

Chapter 1. Road Construction



Asphalt Concrete



Cement Concrete

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1. Subgrade Preparation and Improvement

1.1 Construction of Staking (Setting out)

- Prior to the construction activity the design information has to be moved from the plan to the ground. This is accomplished by **staking**.
- Slope stakes are an effective way to insure compliance with the design standards and to keep soil disturbance to an absolute minimum.
- Stakes, marking various road design points, are typically destroyed during the clearing and grubbing phase.

- In order to relocate the stakes (centerline, slope stakes) it is helpful to establish reference points outside the clearing limits. Reference points should be set behind the uphill clearing limits.
- On the average, reference points (or RP's) should be set at least every 70 to 100 meters.
- Typically, reference points are placed at points where the center line alignment can be easily re-established, such as points of curvature

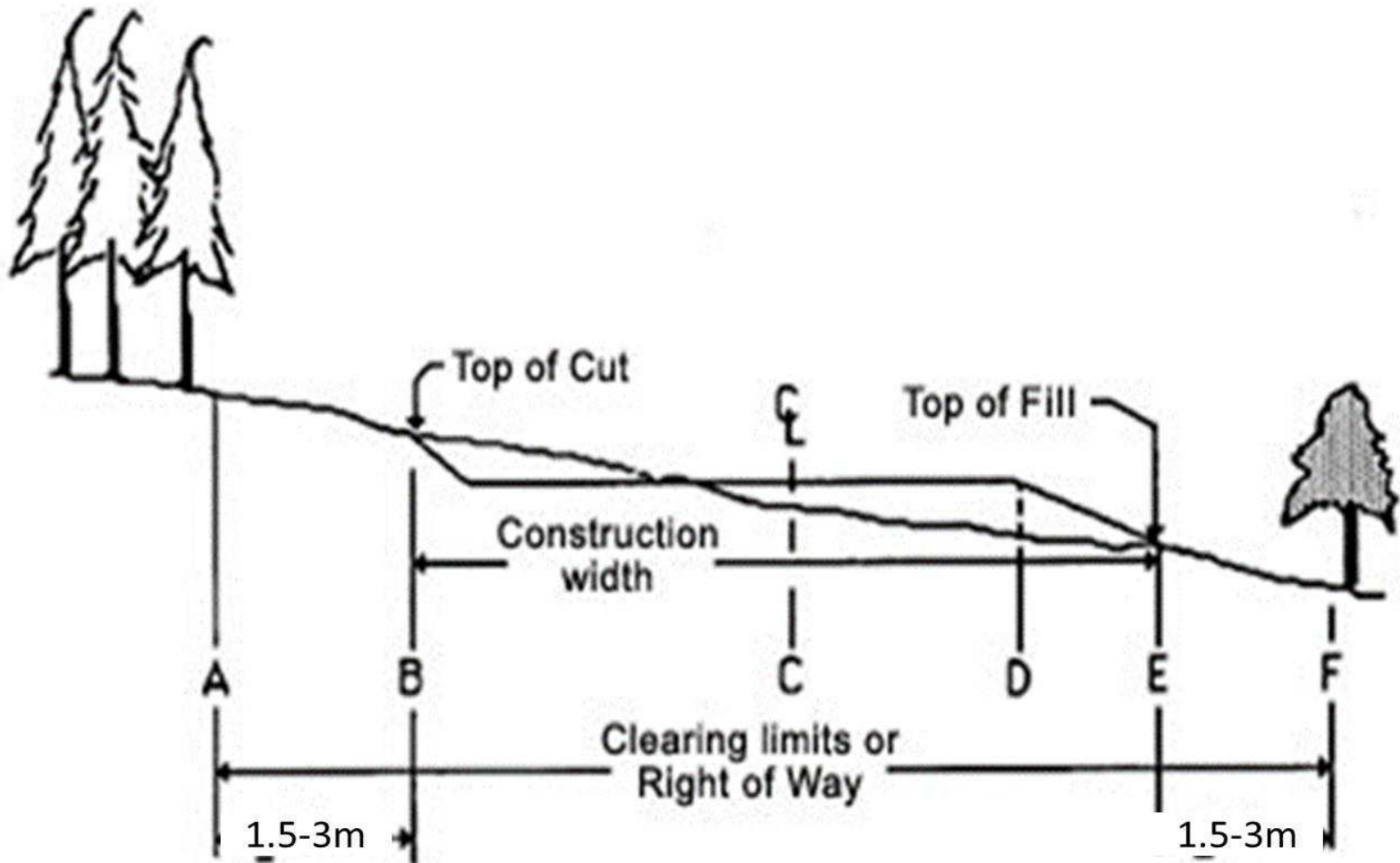
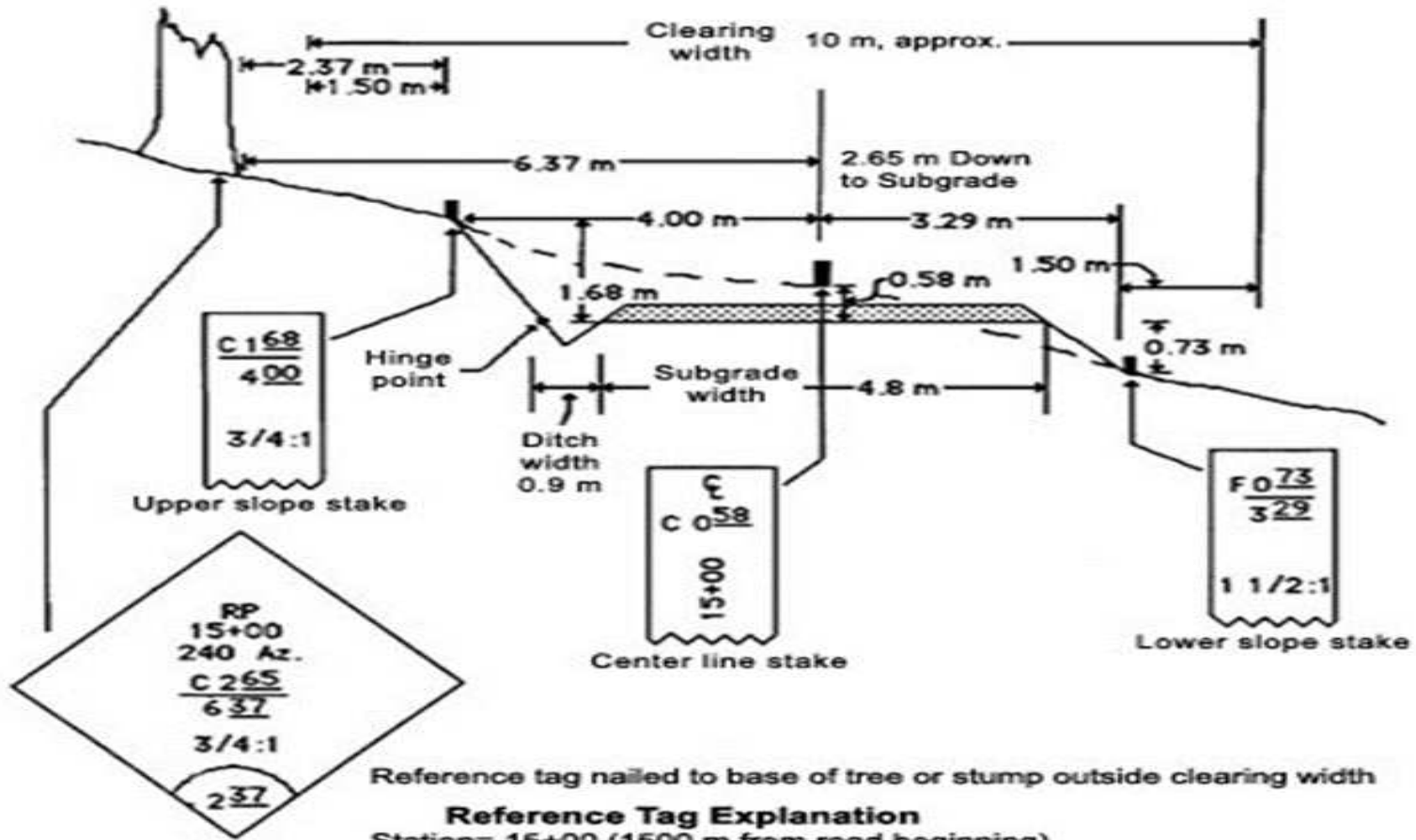


Figure: Clearing limits



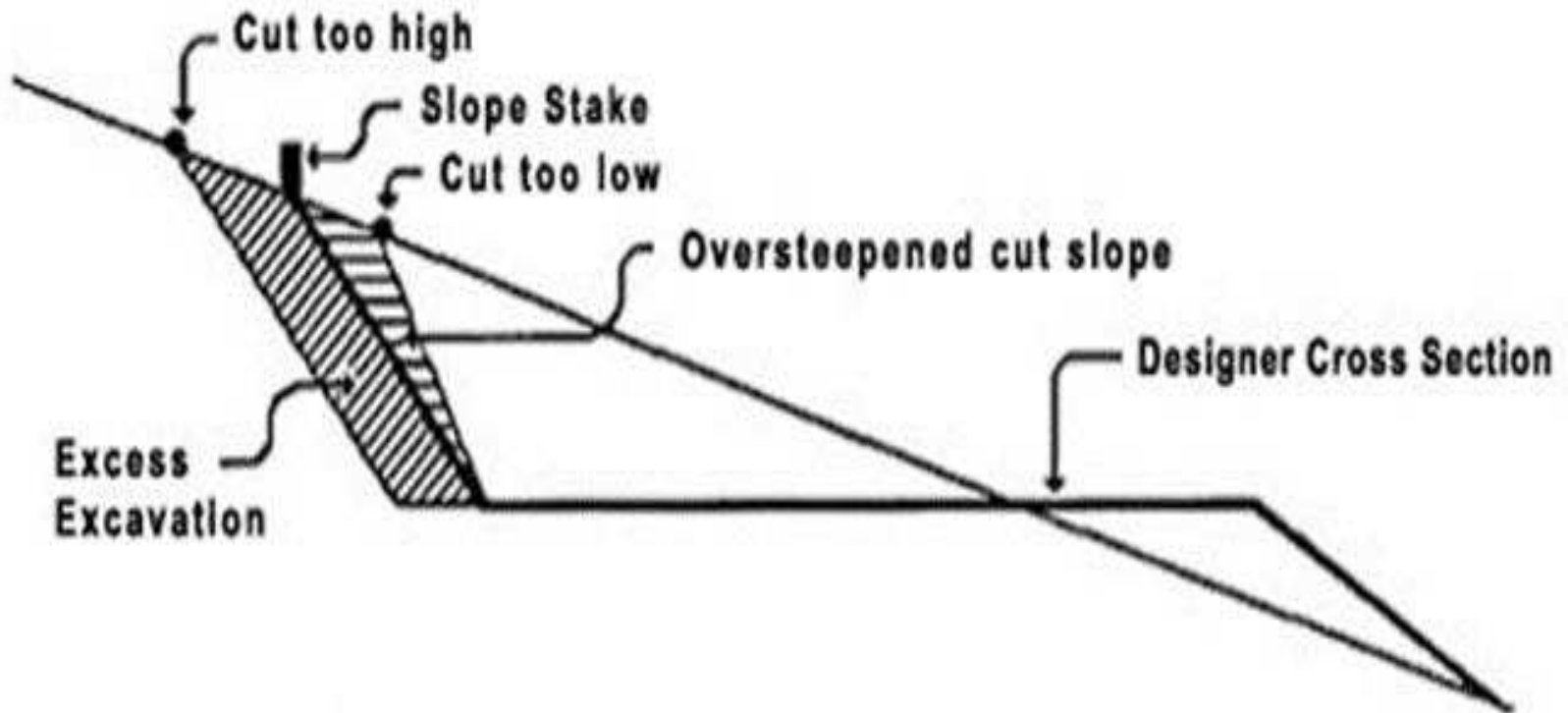
Reference tag nailed to base of tree or stump outside clearing width

Reference Tag Explanation

- Station= 15+00 (1500 m from road beginning)
- = Planned centerline is 2.65 m below this point
- = Centerline is 6.37 m horizontal distance away
- 3/4:1 = Cutslope steepness
- = 2.37 m to point where cutslope begins
- 240 Az.= Compass direction from RP to centerline stake

Figure: Road cross section showing possible construction information.

Figure: The effect of improperly starting the cut as marked by the slope stake. Starting the cut too high results in excess excavation and side cast. Starting the cut too low leaves an oversteepened cut bank.



1.2 Clearing and Grubbing

- The removal of trees, stumps, roots, down timber, rotten wood, rubbish and other objectionable materials from the site designated by the engineer.
- Measurements of this item for the purpose of payment are made in units of hectare.
 - **Clearing** –the removal of materials above the existing ground surface.

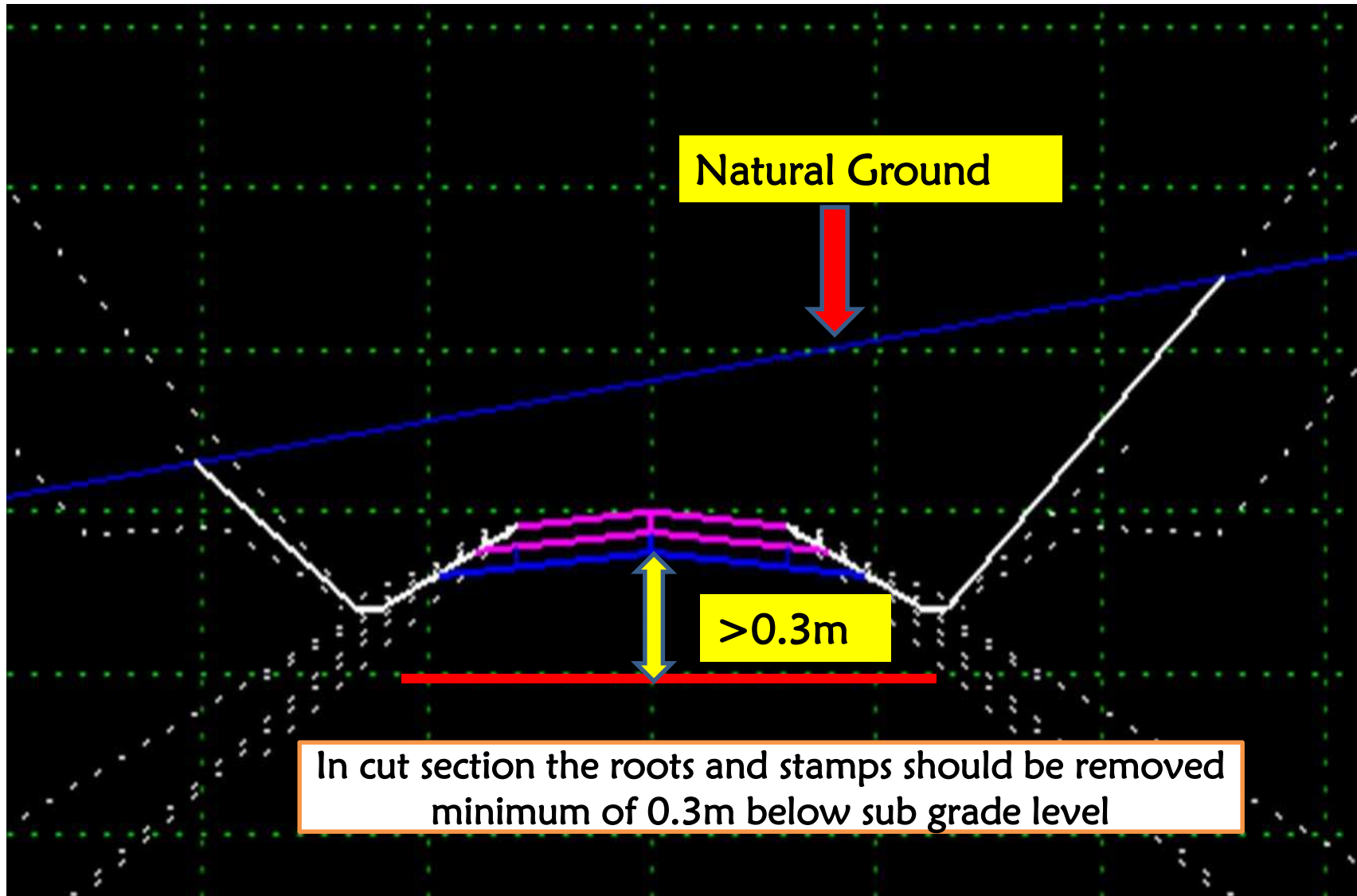
- **Grubbing** – removal of roots, stumps and similar objects to a **normal depth** below the ground surface.
- In cut areas, in addition to the removal of materials above the ground, specification generally require that all stumps and roots should be removed to a depth not less than **0.3 m** below the sub grade level.
- This requirement usually holds in embankment areas where the height of the fill is less than about 1.5 m.

□ In embankment sections, when the height is more than 1.5 m, trees and stumps may be left in place and cut off at ground level or at a height of 75 to 150 mm above the existing ground surface.

□ Some agencies require that all large trees 450 mm or more in diameter be removed, regardless of the height of the fill.

