Excavator and Truck numbers

$$Deks\ \left(\frac{m3}{day}\right) = \frac{\beta * d * (3600 - n * \tau) * K * S}{(1 + \theta g\ \text{temperorary}\ ) * t}$$ Displacement number per hour, **n**   Time spent for each displacement, **τ,** seconds   The cycle time ***t***, seconds.   The batch site efficiency **β** =0.75-95 or 0.75%-95%   Sift work hours per day, **S**= 8,16,24 hours   Temporary soil expansion coefficient, **Ɵt.** 0.10-0.40   K coefficient value for excavator
$$Dtruck/day = \frac{\beta * H * 60 * S}{(1 + \theta g\ \text{temperorary}\ ) * \text{tminutes}}$$ **H**:Houlage volumeof the truck, m^3 $\mathbf{t}_{minutes}$=time spent in minutes to complete on cycle or loop. It includes time spent on loading, unloading and travel.
$$V\ (km/hour) = \frac{0,243 * Nm}{G(w \mp s)}$$ Engine power, **Nm**, BB   Resistance against truck movement, **wr** = kgf/kgf   Slope of the road, **S,**   Truck weight, **G**, tons

Example questions

Q1. The natural ground with a volume of 2000 m^3 will be excavated with a 0.9 m3 volume spoon shaped excavator and will be loaded on the trucks. What is the time duration necessary to complete the job?

The excavator makes two displacements per hour (n=2), spending 150 seconds for each displacement (τ =150) The cycle time is 16 seconds (*t*=16 seconds). K=1.1. The batch site efficiency is β=0.80. Temporary soil expansion coefficient $\theta\text{gtemperorary} = 0.16$

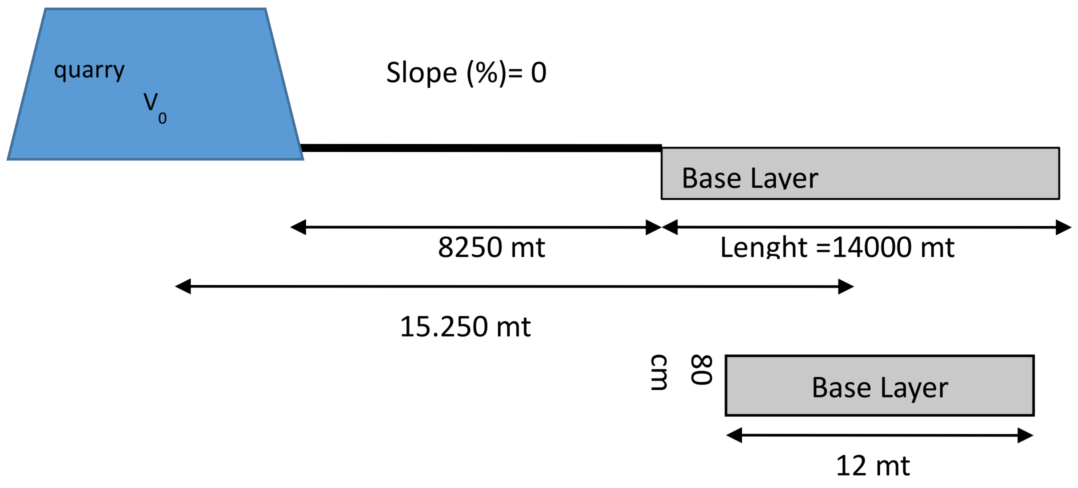
S=8 hours β=0.8 K= 1.1 τ=150 seconds θk =0.16 n=2 t=16 seconds

Answer

$$Deks = \frac{\beta * \mathrm{d} * (3600 - \mathrm{n} * \tau) * \mathrm{K} * \mathrm{S}}{(1 + \theta\mathrm{g\ temperorary}\ ) * \mathrm{t}} = \frac{0.8 * 0.9 * (3600 - 2 * 150) * 1.1 * 8}{(1 + 0.16) * 16} = 1.126{,}55\,\frac{m3}{day}$$

Time duration =2.000/1.126,55= 1.8 days

Q2 A pavement base layer is to be constructed in 30 days. Find the necessary **truck numbers.**



Truck loading volume capacity (m3) 6
Truck engine power BB 250
Truck empty weight (kgf) 4250
Load and unload time (minutes) 2.75
Wr (kgf/kgf) 0.15

Work site efficiency (%) 85
Project time duration (day) 30
Max. trafik speed (km/hour) 60

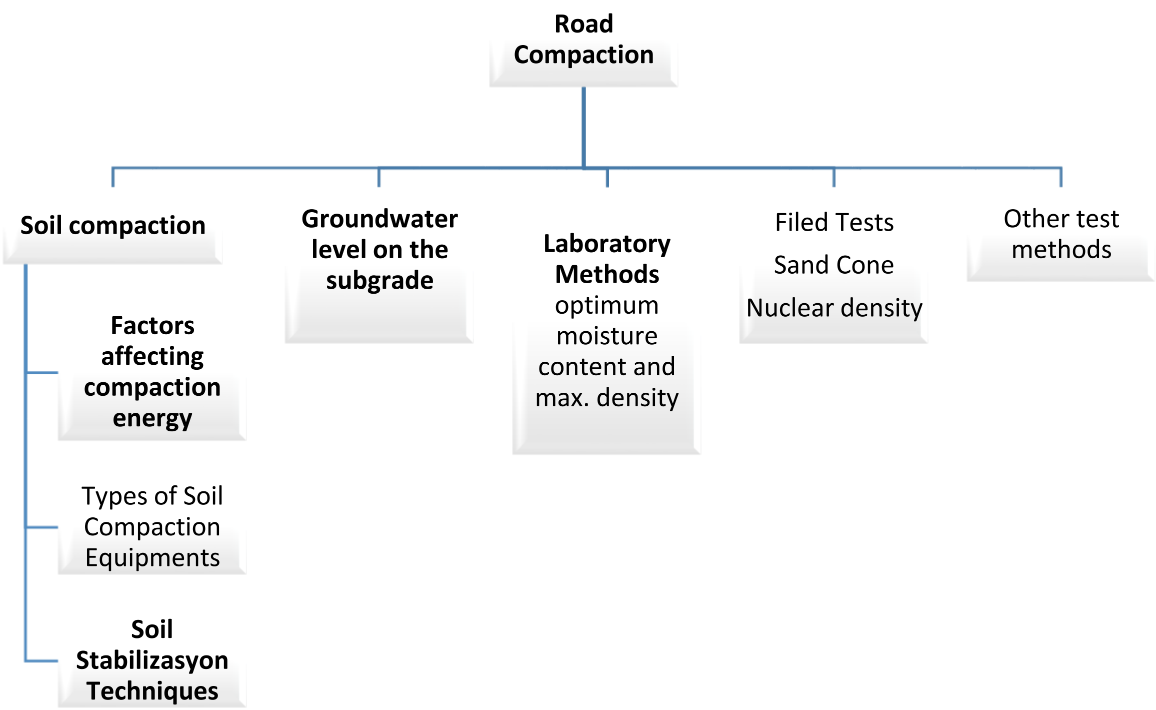
Shift (hours/day) 8+8
Base layer density (t/m3) 2
ϴtemporary (%) 20
ϴpermenant (%) 9.8
Loader efficient (m3/hour) 130

