

CHAPTER 13: ROAD CONSTRUCTION WORKS

13.1 Introduction of the Unit of Learning

This unit specifies the competencies required to perform road construction works. It involves carrying out earthwork activities, constructing road/pavement structure layers and constructing parking, walkways and cyclist lanes, footbridges and bus bays. It also includes installing road furniture, construction of erosion prevention structures, constructing highway drainage and hydraulic structures and undertaking highway maintenance

13.2 Performance Standard

Carry out earthwork activities, construct road/pavement structure layers, parking, walk ways and cyclist lanes, foot bridges, bus bays, erosion prevention structures, highway drainage and hydraulic structures, install road furniture, and undertake highway maintenance as per contract documents, construction procedures, design output and SOPs.


13.3 Learning Outcomes

13.3.1 List of Learning Outcomes

- a) Carry out earthwork activities
- b) Construct road/pavement structure layers
- c) Construct parking, walk ways and cyclist lanes, foot bridges, bus bays
- d) Install road furniture
- e) Construct erosion prevention structures
- f) Construct highway drainage and hydraulic structures
- g) Undertake highway maintenance

13.3.2 Learning Outcome No 1: Carry out Earthwork Activities

13.3.2.1 Learning Activities

Learning Outcome No 1: Carry out Earthwork Activities	
 Learning Activities	Special Instructions
1.1 Obtain relevant legal documents 1.2 Identify and mobilize earthwork resources 1.3 Carry out Site clearance and demolition activities 1.4 Interpret drawings 1.5 Conduct Setting out for earthworks 1.6 Obtain Statutory requirements 1.7 Establish Road formation 1.8 Take and document ground levels 1.9 Determine Volumes of cut and fill materials 1.10 Carry out Haulage and disposal of waste material 1.11 Operate and maintain construction tools and equipment	<ul style="list-style-type: none"> • Direct instruction • Case studies • Field trips/site visits • Group discussions • Demonstration by trainer • Computer Aided Learning (CAL) • Practice by the trainee

13.3.2.2 Information Sheet No13/LO1 Carry out Earthwork Activities



Introduction to learning outcome

This learning outcome covers various learning activities such as interpreting drawings, determining volumes of cut and fill and operating and maintaining construction tools with the end goal of learning how to carry out earthwork activities which is part of road construction works.

Definition of key terms

Earthwork resources; earth filling or excavation of soil or rocks from one area to another by, hauling, dumping, crushing and compaction of soil

Site clearance and demolition activities; this involves removal of old infrastructure, removal of top soil, cut and fill.

Statutory requirements; verified documents used for the road construction.

Content/Procedures/Methods/Illustrations

1.1 Obtain Relevant legal documents as per the contract requirement

Legal document: it is an official document required by law that binds the client and the contractor

Types of legal document

- Scope of work: work is clearly defined including the materials to be used.
- Construction schedule: it helps the clients and contractors to know how and when the project will be completed.
- Conditions: involving general and specified conditions, general is rights for each party while specified is conditions for a given work and certain circumstances.
- Bill of quantities: this is the part of contraction project which includes labour, list of materials etc.
- Drawings: all contracts require drawings this include actual blueprints For project.

Steps of obtaining relevant Legal documents

- Obtaining surveying plan: this is to confirm if the land is the exact one and proof of the land ownership
- Obtain project report from (NEMA): this is to approve environmental impact of the project
- Obtain approval of the architectural plans: drawings are approved
- Obtain stamps on architectural and structural plans.

1.2 Identify and mobilize Earthwork resources as per the contract document

This is the process of determining the resources required and getting the necessary finance to acquire these resources.

Types of Earthwork resources

- Bulldozer: heavy tractor which assist in digging, pushing, excavating and levelling
- Hoe, mattock, pick axe, crowbar, spade: used for excavating materials
- Basket, stretcher, shovel, wheelbarrow: used for removing materials
- Rake, spreader, hoe: used for spreading
- Hand hammer: used for compaction
- Excavators: used to dig and load materials in a tractor
- Trenchers: used to dig trenches in the ground

Steps of Identifying and mobilizing the necessary resources

- (i) Determine the particular earthwork activity to be carried out at the site. This is done so as to determine the type of earthwork resource required for the particular activity.
- (ii) Acquire the necessary permits and financial resource to mobilize these resources.
- (iii) Mobilize the earthwork resources from whichever location you identified as per the standard specifications of the contract documents.

1.3 Carry out site clearance and demolition activities based on contract document and construction procedure

Site clearance is the process of removing unnecessary vegetation and structures along the route planned for construction of the road. This is done so as to get a clear and workable site. It involves the removal and disposal of all bush, trees, roots, grass and top soil. This activity must be done before any construction of the roadway starts. Unless the Engineer agrees in writing otherwise, all materials including trees, grass, crops and structures, which fall within the road alignment must be removed.

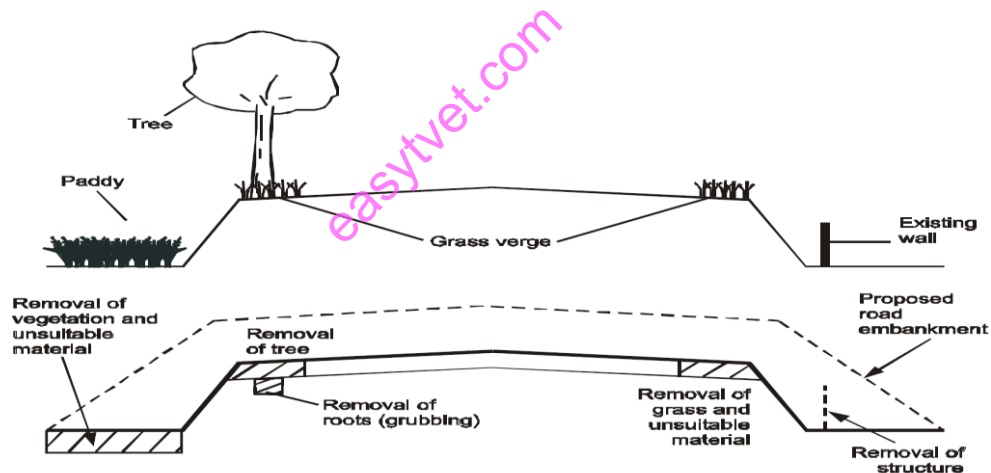


Figure 133: Clearing and Grubbing

Source: Construction practices and procedures manual May 2001

1.4 Interpret Drawings as per construction procedures

For easier interpretation and understanding of a drawing one should follow the following steps

- Commencing with the title block, which shows you the title of the drawing and what the drawing is all about
- Understand the basic symbols on the drawing
- Identify specific abbreviations and try to understand what they mean

Try to visualize the structure in your imagination

1.5 Conduct setting out for earthworks based on design output

Setting out process is used to establish the boundaries and marks for excavation of earthworks and is based on the design output. It enables construction to be carried out as it has been planned according to dimensions specified in layout drawings. Setting out can be done using various methods the most common being the profile board method.

Steps of Setting out Using the Profile Board Method

This method uses several profile boards and a string line level so as to provide control levels when constructing. A series of level boards are placed along where excavation will take place.

- (i) The level boards have to be a meter above the excavation level.
- (ii) Between 2 subsequent profile boards, a third profile board, called a traveler is used to control the depth of excavation. It has a fixed height and is put between the line of sight and the 2 profile boards. If it is below the line of sight, the excavation has been done too deep. If it is above the line of sight, more excavation is required.
- (iii) Slots are established using the traveler where the right depth of excavation should be done. They are made at regular intervals of 4 to 5 meters along the line of sight.
- (iv) Excavation is then done by joining the slots.

The traveler is then used to ensure that there are no too high or too low points.

A line level is used to control the level of the profile boards in the following ways:

- a. Transferring the exact level of one profile board to another thus ensuring uniform level.
- b. Measuring higher or lower from the horizontal level to set another profile board at a different level.
- c. Measuring the slope between two fixed profile boards.

1.6 Obtain Statutory requirements based on contract document and standard construction procedures

Statutory requirements are the standard needs requires in carrying out road construction activities. These are required by the state.

Examples of Statutory requirements

- Bill of Quantities
- Drawings
- Contract Documents
- Practicing licenses

Reasons for obtaining statutory requirements

- These are legally binding documents which are necessary as per the contract terms

Steps of Obtaining Statutory requirements.

- Determine the activities to be conducted and the necessary statutory requirements for each specific activity.
- Acquire the statutory documents from the respective offices as per the Kenyan standard specifications on road construction

1.7 Establish Road formation based on standard construction procedures

A road formation is the surface of finished earthworks where the road pavement will be constructed. It includes the shape of the road, the basic drainage infrastructure but excludes storm water infrastructure.

Steps of establishing Road formation

Step 1: preparation of subgrade- This is the lowest layer of the pavement and is the first to be constructed.

Step 2: construction of sub-base- This a layer laid on the subgrade and is made up of mainly aggregates

Step 3: construction of base: This is the structural layer of the pavement and standards must be followed to the later during its construction

Step 4: Construction of Surfacing: This is made of mainly asphalt for flexible pavements

Step 4: preparation of wearing course- This layer is mainly made of aggregates that acts as a layer that induces friction to the tyres.

Step 5: construction of shoulders

Step 6: opening traffic

All construction standards and procedures must be followed as per the Design manuals and the contract terms.

1.8 Take and document Ground levels according to SOPs

SOP is a procedure that provides clear instructions to how teams operate for completion of certain processes. The ground level is the level of the ground as defined in a field survey authorized by a qualified surveyor. For road construction, ground levels are established by the process of levelling. Levelling is done using the following equipment:

- Dumpy level/ optical level
- Tilting level
- Automatic level
- Laser level
- Digital level
- Water level

The levels observed are booked in a levelling book. The steps followed when booking include:

- (i) A new page should be used for a new job
- (ii) Details are to be entered at the top of the page.
- (iii) Observations that are booked should be legible and any mistakes should be crossed out. Avoid overwriting.
- (iv) One line should be used for each position of the staff
- (v) An entry should always be made in the remarks' column.
- (vi) Work should be appropriately spread.

