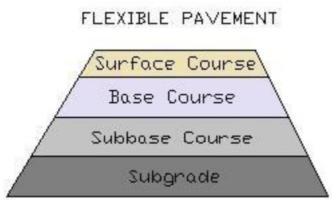
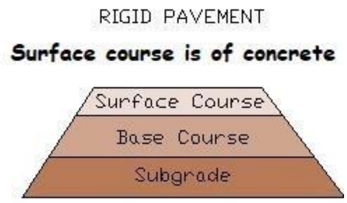
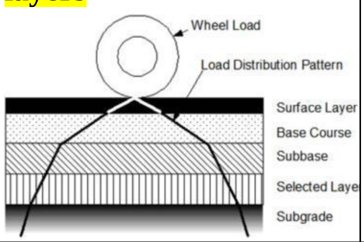
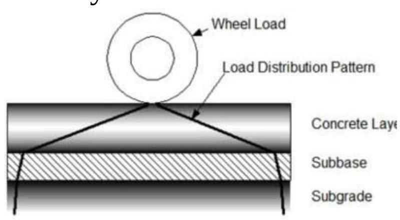
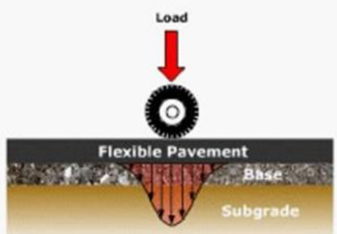
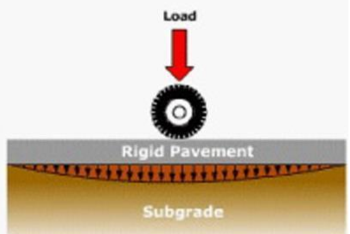
Internal Assessment Test 1– May- 2022

(solution and scheme of valuation)

Sub:	**Pavement Design**					Sub Code:	**18CV825/17CV833 /15CV833**	Branch:	Civil
Date:	14/5/2022	Duration:	90 min	Max Marks:	50	Sem/Sec:	VIII – A & B & C		marks

1 Critically compare flexible and rigid pavement, at least 10 points. — 10 — CO2 — L2

S. N	**Particulars**	**Flexible pavement**	**Rigid pavement**
1	Cross section	It consists of a series of layers with the highest quality materials at or near the surfaceof pavement. 	It consists of one layer Portland cement concrete slabor relatively high flexuralstrength. 
2	Characteristic	It **reflects the deformations of subgrade** and subsequentlayers on the surface.	It is able to bridge over localized failures and area of inadequate support.
3	Load transfer	Its stability depends upon the **aggregate interlock, particle friction and cohesion** or by **means of grain to grain contact**	Its structural strength isprovided by the pavement slab itself by its **beam action**.
4	Design parameter	Pavement design is greatly influenced by the **subgradestrength.**	**Flexural strength of concrete** is a major factor for design.
5	Distribution of load	It functions by a way of **load distribution through the component layers** 	It distributes load over **a wide area of subgrade** because of its rigidity and high modulusof elasticity. 
6	Distribution of stresses		

7	Design life	15-20 years	20-40 years
8	Temperature stresses	**No thermal stresses** are induced as the pavement have the ability to contract and expand freely	Thermal stresses **are more vulnerable** to be induced as the ability to contract and expand is very less in concrete
9	Deformations	Flexible pavements have self healing properties. **Settlements due to heavier wheel loads are recoverable** to some extent.	Any excessive deformations occurring due to heavier wheel loads are not recoverable, i.e. **settlements are permanent.**
10	Overall cost	Have **low completion cost** butrepairing cost is high	Have low repairing cost but **completion cost is high**
11	Maintenance cost	Have low life span (**HighMaintenance Cost**)	Life span is more as compareto flexible (**Low Maintenance Cost**)
12	Effect of oil spills	**Damaged by Oils and Certain Chemicals**	**No Damage** by Oils and Greases
13	Curing period	Road can be used for traffic **within 24 hours**	Road cannot be used **until 14 days of curing**
14	Colour and visibility	**Poor visibility** at night due to its black colour	**Better visibility** at night owed to its white/gray colour
15	Design parameter of subgrade	**CBR value**	**Modulus of subgrade reaction (k)**