Answer:

Soil	
Excavated volume necessary (m^3)	$V0 = \frac{\text{Vk}}{(1+\text{ϴk})} = \frac{134400}{(1+0.098)} = 122404.37$
Excavated volume necessary per day (m3/day)	$\frac{\text{V0}}{30} = \frac{122404{,}37}{30} = 4080$
Loader	
Loader efficiency (m3/day)	130 m^3/day x (8+8) hours = 2080
Loader number needed to complet the work in 30 days	$\frac{4080}{2080} = 1.96 = 2$
$V_{departure}$ (km/hours)	$\frac{0.243x250}{14250x(0.15+0)} = 28.42$
V_{return} (km/hours)	$\frac{0.243x250}{4250x(0.15+0)} = \mathbf{95} > 60\ take\ 60$

Truck	
Load (tons)	$\frac{2x6}{(1+0.2)} = 10$
t departure (minutes)	$\frac{15.250}{2028,42} = 0.537\ hours = 32.2$
t return (minutes)	$\frac{15.250}{60} = hours = 15.25$
One period time (minutes)	32.20+15.25+2.75 (loading and unloading) = 50.20
D_{truck} efficiency (m^3/day)	$x = \frac{0.85x6x60x(8+8)}{(1+0.2)x50.20} = 81.2$
Number of truck $=\frac{Deks}{Dtruck}$	$\frac{4160}{81.2} = 51$
2x2080 = 4160 m^3	

Road Soil Compaction



Road Soil Compaction

Compaction is a process of increasing soil density and removing air, usually by mechanical means. The size of the individual soil particles does not change, *neither is water removed*. Objective of compaction is intended to improve the strength and stiffness of soil.Compaction of the soil and removing air voids generally increases the soil's sheer strength, decreases its compressibility, and decreases its permeability. It will reduce the voids ratio making it more difficult for water to flow through soil.

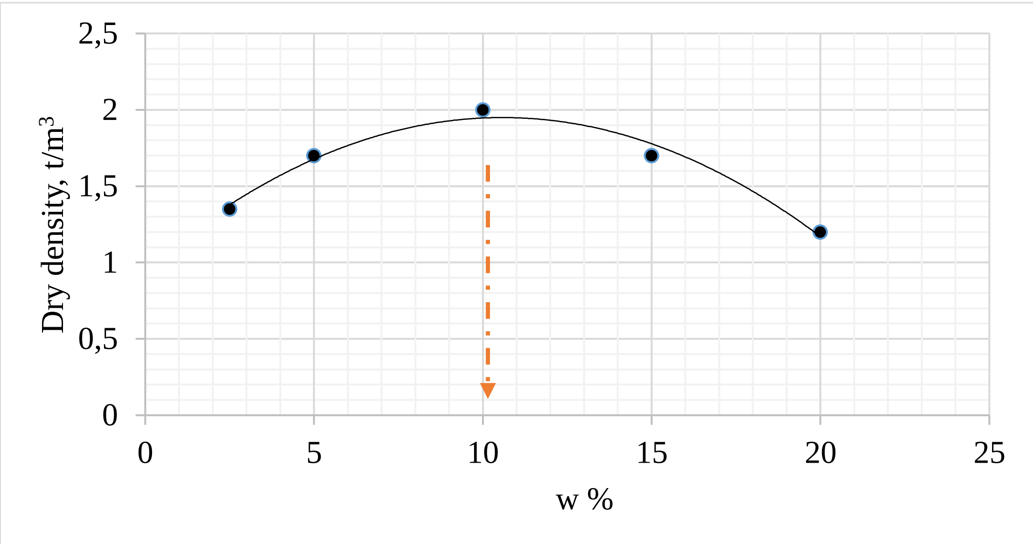
Factors affecting compaction energy:

1. **Gradation**: Well graded gradation is preferable.
2. **Gravel shape and surface texture**: Sharp-edged, angular, rough, grained gravel are hard to compress, while round ones are easier to compress.
3. **Compaction energy:** As the compression energy increases, the compression rate increases.
4. **Water content, %:**Soil are compacted at optimum moisture content, Wopt in order to get higher bearing capacity

   When compacting the soil make sure that the soil is at W_{opt}%. If;

$$\boldsymbol{W\%_{soil} < W_{opt}\%} \quad \textbf{then wett the soil.}$$
$$\boldsymbol{W\%soil > W_{opt}\ \%} \quad \textbf{then soil should be swelled and ventilated.}$$

Usually 5-7 % of water content is aimed after the layer is compacted.