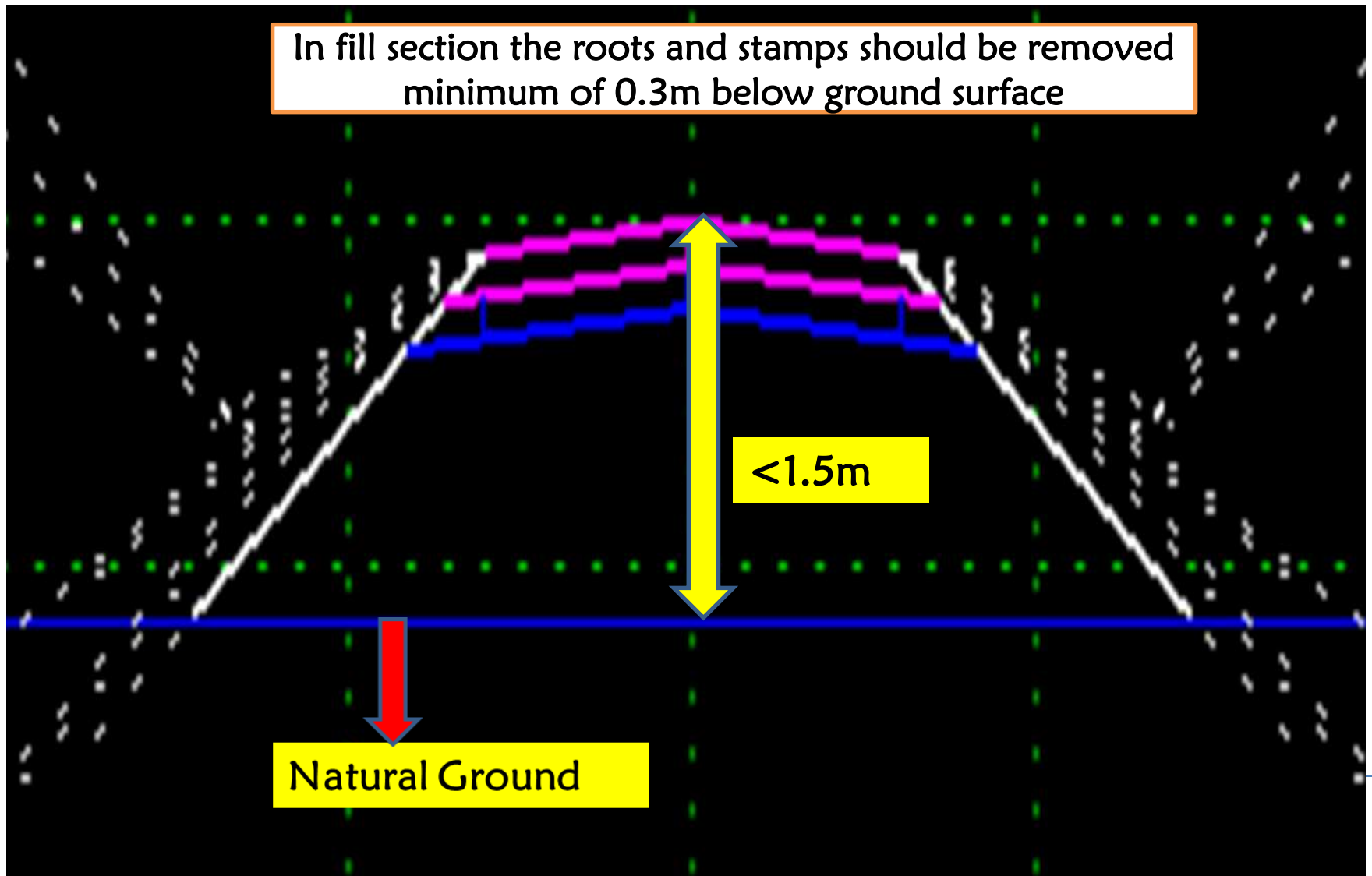
□ Clearing and grubbing operations are generally performed with:

- bulldozer, and tree dozers.
- hand labour may be necessary



Cut Section

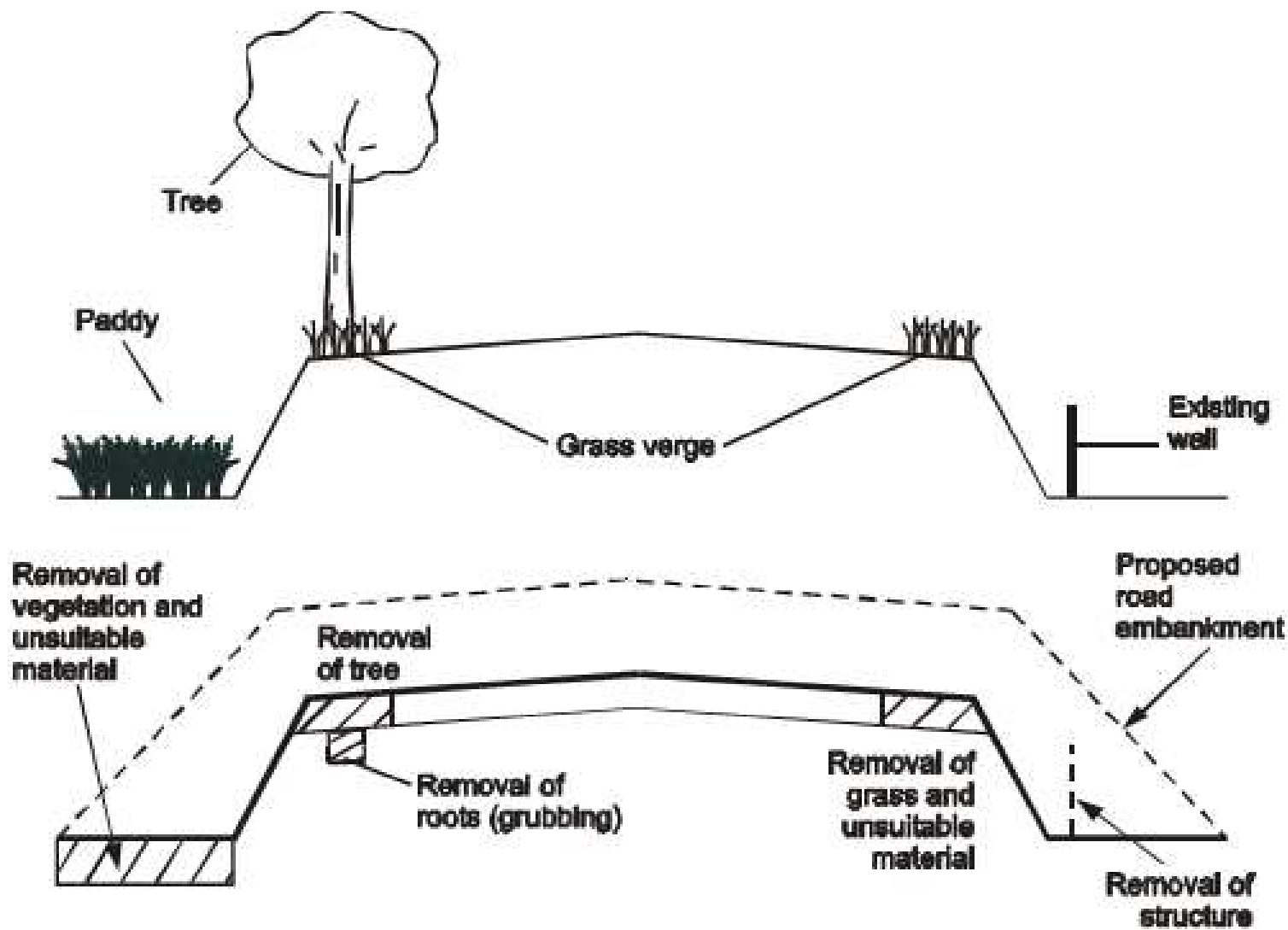
In fill section the roots and stumps should be removed minimum of 0.3m below ground surface



Fill Section

1.3 Demolition of Structures

□ Demolition of buildings, bridges, drainage structures, retaining walls, wells, buildings, service ducts, foundations, fencing, walls, kerbs, old pavements, abandoned pipelines, disused public utilities and any other obstructions which are not designated or permitted to remain.



Clearing and Grubbing and Demolishing of structure

1.4 Earth Work

1.4.1 Excavation

- The process of loosening and removing earth or rock from its original position in a cut and transporting it to a fill or to a waste deposit.
- Specification usually classify excavations based on the type and ease of excavation:
 - Rock Excavation
 - Common Excavation
 - Unsuitable Excavation
 - Borrow Excavation

- **Rock excavation:** materials that can not be excavated without blasting or the use of rippers and all boulders or other detached stones, each having a volume of 1 cub. Meter or more.
- **Common Excavation :** excavation and disposal of all materials of whatever encountered in the work not otherwise classified
- or material which can be efficiently removed or loaded by equipment's.

- **Unsuitable Excavation:** the removal and disposal of deposit of not saturated or unsaturated mixture of soil and organic matter unsuitable for embankment material.
- Unsuitable Material consists of:
 - Peat and other organic materials from swamps, marshes and bogs that contain compressible soils and excessive amounts of degradable organic matter such as decomposing wood and other vegetation
 - Other problem soils such as expansive clays; collapsible sands; dispersive soils; saline soils; micaceous soils; and low strength soils.

- Clay material having a Liquid Limit (LL) $> 60\%$; or a Plasticity Index (PI) $> 30\%$; or CBR value $< 3\%$ at 95% of modified AASHTO compaction (AASHTO method T-180) after 4 days soaking;
- Clay having a swell value $> 3\%$ (with two surcharge rings) when determined in accordance with AASHTO T-193 at 95% of modified AASHTO compaction.
- **Borrow Excavation:** Excavation of approved material required for the construction of embankments and other element of the road.

- All excavated materials that are suitable are used in constructing the elements of the roadway structure, including embankments, shoulder, subgrade, slopes, and backfill for structures. Unsuitable or surplus materials are disposed.
- Specifications or provisions are normally given for every activity in the clearing and excavation works including for grading, the roadbed, intersections, shoulders, slopes, ditches, etc.. in accordance with the plans and alignment.

□ When rock is encountered in cut sections, it is generally required that it be excavated to a depth of at least **150 mm** below the grade line and that suitable backfill material then be used in bringing the cut section up to the proposed grade.

