1 Soil Stabilization Methods

- **Lab testing**

Laboratory testing is important to determine the product type and minimum dosage rate as well as the water necessary to reach optimum moisture content.

- **Transportation and spreading**

Lime typically arrives at the jobsite via pneumatic truck before being transferred into a spreader truck. Spreader trucks distribute the material on the job site at the specified dose rate. Once the chemical reagent is applied, water is usually added, and the amount is dependent on the desired results and current water content of the soil. For smaller or remote jobs, lime can be delivered in dump trucks or bulk bags.

- **Mixing**

The lime and water need to be properly incorporated into the soil to achieve a homogeneous mix and help break down the soil. Re-claimers are the preferred mixing equipment for this portion of the process. However, backhoes and bulldozers work well for smaller jobs or when the initial soil bearing

capacity is low, which is often the case on environmental sites involving lagoon, sludge or sediment stabilization projects.

- **Compaction and grading**

Both compaction and grading are important to allow free water to drain to keep the integrity of the stabilized soil. Compaction, targeting maximum dry density, can be achieved by using a number of different soil compaction methods. The compacted material is then graded to a profile and cross slope. Finally, the surface is ready for a final smooth roll to seal the soil making the subgrade ready for further construction to continue.

Step by step process of stabilization	
Step 3: A spreader truck then spreads product over the problematic soil 	Step 4: A drum roller or pad foot compacts the pulverized mix 

3.3 Operate stabilizer

State-of-the-art cold recyclers and soil stabilizers work

Soil stabilization outperforms soil replacement thanks to fewer truck trips, shorter construction times, conserved resources, and lower CO2 emissions. The WR soil stabilizer uses its powerful milling and mixing rotor to mix pre-spread binding agents such as lime or cement into existing soil with insufficient bearing capacity, transforming it into a high-grade building material right on the spot. The resulting homogeneous mixture of soil and binding agent offers excellent tensile, compressive, and shear strength, long-term resistance to water and frost, and volume stability.

Typical applications include the construction of paths, roads, highways, routes, parks and sports fields, commercial zones, industrial parks, airfields, dams, backfilling, and landfills.

Operating Tutorials for the WR Series

E) Explanation of the most important machine functions and daily maintenance tasks
F) Valid for the complete WR series

Quick Checks

G) You haven't been on your WR for quite some time – here is all you need to put it into work properly.

Homogenization

H) In the homogenization process, the WR's powerful milling and mixing rotor granulates the native soil without the addition of binding agents and loosens it. While a grader profiles the homogeneous soil mixture that is produced, various HAMM rollers take care of the compaction process.

3.4 Additive Mixing materials

3.4.1 Additives

- Additives are the materials which are added to improve lime-soil mix to improve its strength.
- Some additives generally used are Portland cement, fly ash, surkhi etc.
- If fly ash is available as a waste product, then it is most recommended additive since it gives desirable strength at economical rates.
- Chemical additives like sodium metasilicate, sodium sulphate, sodium hydroxide etc. are also available.

Cement Stabilization process

The soil stabilization process is carried out in layers and consists of:

Excavation and spreading of material to the required layer thickness for stabilizing

1) Lime or cement spreading, with regular checks to control dosage
2) Mixing, to a depth depending on the soil and on the design requirements
3) Sealing the material, preventing carbonization of the lime while it reacts with the moisture in the soil. This involves trimming of the treated layer using bulldozers and passing over by a smooth roller
4) Allowing (or maturation) period - to allow time for the exothermic chemical reaction to take place between the lime and clay
5) Compacting the treated layer with a roller until required compaction is achieved
6) 7 days curing

The method of mixing lime into soil for stabilization contains following steps.

1. The soil which needs stabilization is scarified and pulverized by suitable equipment.
2. Now add some amount of lime to the pulverized soil either in powder form or in the form of slurry and mix using suitable equipment. In general slurry is recommend for better mixing.
3. If lime powder is used, water should be sprayed all over the soil.
4. Leave this mixture for 1 to 4 days since, lime-soil reaction is slow process and needs some time.
5. After that, add rest of the lime content and mix it for the final time.
6. Spread the soil to required grade and compact it using rollers. Compaction should get required maximum dry density.
7. The compacted lime-soil layer is allowed for moist curing for 1 week.
8. Field tests are conducted to check water content and maximum dry density of compacted soil.