2 What are the different layers of pavements and what are its functions? [10] CO2 L2

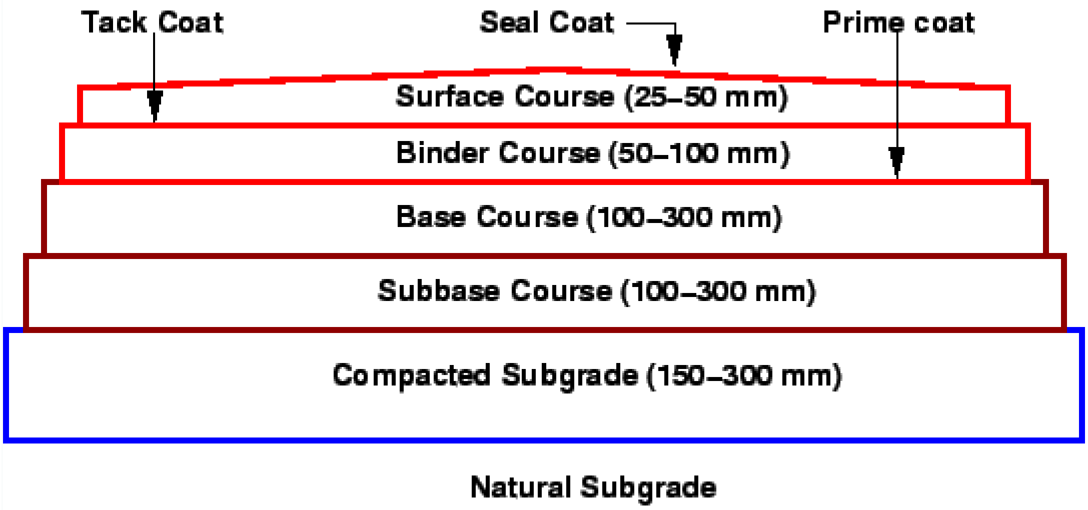
Typical layers of a flexible pavement

Typical layers of a conventional flexible pavement includes seal coat, surface course, tackcoat, binder course, prime coat, base course, sub-base course, compacted sub-grade, and natural sub-grade.

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

Tack Coat: Tack coat is a very light application of asphalt, usually asphalt emulsion diluted with water.It provides proper bonding between two layer of binder course and must be thin, uniformlycover the entire surface, and set very fast.

Prime Coat: Prime coat is an application of low viscous cutback bitumen to an absorbent surface like granular bases on which binder layer is placed. It provides bonding between two layers. Unlike tack coat, prime coat penetrates into the layer below, plugs the voids, and forms a water tight surface.



Surface course: Surface course is the layer directly in contact with traffic loads and generally contains superior quality materials. They are usually constructed with dense graded asphalt concrete(AC). The functions and requirements of this layer are:

- It provides characteristics such as friction, smoothness, drainage, etc. Also it will prevent the entrance of excessive quantities of surface water into the underlying base, sub-base and sub-grade,
- It must be tough to resist the distortion under traffic and provide a smooth and skid-resistant riding surface,
- It must be water proof to protect the entire base and sub-grade from the weakening effect of water

Binder course: This layer provides the bulk of the asphalt concrete structure

- It's chief purpose is to distribute load to the base course
- The binder course generally consists of aggregates having less asphalt and doesn'trequire quality as high as the surface course
- Replacing a part of the surface course by the binder course results in more economical design

Base course:

- The base course is the layer of material immediately beneath the surface of bindercourse. It provides additional load distribution and contributes to the sub-surface drainage
- It may be composed of crushed stone, crushed slag, and other untreated or stabilized materials

Sub-Base course: The sub-base course is the layer of material beneath the base course and the primary functions are

- To provide structural support, improve drainage, and reduce the intrusion of finesfrom the sub-grade in the pavement structure
- If the base course is open graded, then the sub-base course with more fines

can serve as a filler between sub-grade and the base course

- A sub-base course is not always needed or used. For example, a pavement constructed over a high quality, stiff sub-grade may not need the additional features offered by a sub-base course. In such situations, sub-base course may not be provided