Equipment

- Common Excavation

Excavator

Dozer

- Hard Rock Excavation

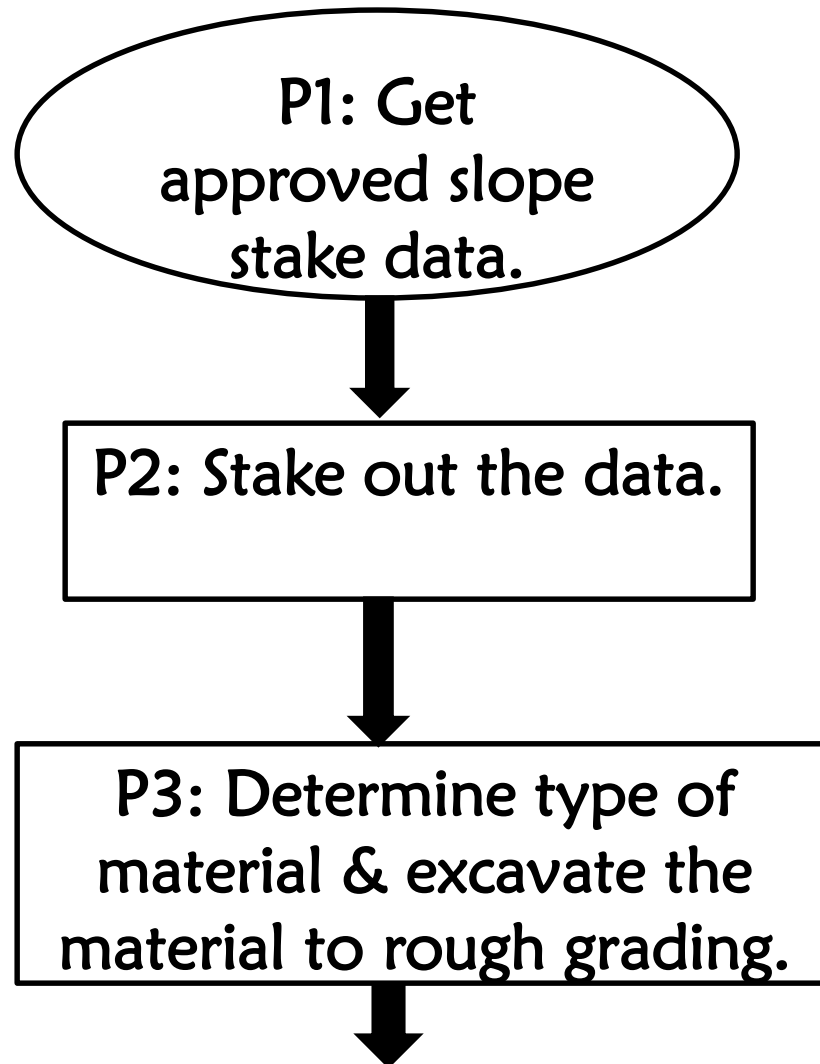
Excavator

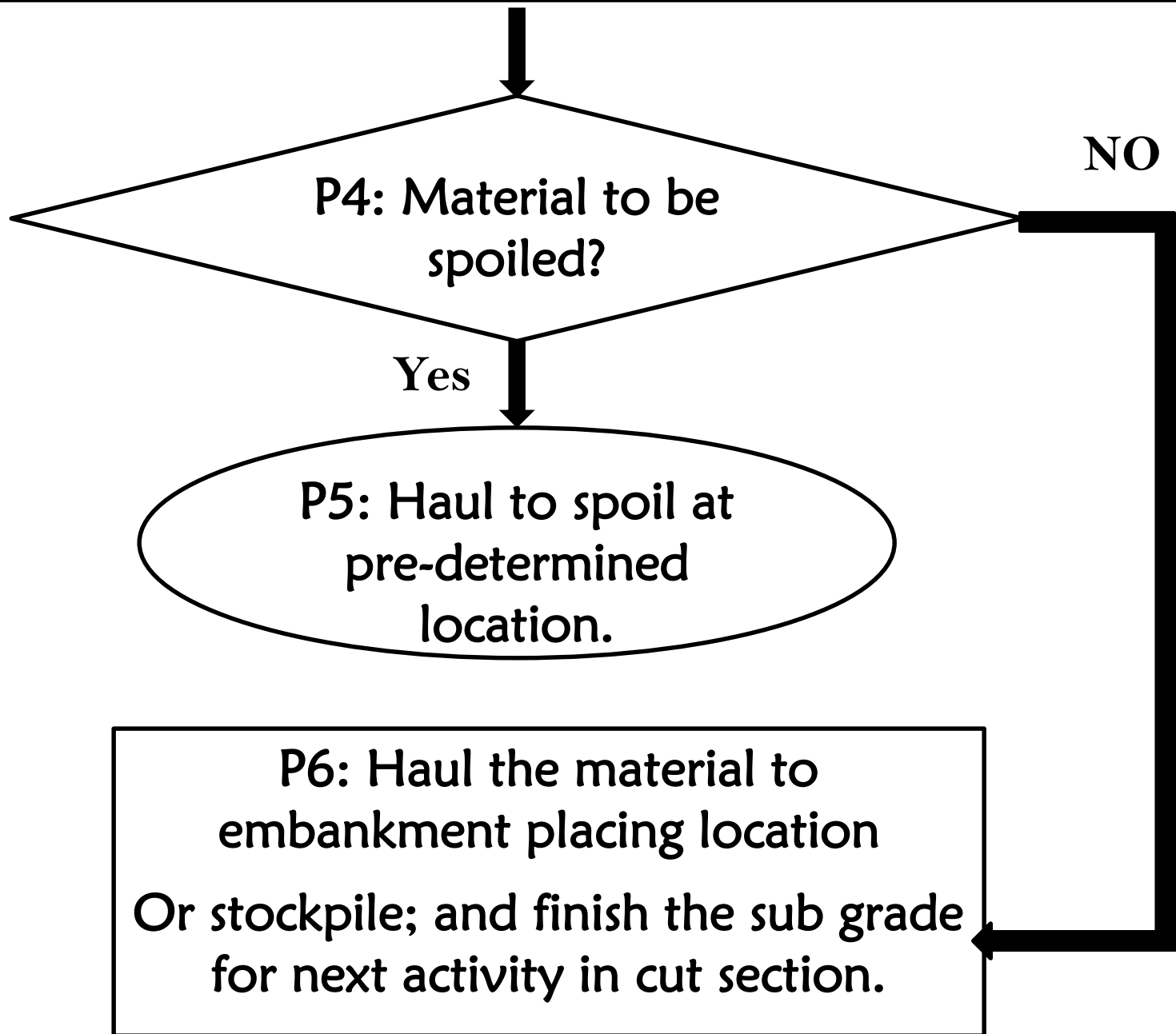
Dozer

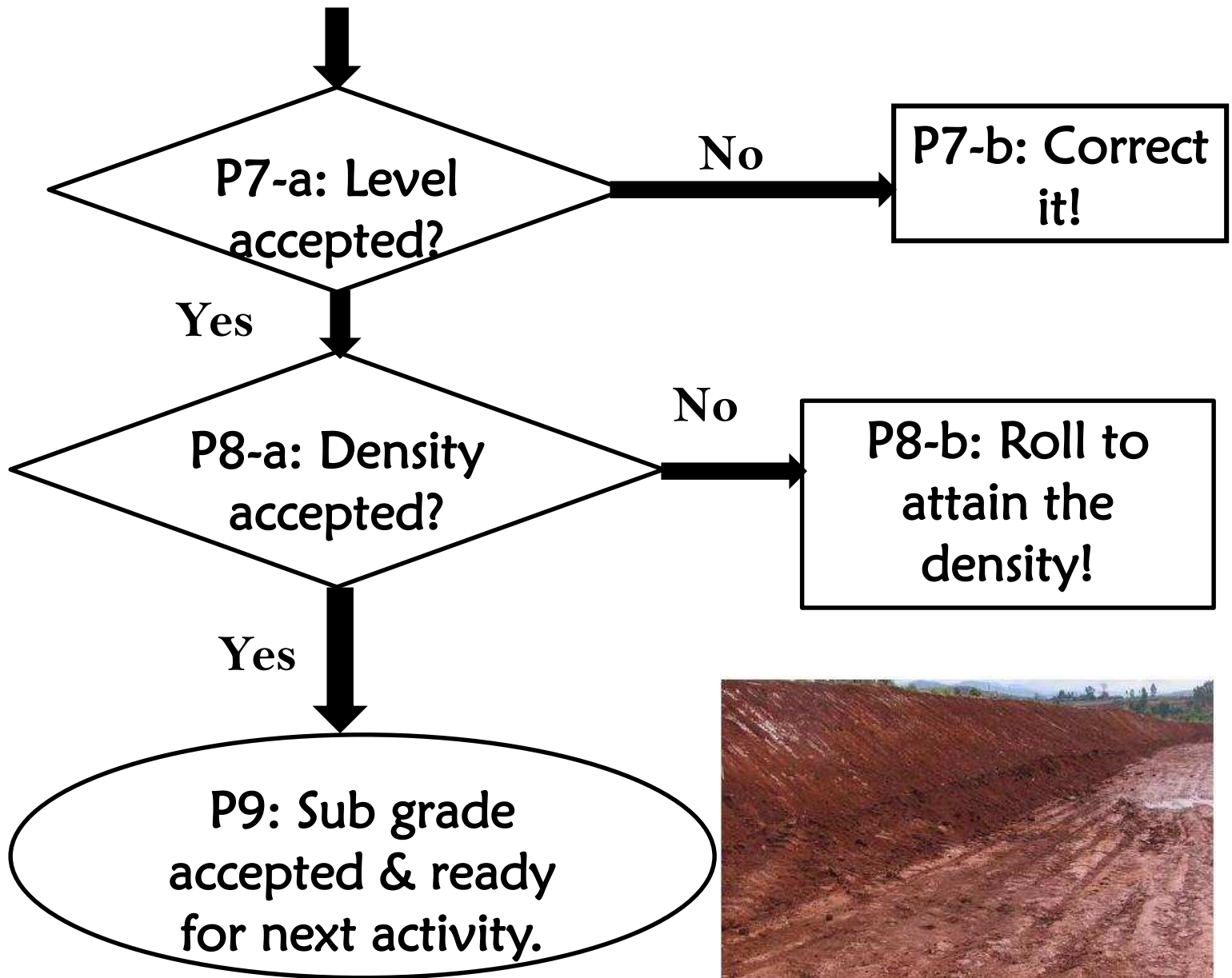
Air compressor

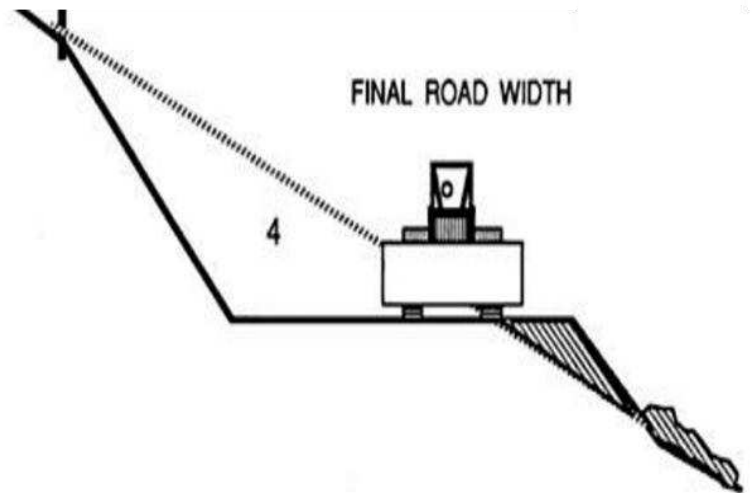
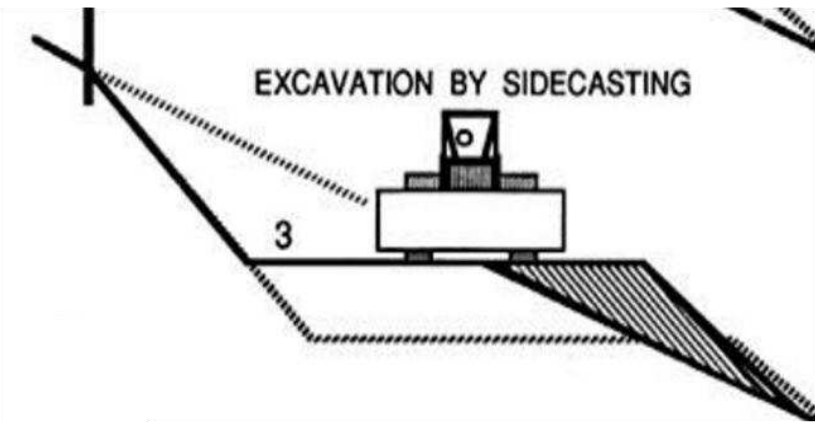
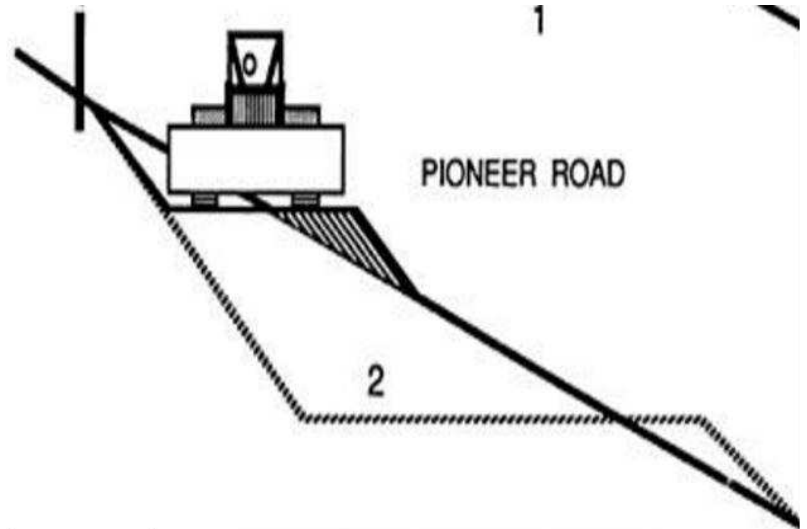
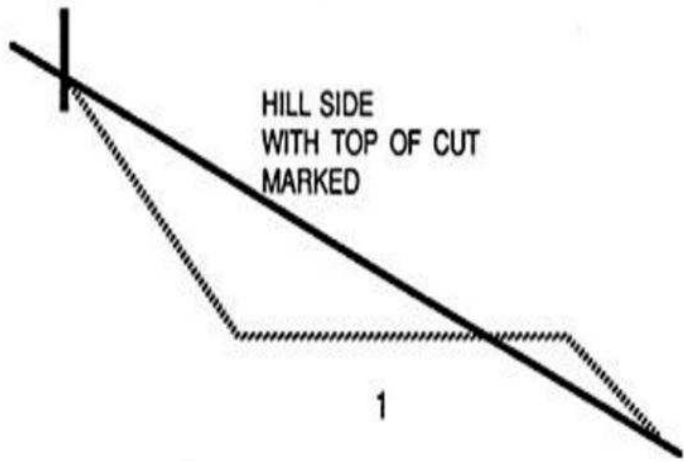
Wagon Drill

□ Earthwork (Excavation in all Materials to Spoil & Sub grade Finishing)
process









Subgrade preparation with dozer

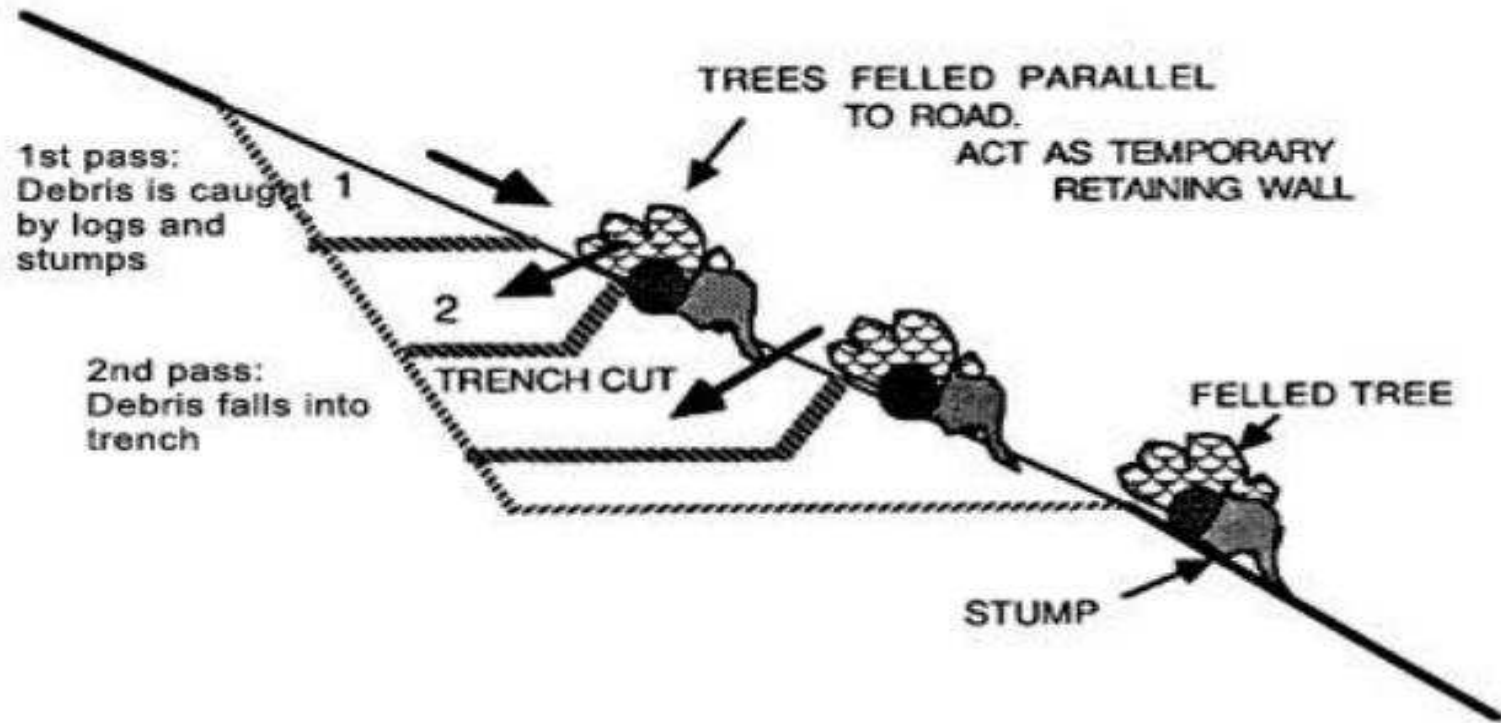


Figure: Trench-excitation to minimize side hill loss of excavation material. Debris and material falls into trench in front of the dozer blade. Felled trees and stumps are left to act as temporary retaining walls until removed during final excavation.

1.4.2 Embankments

- The fill added above the low points of the existing ground surface along the roadway to raise the level to maintain the required design standard or prevent damage to the highway through the action of surface or ground water.
- In the majority of cases, rolled-earth fills of 4.5 m or less in height (commonly less than 1 m) are used,
- The basic factors involved in the design of embankments include height, stability of slopes, stability of foundations, and the selection of materials.

1) Height:

- fixed by consideration related to the general location of the road to **maintain the grade** to some fixed point as in the approach of bridge or a large culvert structure, or to maintain desirable grades in rolling or mountainous country.
- In low-lying areas where the water table is at or close to the surface of the ground, the minimum height of embankment is frequently established by the desirability of preventing the intrusion of the ground water into the subgrade and to be at least **0.6 m** above the water table, and it may be considerably more when soils subjected to capillary action.

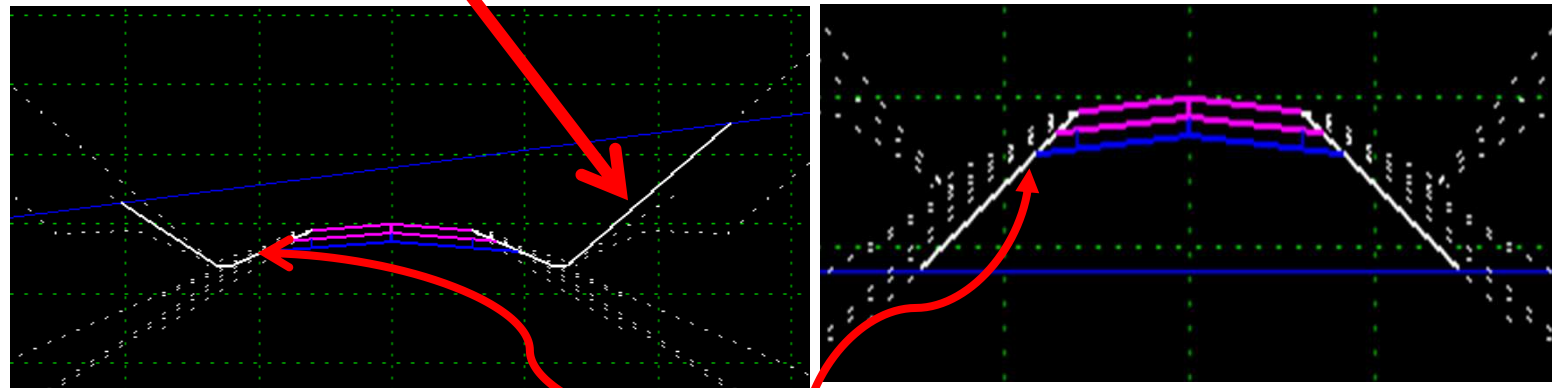
2) Embankment slopes:

- flat side slopes are generally preferred to facilitate maintenance and for embankment stability.
- Embankments constructed of high quality material (A-1 and A-3) can be constructed with slopes as steep as 1.5 to 1 .
- For other soil classes, a maximum slope 2 to 1 has been recommended, and where flooding is suspected, a 3 to 1 is preferred.

□ ERA's Recommendation

Material	Height of Slope	Side Slope		Back Slope	Zone Description
		Cut	Fill		
Earth or Soil	0.0 - 1.0m	1:4	1:4	1:3	Recoverable
	1.0 - 2.0m	1:3	1:3	1:2	Non-recoverable
	Over 2.0m	1:2	1:2	1:1.5	Critical
Rock	Any height	See Standard Details			Critical
Black Cotton Soil*	0.0 - 2.0m	-	1:6	-	Recoverable
	Over 2.0m		1:4		

Back Slope



Cut section

Side Slope

Fill Section

3) Embankment foundation:

- The design of embankment consists of checking the stability of the side slopes or the body of the embankment itself.
- It should, however, include an examination of the soil beneath or “the embankment foundation” against failure due to excessive stress of the weight of the fill (low bearing capacity) or settlement due to consolidation of the underlying soil.

- These occur when a high fill is founded on cohesive soil or where the foundation material is soft, compressible, fine-grained soil, such as organic silt or clay, peat, or muck.
- The general practice require that the original ground be compacted before the overlaying layers are placed to a depth of 100 to 300 mm.

4) Selection of Materials

Material Requirements for the Construction of Embankments

1. Particle size	Well Graded
2. Grading Modulus	Min. of 0.75
3. CBR	Not less than 5% AASHTO T-193
4. Swell	Not more than 2% AASHTO T-193
5. LL	Not exceeding 60 AASHTO T-89,90
6. PI	Not exceeding 30 AASHTO T-89,90

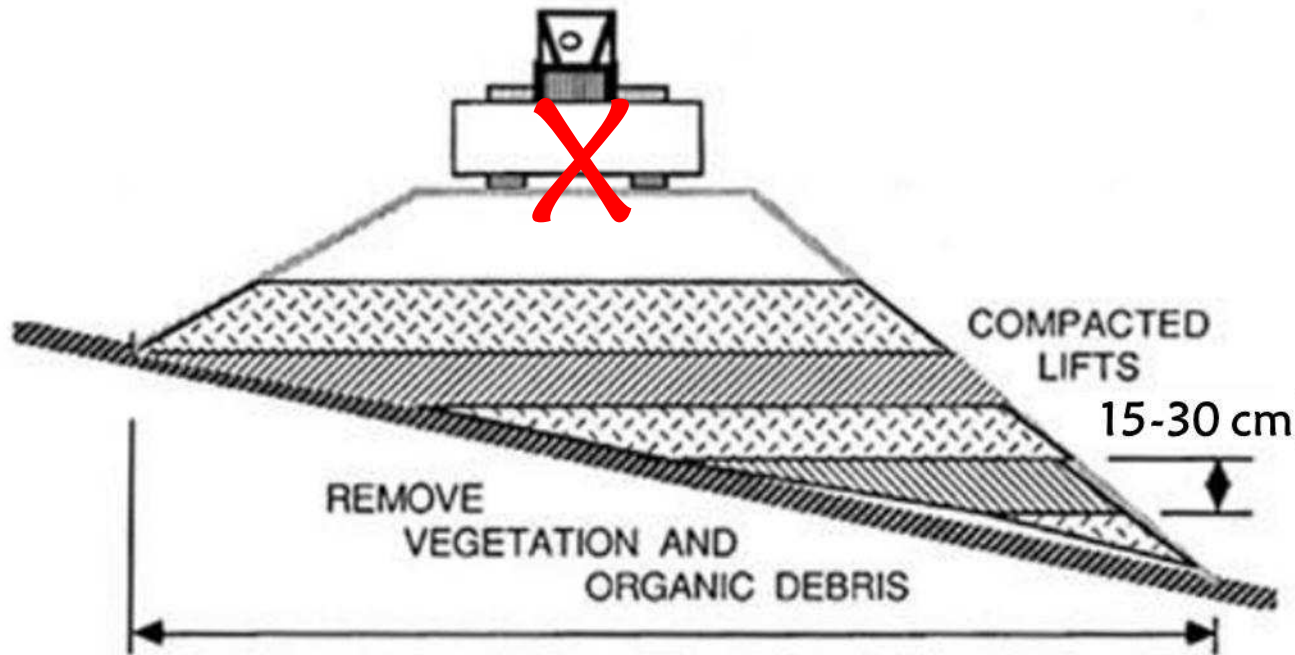
- For each layers of fill, the fill material shall not contain particles with a maximum dimension exceeding two-thirds of the specified layer thickness after compaction (except in the case of rock fill)

1.4.2.1 Embankment Construction

- Embankments are constructed by spreading uniformly a thin layer of 150 to 300 mm thick loose soil and compacting it to a satisfactory degree of density before the next layer is placed over it up to the desired height of the embankment.
- ❖ Two general methods of construction are used:
 - Direct dumping and spreading the soil by **scarper units** in one operation depending on the suitability of the units, and
 - Dumping of the material at proper locations by trucks or wagons, and the dumped material is then spread to the required uniform thickness by dozers or motor graders.
- ERA recommends that the upper 25 cm of soil immediately beneath the subbase or capping layer, i.e. the top of the embankment fill or the natural subgrade, be compacted to a minimum of 100 % of the maximum dry density obtained (standard compaction). Alternatively, 93 % of the maximum dry density achieved (heavy compaction) may be specified.