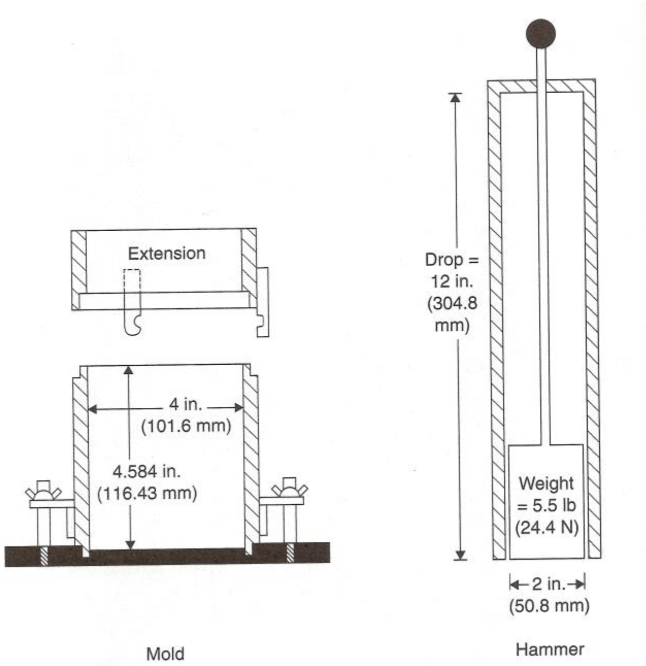


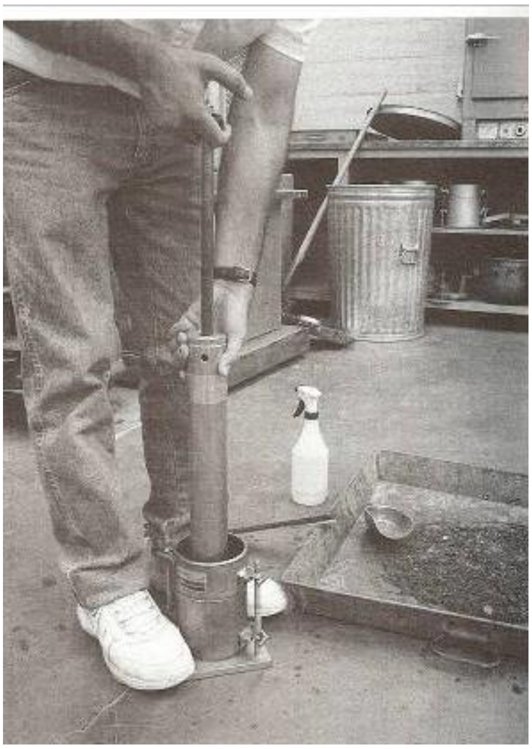
A minimum value 98 % relative compaction is required.

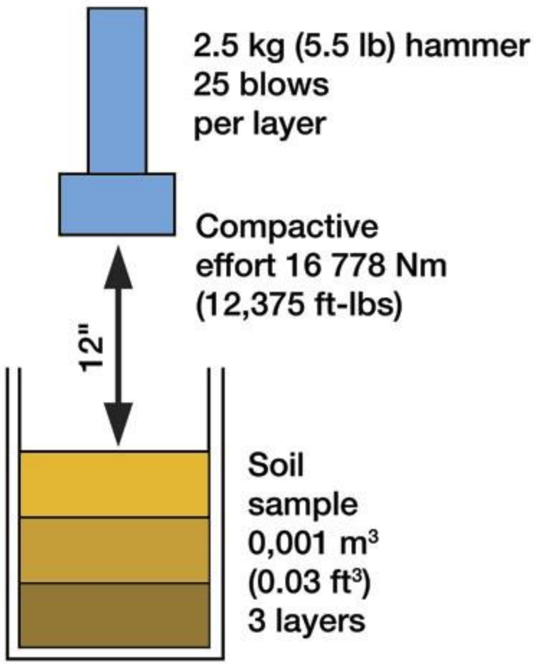
$$\textbf{Relative compaction}\ \% = 100\text{x}\frac{\text{Dry density field}}{\text{dry density lab}}$$

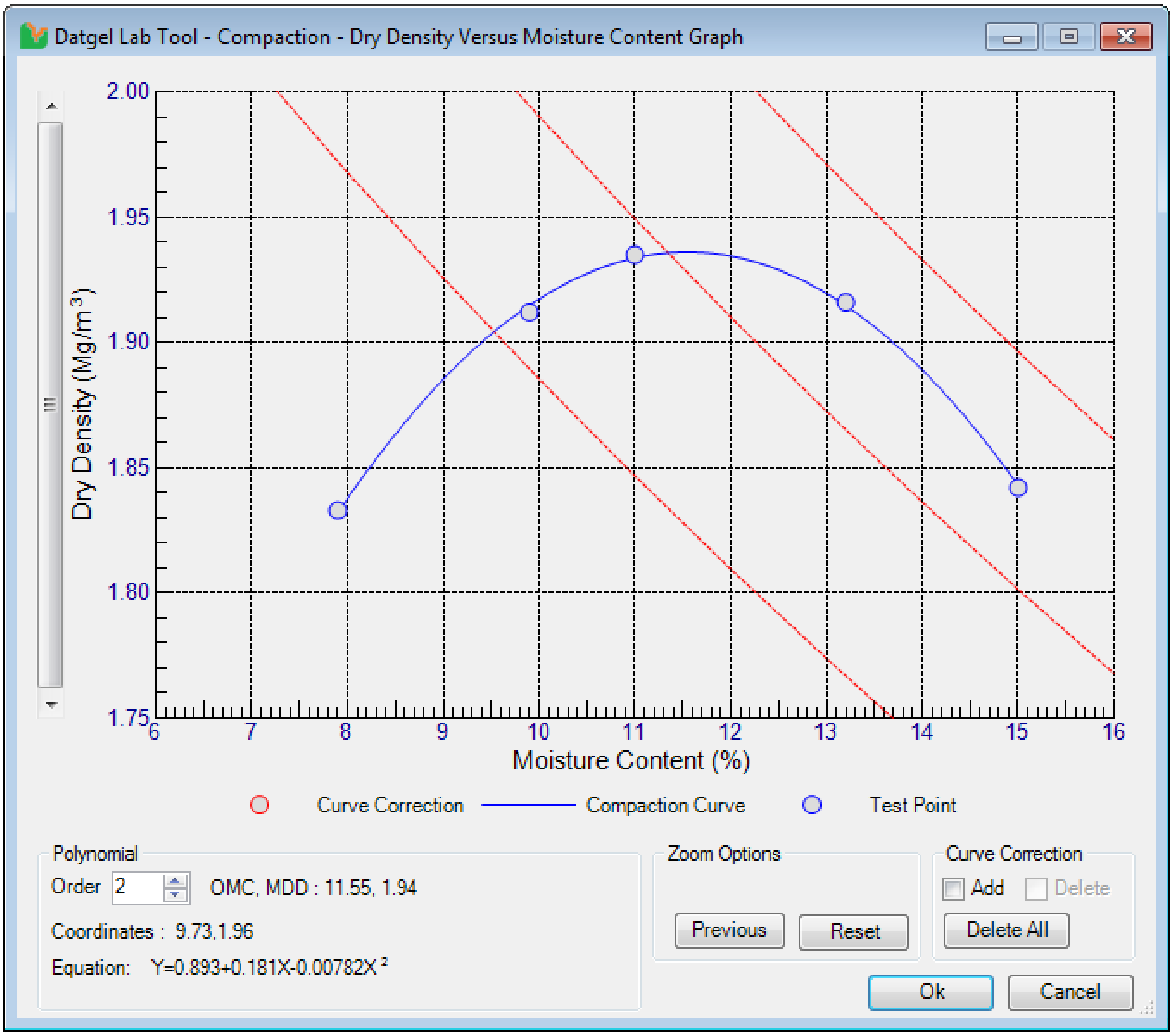
Laboratory Methods optimum moisture content and max. density