1.9 Determine Volumes of cut and fill materials in accordance with contract document

This is a procedure of achieving the standard level by removing some material in raised parts and adding standard material to sloppy parts. There are three major methods to compute volume of earthworks; cross-section method, spot height method and contours method. Volume from cross-section has four methods: mid-cross-section method, mean area method, end area method and prismoid formula.

Procedure of obtaining volume of cut and fill

- Calculate cross-section areas at given intervals along the projects
- Calculate area of cut and fill between areas of proposed formations
- Calculate aggregates algebraic volume for each section
- Longitudinal section along the proposed centerline is plotted proposed level included
- Axes of mass haul are drawn underneath the longitudinal profile
- Mass haul curve as the aggregates volume on the coordinates is plotted

1.10 Carry out Haulage and disposal of waste material as per the standard construction procedures

Haul is the total volume of material multiplied by the distance the material has been moved. Waste is the volume of the materials which is disposed due to unsuitability.

Disposal of waste materials

- Landfilling; the ground is covered with soil for use
- Incineration; burning at high temperatures
- Reuse; using materials which attain the standards required
- Compositing; waste is dumped in a pit

1.11 Operate and maintain Construction tools and equipment as per the SOPs

Equipment's are classified into two types, hand tools and machineries. Hand tools are generally used in small depths of excavations.

Machinery tools

- Excavators; used to remove materials from ground
- Bulldozer: used to push
- Trenchers: used to dig trenches in the ground

Construction tools

- Hoe; used for soft soil
- Forked hoe; used for hard soil or stony
- Pick axe; used for hard stony soil
- Crow bar; stony soil
- Mattock;

Maintenance of tools

- Cutting tools are maintained sharpening
- Clean all the tools after use
- Store in dry and secure places
- Make sure all the tools are in there initial packaging
- Moving parts should be oiled

Conclusion

This learning outcome covered various learning activities such as, determining volumes of cut and with the end goal of learning how to carry out earthwork activities which is part of Road construction works.

Further Reading



Read more on:

Constructing the rise and fall and calculations involved.

Setting out of curves and their calculation.

From J. Uren, W.F.Price (2010), surveying for engineers, Fifth Edition Publishes by Palgrave Macmillan curves and mass haul diagram

13.3.2.3 Self-Assessment



Written Assessment

1. Which of the following is waste haulage waste disposal.
 - a) Landfill
 - b) Turning
 - c) Setting out
 - d) Haul
2. Which of the following refers to volume of material required to be excavated in a proposed area
 - a) Mass haul
 - b) Haul
 - c) Overhaul
 - d) Waste
3. Which of the following has the meaning of establishment of marks
 - a) Excavation
 - b) Setting out
 - c) Benchmarks
 - d) Waste
4. Which of the following require setting out
 - a) Disposal of waste
 - b) Types of excavation
 - c) Tool maintenance
 - d) Procedure of excavation
5. Which of the following is needed while carrying out excavation
 - a) Spoons
 - b) Seesaw
 - c) Pickaxe
 - d) Screw
6. Which of the following is a method of excavation
 - a) Mass haul
 - b) Bracing
 - c) Levelling
 - d) Overhaul

7. Which of the following tools is used for soft soil
 - a) Hoe
 - b) Crow bar
 - c) Mattock
 - d) Pick axe
8. Analyze the procedure for earthwork
9. Analyze importance of earthwork
10. Exam various type of earthwork
11. Give the procedure of setting out of curves
12. Draw a mass haul diagram and explain all the terms in it

Oral Assessment

1. Define terms used in excavation
2. Construct a mass haul diagram

Practical Assessment

Set out curves in the field and setting out

Project Assessment

Construct a mass haul diagram, and set out of curves after going to the field with the help of your lecturer.

13.3.2.4 Tools, Equipment, Supplies and Materials

- Computer
- Internet
- Workshop
- Construction materials
- Construction tools and equipment
- Construction designs and drawings
- Sample contract documents
- Computer software e.g. AutoCAD, ArchiCAD, Civil3D
- Stationery
- Road construction site
- Material testing labouratory
 - Molds
 - Tamping rods
 - CBR Machines
 - Crushing machines
- Schedule of work
- Standard manuals

- Road under construction
- Contract documents

13.3.2.5 References




Sixth edition Engineering Surveying W.Schofield and M.Break

J. Uren, W.F.Price (2010), surveying for engineers, Fifth Edition Publishes by Palgrave Macmillan

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13.3.3 Learning Outcome No 2: Construct Road/Pavement Structure Layers

13.3.3.1 Learning Activities

Learning Outcome No 2: Construct Road/Pavement Structure Layers	
 Learning Activities	Special Instructions
2.1 Acquire and mobilize required road construction resources 2.2 Interpret drawings 2.3 carry out levelling activities 2.4 Construct sub-grade pavement layer 2.5 Construct sub-base pavement layer is 2.6 Construct base layer 2.7 Document ground levels 2.8 Road surfacing is constructed 2.9 Carry out Quality control operations 2.10 Undertake maintenance of road/pavement structures	<ul style="list-style-type: none"> • Direct instruction • Case studies • Field trips/site visits • Group discussions • Demonstration by trainer • Computer Aided Learning (CAL)

13.3.3.2 Information Sheet No13/LO2 Construct Road/Pavement Structure Layers



Introduction to learning outcome

This learning outcome will cover various processes and activities that goes into the construction of road/pavement structure layers.

Definition of key terms

Road construction resources-these are elements such as materials, human resources, machinery and plant that are required in the process of road construction.

Levelling activities-these are actions undertaken in order to determine the height of one level relative to another.

Quality control operations-are activities undertaken to ascertain that products and facilities being generated meet the established standards.

Content/Procedures/Methods/Illustrations

2.1 Acquire and mobilize required road construction resources as per contract document

In this process, all the relevant resources that are essential in the construction process are identified and sourced out. This involves the following steps

- i. Identify the required resources (materials, plant and machinery) and their providers
- ii. Make plans on how these resources will reach your site
- iii. Make necessary arrangement for the proper storage of these resources

2.2 Interpret drawings as per construction procedures

For easier interpretation and understanding of a drawing one should follow the following steps

- i. Commencing with the title block, which shows you the title of the drawing and what the drawing is all about
- ii. Understand the basic symbols on the drawing
- iii. Identify specific abbreviations and try to understand what they mean
- iv. Try to visualize the structure in your imagination

2.3 carry out levelling activities as per standard construction procedures

Levelling activities include the following steps

- i. Setting out-this process involves putting marks and lines that define a position and level where construction work is start with respect to them.
- ii. Eliminating parallax error which results from the movement of the observer's eye at the eyepiece. Parallax will be eliminated when the eyepiece is adjusted until the cross hairs are in sharp focus.
- iii. Making bookings

2.4 Construct sub-grade pavement layer according to contract document and standard road requirements

The process of constructing the sub-grade layer of the pavement begins at the sub-grade formation where the following activities are undertaken

- i. The soil of choice in its loose condition is spread in a layer over the prepared surface using the appropriate equipment.
- ii. Water is sprayed on the soil for it to achieve the optimum moisture content as determined in the laboratory.
- iii. The soil is then compacted by a roller this aids in achieving the required density.
- iv. This process is repeated till the required subgrade thickness is achieved.

2.5 Construct sub-base pavement layer is as per contract document and standard road requirements

The sub base layer is optional in some road construction work. It is mostly used in the strengthening of a weak subgrade or when it's economical (when the sub-base material is cheaper compared to base material). The procedure of construction of the sub base is the same as discussed previously in the sub grade construction.

2.6 Construct Base layer according to standard road construction procedures and contract document

This layer is composed of gravel and crushed rocks that is stabilized by either lime, cement or bitumen. It's a layer of very high stability and density. The main function of the base layer is to distribute the stresses created by the wheel load to the sub grade. In road construction the base course materials are spread on the prepared sub base. The thickness and cross section is maintained as per the design.

2.7 Document ground levels as per standard procedures

These are levels at the ground. During construction processes ground markings for boundaries and other elements can be made by following the procedure of setting out which involves

- i. On the ground level a temporary bench mark is placed. This bench mark can either be a man hole cover or a post
- ii. A baseline is then established where all the setting out activities start from.
- iii. Horizontal controls –which are points of known coordinates with respect to a specific point are placed. Vertical points are also placed by timber post. These points are established through levelling.

2.8 Road surfacing is constructed as per the contract document and standard construction procedures

There are many road surfacing material available but the best material used in road construction is concrete and asphalt. Concrete is usually used in areas where the road is expected to carry large volumes of vehicles thus a strong and durable road is needed, whereas asphalt is more resistant to weathering and it's also economical.

2.9 Carry out Quality control operations according to standard construction procedures

Quality control operations can be conducted on construction materials this is done by

- i. Making sure all the materials that arrive to the site are at par with the set standards
- ii. Ensure proper storage of materials so that they maintain their quality
- iii. Materials that stay longer without usage should first be re-tested to ensure their quality is in check

2.10 Undertake maintenance of road/pavement structures as per maintenance procedures

The main purpose of road maintenance is to try keeping the roads in their best form. There are many types of maintenance that can be undertaken in order to preserve roads these include crack sealing, pothole repair, repair of paved edges, regular grading and reshaping of roads.

Conclusion

This learning outcome covered all the activities and processes that are involved during the construction of road/pavement structure layers

Further Reading



The learner can read and research further on types of pavements, the materials used in road construction and machineries used on the road construction.