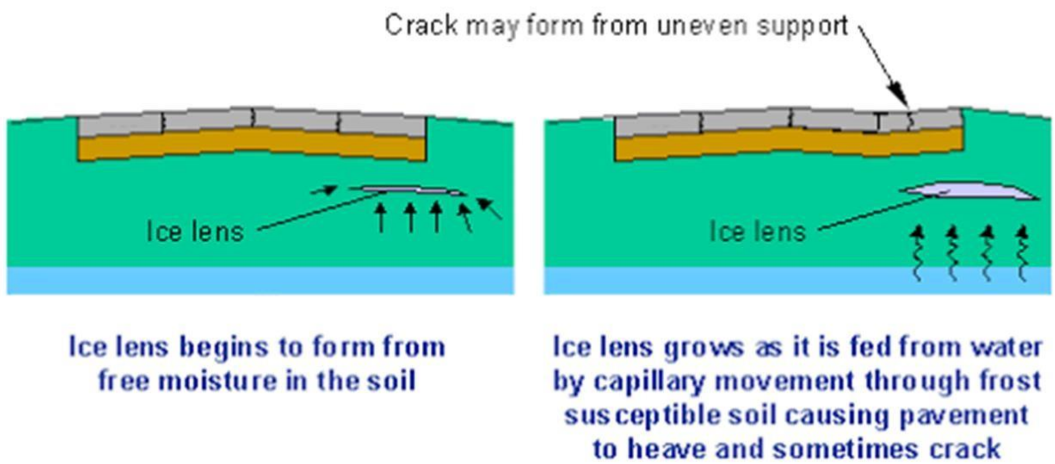
Sub-grade: The top soil or sub-grade is a layer of natural soil prepared to receive the stresses from thelayers above.

- It is essential that at no time soil sub-grade is overstressed.
- It should be compacted to the desirable density, near the optimum moisture content

3 Explain frost action. What are the measures adopted to reduce its effects? [10] CO2 L2

Frost action: Frost action can be quite detrimental to pavements and refers to two separate but related processes:

➢ Frost heave. An upward movement of the subgrade resulting



The three elements necessary for ice lenses and thus frost heave are:

➢ Frost susceptible soil.

➢ Subfreezing temperatures.

➢ Water.

Differential heave is more likely to occur at locations such as:

➢ Where subgrades change from clean not frost susceptible (NFS) sands to siltyfrost susceptible materials.

➢ Abrupt transitions from cut to fill with groundwater close to the surface.

➢ Where excavation exposes water-bearing strata.

➢ Drains, culverts, etc., frequently result in abrupt differential heaving due to different backfill material or compaction and the fact that open buried pipes change the thermal conditions (i.e., remove heat resulting in more frozen soil).

➢ Ground water table

- Temperature gradient
- Mobility of water

Frost penetration: This indicates the formation of ice lenses in a subgrade. This makesthe subgrade strong during winter and weak during summer because of the melting of ice lenses.

Freezing index: Severity of frost action can be expressed in terms of degree days. Onenegative degree day defines one day with a mean air temperature of 1°C below freezing. Similarly, one positive degree day is one day with a mean air temperature of 1°C above freezing.

Thaw Weakening: Thawing is essentially the melting of ice contained within the subgrade. As the ice melts and turns to liquid it cannot drain out of the soil fast enough and thus the subgrade becomes substantially weaker (less stiff) and tends to lose bearing capacity. Therefore, loading that would not normally damage a given pavement may be quite detrimental during thaw periods (e.g., spring thaw).