Self-Check 3	Written test

Name…… ID…… Date…….

Part I: True or False question

I. Instruction: Say true if the statement is correct and false if the statement is incorrect.

1. Additives are the materials which are added to improve lime-soil mix to improve its strength

2. Accidents involving Personnel, Vehicles, Equipment, and Materials are mostly happened on site.

3. Spreader trucks are used to mix the material on the job site at the specified dose rate.

Part II: Matching

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

A		B	
1	Typical applications of soil stabilizing	A.	sodium metasilicate, sodium sulphate, sodium hydroxide etc.
2	Types of Stabilizer site hazard	B.	Portland cement, fly ash, surkhi etc.
3	Additives	C.	Remixing Hazards
4	Chemical additives	D.	Roads, highways, routes, parks and sports fields airfields, dams, etc.

Part III: Short Answer Questions

1. Mention the types of stabilizer site hazards
2. Write down the soil stabilization methods.
3. What is the purpose of additives in soil stabilization?
4. List the step by step process of stabilization.

Operation sheet-1

Operation Title:

- Operate stabilization

Purpose:

- Ensuring the soil is stable by reducing the permeability and increasing its overall strength

Precautions:

- requirement of tools and materials
- Environmental identification
- OHS requirement.
- Practice active listening.
- Acknowledge criticism Procedures

Tools and materials

- Shovel and spade
- Pick and mattock
- Hoe
- Rake and spreader
- Grass cutter or slasher
- Hand rammer
- Wheelbarrow

Procedure:-

1. Spreading materials with regular checks to control dosage
2. Mixing, to a depth depending on the soil and on the design requirements
3. Sealing the material, preventing carbonization of the lime while it reacts with the moisture in the soil
4. Compacting the treated layer with a roller until required compaction is achieved
5. Curing

Quality criteria: At the end of this operation customer satisfaction and improvement of the work progress.

- Check the excavation area is excavated according to drawing and specification.
- Must full fill the required optimum moisture content and maximum dry density

Unit Four: Relocate stabilizer

This unit to provide you the necessary information regarding the following content coverage and topics:

- Stabilizer safely between worksites.
- locating technique

Overview

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

- Move stabilizer safely between worksites.
- Prepare locating technique

4.1 Move stabilizer safely between worksites

This Guidance Note focuses primarily on the safe retraction of swing-up stabilizers. Guidance is required because where the swing-up stabilizer rotates across the position of fixed hold-to-run controls (on one or both sides of the vehicle), there is a risk of the Operator being crushed if they fail to correctly use and observe the stabilizer throughout the retraction process.

Who the Guidance is aimed at:

- Loader crane installers.
- Persons and organizations undertaking maintenance / service / repair activities within the lorry loader industry.
- Persons and organizations that own and operate lorry loaders.
- Persons and organizations receiving goods being delivered by lorry loaders.
- Appointed Persons.
- Lorry Loader Operators.

What the Law says:

- Product design Standard, BS EN 12999, provides one means for loader cranes to comply with the essential health and safety requirements of the Machinery Directive 2006/42/EC, which is implemented in the UK by the Supply of Machinery (Safety) Regulations.

BS EN 12999:2020 stipulates the following requirements regarding stabilizers:

- Clause 5.8.1 (extract): A control station for each stabilizer function shall be positioned so that the operator has an unobstructed view of the movements being controlled. If the stabilizers can be operated with a suspended load, a two stage control action shall be required for the operation. The control station for stabilizer extension deployment shall only operate movements in full view of the operator. These requirements also apply to stabilizer extensions that are remote controlled, in which case a device shall be provided that detects that the operator can have a clear view of a stabilizer extension before it may start to extend or retract.
- Clause C.2.4 (an informative Annex): The safety function for stabilizer extension clear view prevents remote controlled stabilizer extensions from being extended or retracted unless it is detected that the operator can have a clear view of the area where the stabilizer extensions are to be moved.