13.3.3.3 Self-assessment



Written Assessment

1. What is not a levelling activity?
 - a) Setting out
 - b) Making bookings
 - c) Preparing the subgrade
 - d) Elimination of parallax errors
2. Which of the following is not among construction resources?
 - a) Machinery
 - b) Human resource
 - c) Economics
 - d) Materials
3. Which among the following is not a proper maintenance practice?
 - a) overworking equipment
 - b) following of safety rules
 - c) wearing of protective garments
 - d) regularly lubrication of machinery

4. In detail analyze levelling
5. In detail Examine quality control
6. In details investigate the necessary resources road construction
7. Examine in details all the activities that are carried out during levelling activities
8. Quality control involves activities that test materials to ascertain their viability discuss

Oral Assessment

1. Name the principle layers of a road/pavement
2. Give two road construction resources.

Case Study Assessment

Suppose you are invited by your community to help in a project of constructing an unpaved road. What steps will you follow in order to finish your task successfully?

Practical Assessment

Your lecturer asks you to carry out levelling around the department of civil engineering. How will you proceed to ensure your task is completed?

13.3.3.4 Tools, Equipment, Supplies and Materials

- Computer
- Internet
- Workshop
- Construction materials
- Construction tools and equipment
- Construction designs and drawings
- Sample contract documents
- Computer software e.g. AutoCAD, ArchiCAD, Civil3D
- Stationery
- Road construction site
- Material testing labouratory
 - Moulds
 - Tamping rods
 - CBR Machines
 - Crushing machines
- Schedule of work
- Standard manuals
- Road under construction
- Contract documents

13.3.3.5 References




M, G. Lay (2010). Handbook of road Technology 4th Edition. Taylor & Francis Publishers.

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13.3.4 Learning Outcome No 3: Construct Parking Walk Ways and Cyclist Lanes, Foot Bridges, Bus Bays

13.3.4.1 Learning Activities

Learning Outcome No 3: Construct Parking Walk Ways and Cyclist Lanes, Foot Bridges, Bus Bays	
 Learning Activities	Special Instructions
3.1 Acquire and mobilize required resources 3.2 Interpret Drawings 3.3 Construct parking 3.4 Construct Walk ways, cyclist lanes and bus bays 3.5 Construct foot bridges 3.6 Carry out Levelling activities 3.7 Document Ground levels 3.8 Carry out Quality control operations 3.9 Undertake maintenance of parking, walk ways and cyclist lanes, foot bridges, bus bays	<ul style="list-style-type: none"> • Direct instruction • Case studies • Field trips/site visits • Group discussions • Demonstration by trainer • Computer Aided Learning (CAL)

13.3.4.2 Information Sheet No13/LO3 Construct parking walk ways and cyclist lanes, foot bridges, bus bays



Introduction to learning outcome

This outcome covers all the activities that go into the construction of parking walk ways and cyclist lanes, foot bridges and bus bays. Some of the learning activities are; interpreting drawings, carrying out levelling activities and carrying out quality control operations as per standard construction procedures.

Definition of key terms

Quality Control- defines of a framework which specify all the procedures and works that should be undertaken so that the end product meets or surpasses the specified quality requirements as per the agreement.

Levelling-is the process undertaken to establish the height of one point in relation to another.

Content/Procedures/Methods/Illustrations

3.1 Acquire and mobilize required resources as per contract document

In this process, all the relevant resources that are essential in the construction process are identified and sourced out. This involves the following steps

- (i) Identify the required resources (materials, plant and machinery) and their providers
- (ii) Make plans on how these resources will reach your site
- (iii) Make necessary arrangement for the proper storage of these resources

3.2 Interpret Drawings as per standard construction procedures

For easier interpretation and understanding of a drawing one should follow the following steps

- (i) Commencing with the title block, which shows you the title of the drawing and what the drawing is all about
- (ii) Understand the basic symbols on the drawing
- (iii) Identify specific abbreviations and try to understand what they mean
- (iv) Try to visualize the structure in your imagination

3.3 Construct parking according to contract document, design manuals and standard construction procedures

After all the design considerations for the parking lots are made, the following should be undertaken

- (i) Preparation of the subgrade- the area where the subgrade is to be laid should be adequately prepared through clearing of bushes and vegetation cover on the surface. The subgrade material should be spread and properly compacted with the appropriate equipment
- (ii) Paving of the parking lot- here paving blocks are laid and fitted properly to cover the entire area. Kiln dried sand is then poured to fill the spaces between the paving blocks

3.4 Construct Walk ways, cyclist lanes and bus bays according to contract document, design manuals and standard construction procedures

After all the design considerations for the walk ways, cyclist lanes, bus bays are made, the following should be undertaken

- Preparation of the sub base- the area where the sub base is to be laid should be adequately prepared through clearing of bushes and vegetation cover on the surface. The sub base material should be spread and properly compacted with the appropriate equipment
- Paving of the parking lot- here paving blocks are laid and fitted properly to cover the entire area. Kiln dried sand is then poured to fill the spaces between the paving blocks

3.5 Construct foot bridges according to contract document, design manuals and standard construction procedures

A foot bridge is a structure linking two points that are above the ground. This structure is to allow the passage of pedestrians only. After deciding on a suitable location and design of the footbridge to be constructed, the following can be undertaken:

- Making all the necessary clearance on the substructure works ie preparing the ground level where the abutments are to be erected etc.
- Making all the clearance on the superstructure work clearing of vegetation and bushes that may block the view/ the footbridge

Below is a picture of a simple footbridge design.

3.6 Carry out Levelling activities as per standard construction procedures

Levelling activities include the following steps

- i. Setting out-this process involves putting marks and lines that define a position and level where construction work is start with respect to them.
- ii. Eliminating parallax error which results from the movement of the observer's eye at the eyepiece. Parallax will be eliminated when the eyepiece is adjusted until the cross hairs are in sharp focus.
- iii. Making bookings

3.7 Document Ground levels as per standard procedures

These are levels at the ground. During construction processes ground markings for boundaries and other elements can be made by following the procedure of setting out which involves

- i. On the ground level a temporary bench mark is placed. This bench mark can either be a man hole cover or a post
- ii. A baseline is then established where all the setting out activities start from.
- iii. Horizontal controls –which are points of known coordinates with respect to a specific point are placed. Vertical points are also placed by timber post. These points are established through levelling.

3.8 Carry out Quality control operations according standard construction procedures

Quality control operations can be conducted on construction materials and is done by

- Making sure all the materials that arrive to the site are at par with the set standards
- Ensure proper storage of materials so that they maintain their quality
- Materials that stay longer without usage should first be re-tested to ensure their quality is in check

3.9 Undertake maintenance of parking, walk ways and cyclist lanes, foot bridges, bus bays as per maintenance procedures

Regular maintenance of parking, walk ways, cyclist lanes, foot bridges, bus bays should be conducted to ensure proper working of these structure. These can be achieved through the following steps

- Clearing of bushes and vegetation cover that tend to cause an obstacle on and along the paths
- Cleaning of the side drain freeing it from any silt, rock debris and other obstacles that may interfere with the free flow of water
- Repair all the defective path surfaces i.e. through filling of pot holes

Conclusion

This learning outcome covered all the major activities and standard procedures that goes into the construction of parking, walk ways and cyclist lanes, foot bridges and bus bays.

Further Reading



The student should read extensively on different designs of foot bridges, the various materials used on the construction of parking lots, walk ways and foot bridges.

13.3.4.3 Self-Assessment



Written Assessment

1. Which of the following is not a levelling activity?
 - a) making bookings
 - b) elimination of parallax
 - c) preparing of base layer
 - d) Setting out
2. Which of the following is not a maintenance practice in caring of parking lots, cycle ways and bus bays?
 - a) Clearing of bushes
 - b) Preparation of subgrade
 - c) Cleaning of side drains
 - d) Repairing defective pathways

3. Which is not a method of operating and maintain construction equipment?
 - a) Lubricate machine
 - b) Following of safety rules
 - c) Allow anyone without skills to operate complex equipment
 - d) Wearing of protective gear
4. Explain the procedure of interpreting engineering drawings?
5. Summarize the procedure of levelling.

Oral Assessment

1. What is meant by quality control?
2. What is levelling?

Practical Assessment

You are invited in a community activity where they are to repair existing parking lots, walk ways and cyclist lanes in your area. As an expert in civil engineering, how are you going to guide them through this process?

13.3.4.4 Tools, Equipment, Supplies and Materials

- Computer
- Internet
- Workshop
- Construction materials
- Construction tools and equipment
- Construction designs and drawings
- Sample contract documents
- Computer software e.g. AutoCAD, ArchiCAD, Civil3D
- Stationery
- Road construction site
- Material testing labouratory
 - Moulds
 - Tamping rods
 - CBR Machines
 - Crushing machines
- Schedule of work
- Standard manuals
- Road under construction
- Contract documents

13.3.4.5 References




Ursula Baus, Mike Schlainch (2007). Footbridges: Construction, Design and History. Birkhauser Publishers.

Robert Delatte. (2008). Concrete Pavement Design, Construction and Performance. USA: Taylor and Francis Publishers.

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13.3.5 Learning Outcome No 4: Install Road Furniture

13.3.5.1 Learning Activities

Learning Outcome No 4: Install Road Furniture	
 Learning Activities	Special Instructions
4.1 Mobilize road furniture 4.2 Carry out interpretation of drawings 4.3 Determine location of road furniture on the road 4.4 Identify and acquire road furniture for installation 4.5 Install road furniture on the road 4.6 Undertake quality control procedures on road furniture installation 4.7 Carry out maintenance activities on road furniture 4.8 Review traffic signs 4.9 Undertake maintenance of road furniture	<ul style="list-style-type: none"> • Direct instruction • Case studies • Field trips/site visits • Group discussions • Demonstration by trainer • Computer Aided Learning (CAL)

13.3.5.2 Information Sheet No13/LO4 Install Road Furniture



Introduction to learning outcome

Installation of road furniture is a major activity during road construction that may ensure the safety of road users. The learning activities range from determining location of road furniture to understanding quality control procedures on road furniture.