The Proctor Test (after Ralph R. Proctor, 1933)





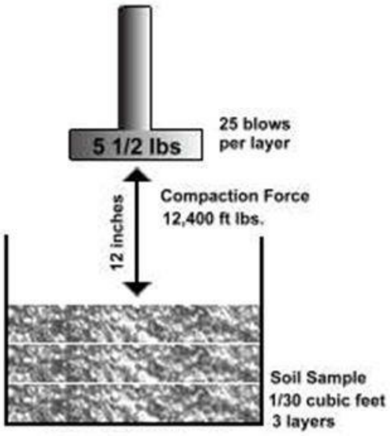



Datgel Lab Tool - Compaction - Dry Density Versus Moisture Content Graph
Dry Density (Mg/m³)
2.00
1.95
1.90
1.85
1.80
1.75
6
7
8
9
10
11
12
13
14
15
16
Moisture Content (%)
Curve Correction
Compaction Curve
Test Point
Polynomial
Order 2
OMC, MDD : 11.55, 1.94
Coordinates : 9.73,1.96
Equation: Y=0.893+0.181X-0.00782X²
Zoom Options
Previous
Reset
Curve Correction
Add
Delete
Delete All
Ok
Cancel

Standard Vs. Modified Proctor Compaction

$$Energy_{Std} = \frac{(5.5\,lb/blow)(25\,blows/layer)(3\,layers)(1\,foot)}{(1/30\,ft^3)}$$

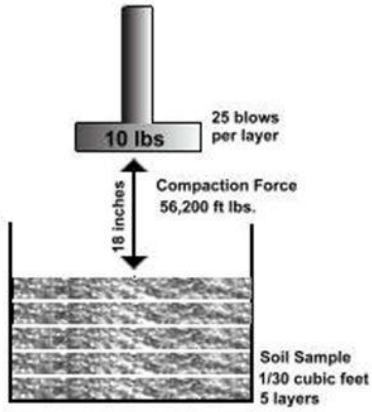
$$Energy_{Std} = 12{,}375\,\frac{ft-lb}{ft^3} = 593\,\frac{kJ}{m^3}$$



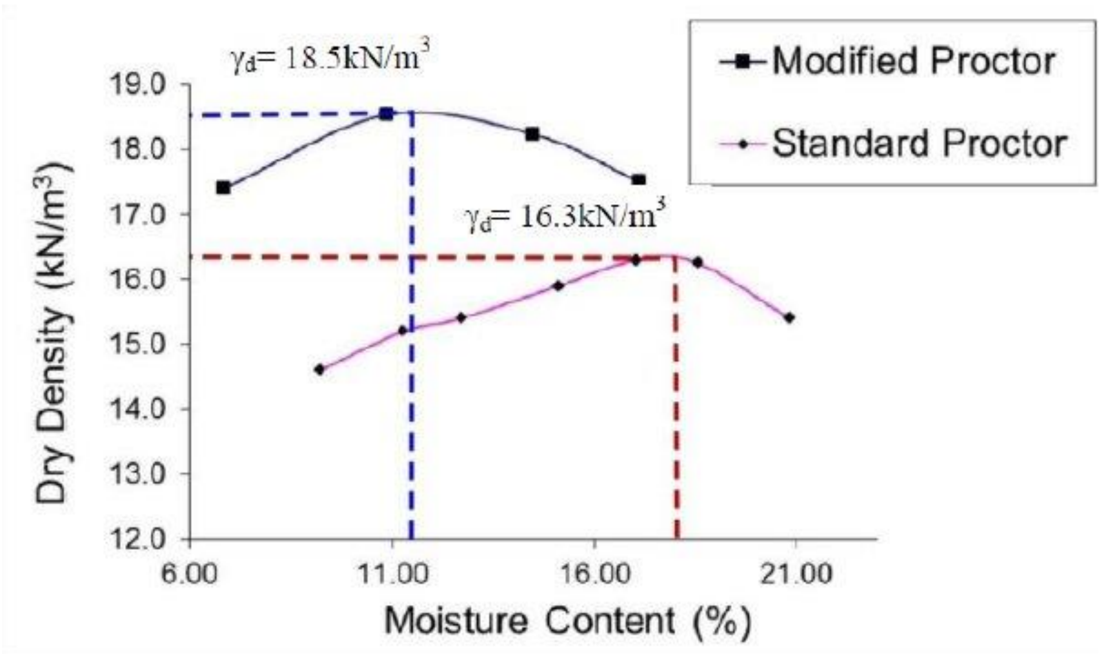
Standard Proctor

$$Energy_{mod} = \frac{\left(10\,{}^{pounds}/_{blow}\right)\left(25\,{}^{blows}/_{layer}\right)(5\,layers)(1.5\,ft)}{{}^{1}/_{30}\,ft^3}$$