Measures adopted to reduce damage due to water and frost action

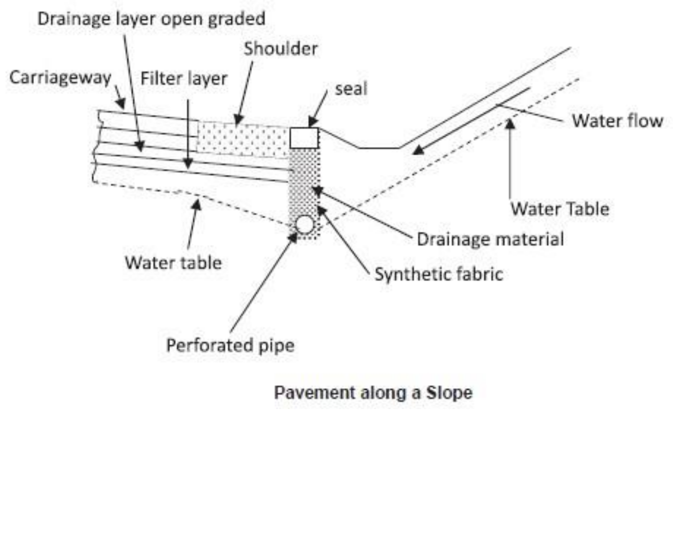
- Install proper surface and sub-surface drainage system
- Construction of base, sub-base and top layer of subgrade. up to the desired depth, by granular and non- frost susceptible material with good drainage characteristics.
- Requirement of filter layer is as follows:

$$\frac{D_{15} of\ filter\ layer}{D_{15}\ of\ subgrade} \geq 5$$

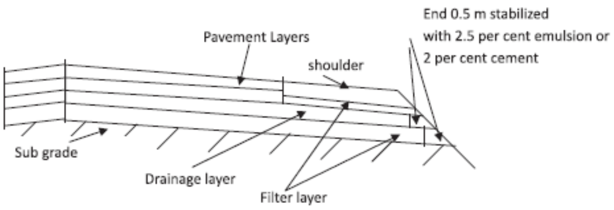
$$\frac{D_{15} of\ filter\ layer}{D_{85}\ of\ subgrade} \leq 5$$

To prevent entry of soil particles into the drainage layer:

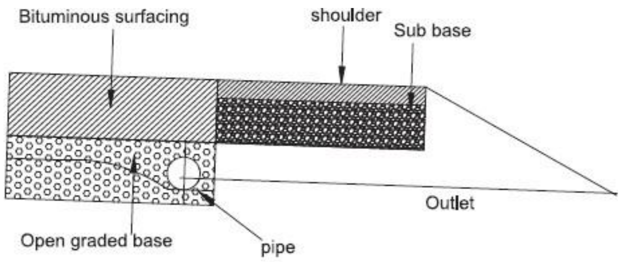
$$\frac{D_{50} of\ filter\ layer}{D_{50}\ of\ subgrade} \leq 25$$