- ✓ This safety function is only required if the crane has remote controlled stabilizers.
- ✓ It should prevent stabilizer extensions from being extended or retracted unless it is detected that the operator can have a clear view of the area where the stabilizer extensions are to be moved.
- ✓ The permitted time for operation of stabilizer extensions should be limited based on the time it takes to extend or retract the stabilizer extensions and the related tasks associated with it, e.g. placing foot plates.

Guidance:

In all cases, where lorry loaders are fitted with swing-up stabilizers:

There is a potential crush risk on the side where the swing-up stabilizer tilts towards the operator / levers at the crane base. To avoid this, the control measures listed below should be followed.

- Swing-up stabilizers should be pinned / locked in the vertical / upright position before the stabilizer beam is deployed or retracted.
- It is essential that Operators fully observe the operation of the stabilizer leg during deployment and stowage.
- Operators must be made aware that the operation of the swing-up function must be separate from the movement of the stabilizer beam (i.e. they should not use both functions simultaneously).
- Operators must be fully conversant with the manufacturer's instructions regarding the deployment and stowage of swing-up stabilizers. There can be considerable variation between different manufacturer systems.
- Operators must not be positioned in (or lean / reach into) danger zones where there is a risk of crushing.
- If swing-up stabilizers are used on sites where the stabilizer is only partially deployed, there is an increased risk of creating a danger zone where the swing-up stabilizer tilts towards the Operator / levers at the crane base. In this case, consideration should be given to repositioning the vehicle to ensure further extension of the stabilizer beam is achievable prior to the swing-up leg being deployed.
- Residual risk warning stickers / decals must be visible and maintained.
- All loader cranes with remote control have the option to use emergency levers at the crane base. Such levers are only required in the event of remote control failure, following

confirmation that the spare battery does not resolve the issue and failure of the remote control 'umbilical cord' (i.e. the umbilical cord should be tried first, before using the emergency levers). Fleet owners are advised to confirm the umbilical cord is available in the cab at all times and is serviceable / fit for use. Should emergency levers need to be used, the above guidance applies in the same way as it would to standard controls.

4.2 locating technique

The role of soil is crucial for the design and construction of any structure, be it roads, runways or railway tracks. This is because it acts as the medium for effective load transfer in to the earth. This implies that a weak soil base will eventually cause settlement of the structure, leading to failure. Stabilization is the process of improving the engineering properties of the soil before construction. Stabilization is done to improve the strength of the soil and shrink/arrest the swelling potential, thus improving the load bearing capacity and the overall performance of the in-situ soils.

Self-Check 4	Written test

Name…… ID…… Date…….

Part I: True or False question

I. Instruction: Say true if the statement is correct and false if the statement is incorrect.

1. The primary focuses on stabilizer safety is the safe retraction of swing-up stabilizers.

2. Stabilizer leg during deployment of stowage operators fully observe the operation of equipment.

Part II: Matching

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

	A		B
1	weak soil base will eventually cause	A)	Repair activities within the lorry loader industry
2	Residual risk warning stickers	B)	where there is a risk of crushing
3	Operators must not be positioned in danger zones	C)	Guidance
4	Persons and organizations undertaking maintenance	D)	Settlement of the structure, leading to failure

Part III: Short Answer Questions

1. How to move the soil stabilizer safely between worksites?
2. Mention the guidance criteria of stabilizer equipment
3. What are the potential risks of equipment during locating techniques?

Unit Five: Check equipment performance

This unit to provide you the necessary information regarding the following content coverage and topics:

- Ensuring inspection and fault finding
- Servicing and lubrication
- Minor maintenance
- Recording performance of machine and equipment

Overview

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

- Carry out routine operational service and lubrication tasks.
- Carry out minor maintenance.
- Record performance of machine and equipment

5.1 Ensuring inspection and fault finding

5.1.1 Procedures of ensuring inspection

- Check the battery master switch is locked or unlocked
- Check additional emergency stop switch and see error messages on the screen
- See the open rear door of the mixing chamber is functional or not
- Attaching the crank handle to the lower power belt pulley allows to turning of the milling loader.
- Check the engine compartment should free of contamination and links
- Check the second deep stich to see the oil quantity of the hydraulic pump drive
- The oil level of the diesel engine can be checked by means of deep stick and the filling level should be between the two red check marks
- Check the diesel tank cap is whether closed or not
- Check the sufficiency of pressure of the tires
- Check the state of the power belt and guide rollers
- For further information please check the manual.