$$Energy_{mod} = 56{,}250\,\frac{ft-pounds}{ft^3} = 2695\,\frac{kJ}{m^3}$$

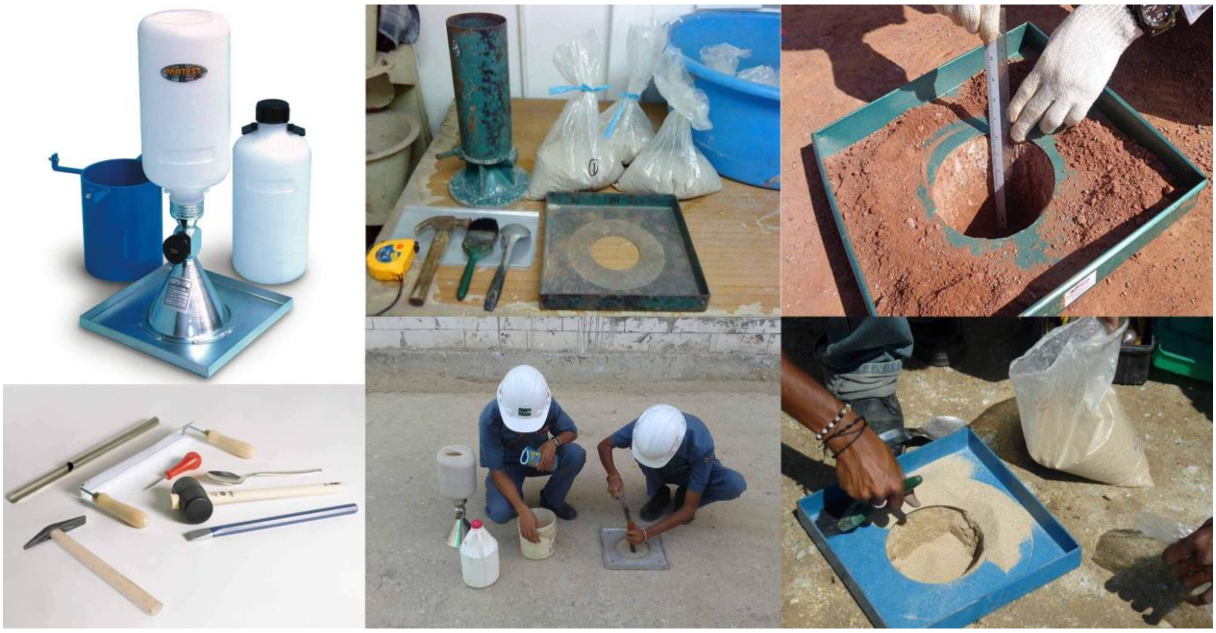


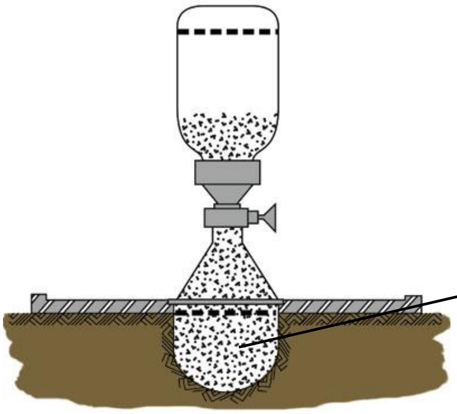
Modified Proctor



Field Tests

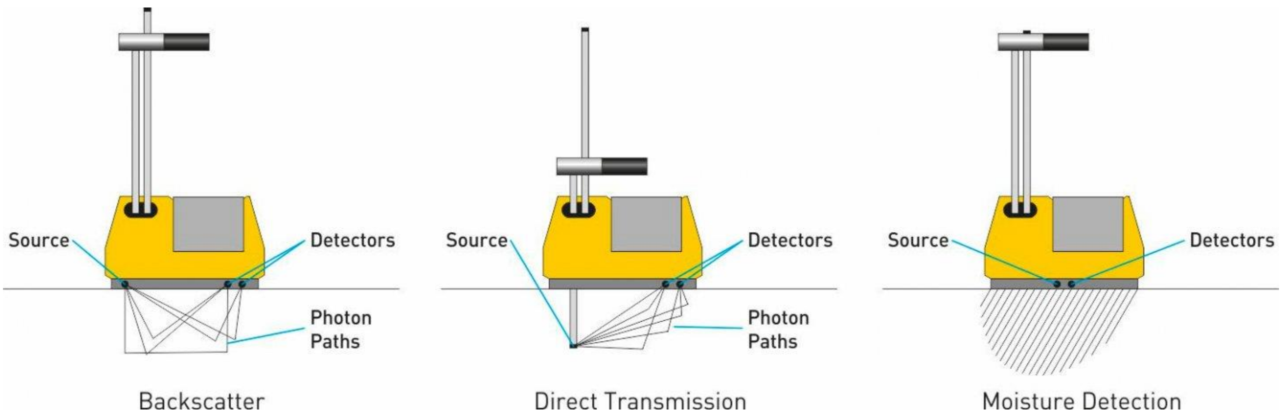
1.Sand Cone Test





$$\text{Moisture Content} = \frac{\text{weight of soil and water}}{\text{volume total of soil}}$$

2. Nuclear density



Soil Stabilizasyon Techniques

Even if improvement is achieved by constructing a very thick pavement layer on the subgrade with insufficient bearing capacity, this will be very expensive and an appropriate pavement layer behavior may not be achieved anyway. Materials with a CBR value of the base layer or subgrade is less than 3% should not be used in the construction of road bodies.

If compaction with machines are expensive the bearing capacity of the ground must be improved by making stabilization.By adding additives to the soil, it means we are ensuring that it becomes stable(higher CBR, K, shear resistance. etc. . To increase the resistance of the ground or to expel the resistance they have under certain weather conditions in all weather conditions.

a) Mechanical stabilization (using selected material)

b) Cement stabilization

The cementing action is believed to be the result of chemical reactions of cement with siliceous soil during hydration reaction. The important factors affecting the soil-cement are nature of soil content, conditions of mixing, compaction, curing and admixtures used.The appropriate amounts of cement needed for different types of soils may be as follows:

- Gravels – 5 to 10%
- Sands – 7 to 12%
- Silts – 12 to 15%, and
- Clays – 12 – 20%

b) Limestabilization

Slaked lime is very effective in treating heavy plastic clayey soils. Lime may be used alone or in combination with cement, bitumen or fly ash. Lime has been mainly used for stabilizing the road bases and the subgrade. Lime changes the nature of the adsorbed layer and provides pozzolanic action. Plasticity index of highly plastic soils are reduced by the addition of lime with soil. Normally 2 to 8% of lime may be required for coarse grained soils and 5 to 8% of lime may be required for plastic soils. The amount of fly ash as admixture may vary from 8 to 20% of the weight of the soil.

c) Soil Stabilization by Grouting

In this method, stabilizers are introduced by injection into the soil. This method is not useful for clayey soils because of their low permeability. This is a costly method for soil tabilization. This method is suitable for stabilizing buried zones of relatively limited extent. The grouting techniques can be classified as following:

- Clay grouting
- Chemical grouting
- Chrome lignin grouting
- Polymer grouting
- Bituminous grouting

d) Geosynthetcis stabilization

Geotextiles, Geombranes, geocells, geogrids and geocomposites made of synthetic materials such as polyethylene, polyester, nylons and polyvinyl chloride.

e) Bitumen (asphalt) stabilization

Bituminous materials when added to a soil, it imparts both cohesion and reduced *water absorption*. Depending upon the above actions and the nature of soils, bitumen stabilization is classified in following four types:

- Sand bitumen stabilization
- Soil Bitumen stabilization
- Water proofed mechanical stabilization,
- Oiled earth.

f) Chemical Stabilization

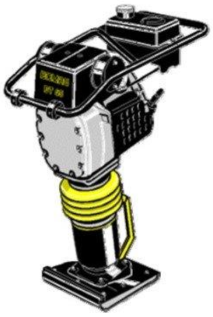
- Calcium chloride
- Sodium chloride
- Sodium silicate

Calcium chloride being hygroscopic and deliquescent is used as a water retentive additive in mechanically stabilized soil bases and surfacing. The vapor pressure gets lowered, surface tension increases and rate of evaporation decreases. The freezing point of pure water gets lowered and it results in prevention or reduction of frost heave. The depressing the electric double layer, the salt reduces the water pick up and thus the loss of strength of fine grained soils. Calcium chloride acts as a soil flocculent and facilitates compaction.

g) Electrical Stabilization of Clayey Soils

Electrical stabilization of clayey soils is done by method known as electro-osmosis. This is an expensive method of soil stabilization and is mainly used for drainage of cohesive soils.

Table Types of Soil Compaction Equipments

<table>
<tr><td colspan="2">1. Light Soil Compacting Equipments</td></tr>
<tr><td></td><td>Rammers

Rammers are suitable for compacting cohesive soils as well as other soils. Rammers are used for compacting small areas by providing impact load to the soil. This equipment is light and can be hand or machine operated.</td></tr>
<tr><td></td><td>Vibrating Plate Compactor

Vibrating plate compactors are used for compaction of coarse soils with 4 to 8% fines. These equipments are used for small areas</td></tr>
<tr><td colspan="2">2. Heavy Soil Compaction Equipments</td></tr>
<tr><td></td><td>Smooth Wheeled Rollers

Static orVibrating

Used for:
well graded sand, gravel, crushed rock, asphalt etc. where crushing is required.

finishing the upper surface of the soil.
not used for compaction of uniform sands.</td></tr>
</table>

	
	**Sheepsfoot roller Roller Types** static or vibratory **used for: fine grained soils such as heavy clays and silty clays.**
	**Pneumatic Rubber Tyred Rollers:** **Used for: compacion of coarse grained soils with some fines** Least suitable for uniform corse soils and rocks **Used in: pavement subgrade and asphalt pavement layer**
	Trucks Random passing is required

In practice the first choice compactor for silt and clay soils.

Highway Drainage

- Significance of Drainage
- Requirements of Highway Drainage
- Surface Drainage
- Methods of Surface Drainage
- Shoulder Drainage
- Median Drainage
- Sub-Surface Drainage
- Methods Of Sub-Surface Drainage
- Road Construction in water logged area

Issues to consider during a surveillance study when investigating a good passage in terms of drainage:

- Slopes should be chosen instead of valley floors.

- Regions where the groundwater level is deep should be preferred.

- In rain fall regions, the red line should be crossed by filling the flat areas so that the road is not submerged.

- Where possible, the red line should be above the flood level.

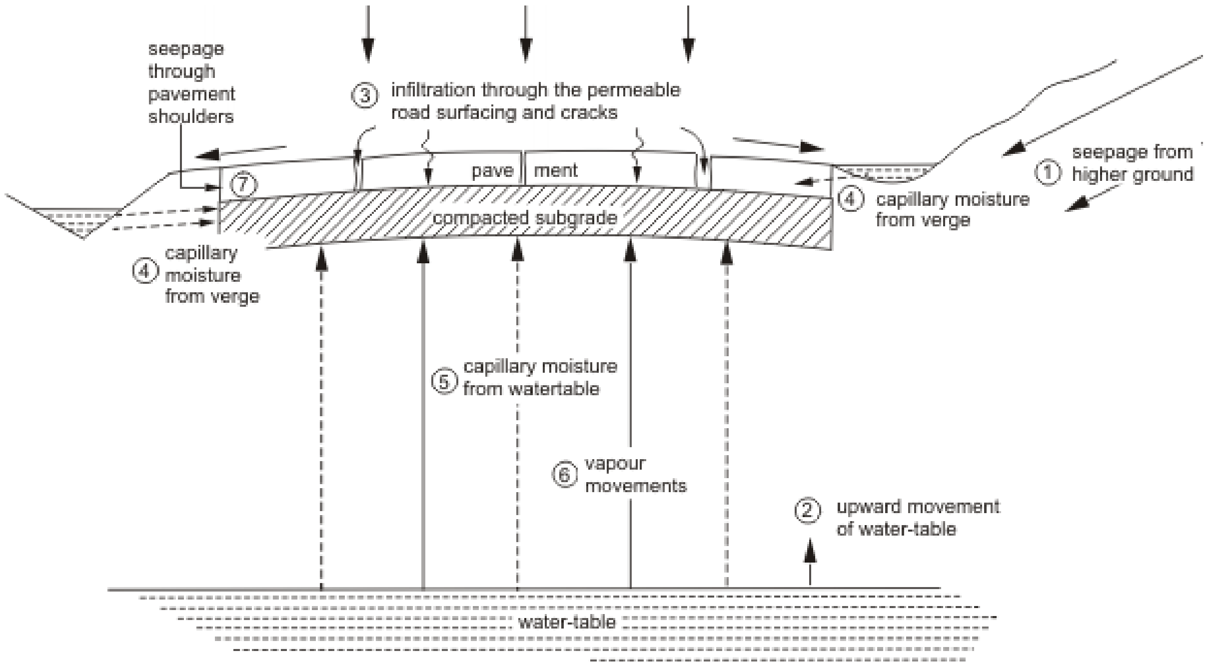
- Roads should be constructed from the southern slopes that see less snow in the hills.

- It should not be passed through clayey floors that grow in volume in contact with water.

- Natural water resources and deposits should be protected as much as possible

- Edge ditches, head ditches and culverts used in surface drainages should be determined correctly.