Definition of key terms

Road furniture- these are objects that are fixed on the roads and road reserves that serves as a guide for traffic and pedestrians

Contract documents- are legal- binding documents that outlines the work, roles and responsibilities in a construction project as per the agreement between the parties involved.

Traffic signs-these are signs that are put up above or at roadsides to direct and give information to road users.

The following is an example of road furniture in Kenya



Figure 134: Traffic signs
Thika Road sign board. Photo Courtesy;

Content/Procedures/Methods/Illustrations

4.1 Mobilize road furniture according to contract document and designs

After identifying the type of road furniture to be set up at a particular area and the relevant authority has approved the installation, road furniture will be designed and manufactured in accordance to all the set standards. Once they are ready they will be transported to required location awaiting installation.

4.2 Carry out interpretation of drawings according to the contract document and relevant manuals

For easier interpretation and understanding of a drawing one should follow the following steps

- i. Commencing with the title block, which shows you the title of the drawing and what the drawing is all about
- ii. Understand the basic symbols on the drawing
- iii. Identify specific abbreviations and try to understand what they mean
- iv. Try to visualize the structure in your imagination

4.3 Determine location of road furniture on the road according to standard road procedures and legal requirements

There are many factors that determine where road furniture are placed along or on road sides. These include:

- Crash history of a site- with this analysis, the highway authority is able to place road furniture on these areas this helps guide road users of black spots
- Volume of traffic – the amount of vehicles on the road aid the planner on where to put road furniture.
- The number of school children that are crossing a particular road.
- The size of the community also helps in determining where road furniture are to be placed

4.4 Identify and acquire road furniture for installation as per contract document

The process of acquiring approval for the installation of road furniture take time, for instance it can go up to two years. The following is the process of acquiring approval for installation of road furniture.

- The applicant shall have to submit written documents on why they seek to have the road furniture
- Also the design concept and drawings shall also be submitted to the relevant authority.
- Wait for the relevant authority to decide if the applicant will be granted the approval.

4.5 Install road furniture on the road based on standard construction procedures

The installation process should be undertaken with keen and minimum disturbance to the road users. General safety should be practiced to avoid any accidents during the installation process. Before any installation process commences, a plan of the site must be reviewed. The following are the activities done during the installation process

- Barriers and sign board should be erected so signal vehicles and pedestrians of ongoing works.
- Excavation works of trenches where the signs are to be situated- the depth of these trenches will be as per the standards.
- Backfilling materials.
- Removal of surplus materials away from the site.
- Levelling of foundation ready to receive the road furniture for installation
- The installation of the equipment.

4.6 Undertake quality control procedures on road furniture installation as per relevant manuals

Before the installation process the quality of road furniture should be assessed to ensure standard work is put up. These include checking on this such as

- The road furniture should be visible at a legible distance for road users to easily spot them day and night.
- The road furniture should be the correct size, they should be big enough
- The road furniture should be durable to withstand harsh conditions i.e. (rain, dust and fog)

4.7 Carry out maintenance activities on road furniture based on standard maintenance procedures

Road furniture are regularly inspected so that it performs its function effectively. Maintenance of road furniture can be done through the following ways

- Cleaning – due to dirt build up, the visibility of road furniture is usually compromised the chemicals that may damage the road signs.
- Most of the times road furniture is stolen or vandalized. To prevent this, road furniture should always be fixed with special fasteners that make it difficult to remove these signs
- Clearing of vegetation cover- the growth of vegetation around road furniture reduces visibility. Clearing should be done regularly in areas where vegetation grows rapidly.
- Checking on the firmness of sign support – road furniture should always be in an upright position for easier visibility. Regular inspection should be done to make sure that these road furniture are in the correct standing position.

4.8 Review traffic signs according to standard requirements

This is the process of evaluating the effectiveness of traffic signs. Proper evaluation of traffic signs can be done by looking at a number of things/factors which indicate how effective the signs are. These factors are

- the development of an area
- the general layout of the area
- the number of vehicles using accessing that area
- the number of pedestrians using that road

The following picture shows the various traffic signs that are used in Kenya

4.9 Undertake maintenance of road furniture as per maintenance procedures

Road furniture regularly inspected so that it performs its function effectively. Maintenance of road furniture can be done through the following ways

- Cleaning – due to dirt build up, the visibility of road furniture is usually compromised therefore cleaning should be done. The cleaning agents should be free from any harsh chemicals that may damage the road signs.
- Most of the times road furniture is stolen or vandalized. To prevent this, road furniture should always be fixed with special fasteners that make it difficult to remove these signs
- Clearing of vegetation cover- the growth of vegetation around road furniture reduces visibility. Clearing should be done regularly in areas where vegetation grows rapidly.

Checking on the firmness of sign support – road furniture should always be in an upright position for easier visibility. Regular inspection should be done to make sure that these road furniture are in the correct standing position

Conclusion

This learning outcome covered all the processes go into the installation of road furniture from mobilization, acquiring, identifying and maintenance.

Further Reading



The student should read further on the types of road furniture and how to read them. This will aid to increase on their body of knowledge.

13.3.5.3 Self-Assessment



Written Assessment

1. Which of the following is not a maintenance practice of tools and equipment?
 - a) Regular cleaning of tools
 - b) Lubrication of tools
 - c) Overworking of tools
 - d) Proper storage of tools

2. Which of the following is not a maintenance activity on road furniture?
 - a) Clearing of vegetation
 - b) Not replacing stolen road furniture
 - c) Anti-theft measures
 - d) Regular cleaning of road furniture
3. Which is not a factor to consider when positioning road furniture?
 - a) Crash history
 - b) Size of the community
 - c) Empty roads
4. Evaluate the procedure of acquiring road furniture.
5. Explain how you interpret drawings
6. Supposed you are asked to participate in a school project to install a crossing sign board near our school. What steps will you take to ensure the work is completed?

Oral Assessment

1. Summarize traffic signs
2. Explain road furniture

13.3.5.4 Tools, Equipment, Supplies and Materials

- Computer
- Internet
- Workshop
- Construction materials
- Construction tools and equipment
- Construction designs and drawings
- Sample contract documents
- Computer software e.g. AutoCAD, ArchiCAD, Civil3D
- Stationery
- Road construction site
- Material testing laboratory
 - Moulds
 - Tamping rods
 - CBR Machines
 - Crushing machines
- Schedule of work
- Standard manuals
- Road under construction
- Contract documents

13.3.5.5 References




Us. Department of Transportation (2015). Standard highway signs 2004 edition. Create space Publishers

National Transport and Safety Authority (2016). Highway Code for Road Users. Nairobi. Government Printers.

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13.3.6 Learning Outcome No 5: Construct Erosion Prevention Structures

13.3.6.1 Learning Activities

Learning Outcome No 5: Construct Erosion Prevention Structures	
 Learning Activities	Special Instructions
5.1 Mobilize construction resources 5.2 Determine erosion control structures for construction 5.3 Establish location of erosion prevention structures 5.4 Carry out interpretation of drawings 5.5 Carry out construction of erosion prevention structures 5.6 Undertake quality control procedures 5.7 Undertake maintenance of erosion prevention structures	<ul style="list-style-type: none"> • Direct instruction • Case studies • Field trips/site visits • Group discussions • Demonstration by trainer • Computer Aided Learning (CAL)

13.3.6.2 Information Sheet No13/LO5 Construct Erosion Prevention Structures



Introduction to learning outcome

This learning outcome deals with the construction of erosion prevention structures in road construction and involves various learning activities ranging from mobilizing construction resources to operating and maintaining construction tools and equipment

Definition of key terms

Sediment Control Basins-These are basin structures that are constructed to control the flow within a drainage area

Diversion terraces-These are structures constructed in lieu with terraces across a slope to handle runoff

Grassed waterways-These are saucer-shaped channels constructed to move surface water across a farmland without causing erosion

Content/Procedures/Methods/Illustrations

5.1 Mobilize construction resources as per contract document

Mobilizing consists of making sure one has resources and people agreed upon in the contract ready to begin work. The construction resources could include:

- Excavators
- Tractors,
- Ploughs,
- Man-power
- Bull dozers
- Graders,
- Back hoes

To mobilize the construction resources the following steps are to be considered;

- i. Identify the key stakeholders in indicated in the documents
- ii. Generate a work plan and share with all involved
- iii. Continuously recognize effort and identify how to outsource the tasks if need be

The Mobilization of construction resources ensures efficient and effective delivery of product and service within the allocated time and within a pre-determined budget. Therefore, the mobilization occurs at the onset of the construction process

5.2 Determine erosion control structures for construction based on prevailing site conditions

Erosion control structures are devices that are used to reduce the erosive power of water hence protect soil. They are categories of Erosion construction structures such as;

- Control Basins-These are basin structures that are constructed to control the flow within a drainage area
- Diversion terraces-These are structures constructed in lieu with terraces across a slope to handle runoff
- Grassed waterways-These are saucer-shaped channels constructed to move surface water across a farmland without causing erosion

The erosion construction structures are determined by;

- a. Making inquiries of the prevailing site
- b. Determining the soil characteristics of the site
- c. Observing the effects of uncontrolled flow of water to the site hence deducing the best way forward

The erosion control structures are based on prevailing site conditions to ensure the longevity and the efficiency of the structure. This activity is undertaken by the expert at the onset of the process, and as the process progress alterations may be adopted

5.3 Establish location of erosion prevention structures according to contract document

The location of prevention structures is a process that requires the skill of an expert such as a surveyor or engineer. When locating the appropriate site for such a structure the following must be considered;

- The topography of the location
- The type of the prevention structure to be constructed
- The supplementary uses of the water collected
- The drainage of the water collected

These is established by;

- Identifying the available resources
- Consulting the relevant authorities
- Approaching experts and research previously done on the location

The location is a critical piece of information so therefore it is established promptly by all the stakeholders involved, to ensure commencement of work and that all processes are abiding to the set regulations.