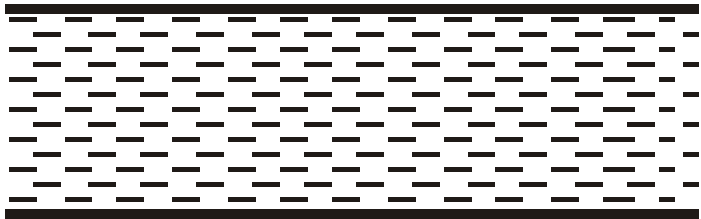
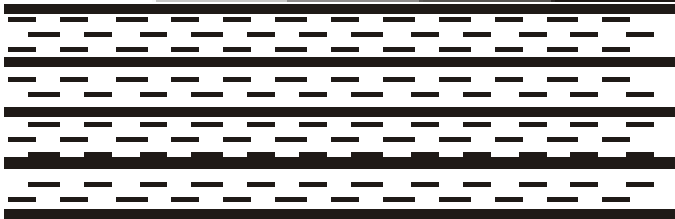


Construction of Embankments



- Figure: Fills are constructed by layering and compacting each layer. Lift height should not exceed 30 cm. Compaction should be done with proper compaction equipment and not a bulldozer. In case of cohesionless sand thickness may be up to 40cm

Comparison of Alternative Methods

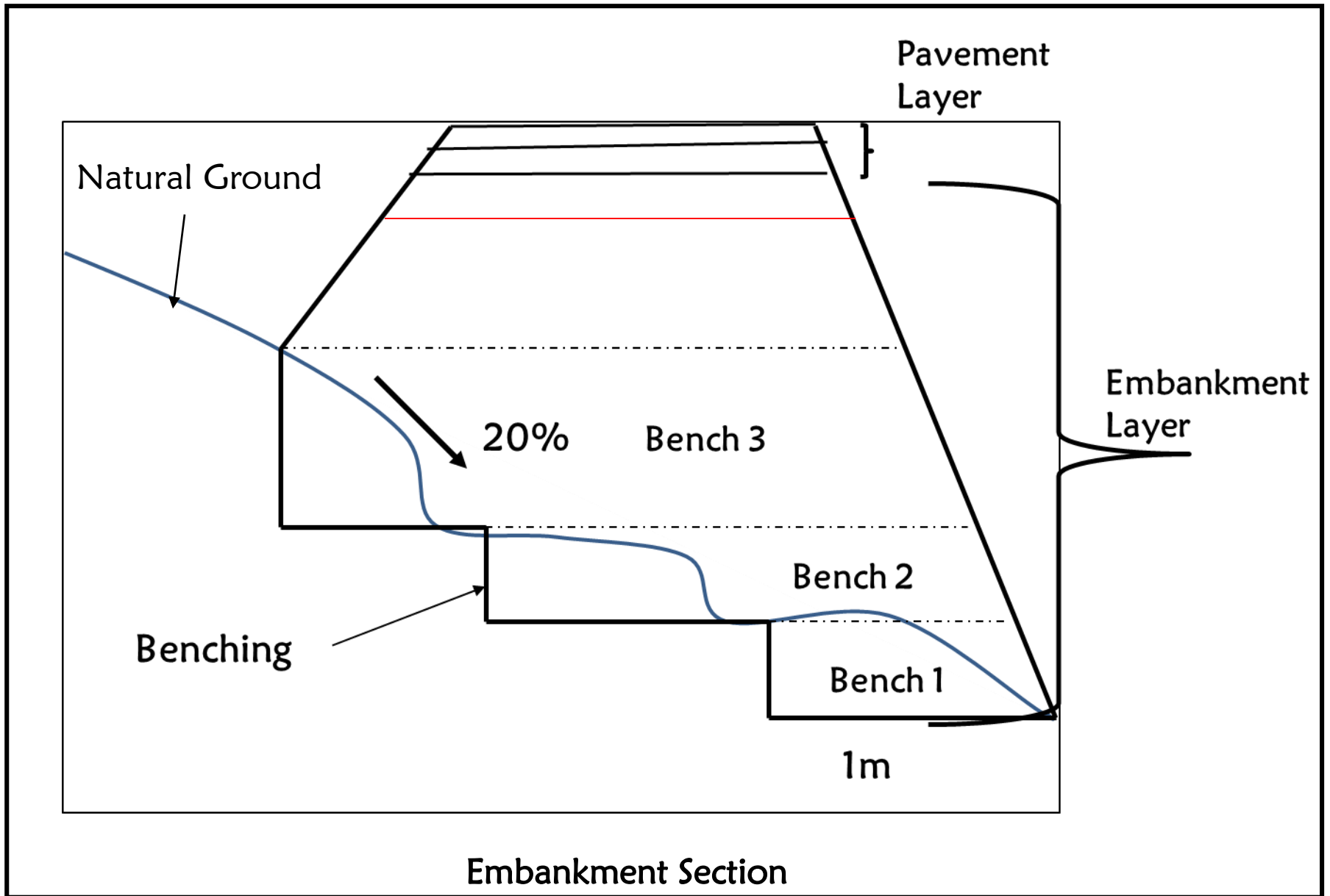
THICK LAYER PLACED THEN COMPACTED	THINNER LAYERS EACH COMPACTED
	
<p>Top of layer compacted, but overall poorly compacted.</p> <p>Gaps between materials (high voids).</p>	<p>All layers well compacted.</p> <p>Few gaps between materials (low voids).</p>
<p>Poor compaction.</p> <p>Allows water to enter layer. Weakens the material.</p> <p>Settling in time, may cause uneven pavement surface.</p>	<p>Good compaction.</p> <p>Prevents water entering layer. (material retains its strength).</p> <p>Little Settlement.</p>
UNACCEPTABLE	APPROVED MANNER
	SPECIFIED



Failure due to thick layer placed compacted

1.4.2.2 Benching

- Where the slope of the existing ground, in any direction is greater than 20%, the existing ground shall be excavated to form horizontal benches which shall be a minimum of 1m wide or otherwise, as described in the Contract. Each bench shall be excavated as the fill material is compacted and the embankment is raised.
- This requirement shall also apply to embankments constructed on rock with slopes greater than 20%.
- Suitable material excavated from the benches shall be incorporated into the embankment.



□ The field compaction is controlled by making frequent checks of the density and moisture content using suitable techniques.

□ Principal factors involved in the selection of compaction equipment for use on a given project include the specifications under which the work is to be carried out **based on the type material to be compacted and the choice of equipment available to the contractor.**

□ Compactors include tamping, sheeps foot, grid, pneumatic-tired, and smooth steel-wheeled rollers; segmented plate compactors; vibratory compactors; and others. They are available in various weights.

□ 1.4.2.3 Embankment Construction in Problem Areas

- If problem soils be found (and especially expansive soils with $PI > 30\%$, and $swell > 2.0\%$), the problem soil shall be excavated to the required depth in line with the ERA's Site Investigation Manual and replaced by a non-expansive material with CBR of 5-7% to the satisfaction of the Engineer.

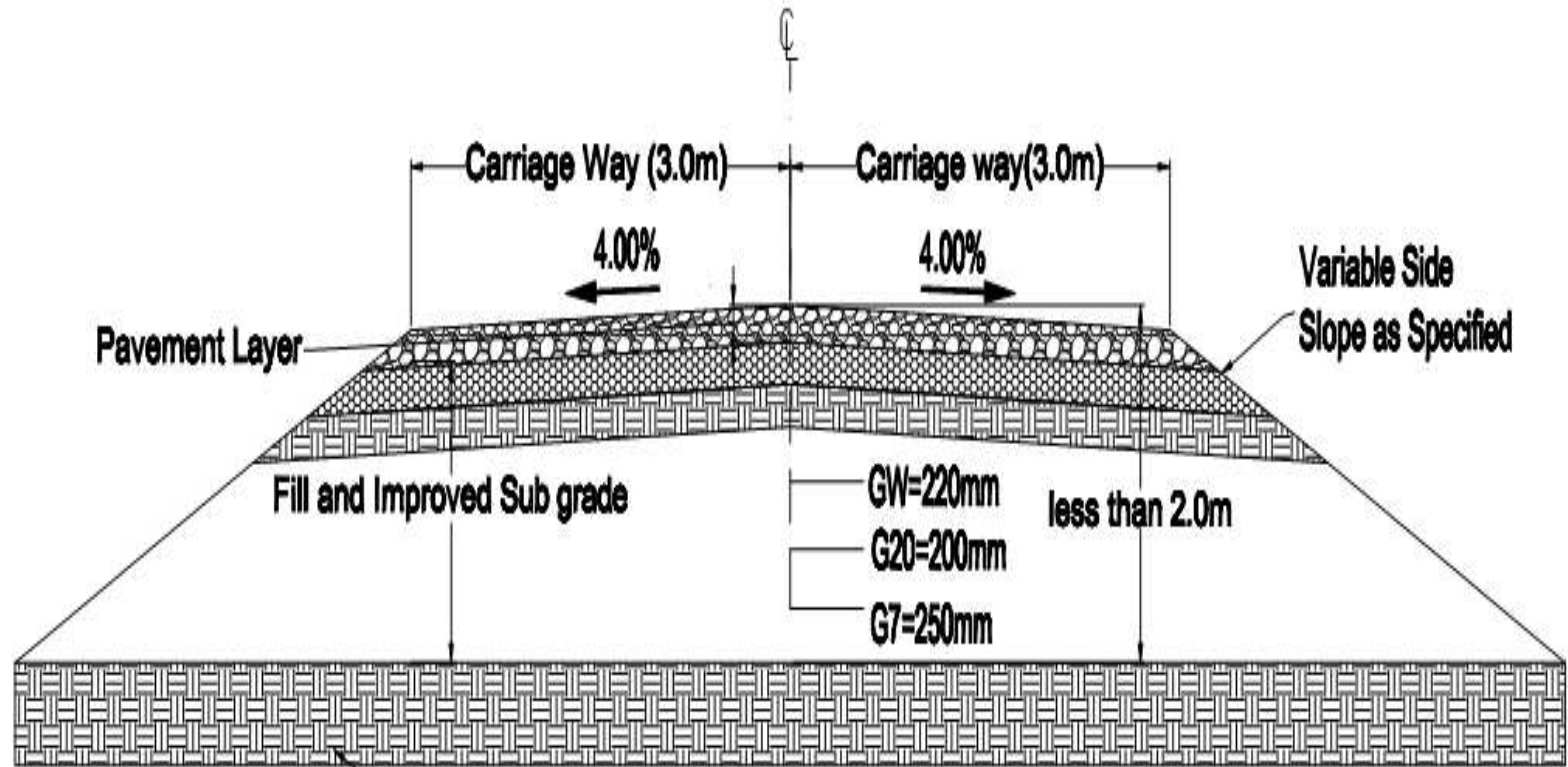
□ The following minimum treatment shall apply

□ Removal of problem soil;

- Where the finished road level is designed to be less than 2m above ground level, remove the problem soil to a minimum depth of 600mm over the full width of the road

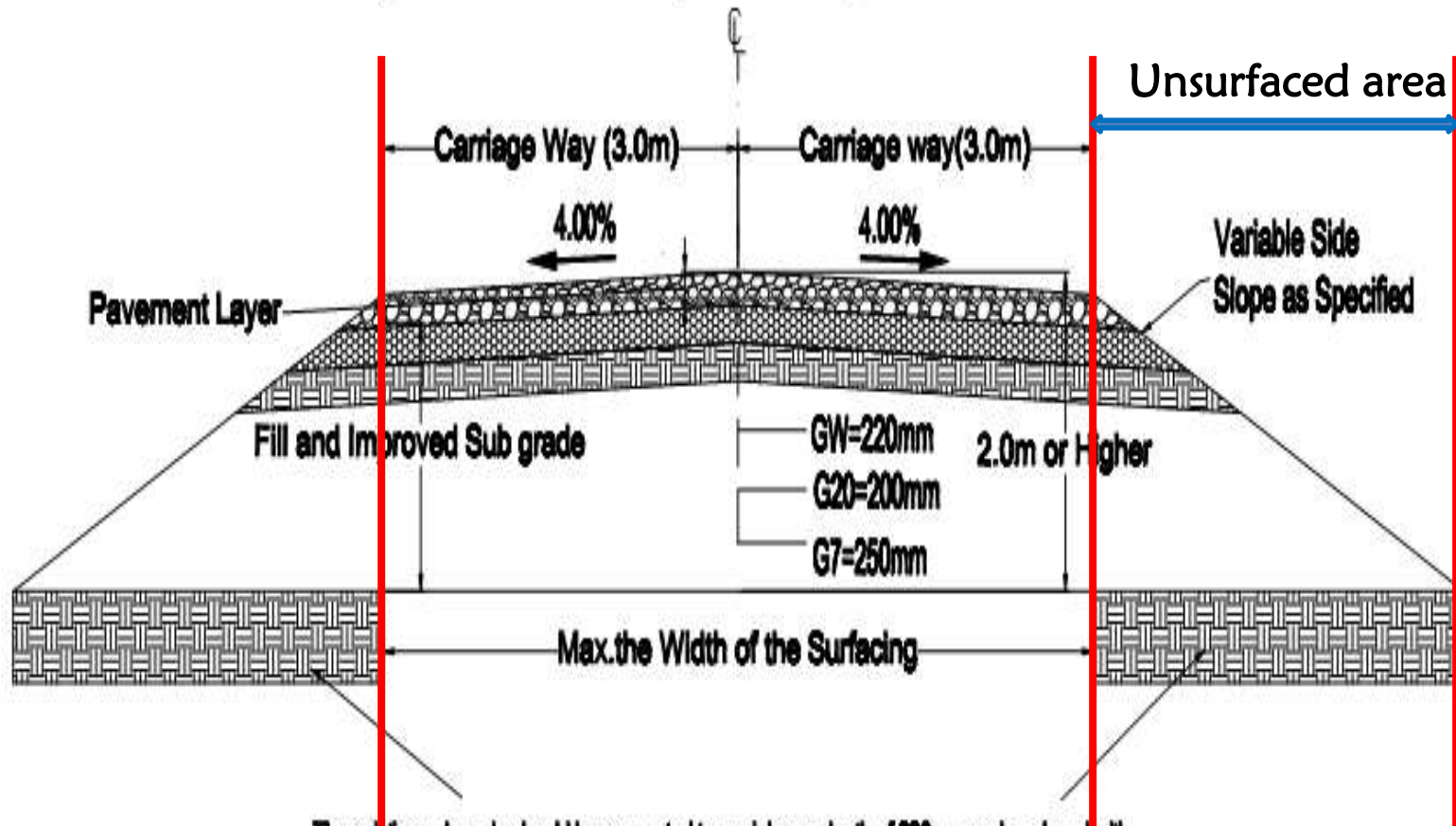
- Where the finished road level is designed to be greater than 2m above ground level, remove the problem soil to a depth of 600mm below the ground level under the unsurfaced area of the road structure;
- Where the expansive soil does not exceed 1m in depth, remove it to its full depth.
- The excavated area shall be backfilled with a non-expansive material of CBR value greater or equal to 5% and swell value of less than 2% compacted to a density of 93% modified AASHTO T-193.

Typical cross-section - 1 for design section with expansive soil stretches



The existing subgrade should be excavated to a minimum depth of 600mm and replaced with selected borrow material having a CBR value of greater than 5% and Swell value of less than 2% .

Typical cross-section - 1 for design section with expansive soil stretches

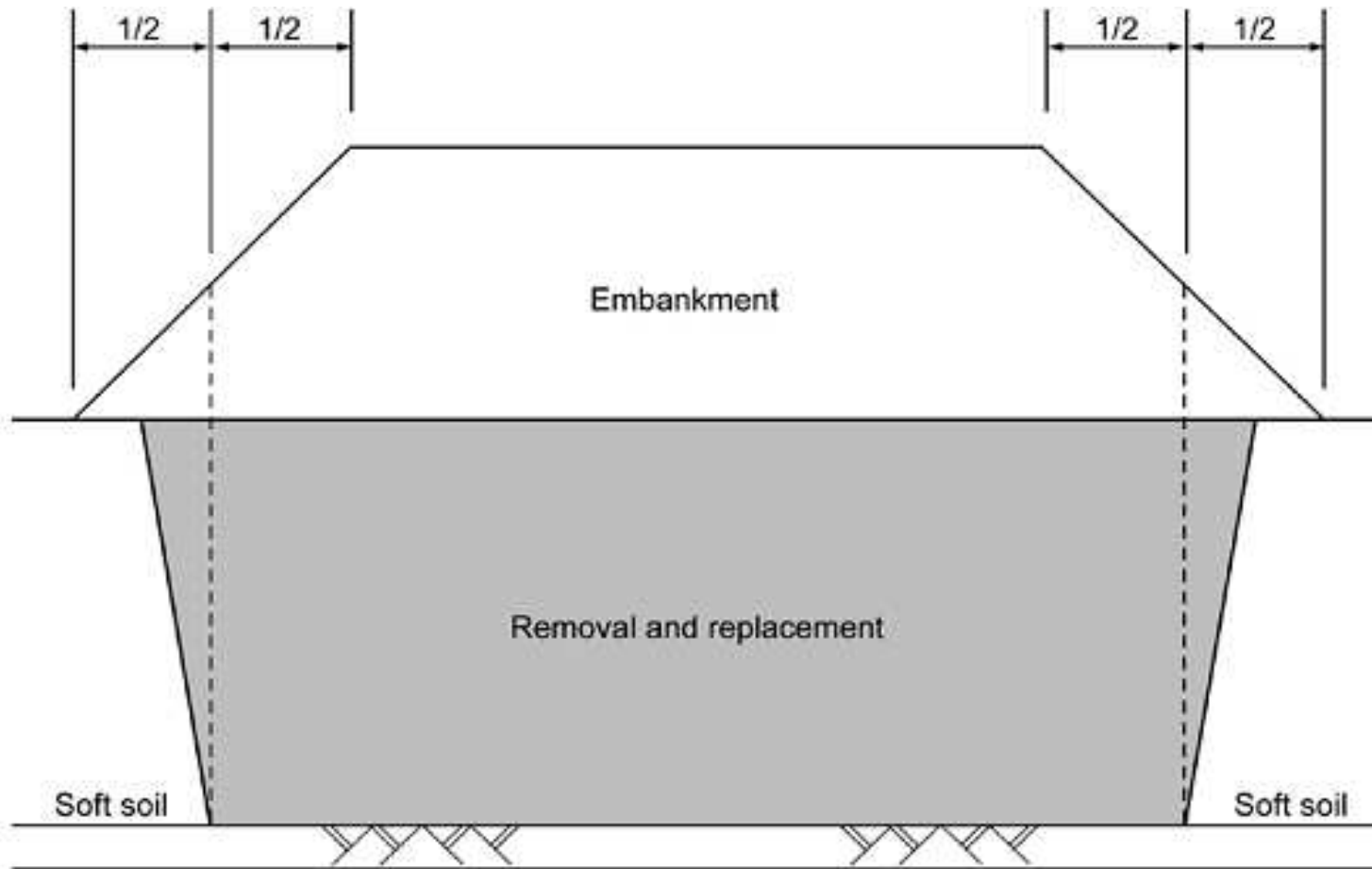


The existing subgrade should be excavated to a minimum depth of 600mm and replaced with selected borrow material having a CBR value of greater than 5% and Swell value of less than 2%.