- With the transverse and longitudinal slope to be given to the road, the amount of precipitation in the region should be selected in accordance with the road width and the type of location.



Causes of excess moisture content

- Fluctuations in Ground Water Table
- Seepage Flow
- Movement of Capillary Water

Presence of moisture causes:

- Reduction in the **beaing capacity (**reduction in strength) **and stability** of the soil mass.
- Considerable variation in volume of subgrade in clayey soils.
- Waves and corrugations failure in flexible pavements.
- S**tripping failure of bitumen from aggregates** like loosening or detachment and formations of pot holes in flexible pavements.
- In cold regions presence of water in the subgrade and a continuous supply ofwater from the groundwater can cause considerable damage to the pavement due to **frost action**

Drainage of the highway is the process of **removing and controlling excess surface and sub-soil water** within the right of way. It includes interception and diversion of water from the road surface and subgrade.

Drainage Types

1.**Surface drainage** (removal & diversion of surface water from the roadway & adjoining land)

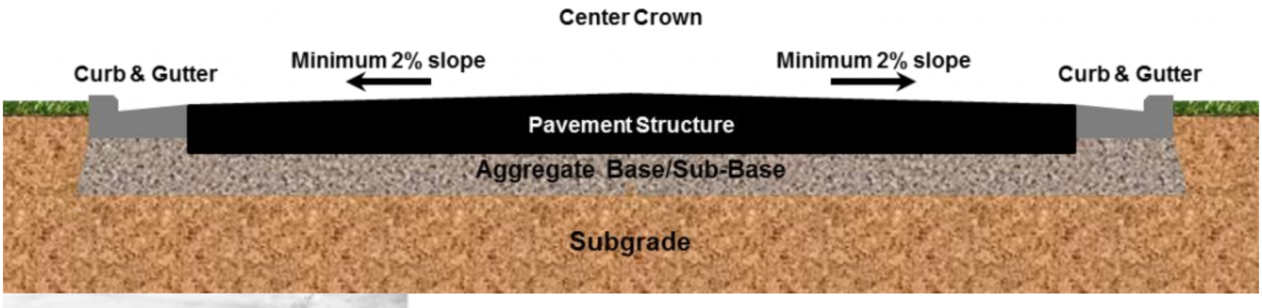
2.**Subsurface drainage** (diversion or removal of excess soil-water from subgrade

1.**Surface drainage** (removal & diversion of surface water from the roadway & adjoining land).

- Collected in longitudinal drains and then disposed of at the nearest stream, valley or water course.
- Providing cross slope to the road surface.
- Surface is made impervious to prevent the water entering the subgrade.

Methods of surface drainage

- Providing sufficient **slope to the sides**
- By **Longitudinal side drains**.
- Catch basin sand Inlets in urban areas
- Providing damp proof course
- Keeping the level of carriage way at least 60-100 cm above the High Flood Level



In streets

On highways

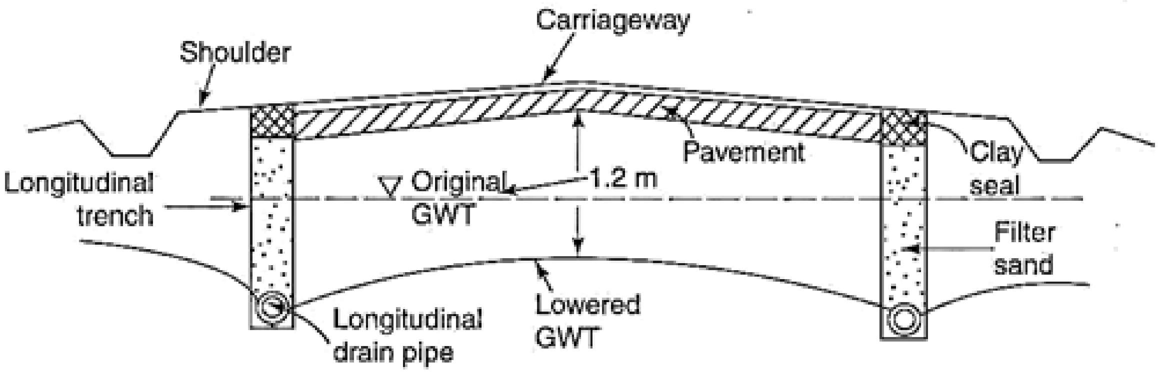
Side drains

median drainage

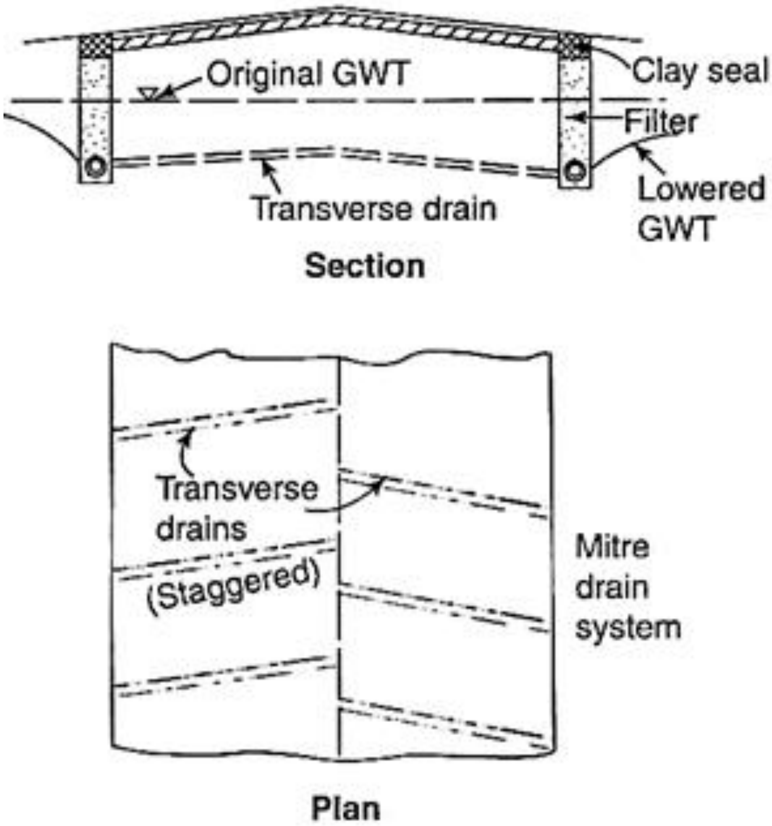
2. Subsurface Drainage (diversion or removal of excess soil-water from subgrade)

Causes	Solution
1.Fluctuations in Ground Water Table	Constructing longitudinal and transverse drainage
2. Seepage Flow	Trenches with drain pipe and filter sand and top of trenches is covered with clay seal
3. Movement of Capillary Water	

1. Lowering the ground water table



Highest level of **groundwater table** should be kept well **below the level of subgrade**, preferably by atleast 1.2m.