5.4 Carry out interpretation of drawings as per standard construction procedures

Interpretation entails using the skill of a trained personnel to explain and represent the drawings taken at the site. This is important as it helps to design the control structure appropriately avoiding wastage of time and resources. The drawings may be in form of Charts, Diagrams graphs and the drawings themselves which have used national and International standards and conventions to provide a universal visual language. There are various sources used for interpretation such as GIS, AUTOCAD and other design software's as this is done before the commencement of construction

A Standard scale of interpretation is already established by the parties concerned and experts are consulted to ensure it meets the standards agreed upon.

The following procedure is used when interpreting drawings;

- i. Acquaint oneself with scale drawings -Always determine the scale first before examining in detail, if unsure consult the engineer who drew it for clarification
- ii. Acknowledge the basic symbols used in engineering drawings-They may be rectangles, circles or triangles mainly indicating shapes, processes and dimensions. If unsure consult the engineer who drew it
- iii. Look at circled numbers-Due to a very detailed drawing that may be produced and in a small scale the circled number often shows an area identified in greater detail on another page
- iv. Identify specific abbreviations-Some common abbreviations may be ;DP-Depth and DIA-Diameter

5.5 Carry out construction of erosion prevention structures in accordance with standard construction methods

This entails involving all the personnel agreed upon to participate in the various activities such as;

- i. Site clearance activities
- ii. Cut and fills
- iii. Standard road construction procedures e.g. excavation, cut material disposal and compaction
- iv. Interpret drawings
- v. Quality control procedures
- vi. Levelling activities
- vii. Establishment of structure

The process is a lengthy one and requires the continual advancement of the area, the construction of the structure will not only improve the quality of life in the region but improve the quality and quantity of products from the location

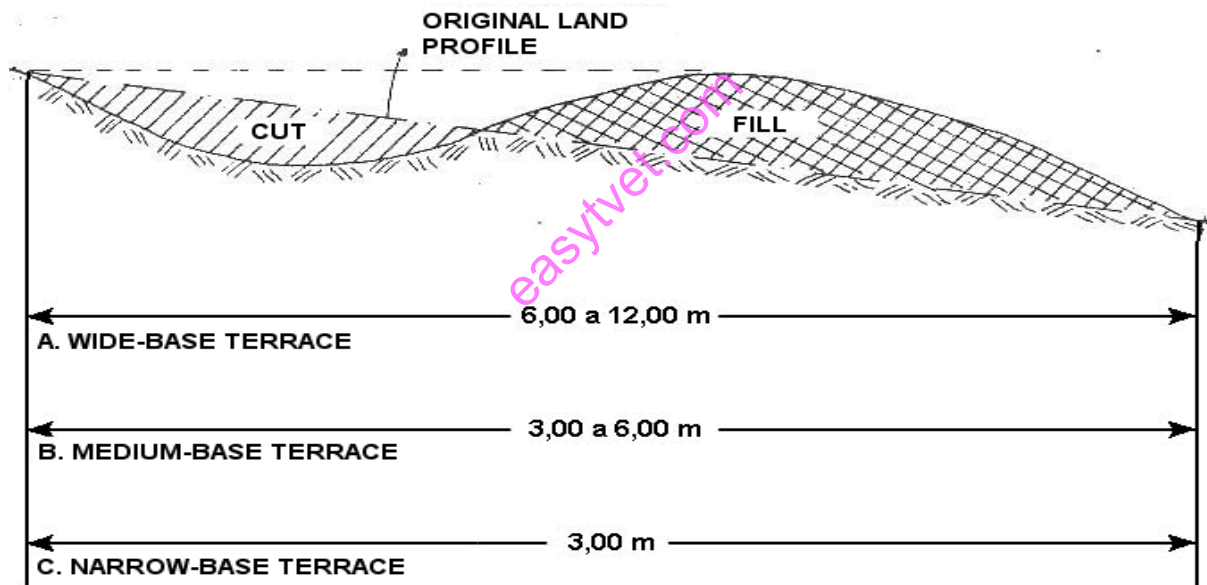


Figure 135: terrace showing different base sizes

A terrace showing different base sizes (FAO,2000)

5.6 Undertake quality control procedures according to standard procedures

Quality control procedures are a set of activities that are done at the area to ensure that the quality of the control structure meets the standard requirements of both the client and the specification. They are conducted by an expert in the field (surveyor, engineer) after the construction of the control structure with the guide of established standards such as those by AASHTO standards and FAO e.g.

- i. Maximum dry density
- ii. Cone penetration

- iii. Plasticity index
- iv. California Bearing Ratio (CBR)
- v. Shear tests
- vi. Marshall test

The tests are important to be undertaken early in the project so as to ensure that the characteristics and the conditions of the land are not overlooked that may cause adverse effects to the structure in future

5.7 Undertake maintenance of erosion prevention structures as per maintenance procedures

Maintenance of the erosion prevention structures ensures the preservation of the structure and its continued efficiency. The maintenance is done every season and requires the input of an expert, and the use of the earthwork machinery sparingly. They could include methods such as reinforcing the terrace and removing rocks inside the waterways firming up the soil through compaction.

An example of Maintenance Plan for sediment control structures;

- All Erosion and Sediment control practices will be checked for stability and operation after every run-off producing rainfall mandatorily every week. Repairs are carried out immediately to ensure practices are maintained as designed
- The sediment basin will be cleaned out when the level of sediment reaches 2.0ft below the riser. Gravel will be cleaned/replaced when the sediment pool no longer drains properly
- Sediment will be removed from the sediment trap and obstruct the gravel intake protection device when the storage capacity has been approximately 50% filled., Gravel will be cleaned/replaced then
- Sediment will be removed from behind the sediment fence when it becomes about 0.5 ft deep at the fence. The fence will be repaired as necessary to maintain the barrier
- All seeded areas will be fertilized, reseeded as necessary and mulched according to specifications in vegetative plan to maintain vigorous, dense vegetative cover

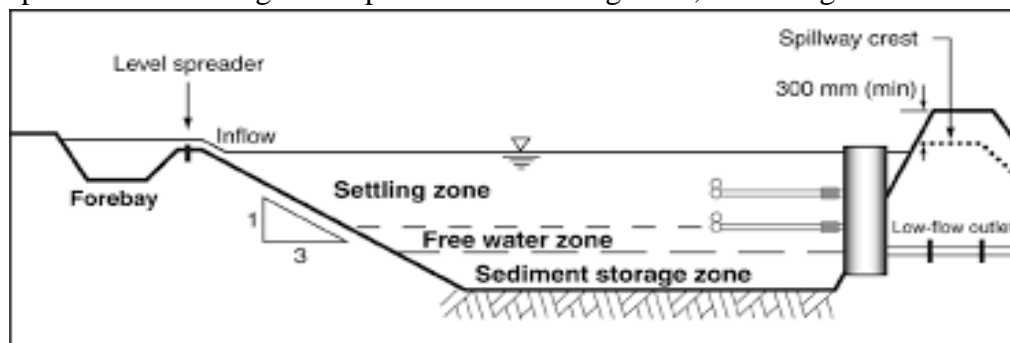


Figure 136: Sediment Basin Control Technique

Source; IECA Australia (June 2018) Sediment Basin Control Technique

Conclusion

This learning outcome covered the construction of erosion prevention structure and their maintenance procedures.

Further Reading



1. Read Erosion and Sediment Control Planning and Design Manual and identify the various erosions structures developed by governments
2. Read on technologies to combat soil erosion by World Overview of Conservation Approaches and Technologies
3. Sample Erosion and Sedimentation Control Plans

13.3.6.3 Self-Assessment



Written Assessment

1. Which of these is not an earthwork equipment?
 - a) Grader
 - b) Bull dozer
 - c) Sub-soil
 - d) Excavator
2. Which of the following is not an Erosion control Structure?
 - a) Diversion terrace
 - b) Green house
 - c) Control Basins
 - d) Grassed waterways
3. Which of the following is of most importance when determining the location of an erosion control structure?
 - a) Topography
 - b) width
 - c) material
 - d) procedure Manual

4. A grassed waterway
 - a) These are saucer-shaped channels constructed to move surface water across a farmland without causing erosion
 - b) The topography of the location
 - c) The tools and equipment that are used in the construction of erosion control structures
 - d) These are basin structures that are constructed to control the flow within a drainage area
5. Which of the following is not a Personal Protective Equipment (PPE) used during construction of an erosion control structure?
 - a) Head gear
 - b) Lab coat
 - c) Gloves
 - d) Reflective clothing
6. Which of the following is not an expert required in designing an Erosion control Structure?
 - a) Engineer
 - b) Agriculturalist
 - c) Surveyor
 - d) Telemarketer
7. Is a Terrace Constructed?
 - a) Across a slope
 - b) Below a valley
 - c) Along the river
 - d) Adjacent a basin
8. Evaluate 7 erosion construction structures and state their importance
9. Summarize the activities undertaken when conducting site clearing
10. Explain the different types of cut and fill materials used in construction
11. Evaluate the various procedures carried out in Quality control operations and state their importance?
12. Explain the statutory requirements and what are their importance?
13. What are control erosion structures and what are their importance?
14. What is the personal protective equipment required and what are their relevance?