1.4.2.3 Methods of embankment construction on marshy area

Conventional construction is unsatisfactory and special procedures are necessary to construct embankments through marshy areas. These include:

1. **Removal and replacement method:** suitable where the undesirable soil is of shallow depth say up to 2.4 to 3.0m and is under laid by a soil of satisfactorily character or rock. Some times, partial excavation and replacement is practiced for secondary roads when encountered deep swampy deposits.



Removal and Replacement beneath the embankment

□ because of high costs associated with excavating and disposing of unsuitable soils and the difficulty of excavating below the water table, removal and replacement is only justified under certain conditions. Some of these conditions include the following:

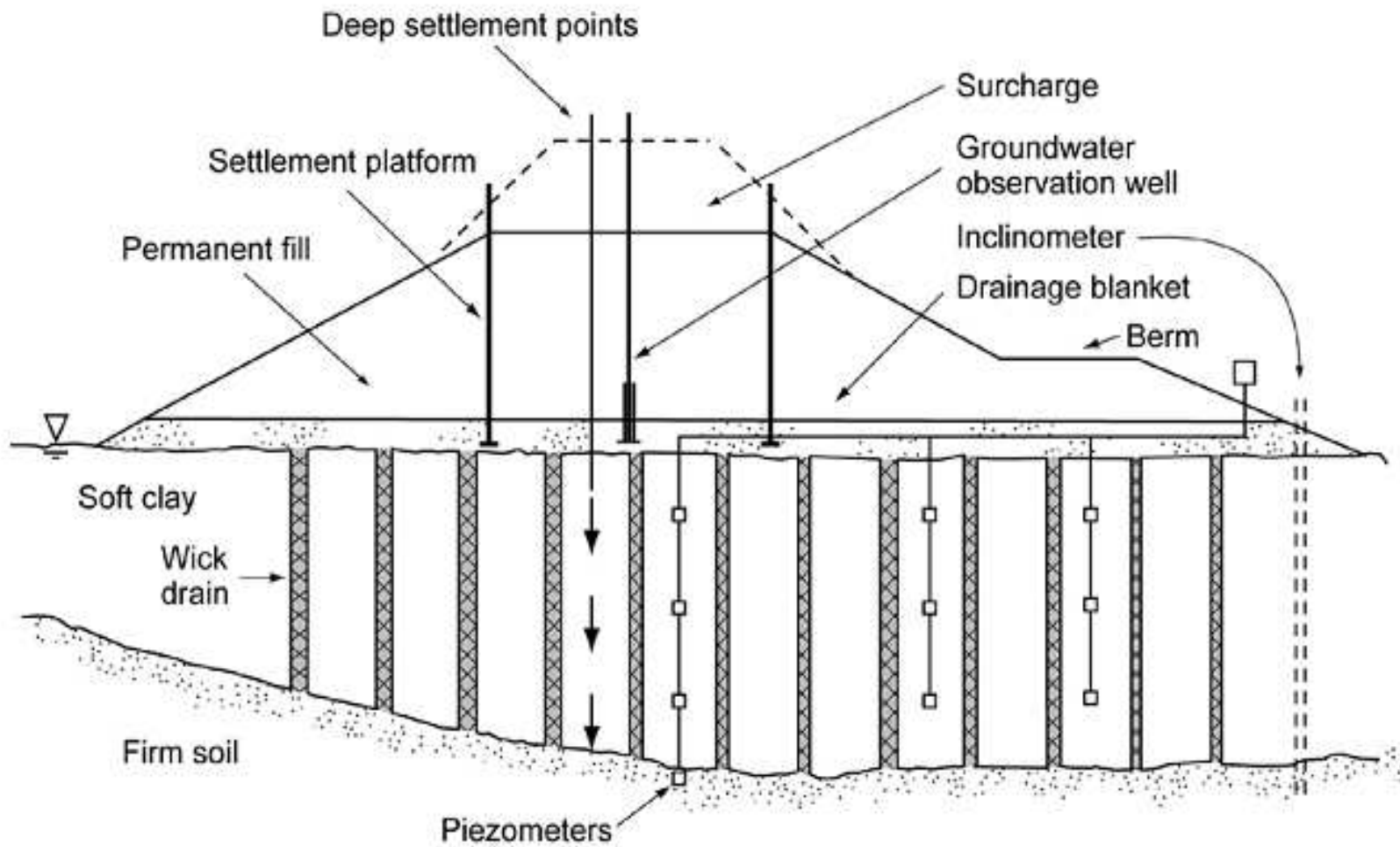
- The area requiring over-excavation is not wide;
- The unsuitable soils are near the ground surface and do not extend very deeply (removal of unsuitable material beyond the depth of 3 m is not normally economically feasible);
- Temporary dewatering is not required to support or facilitate the excavation;
- Suitable fill materials are readily available to replace the volume of unsuitable soils.

2. Displacement method: this is a method by which the unsuitable muck is displaced by the weight of the fill and possibly a surcharge or by this weight supplemented by explosives or water jetting. The blast serve to displace the material by the force of the explosions and by liquefying the remaining unsuitable material so that it is displaced more readily by the weight. The process of jetting involves the pumping of water into the underlying soil layer in order to liquefy and ease the displacement of the layer by the weight of the embankment. The surcharge is uncompacted fill added over the compacted fill to accelerate the displacement.

3. Vertical sand drain: it is a method by which vertical columns of sand from 450 to 600mm in diameter, spaced from 2 to 6 m apart on centers beneath the embankment section carried completely through the compressible soil to accelerate consolidation.

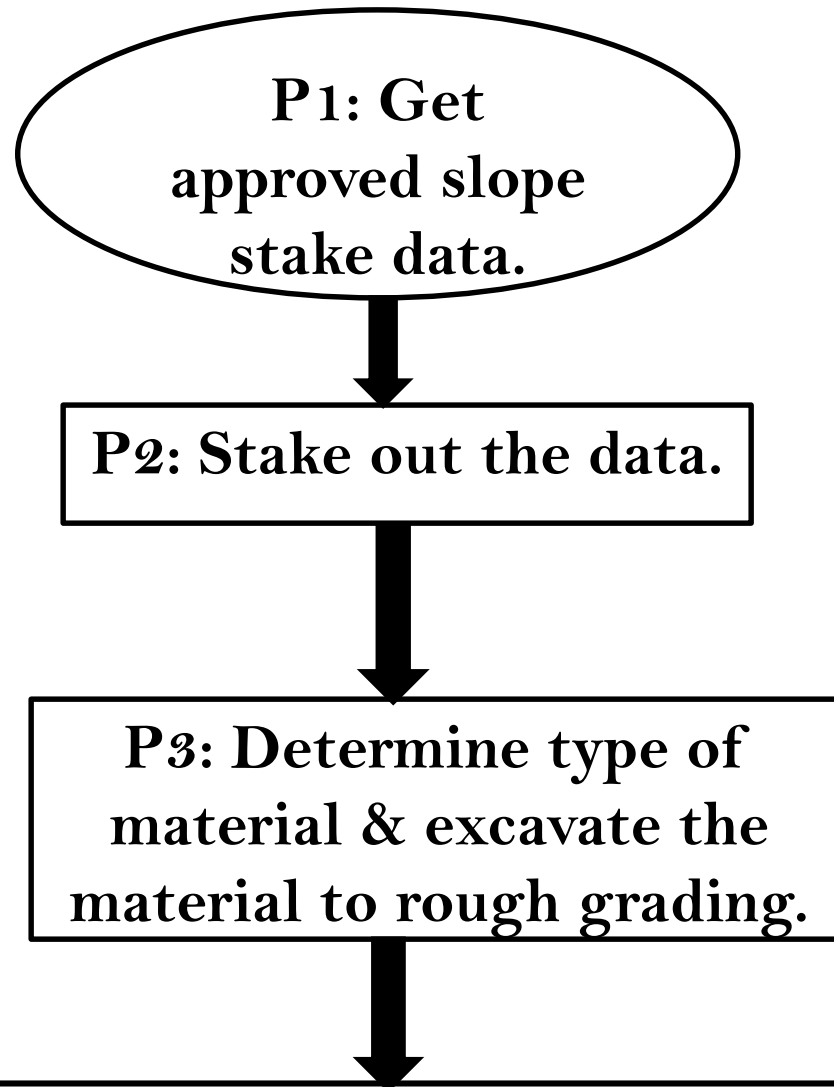
□ A sand blanket 1 to 1.5 m thick is generally placed at the top of the drain extending across the entire width of embankment section. The embankment is then constructed by normal methods on top of the sand blanket.

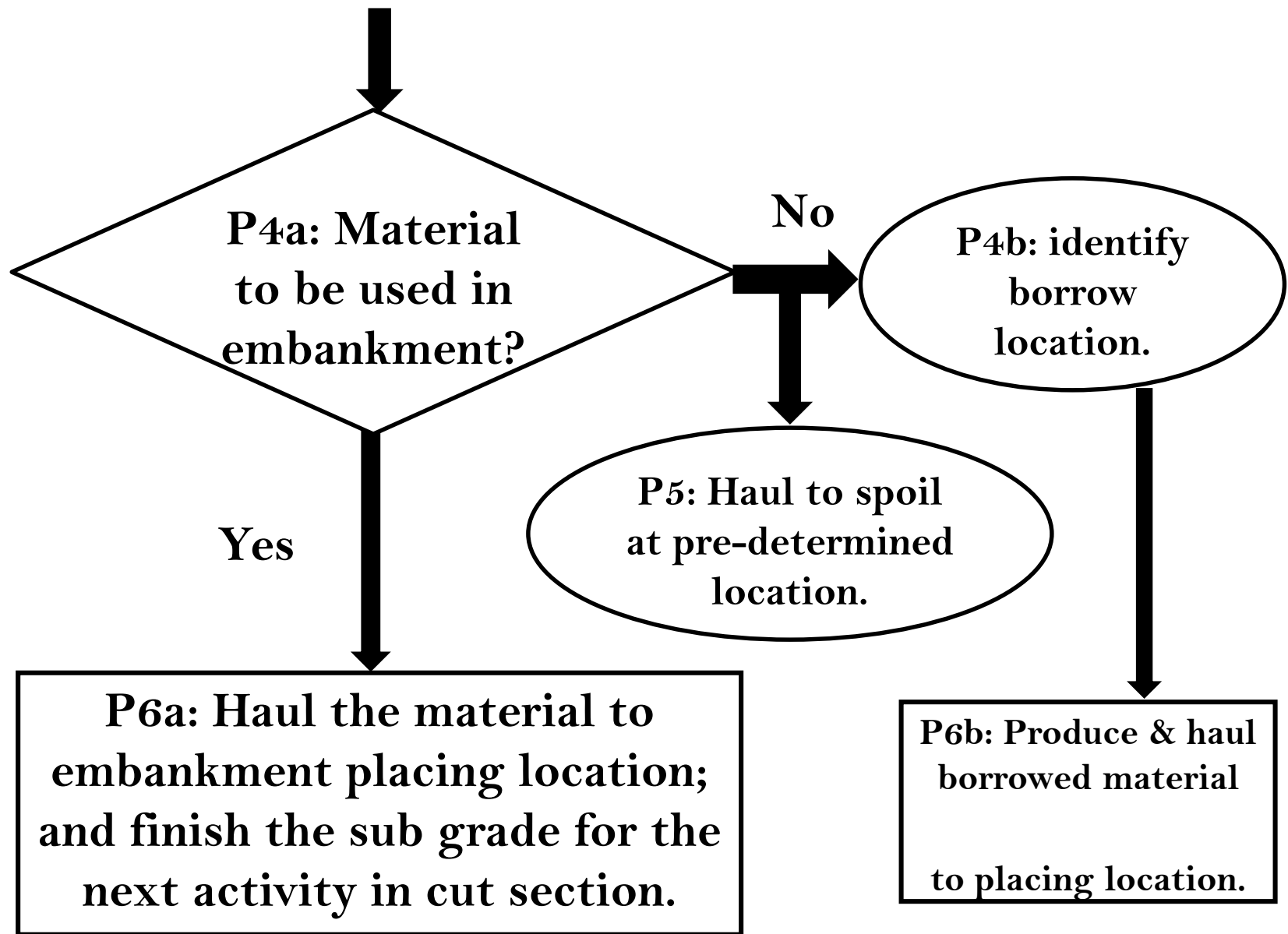
4. Fabric reinforcement: this is the use of engineering fabrics such as geotextiles or geotechnical fabrics placed on weak foundation (to increase the bearing capacity) and overlaid with the embankment fill.

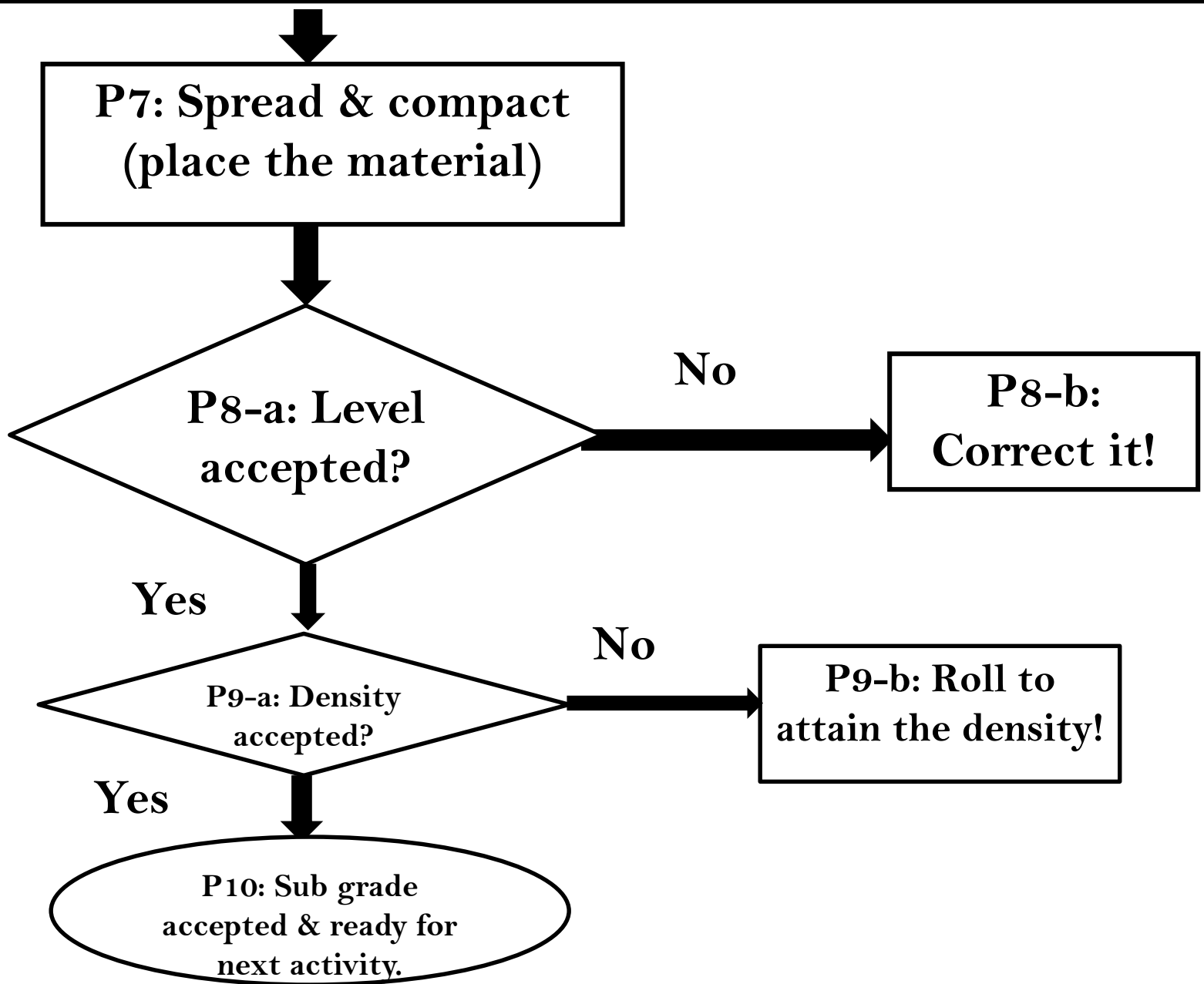


Vertical drains

□ Earthwork (Excavation or Borrow to Embankment in all Materials & Sub grade Finishing) process







2. Subbase Course Construction

2.1 Material Source for sub base

□ The materials used for the construction of sub-base layers shall be either:

1. Natural Gravel;
2. Scoria (Cinder Gravel);
3. Weathered Rock;
4. Crushed Gravel;
5. Crushed Rock or crushed Boulders;
6. Recycled Pavement Material.