5.2 Servicing and lubrication

Machine lubrication should play a role in any maintenance strategy, with the potential to yield a significant return on investment in materials and resources.

What is equipment lubrication?

It is the practice of introducing a lubricating agent — almost always an oil — into machine components to achieve several goals:

- Reduce friction
- Lower component and operating temperatures
- Wick away debris and contaminants

Lubrication is critical for, essentially, any moving parts that encounter one another in a machine. Most frequently, these are rotating parts and components such as gears.

Machine lubricant is designed to prevent:

- Undue wear and tear on components
- Premature failure of components
- Excessive unplanned maintenance
- Equipment overheating
- Part seizure

In this piece, we will take an in-depth look at machine lubricants, the purposes of lubrication, the benefits it can provide and how it can help you.

The concept of lubrication is related to that of friction. Friction is a force generated when two objects move against one another — think of one gear interacting with another. This force converts kinetic energy (movement) into thermal energy (heat), which can quickly become a significant level of heat at high speed and frequency. Lubrication introduces another element or medium into the friction equation to transfer heat away from the point of friction. It plays several other roles, as well.

These roles include:

- **Part wear reduction:** As parts move against each other, contact points begin to erode. Lubrication provides a buffer against this raw wear.
- **Shock absorption:** Lubricant can dilute the impact and effect of shock and vibration on parts, further reducing wear while maintaining proper, consistent operation.
- Corrosion reduction: Lubricant protects metal surfaces from environmental elements that can lead to corrosion.
- **Drawing debris and contaminants away from moving parts:** As moving parts come into contact with each other, they begin to erode. The pieces of debris that form because of this can then lead to further friction and erosion. Lubrication serves to move these tiny (and large) contaminants away from moving parts to reduce further damage.
- **Friction and heat reduction:** Already mentioned above, these functions are the primary role of lubrication, and should be reiterated. By reducing friction forces and the heat that they generate, machinery lubrication can reduce wear and tear, lower the chances of

significant component or equipment damage, and yield equipment performance improvements such as increased uptime and less maintenance.

The benefits of lubrication

Lubrication of machinery provides numerous benefits, including:

- **Longer component and equipment service life:** By reducing friction and heat — and thus wear and tear — lubrication allows equipment and components to remain in an optimal operational state for a longer period of time. By helping components to remain intact and closer to their "out of the box" form, the time between breakdown and replacement requirements will be extended, improving OEE and reducing overall costs.
- **Reduced maintenance needs:** With less wear and tear comes less potential for breakdown. Parts that are operating with high friction and high heat are susceptible to unexpected failure and breakdown at just about any time, regardless of the age of the component. Proper lubrication keeps equipment operating at an acceptable temperature and friction level, vastly reducing the potential for unexpected maintenance requirements.
- **Higher part quality:** Lubrication allows for more consistent operation by helping to absorb shock and vibration and keep equipment running as expected. This translates to increased repeatability and quality in part production, creating fewer rejects and a higher productivity yield.
- **Safer operations:** Any time equipment is operating at a high level of heat and with increased vibration — as would be the case in unlubricated or insufficiently lubricated equipment — there is a potential for catastrophic failure, which can create a danger to equipment operators and other employees. Proper lubrication is critical to a safe working environment.

5.3 Minor maintenance

5.3.1 Equipment maintenance

Maintenance is any process used to keep a business's equipment in reliable working order. It may include routine upkeep as well as corrective repair work.

Equipment may include mechanical assets, tools, heavy off-road vehicles, and computer systems. The resources needed to keep it all in good repair will vary by type. For instance, repairs made on heavy construction equipment won't look the same as those performed on automated food processing machines.

If your maintenance department doesn't have a proactive equipment maintenance strategy, machine failures become a daily occurrence and **lead to:**

- budget problems
- production delays
- safety incidents
- increase in overtime labor
- inventory issues
- shorter equipment life cycle
- dissatisfied employees across the plant floor

5.3.2 Types of maintenance

The three types of property maintenance are preventive maintenance, reactive or corrective maintenance, and predictive maintenance.