Oral Assessment

1. Distinguish 6 erosion control structures
2. Explain 3 quality control procedures adopted when constructing erosion control structures

Case Study Assessment

During the months of July and August 2019 the National government proposed the construction of a diversion terrace in Nyandarua. During the heavy downpour later the year the Terrace collapsed .State some of the procedures that would have been overlooked for such a scenario to occur

13.3.6.4 Tools, Equipment, Supplies and Materials

- Computer
- Internet
- Workshop
- Construction materials
- Construction tools and equipment
- Construction designs and drawings
- Sample contract documents
- Computer software e.g. AutoCAD, ArchiCAD, Civil3D
- Stationery
- Road construction site
- Material testing labouratory
 - Moulds
 - Tamping rods
 - CBR Machines
 - Crushing machines
- Schedule of work
- Standard manuals
- Road under construction

Contract documents

13.3.6.5 References




Pablo A Garcia (2015) Erosion control and Land restoration, Outskirts Press

R.P.CMorgan (2005) Soil Erosion and Conservation, 3rd Edition

Andre Bationo (2007) Advances in Integrated Soil Fertility Management in Sub-Saharan Africa

13.3.7 Learning Outcome No 6: Construct Highway Drainage and Hydraulic Structures

13.3.7.1 Learning Activities

Learning Outcome No 6: Construct Highway Drainage and Hydraulic Structures	
 Learning Activities	Special Instructions
6.1 Plan for Highway drainage and hydraulic structures construction 6.2 Construct culverts 6.3 Construct side drains, meter drains and cut-off drains 6.4 Construct sub-surface drains and gullies 6.5 Construct bridges 6.6 Construct drifts and causeways 6.7 Construct retaining walls 6.8 Undertake maintenance of highway drainage and hydraulic structures	<ul style="list-style-type: none"> • Direct instruction • Case studies • Field trips/site visits • Group discussions • Demonstration by trainer • Computer Aided Learning (CAL) • Practical

13.3.7.2 Information Sheet No13/LO7 Construct Highway Drainage and Hydraulic Structures



Introduction to learning outcome

The construction of highway drainage and hydraulic structures is a learning outcome that is critical in the construction of roads/pavements. It involves various learning activities such as the construction of culverts, drains, bridges and retaining walls

Definition of key terms

Hydraulic structures: A hydraulic structure is a structure which remains partially or fully submerged in a body of water which alters, diverts or completely stops the flow of water naturally. eg dam, weir, flumes etc.

Retaining walls: A retaining wall is a structure which is designed and constructed to resist the lateral pressure of soil so as to prevent the material being retained from sliding away.

Bridges: A bridge is a structure carrying a road, path, railway across a river, road or other obstacles. It's constructed above the maximum flood level.

6.1 Plan for Highway drainage and hydraulic structures construction

An efficient drainage system allows disposal of water from the road in the shortest time possible. Some of the crucial features for such a system are:

- Road surface drainage which makes sure that water can flow from the road
- Side drains which are vital in collecting water from the road's surface
- Scour checks which slows down the flow of water and thus prevent the ditches from being eroded
- Culverts which are crucial in leading the water from the side drains.
- Bridges and drifts which ensures that the road can go over roads and streams in all seasons.

To plan for a drainage system the following is required

- Observation of drainage patterns and requirements during rainy periods so that an accurate data about the amount of water can be determined.
- Establishing the exact cause and effect of the drainage failures.
- Determine a center line that avoids poorly drained areas, large runoffs and unnecessary stream crossings.
- Reducing the road gradients for roads with steep gradients so that the drainage of water from the road surface can be done in a controlled manner to avoid erosion

6.2 Construct culverts

Culverts can be built using a variety of material, include brick and stone masonry, corrugated steel, timber and concrete culverts are also constructed in a wide-range of shape and sizes. The most common types of culvert is fitted with one or several rows of circular pipes made of concrete. The most common is the pipe with a diameter of 60 cm.

The stages of construction of culverts

- i. Estimation of the area of the culvert required.

The rule of thumb can be used to assume that the area of the culvert required is one-third of the area of waterway when the stream has reached its highest flood level, i.e. for every three-square meters of waterway one square meter of culvert should be placed.

- ii. An apron should be made to protect the bed from erosion at the outlet side of the culvert
- iii. Head/wing walls should be made at the inlet and outlet side of the culvert to protect the road embankment from the river water and serve also to support the embankment, so that the soil does not slide into the river when a vehicle passes;
- iv. Proper compaction of the soil around, between and on top of the culverts. This compaction should be done in layers not exceeding 15 centimeters.

The gradient of culverts should normally be the same as the gradient of the stream bed and should not be greater than 5 per cent.

When a natural stream crosses the road at an angle, it is often better to construct a skew crossing or to realign the road, so that a 90° crossing can be constructed. If an existing channel bed is altered, usually a lot of erosion problems can be expected.

6.3 Construct side drains, meter drains and cut-off drains

Side drains, meter drains and cut-off drains are used to prevent the flow overshooting the drainage works or to direct flows into culvert inlets. They are also used as erosion checks. The type of side ditch selected must be checked to ensure that it will carry the expected flow without running as deep as to wet the road pavement nor so fast as to cause scour

6.4 Construct sub-surface drains and gullies

Subsurface drains: Includes any type of drain designed to collect groundwater whether this is rising from below or percolating from the surface

Gullies: include a small sump into which detritus may sink for subsequent removal, preventing it entry into the drainage system, where it may otherwise accumulate and cause blockages, and a 'trap' which prevents the entry of floating materials to the system. They can be positioned below the surface of the pavement, in which water will enter through a grating placed flush with the surface – known as channel inlet; or not one side of the pavement with an inlet mounted in the face of the kerb- (kerb inlet). Gratings and covers are in cast or ductile iron whilst the body of the gully is preformed, clayware/ plastic and is bedded in class 25/30 concrete

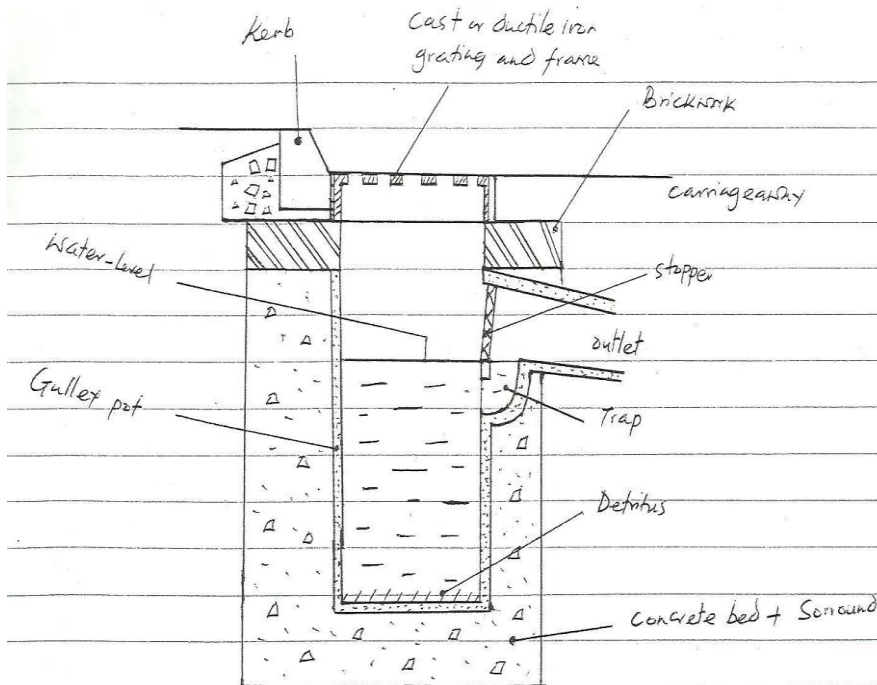


Figure 137: Sub-surface drains and gullies

Source: guide of trainer's manual.

6.5 Construct Bridges

The design procedure of constructing a bridge includes:

- i. Site investigation: In this stage the highway engineer identifies a preferred location for the bridge and decides on the type, size and capacity of the structure
- ii. Sketch of proposed bridge and brief technical descriptions of bridges
- iii. Substructure design: this involves design of spread footings, driven piles, and drilled shaft foundations.
- iv. Superstructure design: this stage deals with analysis and design of bridge decks and deck systems of concrete, metal, and wood or combinations thereof subjected to gravity loads.

6.6 Construct Drifts and causeways

Drifts: these are structures which are normally constructed to provide a firm place to cross wide, normally dry rivers which are periodically flooded. Construction of a drift depends on the design of the drift, however there are some general procedures as stipulated below.

- i. Rechanneling of the water flow so as to obtain a dry working space.
- ii. Setting out the center-line of the drift with survey pegs showing the future level of the drift surface.

- iii. Setting out reference pegs at the down-stream and the up-stream sides of the drift. These pegs should be used to ensure the drift surface follows the gradient of the existing river.
- iv. Place multi-purpose pegs showing where the foundation trenches will be excavated. These trenches should be wide enough to allow sufficient working space to the masons or carpenters.
- v. Excavation of foundation trenches until you have reached a solid layer (rock, hard soil). In case of (high water-table) the water should be drained by means of buckets, pump, and meter drain whichever is convenient. In such conditions, a gabion foundation wall can be used or else fill the trench with rocks up to the water level and continue with masonry until you have reached the correct levels.
- vi. After completing the foundation wall(s) excavate the area in between and place the hand-packed stone.
- vii. Provide a concrete finish if specified in the design.

Causeways: these are structures which are designed in such a way that the normal dry-weather flow of the river passes through culverts below the roadway. The construction procedure of causeways is similar to drifts for the first four steps and thereafter a bed level for the culverts is prepared using a minimum gravel layer of 15cm and preferably topped with a minimum concrete layer of 7.5cm. The culverts are then laid in positions and at a gradient of 3.5 per cent. Thereafter the headwalls are constructed up to road level and a smooth layer of concrete is provided to give a smooth surface for the traffic.