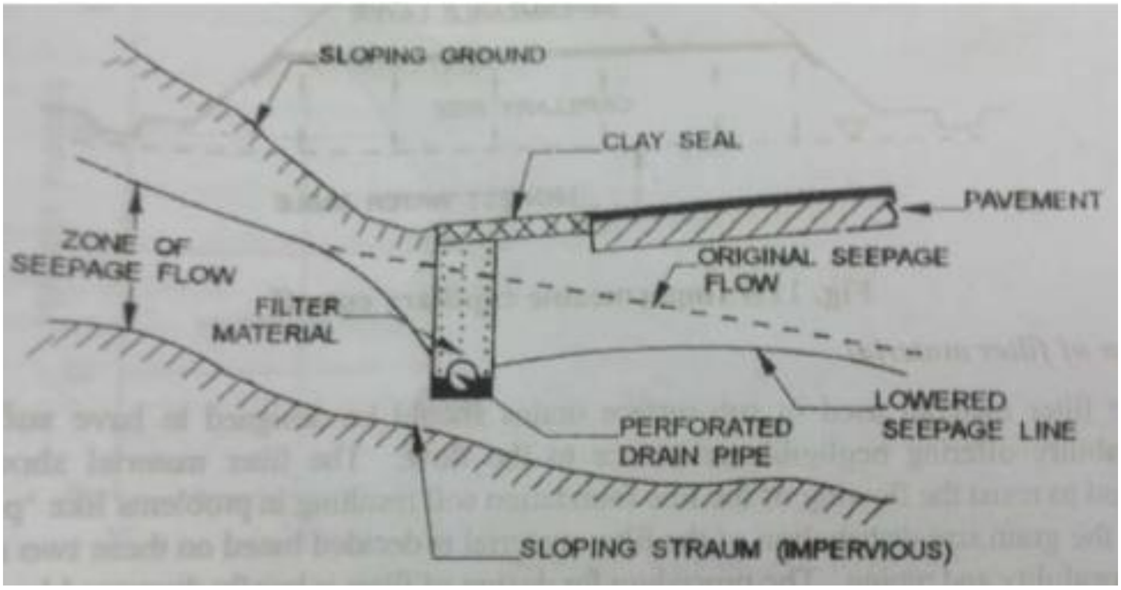


Longitudinal and transverse drain system

The depth of trench depend on:
(i) The required lowering of water table
(ii) distance b/w the drainage trenches
(iii)Types of soil

2. Control of seepage flow

When the general ground as well as impervious strata below are sloping, seepage flowis likely to exist. If seepage zone is at depth less than 0.6-0.9 m from sub-grade level, longitudinal pipe drain in trench filledwith filtermaterial and clay seal may be constructed to intercept the flow.



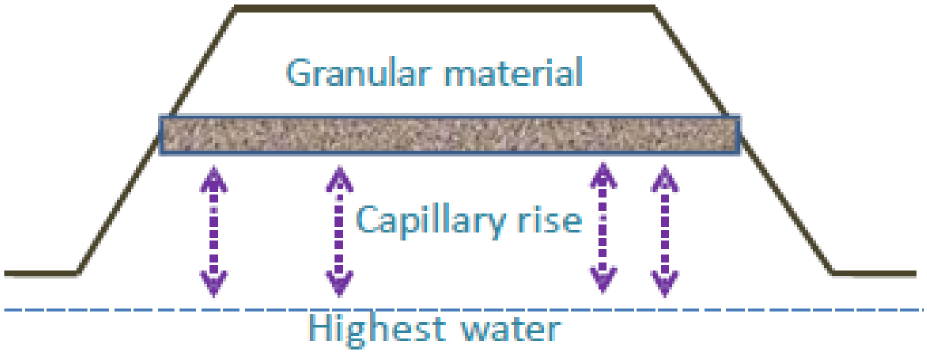
Control of seepage flow

3. Control of capillary rise

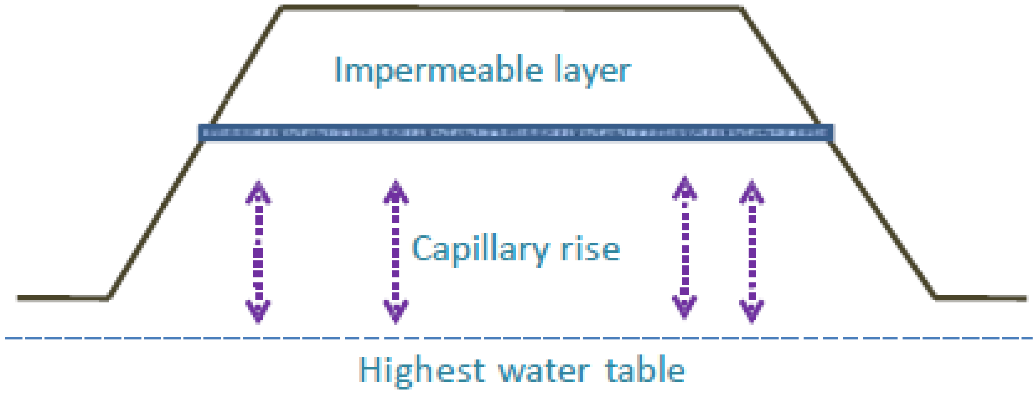
Problem: In case of sub-grade subjected soil water to soaking condition capillary rise.

Solution:

- Raising the road level by constructing embankment
- Using a layer of granular material of suitable thickness.
- Using a layer of impermeable capillary cutoff.
- Capillary water should not rise above the thickness of the granular layer
- Bituminous layer or other geo-textiles, geoembrane can be used as an impermeable layer
- Depressing the sub surface water level by drainage system



Granular material .Capillary cutoff



Impermeable layer capillary cutoff

Control of capillary rise

Culverts