Any other granular material complying with the requirements

2.2 Material Requirements for sub base (ERA)

2.2.1 Particle size distribution and shape

Table 5104/1: Grading Requirements for Sub-base Material

ISO Sieve Size (mm)	Percentage Passing by Mass		
	Natural Gravel	Crushed Stone	
	A	B (37.5 mm)	C (28 mm)
63.0	100		
50.0		100	
37.5	70 – 100	95 – 100	100
26.5			
20	50 - 100	60 – 80	70 – 85
9.5		40 – 60	50 – 65
4.75	30 - 100	25 - 40	35 – 55
2.36		15 - 30	25 – 40
1.0	17 - 75		
0.425	11 - 56	7 - 19	12 – 24
0.075	5 - 25	5 - 12	5 - 12

- ❑ The minimum Grading Modulus shall be 1.5, except where a material, having a lower Grading Modulus (but not less than 1.2) is approved for use by the Engineer.
- ❑ The flakiness index, determined by testing shall not exceed 35.

2.2.2 Plasticity

- Natural gravel sub-base materials shall have a maximum Plasticity Index, when determined in accordance with AASHTO T-90, depending on the climate as shown in Table 5104/2.

Table 5104/2: Plasticity Limits for Natural Gravel Sub-bases

Climate	Typical Annual Rainfall (mm)	Liquid Limit	Plasticity Index	Linear Shrinkage
Moist tropical and wet tropical	> 1000	< 35	< 6	< 3
Seasonally wet tropical	> 500	< 45	< 12	< 6
Arid and semi-arid	< 500	< 55	< 20	< 10

- Crushed stone sub-base shall have a Plasticity Index of less than 6 when determined in accordance with AASHTO T-90.

2.2.3 Density and Strength

- ❑ The minimum dry density to which the material shall be compacted shall be **95% of the MDD** obtained in the AASHTO T-180 method D unless specified otherwise,
- ❑ Field dry densities shall be determined by the **sand replacement method** as specified in AASHTO T 191 or any other method approved by the Engineer and calibrated with the sand replacement method.
- ❑ The minimum soaked Californian Bearing Ratio (CBR) shall be **30%** when determined in accordance with the requirements of AASHTO T-193.

2.3 Construction of sub base layer

- Sub-base materials be spread on the approved sub-grade by mechanical means without segregation. The material shall be loosely spread in layers to give a compacted thickness not exceeding **200mm and not less than 100mm.**
- Mix the aggregate and adjust the moisture content to obtain a uniform mixture with moisture content within **2 percent** of the optimum moisture content
- The surface of each completed layer shall be moistened prior to the construction of the succeeding layer.

- ❑ Compact each layer full width.
- ❑ Roll from the **sides to the center**, parallel to the centerline of the road. Along curbs, headers, walls, and all places not accessible to the roller, compact the material with approved tampers or compactors.
- ❑ Each succeeding pass shall overlap the previous pass by at least **one third of the roller width**. Rolling shall continue until the entire thickness of each layer is thoroughly and uniformly compacted to the specified density.
- ❑ The final compacted layer shall be free from concentrations of **coarse or fine materials**.

2.4 Trial Areas

- prior to the commencement of normal working the Contractor shall construct a trial area of not less than **1000 square meters** using the materials and equipment proposed for the work to demonstrate compliance with the requirements.

2.5 Testing Frequency

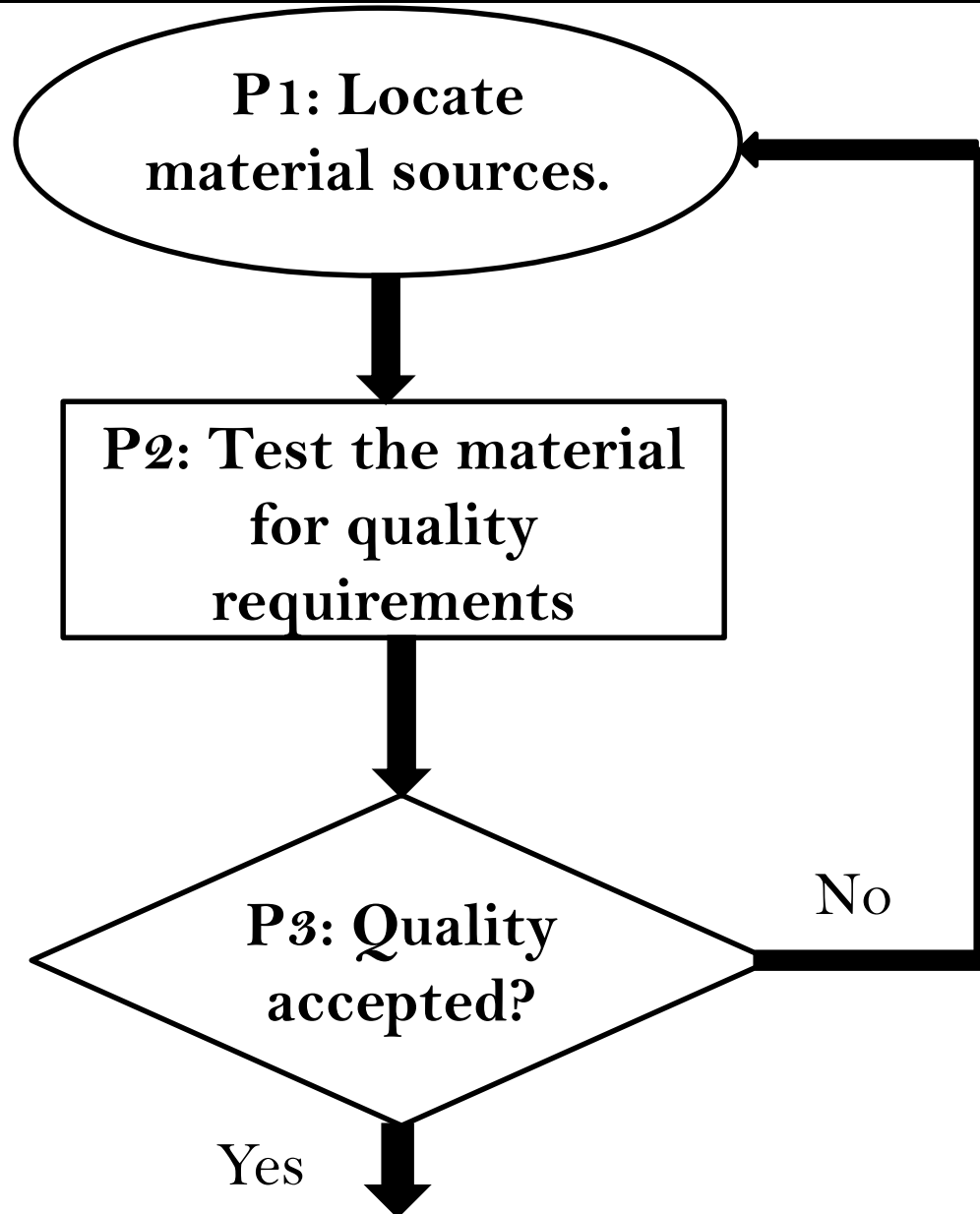
Table 5110/1: Testing Frequency

Test	Frequency (one test every)	Minimum number of tests/lot
Materials		
Field Density and Moisture Content	200 m	4
Atterberg limits and gradings	1 km	4
MDD & OMC	1 km	
CBR	2 km	
Other requirements as in Clause 5104	As directed by the Engineer	
Construction Tolerances		
Surface levels	20 m	3 points/cross section
Thickness	20 m	3 points/cross section
Width	20 m	
Cross section	20m	

Compaction of sub base layer



Natural Sub base Course Production and Placing process



**P4: Acquire quarry
land**



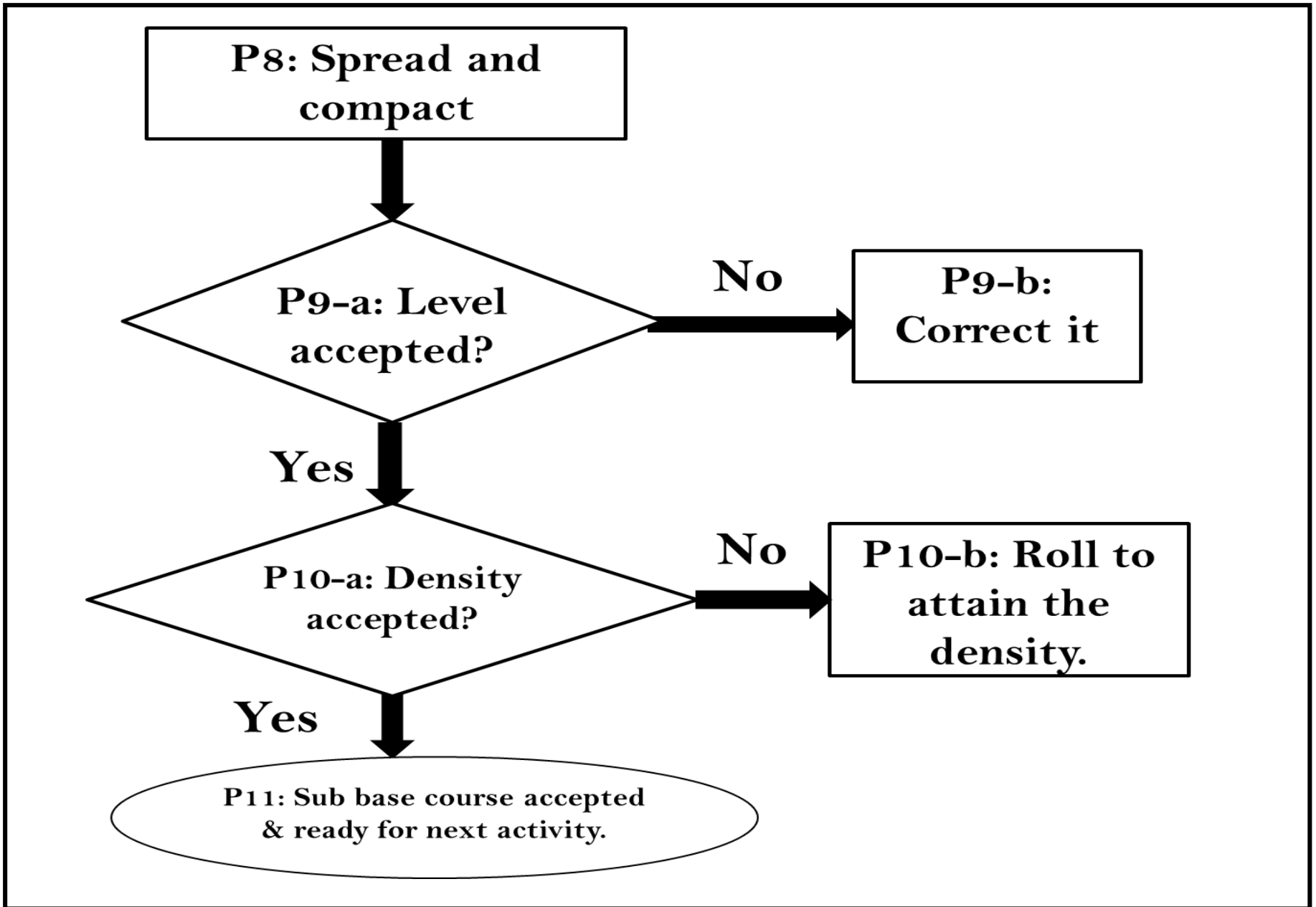
**P5: Produce the
material**



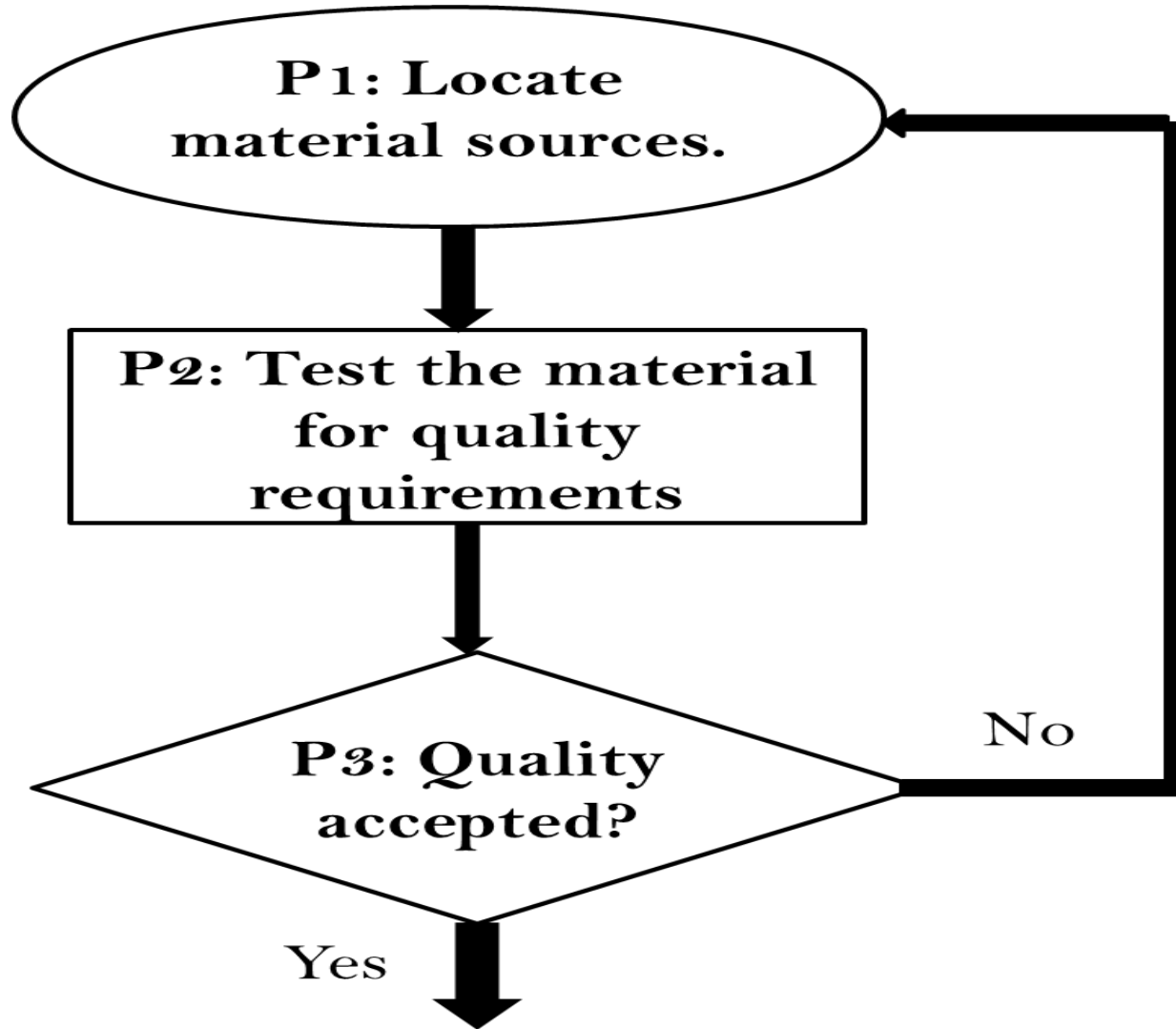
**P6: Completed
& accepted
sub grade**

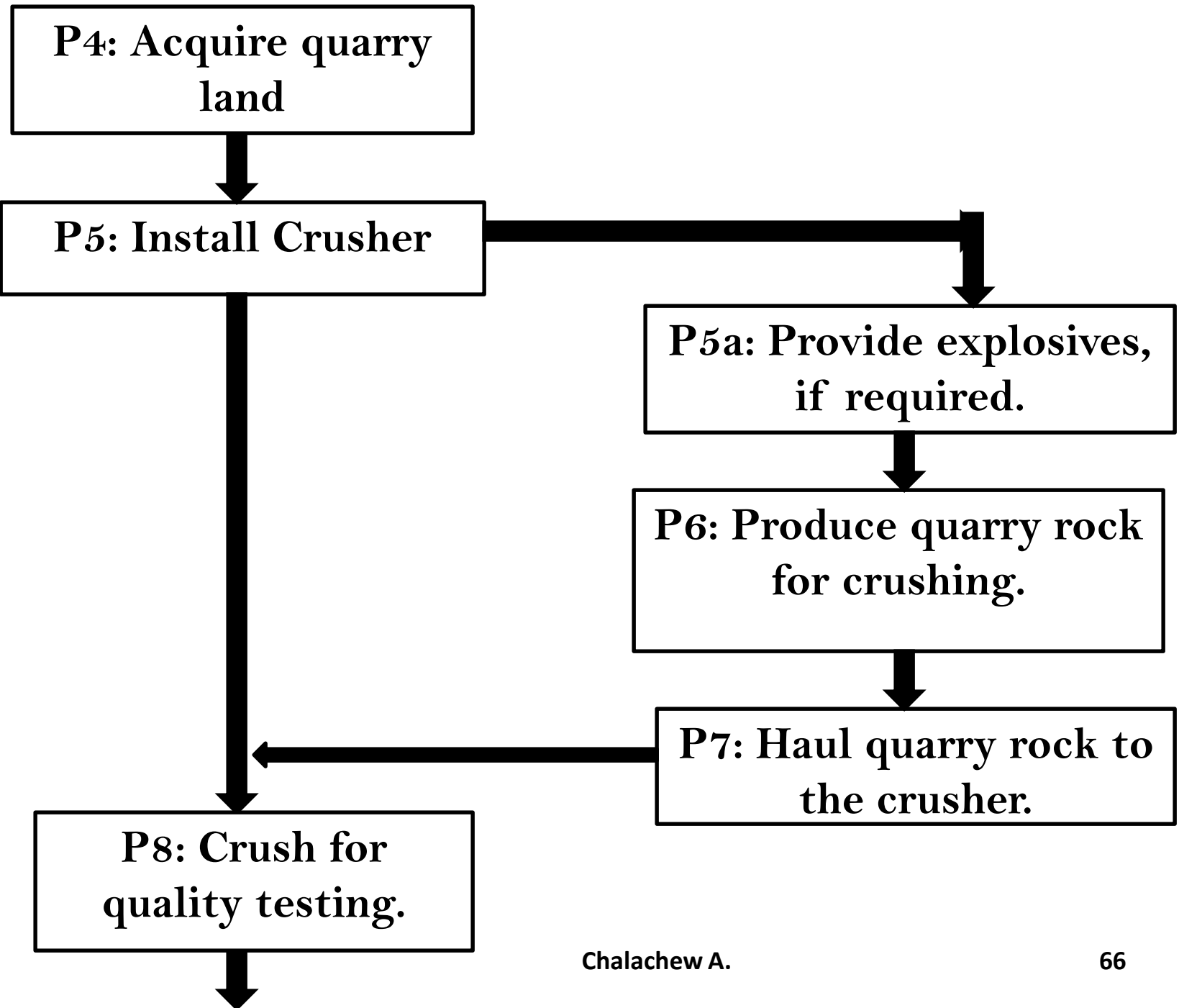
**P7: Haul sub base material to
placing location (to
completed & accepted sub
grade)**