6.7 Construct Retaining walls

There are different procedures of constructing retaining walls depending on their type. Cantilever retaining wall is the most common type and it's constructed from reinforced concrete, precast concrete, or prestressed concrete. The Design criteria of retaining walls involves the subsequent stages: Determining the ranking active pressure and the resisting moments about the toe of footing. Checking the factor of safety and determining the size of key and finally the design of masonry and footing. During construction footings should be placed on firm undisturbed soil, or on adequately compacted fill material. Backfilling against retaining walls should not be permitted until the masonry has achieved sufficient strength or the wall has been adequately braced. During backfilling, heavy equipment should not approach closer to the top of the wall than a distance equal to the height of the wall. During construction, the soil and drainage layer, if provided, also needs to be protected from saturation and erosion. Weep holes should be provided to prevent the accumulation of water behind the face of the wall and to reduce the possible effects of frost action.

6.8 Undertake maintenance of highway drainage and hydraulic structures as per maintenance procedures

It is important to have a drainage plan indicating the location and layout of lateral and main drains, outfalls, surface water inlets and other drainage structures for purposes of maintenance. The maintenance plan involves:

- Looking for signs of sediment in drain discharge and in the receiving ditch Locate the area where the sediment is entering the drainage system and repair the drain or remove the sediment using one of the methods described earlier in this Factsheet.
- Removing any trash, debris or plant material that has accumulated around the inlet to make sure that it functions properly
- Cleaning lateral drains through the use of sewer-cleaning rods or
- Flushing using high pressure pumps where the deposit is only for a short stretch of pipe.

Conclusion

This learning outcome covered the construction of highway drainage and hydraulic structures.

Further Reading



Research on the various types of retaining walls, their design and construction

13.3.7.3 Self-Assessment



Written Assessment

1. State whether true or false a foundation of a culvert can be improved by
 - a) Improving the existing subsoil.
 - b) Placing gravel material.
 - c) Constructing a floating floor.
 - d) Pouring a concrete floor.
2. Which of the following is not part of a bridge superstructure
 - a) Bridge deck
 - b) Bridge guard rails
 - c) Pipe handrails
 - d) Piers

3. Which of the following is not part of a bridge substructure
 - a) Abutments
 - b) Retaining walls
 - c) Culverts
 - d) Bridge bearings
4. State whether true or false
 - a) A bridge site must offer appropriate vertical and horizontal alignments.
 - b) The soil of a bridge site must be of sufficient strength to ensure the stability of the structure.
 - c) The bridge and its associated works should not harm adjoining land or buildings, or be susceptible to damage from/to the local environment.
 - d) A bridge can only be built at a river crossing.
5. Which of the following is not a type of a retaining wall
 - a) Masonry retaining wall
 - b) Cantilever retaining wall
 - c) Counterfort retaining wall
 - d) Gabion wall
6. With the aid of a diagram differentiate between a causeway and a drift
7. Categorize the different types of culverts
8. Categorize the various types of hydraulic structures
9. Differentiate between a kerb inlet and a gully pot
10. Summarize the preliminary stage in the design of the bridge
11. Summarize the phases involved in the construction of a retaining wall.

Oral Assessment

When would a drift be a preferred option over a causeway?

What is the importance of hydraulic structures in the agriculture sector?

Case Study Assessment

Determine the efficiency of subsurface drains a case study along Thika superhighway.

Oral Assessment

Summarize how the drainage and hydraulic structures affect the design life of a pavement?

Practical Assessment

Visit an urban center in your local area and try to identify the various types of culverts, drains retaining walls and any other hydraulic or drainage systems about this chapter.

13.3.7.4 Tools, Equipment, Supplies and Materials

- Computer
- Internet
- Workshop
- Construction materials
- Construction tools and equipment
- Construction designs and drawings
- Sample contract documents
- Computer software, e.g. AutoCAD, ArchiCAD, Civil3D
- Stationery
- Road construction site
- Material testing labouratory
 - Molds
 - Tamping rods
 - CBR Machines
 - Crushing machines
- Schedule of work
- Standard manuals
- Road under construction
- Contract documents

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13.3.7.5 References



Design Manual for Roads and Bridges Part 6(a)-Bridges and Culvert
Guide to the Training of Supervisors - Trainees' Manual/Part 2 - For Labour-Based Road
Construction and Maintenance (ILO, 1981, 254 p.)
Principles and Practices of Highway Engineering- Dr.L. R Kadyali and Dr.N.B. Lal

13.3.8 Learning Outcome No 7: Undertake Highway Maintenance

13.3.8.1 Learning Activities

Learning Outcome No 7: Undertake Highway Maintenance	
 Learning Activities	Special Instructions
7.1 Assess pavement conditions 7.2 Prepare for maintenance activities 7.3 Carry out Emergency maintenance works 7.4 Perform routine maintenance activities 7.5 Carry out periodic maintenance works	<ul style="list-style-type: none"> • Direct instruction • Case studies • Field trips/site visits • Group discussions • Demonstration by trainer

13.3.8.2 Information Sheet No4/LO7 Undertake Highway Maintenance



Introduction to learning outcome

Undertaking highway maintenance is the last outcome in road construction and is a key element that should be mastered

Definition of key terms

- **Maintenance activities**

These are essential procedures undertaken to;

- i. Preserve a highway to be in its initial constructed condition.
- ii. Provide user safety and protection of nearby resources.
- iii. Enable efficient and convenient transportation on the highway.

These activities can be done either as a routine to determine any minor damages to the pavement, slopes or drainage. They can also be carried out periodically, which involves more detailed investigation and works on various facilities and structures. They can also be carried out in case of emergencies to restore the pavement or nearby resources due to the occurrence of an accident or a natural disaster.

Content/Procedures/Methods/Illustrations

7.1 Assess pavement conditions

An accurate assessment of pavement condition is the first step to a successful maintenance procedure. This is mostly done by visual inspection to determine the surface distress; this is to assess the cracking of the surface. This is carried out for each segment of the highway and represented as Surface Rating and Dominant Distress. However, it is important to note that the performance of a highway is not just limited to surface cracking. Factors such as friction, structural soundness and user comfort are also very important in efficient and convenient use of a road. It is important to factor in the road user satisfaction in the decision making, design and maintenance of any road because it is the first thing any road user notices. The ability of a pavement to provide comfortable, safe and economical riding surface to the user can be measured in terms of present serviceability index (PSI). Many countries use pavement condition rating (PCR) to assess a road condition. The structural soundness of a road is measured in terms of response of the road to load application, volume of traffic is represented as Average Annual Daily Traffic (AADT) in this case.

Assessment Procedure

The assessment procedure entails majorly a detailed observation of the road. If the area to be assessed is large, it can be opted to use digital data collection such as a video footage of the road segment or digital images. Data pertaining to roughness can be collected using survey vehicles such as the fifth wheel and appropriate interpretation of the result done. Assessment should be carried out in inspection units. These are small portions of the road usually 15 to 60 meters. The inspection units provide the advantage of a detailed report of the current road conditions and the avoidance of overlooking of some segments.



Figure 138: Alligator cracking

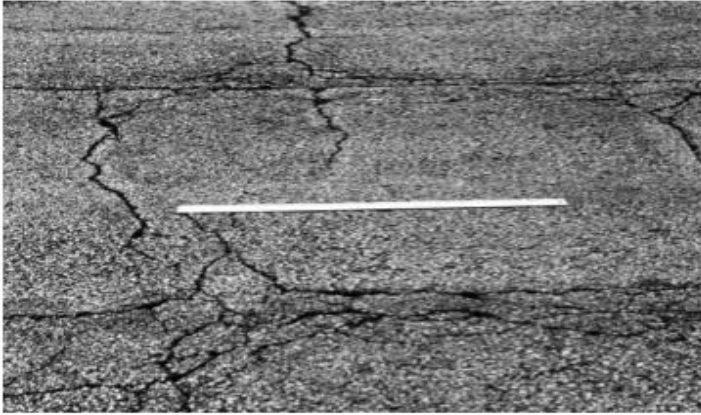


Figure 139: Block cracking

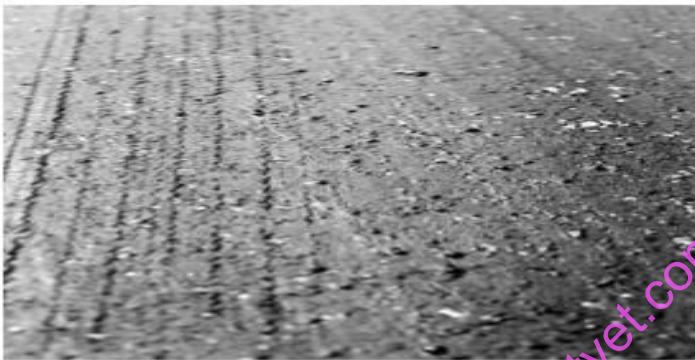


Figure 140: Bleeding



Figure 141: Depression



Figure 142: Edge cracking



Figure 143: longitudinal and transverse cracking



Figure 144: Patching



Figure 145: Rutting



Figure 146: Shoving
Source: FHWA, 1998

7.2 Prepare for maintenance activities

Preparation for maintenance activities would involve the various activities as indicated in the flow chart below.