A) **Preventive maintenance:** involves regular inspections and upkeep of a property to minimize the need for significant repairs or replacements. Put simply, preventative maintenance is fixing things before they break.

B) **Reactive or corrective maintenance:** includes repairing damaged or malfunctioning equipment, such as broken windows, doors, or electrical systems.

C) **Corrective or reactive maintenance:** is the most common type of maintenance since maintenance technicians typically fix something after a resident submits a work order. Finally, predictive maintenance is anticipating issues before they arise. An example of predictive maintenance would be monitoring equipment sensors to identify potential problems before a failure occurs.

5.4 Performance of machine and equipment

5.4.1 Types of performance measures:

- Workload or output measures.

  These measures indicate the amount of work performed or number of services received.
- Efficiency measures.

  Efficiency is generally measured as the price of producing a unit of output, and is generally expressed as a ratio of inputs to outputs. A process is efficient where the production cost is minimized for a certain quality of output, or outputs are maximized for a given volume of input.
- Effectiveness or outcome measures.
- Productivity measures.

5.4.2 Measurement of manufacturing equipment efficiency

There are many ways to measure manufacturing equipment efficiency because of how much information it can provide in one figure. Here are some common ways to complete this practice:

A) Planned production time

Planned production time is the total time that a plant schedules a machine for production. You can calculate planned production time by subtracting scheduled losses from all available time. Scheduled losses are the times when equipment isn't running, like during facility shutdowns or breaks. Available time is every available minute of the work day. The remaining time is the planned production time and is an important value for calculating equipment efficiency.

B) Availability

A machine's availability score measures how often a machine is available for production use. A machine is always available or running during production times when its availability is at 100%. Unexpected equipment downtime, material shortages and machine changeover may all affect equipment availability. You can calculate a machine's availability by dividing its operating time by planned production time.

C) Quality

A machine's quality measures how well it runs while considering its defects. You can calculate the quality of your equipment by dividing the number of suitable pieces it produces during an operating cycle by its total output. A machine with a quality score of 100% has no defects and only produces suitable products. Rejected materials and products that need to be reworked may affect a machine's quality.

D) Performance

A machine's performance compares the number of products it creates every hour with its ideal production rate. You can divide the ideal cycle time by the actual cycle time to calculate a performance score for your equipment. The ideal cycle time is how long it should take a machine to produce one unit, while the actual cycle time is its operating time dividing by the number of units it produces. A machine has a performance score of 100% if it runs at its maximum rate.

E) Effectiveness

You can calculate the overall equipment effectiveness by multiplying a machine's availability, quality and performance scores together. A machine with an effectiveness of 100% is usually free of defective output, runs at the set speed and has no unplanned outages. You might calculate a machine's effectiveness regularly to assess trends for individual equipment. This can provide insight into how to increase productivity for the entire plant. It's often up to the plant operator to determine a machine's target effectiveness for their operations.

F) Efficiency losses

You can identify losses in manufacturing to take precautions and improve efficiency in operations.

There are six subsets based on availability, performance and quality that you may categorize these losses into so you can better understand the factors affecting your plant.

Self-Check 5	Written test

Name…… ID…… Date…….

Part I: True or False question

I. Instruction: Say true if the statement is correct and false if the statement is incorrect.

1. Longer component and equipment service life is one of the benefits of lubrication equipment.

2. Preventive maintenance is maintenance that technicians typically fix something after a resident submits a work order.

3. Efficiency losses are the only way to measure manufacturing equipment efficiency.

Part II: Matching

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

A		B	
1	Machine lubricant is designed to prevent	A)	Undue wear and tear on components
2	Absence of proactive equipment maintenance strategy can causes	B)	Shorter equipment life cycle
3	Preventive maintenance	C)	Regular inspections and upkeep of a property
4	Measurement of manufacturing equipment efficiency	D)	Performance

Part III: Short Answer Questions

1. What is equipment lubrication?
2. Write down the benefits of lubrication for stabilization equipment.
3. Write down the types of maintenance for equipment.
4. How do we measure the performance of equipment?
5. List the efficiency measure of stabilization equipment.

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