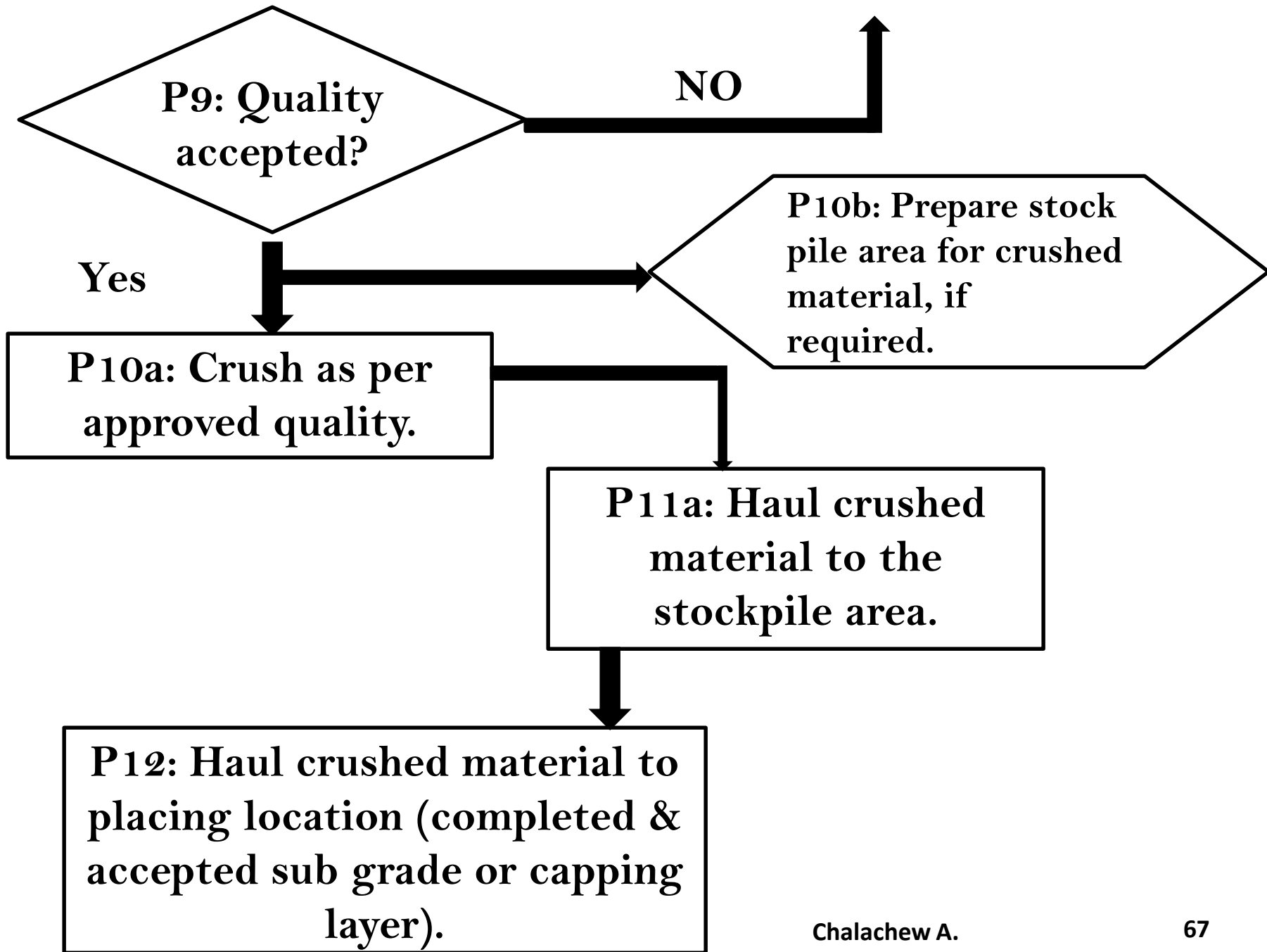


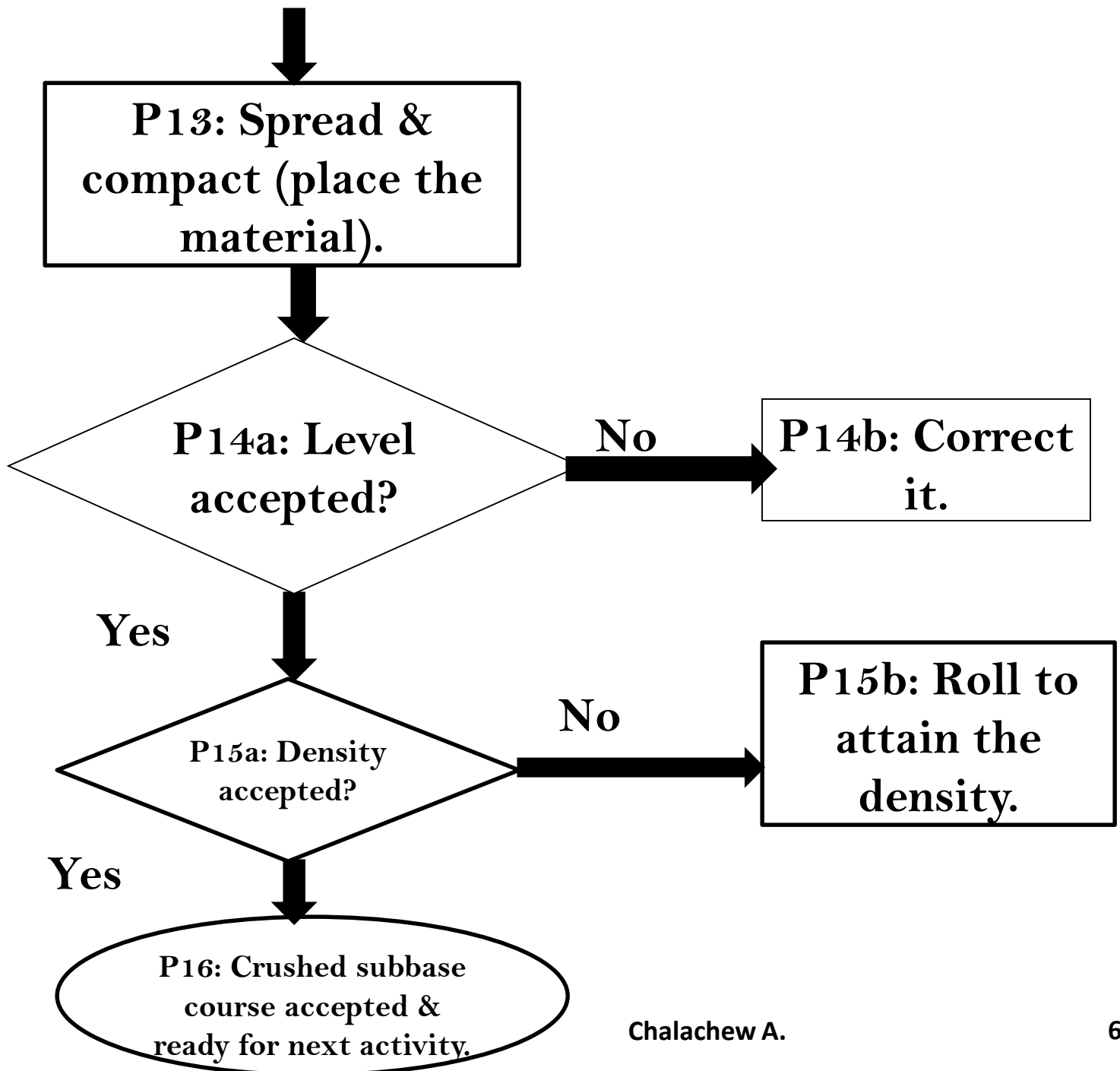


❑ Crushed Sub base Course Production and Placing Process









3. Construction of Gravel Roads

3.1 Sources of Material

- ▣ Gravel wearing course and gravel shoulder materials shall be obtained from approved sources in excavations or borrow areas.

3.2 Requirements of gravel surfacing materials:

- Stability: support the superimposed loads without detrimental deformation,
- They must stand the abrasive action of traffic,
- They must shed a large portion of the rain which falls on the surface,
- They should possess capillary properties to replace the moisture lost by surface evaporation,

- They must be free from large stones so that they can be maintained by balding or dragging, and
- It should be dust proof so that traffic safety is not impaired.
- They must be of low cost.
- The surface of the wearing course should develop as low friction with the tyers as possible.
- The surface of the wearing course should have a texture and adulate roughness to prevent skidding of vehicle

□ Further criteria are:

- Grading requirements to ensure stability, and
- Plasticity requirements.

Table 5403/1: Material Specifications for Gravel Wearing Course for Rural Roads

Property	Specification Requirement	Test Method
Maximum size (mm)	37.5	SANS 3001-AG1
Oversize index (I _o)	≤ 5 %	Calculation based on SANS 3001-AG1
Shrinkage product (S _p)	100 – 365 (max. of 240 preferable)	SANS 3001-GR10 for linear shrinkage
Grading coefficient (G _c)	16 – 34	Calculation based on SANS 3001-AG1
Soaked CBR (at 95% Mod AASHTO compaction)	≥ 15 %	SANS 3001-GR40
Treton impact value (%)	20 – 65	SANS 3001-AG9
I _o = Oversize index (per cent retained on 37.5 mm sieve) S _p = Linear shrinkage x per cent passing 0.425 mm sieve G _c = (Per cent passing 26.5 mm – per cent passing 2.0 mm) x per cent passing 4.75 mm)/100		

Table 5403/2: Material Specifications for Gravel Wearing Course for 'Urban' Roads

Property	Specification Requirement	Test Method
Maximum size (mm)	37.5	SANS 3001-AG1
Oversize index (I _o)	0	Calculation based on SANS 3001-AG1
Shrinkage product (S _p)	100 – 240	SANS 3001-GR10 for linear shrinkage
Grading coefficient (G _c)	16 – 34	Calculation based on SANS 3001-AG1
Soaked CBR (at 95% Mod AASHTO compaction)	≥ 15 %	SANS 3001-GR40
Treton impact value (%)	20 – 65	SANS 3001-AG9
I _o = Oversize index (per cent retained on 37.5 mm sieve) S _p = Linear shrinkage x per cent passing 0.425 mm sieve G _c = (Per cent passing 26.5 mm – per cent passing 2.0 mm) x per cent passing 4.75 mm)/100		

3.3 Trial Areas

- Prior to the commencement of normal working the Contractor shall construct a trial area of not less than 1000 square meters for gravel wearing courses and 250 square meters for gravel shoulder using the materials and equipment proposed for the work to demonstrate compliance with the requirements.

3.4 Construction of Gravel wearing course

- The material shall be transported in such a way, that no segregation occurs.
- The material shall be placed, spread, broken down, watered if necessary and mixed in layers not exceeding 200 mm and not less than 100 mm compacted thickness.
- Prior to compaction, the moisture content of the spread material shall be adjusted as necessary either by the uniform application of water or drying out, to achieve within -1% to +2% of the optimum moisture content when determined in accordance with AASHTO T-180.

- The material shall be compacted by the use of approved rollers progressing gradually from the outside towards the center of the layer, except on super elevated curves, where the rolling shall begin at the low side and progress to the high side. Each succeeding pass shall overlap the previous pass by at least one third of the roller width.
- Rolling shall continue until the entire thickness of each layer is thoroughly and uniformly compacted to the specified density.
- Any area, which is inaccessible to rolling equipment, shall be compacted by means of mechanical tampers or other equipment approved by the Engineer.

- Upon completion of compaction, the surface of the completed layer shall be tightly bound, free from movement under the compaction plant, and free from laminations, ridges, cracks or loose or segregated material.
- The in-situ density of the completed layer shall be 93 or 95% of the maximum dry density, as shown on the Drawings, when determined in accordance with the requirements of AASHTO T-180 method D.

3.5 Testing Frequency

- The minimum testing frequency that will be required from the Contractor in terms of conditions of contract for the purpose of process control shall be as shown.

Test	Frequency (one test every)	Minimum Number of Tests/Lot
Material		
Field Density and Moisture content	2 500 m ²	4
Atterberg Limits	2 500 m ²	4
Construction Tolerance		
Surface Levels	20 m	
Thickness	20 m	
Width	200 m	
Cross Section	20 m	
Smoothness	40 m ²	

3 points per cross section

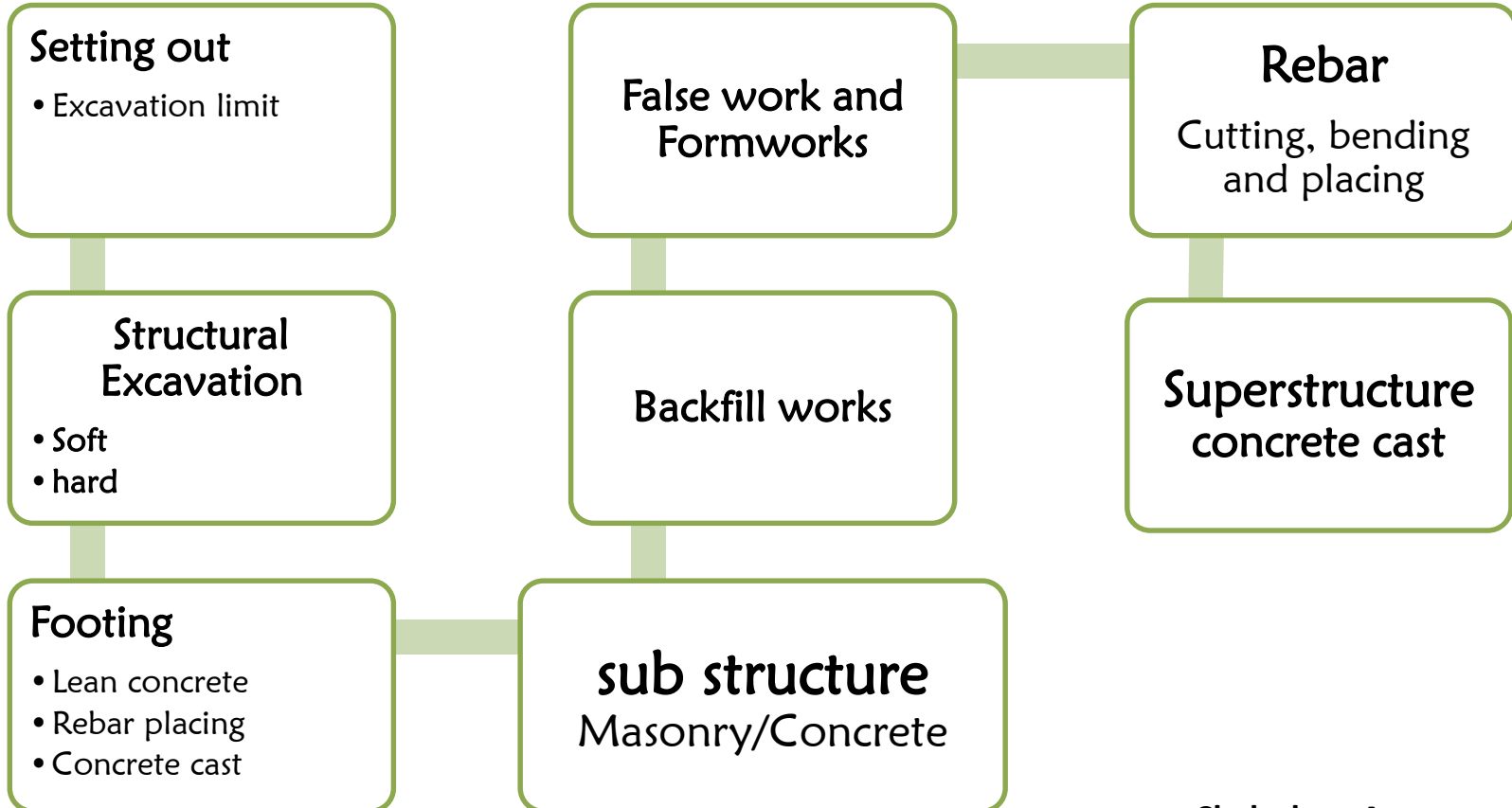
4. Construction of Drainage Structure

Drainage structures

Culverts(Pipe ,Slab and Box)

Bridges

Ditches



Summary of Gravel Road Construction

Site Clearance

- Clearing and grubbing
- Removing obstructions like existing structures, pavement



Earthwork

Road bed preparation

- Roadway excavation
- Embankment



Drainage structure Construction

- Culvert (CP, BC and SC)
- Bridge Construction
- Side drainage works



Surfacing Works

Wearing course construction
Sub base construction



Ancillary works

ROAD FURNITURE AND
SIGNAGE



5. Granular Base Course Construction

5.1 Base Course Material Source

- The materials used for the construction of base layers shall be either:
 1. Crushed Rock or Stone;
 2. Naturally occurring Granular Materials, Boulders,
 3. weathered rock, either unstabilised or chemically stabilized



**Crushed rock base
material**

5.2 Construction Equipment

- Material laid either by a self-propelled paving machine or by grader
- The equipment used be of adequate rated capacity and in good working order
- The mixing plant shall be either a batch or a continuous type, equipped with satisfactory means of accurately controlling the proportions of all constituent materials.
- Compaction shall be carried out using self-propelled 8 – 10 tones deadweight smooth wheeled rollers having a width of roll not less than 450mm, or by multi-wheeled pneumatic tyred rollers of equivalent mass, or by vibratory rollers of equivalent comp active performance, or a combination of these.