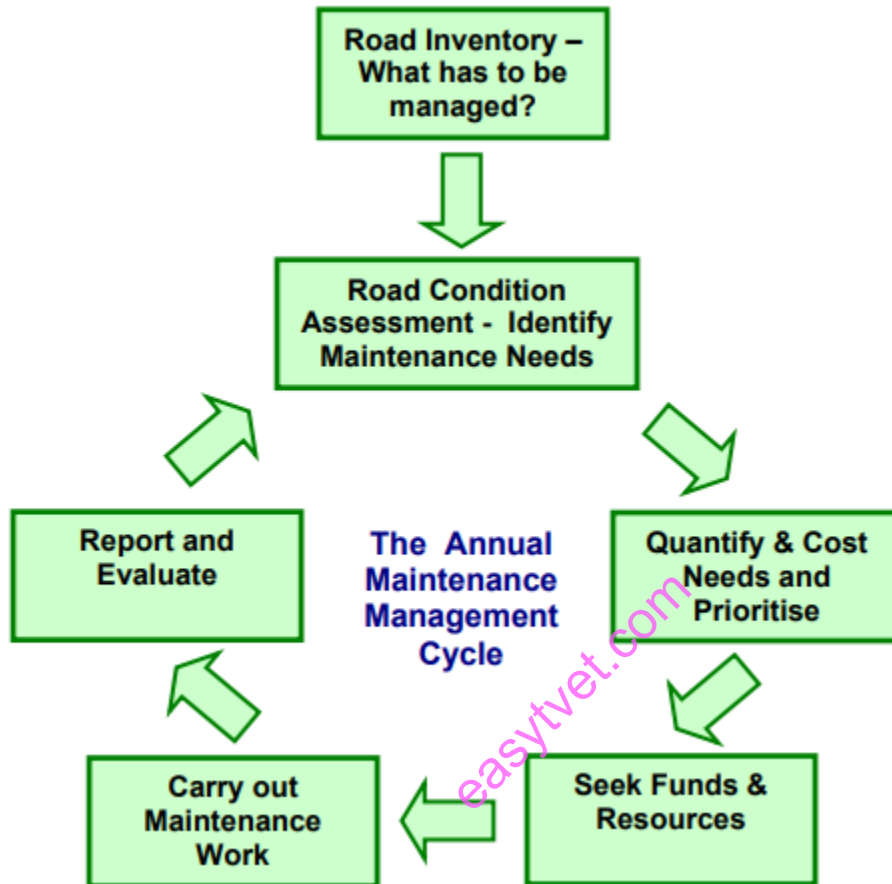


Figure 147: Road maintenance activities

Source: Rural Road Maintenance Handbook / Ministry of Transport, 2003

1. Budget estimate: this is done based on the budget or recent routine maintenance done on the road. This provide useful information in the discussion of the funds required and can also be used pending the final budgeting.
2. Road mapping: this is done by the application of GPS technology
3. Road inventory: this include all the information about the road and can always be found at road departments of each government. The inventory does not need regular updates but is essential to be updated when a major change has been done to the road design.
4. Inspection and assessment of the road: this can be done by an observer in a vehicle moving along the road. He notes and indicates which sections needs maintenance and also recommends the kind of maintenance required.
5. Preparation of the community maintenance agreement: this is the document that outlines the responsibilities of the community as well as the government or local

- government in the routine maintenance of the road. The document should contain the names of signatories, responsibilities under agreement, amount of work, issuing and returning hand tools, timing and condition of payment, starting and expected finish date and how to deal with any disagreement.
6. Selection of the maintenance team: this team should comprise members above 18 years old, live in the locality, literate and with relevant experience.
 7. Inspection of work; this is done to assess the quality of work. Once the work done is satisfactory, interim payments are made. The inspection process continues until the completion of work and would also involve the solution to emerging disputes.
 8. Returning of tools: the team ensures that all the tools issued out are returned in the perfect shape and any damage beyond reasonable expectation from the kind of work deducted from the pay.
 9. Awareness creation: the last step would be to sensitise the locality on the importance of proper road maintenance.

7.3 Carry out Emergency maintenance works

Emergency maintenance works are carried out to restore a road following damage due to accidents or natural disaster. Some of the activities would include;

- Minor repairs of bridges awaiting final restoration following the damage. This would include stiffening with steel, reinforced concrete or timber.
- Replacement or repair of failed or washed away culverts
- Removal of earth material or any debris on the road
- Creation of short-term diversions in the aftermath of an event pending repair of the road.

It is important to have a rapid response structure to deal with emergencies that could interfere with traffic flow or endanger users' lives. Reserve funds should be allocated yearly in order to deal with emergency situations. All emergency maintenance should focus on reinstating the road to its original state or to temporarily enable the road serve awaiting further repair.

7.4 Perform routine maintenance activities

The process of routine maintenance would be carried out on various items as follows;

- i. **Vegetation;** vegetation should be cut if they are affecting the vision of the road user or interfering with the drainage in the shoulder. Also, in the case where the shoulder is getting eroded, grass should be planted. Any cut vegetation should be disposed of safely in order not to affect the functionality of the road.
- ii. **Drainage;** ensure that silt and debris are removed from the drain before the rainy seasons and after storms to avoid blocking of the drains. Construct new drainage or side turnout drains with adequate lining to avoid water ponds on the sides of the road. Repair eroded ditches and drains.

- iii. **Earth works:** Trim and will the embankment with the same material to the appropriate slope. After which vegetation should be planted. Trees may also be planted in order to stabilize the slope. Constant watering should be done to ensure the growth of the vegetation. Fill erodes slopes by first cutting the gully into a workable shape then compacting the material. Drive piles at the bottom of eroded embankment to avoid slope failure. Remove any small landslide material on the road.
- iv. **Shoulder;** the shoulders should be reshaped with the correct slopes to ensure that they drain water away from the road.
- v. **Cleaning;** any debris or loose material should be removed and safely disposed away from the pavement in order to avoid being washed back. Keep bridges and decks clean always. Remove any kind of obstruction in the channels.
- vi. **Dust control:** sprinkle water on dusty roads to avoid vision obstructions on the road that might lead to accidents.
- vii. **Road sign;** regular cleaning of road signs and removal of any form of obstruction to the road sign is necessary.
- viii. **Road surface;** in case of pothole, the surface should be cut in vertical sides and filled with the same material about 1cm above the nearby surfaces. In the case of a wet surface as in rural roads, the road section should be built up with material of appropriate moisture content. Periodic reshaping and cambering of the road is also appropriate.
- ix. **Structures;** loose bolts, damaged rivets, rusted trusses and damaged welding joints for a bridge should be repaired. Other defects on culverts, retaining walls and causeways should be assessed and remedied as well.

7.5 Carry out periodic maintenance works

The process of periodic maintenance would be carried out on various items as follows;

Re-graveling; this involves relaying of the road foundation. This is done following a structural evaluation of the road segment. Graveling can also be done on the pavement to improve the safety of the road by providing more friction

Resealing/surface dressing; this is done to seal the distresses on the surface by applying the necessary sealant so as to protect the subgrade from damage and thus prolong the structural life of the road.

Maintenance of traffic signs and road markings. This is done to ensure the safety of all road users. Traffic signs are very important in providing information to the road user and together with appropriate road markings ensure efficient use of the road.

Conclusion

This learning outcome covered highway maintenance.

Further Reading



Read further on road assessment techniques as described in “Oversees Road Note 1. Road management for district engineers”.

13.3.8.3 Self-Assessment



Written Assessment

1. Which of the following is not an activity conducted in routine maintenance?
 - a) Rehabilitation of embankments
 - b) Marking of road
 - c) Digging of ditches
 - d) Erecting road signs
2. When should payments be made in a road maintenance project?
 - a) At the signing of contract
 - b) After return of tools
 - c) After inspection of work
 - d) After auditing the work
3. Which of the following is assessed in before road maintenance?
 - a) Bleeding
 - b) Creep
 - c) Buckling
 - d) Rutting
4. Which one of the following is not an activity in surface dressing?
 - a) Pre-patching
 - b) Cleaning any loose material
 - c) Applying bituminous binder
 - d) Applying chippings
5. Which one of the following is not a cause of alligator cracking on paved roads?
 - a) Inadequate pavement thickness
 - b) Low modulus base
 - c) Brittle base or wearing course
 - d) High traffic volume

6. Explain three benefits of road maintenance
7. Explain three reasons for carrying out road maintenance.
8. Outline the requirements of an individual to form a maintenance team.
9. Differentiate between routine maintenance, periodic maintenance and emergency maintenance
10. Summarise the preparation process of maintenance activities.
11. Summarise various activities in routine road maintenance.

Oral Assessment

1. Why do we need an inventory for a road in performing a road maintenance?
2. Which in your opinion would be the most expensive phase of road maintenance?

Case Study Assessment

https://openjicareport.jica.go.jp/pdf/11721644_09.pdf consider the following case study of a proposal for a road assessment.

Oral Assessment

1. Why did you choose your recommended maintenance methods?
2. How much do you think your proposal would cost?

Practical Assessment

Visit a local road near you and perform an assessment on the road. Recommend various routine maintenance that should be carried out on the road.

13.3.8.4 Tools, Equipment, Supplies and Materials

- Computer
- Internet
- Workshop
- Construction materials
- Construction tools and equipment
- Construction designs and drawings
- Sample contract documents
- Computer software e.g. AutoCAD, ArchiCAD, Civil3D
- Stationery
- Road construction site
- Material testing laboratory
 - Moulds
 - Tamping rods
 - CBR Machines
 - Crushing machines

- Schedule of work
- Standard manuals
- Road under construction
- Contract documents

13.3.8.5 References



(ASTM, the American Society for Testing and Materials 2007). Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys. ASTM D6433-07 <http://www.astm.org/Standards/D6433.htm>, last accessed on June 23, 2020.

Broten, P.E., and Sombre, D.E. (2001). The Airfield Pavement Condition Index (PCI) Evaluation Procedure: Advantages, Common Misapplications, and Potential Pitfalls. Proceedings of the 5th International Conference on Managing Pavements, August, Seattle Washington, United States.

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