5.3 Placing and Compaction

- The surface on which the crushed rock and crushed boulder road base is to be laid be free from loose or deleterious material.
- The crushed material screened into at least four different aggregate fractions.
- The aggregates recombined in a mixing plant in the proportions necessary to produce a smooth continuous combined grading curve
- The mixed material are transported at the required moisture content and in such a way, that no segregation occurs.
- The material are spread in layers not exceeding 200mm and not less than 100mm compacted thickness.

- The material compacted by the use of rollers progressing gradually from the **outside towards the center of the layer**, except on super-elevated curves, where the rolling shall begin at the low side and progress to the high side.
- Each succeeding pass shall overlap the previous pass by at least **one third of the roller width**. Rolling shall continue until the entire thickness of each layer is thoroughly and uniformly compacted to the specified density.
- Any area, which is inaccessible to rolling equipment, be compacted by means of mechanical tampers or other suitable equipment's

- Upon completion of compaction, the surface of the completed layer be tightly bound, free from movement under the compaction plant, and free from laminations, ridges, cracks or loose or segregated material.
- The in-situ density of the completed layer shall not be less than 98% of the maximum dry density determined by the specification.

6. Construction of Stabilized Layers

6.1 Objective of Soil Stabilization

- To reduce the permeability and compressibility of the soil mass in earth structure and increase its shear strength.
- To increase the bearing capacity of the soil foundation
- For city and sub urban streets to make them more noise absorbing.

6.2 Stabilized materials

6.2.1 Mechanical stabilized materials:

- The process of improving the properties of soil by changing its gradation.

➤ The following three basic procedures are used for base and wearing surfaces as well as to lesser extent for subbase construction and subgrade improvement:

1. Road mix construction: the proper proportions of soil elements that form the material are mixed directly on the surface by bulldozing from one side of the road to the other. Special high-speed rotary mixing machines may be used and can generally provide a more uniform mix. After uniformly mixing at or near the optimum moisture content, it is spread in a uniform layer and then compacted to the specified density.

2 Travelling plant construction: the construction process is not much different from the road mix method previously described, but the mixing and spreading operation of soil elements and water are accomplished by the travelling plant.

3 Central plant method: when a large mileage of roads are to be constructed, it is advantageous to use central mixing plant in terms of uniformity of mixing, ease of control of the proportion of materials and water, and fewer delays due to bad weather. When mixing is completed, the material is transported using dump trucks, and then spread, compacted, finished, and cured similar to those described for in-place construction.

6.2.2 Lime Stabilized Materials

- Is done by adding lime to a soil. when lime is react with soil, there is a exchange of cations in the absorbed water layer and a decrease in plasticity of the soil occurs.
- The amount of lime required for the stabilization varies between 2 to 10% of the soil.
- Lime stabilization is not effective for sandy soil.
- The following amount used as a rough guide
 - 2 to 5% for clay gravel material having less than 50% of silt-clay fraction
 - 5 to 10% for soil having more than 50% of silt-clay fraction
 - About 10% for heavy clays (Expensive Soil) used as base and sub base

6.2.2.1 Stabilization and construction operations:

- a. Spread the specified percentage of lime
- b. Perform mixing
- c. Compact to required density and finish

6.2.2.2 Construction limitation

- The stabilizing agent shall only be applied to such an area that all processing, watering, compacting and finishing can be completed within 10 hours.
- No stabilizing agent shall be applied when the moisture content of the material to be stabilized exceeds the optimum moisture content
- No stabilization shall be done during wet weather

6.2.2.4 Steps:

- **Grade** the roadbed surface to specified lines, grades, and cross sections.
- **Prevent water** from ponding in the roadbed
- **Scarify/ Pulverize:** Scarify the road bed to the specified depth and width and pulverize the scarified material to 100% passing **75-mm sieve**
- **Remove** all unsuitable soil and organic materials
- **Lime:** apply hydrated lime or lime by product as slurry or in dry form. Apply quick lime only in dry form.
- **Mix** quick lime thoroughly with the dry roadbed material before adding water, add water to the mixture within 6 hours of dry mixing.
- **Ensure** the lime is uniformly incorporated within $\pm 5\%$ of requirement

- **Adding water:** add water and thoroughly mix. Limit the maximum moisture content to 3 percent over the optimum
- **Mixing:** Mix the lime and water in to the soil to form uniform, homogenous mixture with 100% passing a 75mm seive. Reshape to specific line, grade and section.
- **Seal** the class 1 and 2 surface with a roller. Compact and finish the
- **Compacting and finishing:** complete the final compaction and finishing within 12 hours of the final mixing
- **Restrict vehicles or equipment** on the treated course for a minimum 7 days cure period after final finish rolling.

6.2.3 Cement stabilized materials:

- Mixing pulverized soil and cement with water and compacting the mix to attain a strong material
 - Cement-soil mixtures may be processed by:
 - Road mixing equipment,
 - Travelling mixing plant, and
 - Central mixing plant

Requirements of cement content for different soil types

Soil Type	Required Cement Content
Sands/Sandy Soils/Soil Gravels	3-5 percent
Silts/Silty Clays of Low PI (less than 15)	4-8 percent
Clays/Black Cotton Soils	8-15 Percent

6.2.3.1 The basic steps in the construction of cement stabilized layer include:

- Pulverization of the soil,
- Adding the required amount of cement and mixing with the soil,
- Addition of the required amount of water and mixing with the soil-cement mixture,
- Spreading on to the prepared layer,
- Compaction, including final rolling and finishing, and
- Curing.



Initial preparation of the soil



Spreading the stabilizer



Watering and mixing



Compaction and finishing



Curing process

5.6 Bituminous stabilized materials:

- Methods of mixing soil-bitumen materials are generally the same as those previously described. An additional step, of course, involves the application of the necessary bituminous material and its uniform distribution through the mixture.
- In the case of **road mixing**, the bituminous material which is moderately heated to the specified temperature for application is applied in a measured amounts by a pressure distributor, along with water applied separately, and the entire mix thoroughly blended by motor graders disk harrows, rotary speed mixers, and so on.
- Where a **travelling or central mixing** plant is used, the measured amount of binder is incorporated in the plant.

➤ The material is spread in a layer of uniform thickness ready for compaction, and compaction is done usually by sheep's-foot roller or with pneumatic-tired rollers until a specified density is achieved. After compaction, curing is necessary before the next layer is placed.

➤ No mechanical mixing is involved for oil earth surface construction. A liquid binder is simply applied to properly prepared natural soil surface. The material penetrates a short distance into the soil layer, thus preventing dust and forming a thin stabilized surface that will be capable of supporting a limited number of light vehicles.

7. Construction of Bituminous Pavement

➤ The commonly practiced Bituminous pavements in Ethiopia are:-

- Hot Mix Asphalt Concrete
- Cold Mix Asphalt concrete
- Surface Bituminous Treatment

7.1 Hot Mix Asphalt Concrete:

- Component of HMA concrete



7.1.1.a Bituminous Prime Coat

The objective of Bituminous Prime Coat ?

- Temporary waterproofing
- To coat and bond loose mineral particles on the surface of the base
- to plunge capillary voids
- Promotes bond between base and HMA
- Hardens the surface



Table 6106/1: Recommended storage and application temperatures

Type of prime	* Maximum storage temperature (°C)		Spraying temperature range (°C)
	Up to 24 hrs	More than 24 hrs	
MC-30 Cutback	50	30	45 - 60
Invert bitumen emulsion	60	Air	50 - 70

* Temperatures may be above the flash point of some materials. Care must be taken to prevent fire and explosion.

7.1.1.b Tack Coat

- An application of bituminous binder to an existing surface to ensure bond between new and old surface.
- **Objective of tack coat**
 - Promotes necessary bond between old surface which is dry and hungry and new treatment which is thin.
 - Thin carpets have a tendency to peel off under excessive tangential stress unless bonded to the old surface
 - Too much of tack coat may create plane of slippage between pavement courses i.e. may act as lubricant rather than as adhesive. It may create fat spots or bleeding on the surface of the new pavement. The rate of application of tack coat shall be 0.2 to 0.6 litre/m² depending on the surface to be treated with tack coat; or as directed by the Engineer

7.1.2 Production of HMA Concrete

- Are prepared at an asphalt mixing plant
 - Operations of batching mixing plant
 - Cold aggregate storage
 - Proportioning
 - Drying/heating
 - Screening
 - Hot aggregate storage
 - Measuring and mixing aggregates with Bituminous mixing
 - Discharging in to trucks ,storage silo or surge bin

7.1.3. Transporting asphaltic mixes

- The asphaltic mixes shall be transported from the mixing plant to the spreader in trucks having cargo trays with beds and sides, which are clean and smooth, without gaps, holes or openings.
- The bed and sides shall be treated to prevent adhesion of the mixture to the truck bodies
- All trucks used for transporting hot asphalt shall be equipped with waterproof covers, insulated metal sheets or other suitable approved covers to minimize temperature loss from the asphaltic mix.

- Such covers shall be securely fixed over the hot asphaltic mix from the time of loading at the mixing plant until immediately prior to the discharge of the asphaltic mix into the paver.



7.1.4 Spread and Compaction

- Too heavy roller may adversely affect the evenness of the layer and, depending on the stability of the hot mix, may cause undesired displacements and misplacements in the material

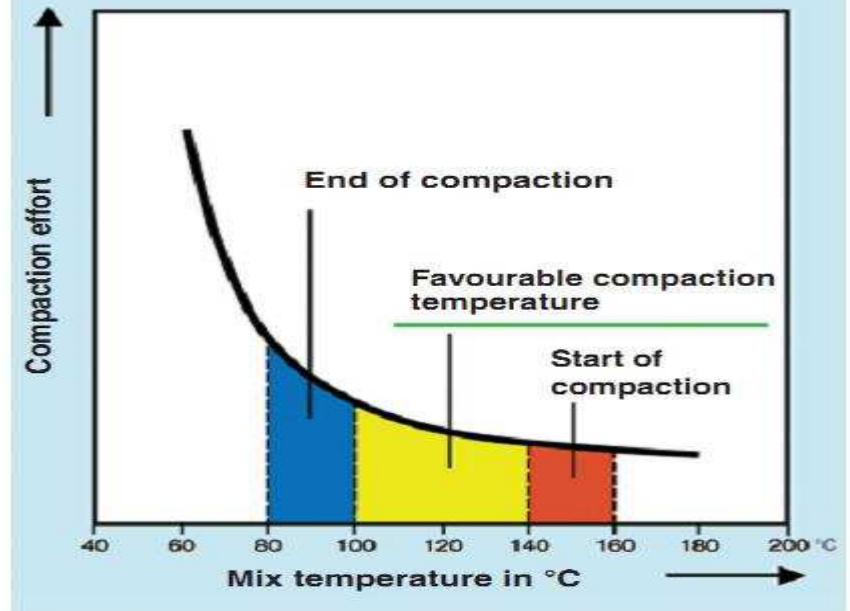
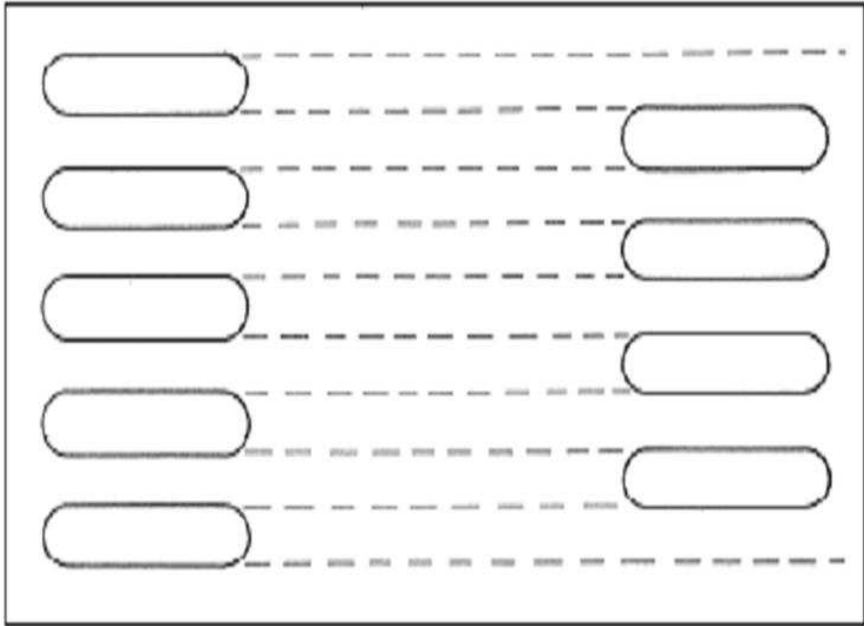
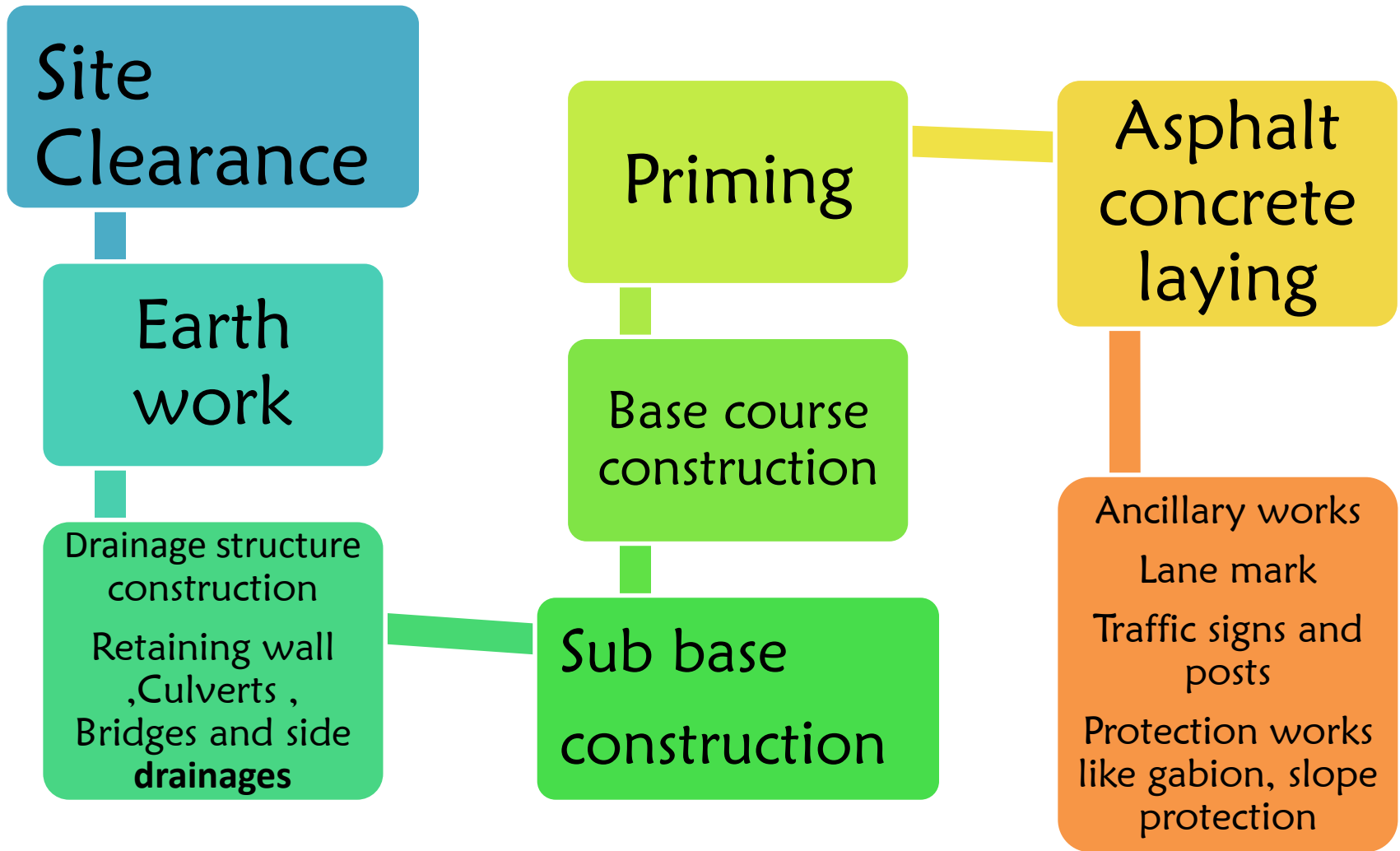


Fig. 6 Initial compaction by the finisher

- In restricted areas where the specified rollers cannot be used, compaction shall be carried out with hand-operated mechanical compaction equipment or approved smaller vibratory rollers. The prescribed density requirements remain applicable throughout over the full layer thickness irrespective of the method of compaction.
- The rolling starts from the edge of the pavement and proceeds to the crown, overlapping on successive trips by the width of the rear wheel for the three wheel rollers and by half the width of the wheel for a tandem roller.
- For super elevated curves, rolling should start at inner side of the curve and proceeds towards the outer side.
- Number of passes of roller determined by the required density



Summary of AC Road Construction



Group Assignment

- Cold Mix Asphalt
- Surface Treatment Asphalt
- and Cement Concrete Asphalt
 - Materials requirements
 - Equipments
 - Construction methods
 - Others

The End