Pavement along a Slope

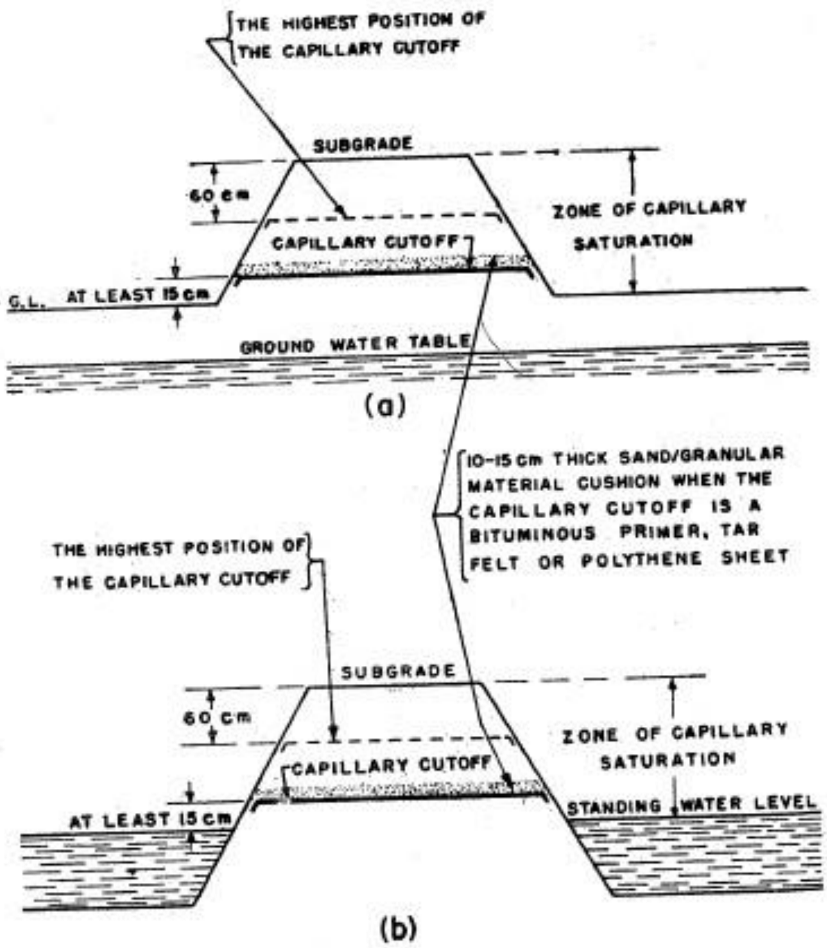


Pavement with Filter and Drainage Layers



Longitudinal Pipe at the Edge of the Drainage Layer with Outlet Pipe

➢ Providing a suitable capillary cut off



SKETCHES ILLUSTRATING DESIRED POSITION OF THE CAPILLARY CUTOFF FOR PREVENTING THE RISE OF CAPILLARY MOISTURE

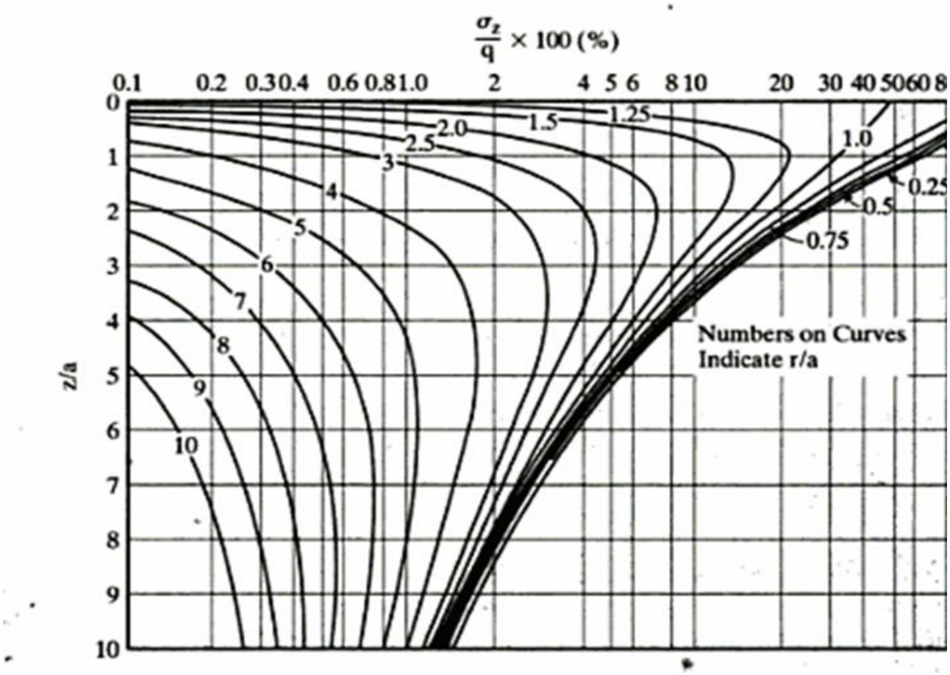
Reduce adverse effects of frost action by soil stabilization so that the soil will be able to withstand the adverse climatic conditions of alternate wet – dry and freeze – thaw cycles

Salts like calcium chloride or sodium chloride when mixed with subgrade soil lowers the freezing temperature of the soil – water and hence temporarily decreases the intensity of frost action

4 A wheel load of 6000kg and contact pressure of 6Kg/cm^2 is applied on the surface of the pavement. Assuming elastic single layer theory find [20]

a. Maximum material stress at a depth of 50cm.

b. Vertical stress at a depth of 2 radius of load and radial distance at r/a = 1,



CO2 L3

A) [Note: Use Boussinesq's vertical stress chart]

given data:

Wheel load $P = 6000kg$

contact pressure $p = 6\ Kg/cm^2$

step① we know that contact radius $a = \sqrt{\frac{P}{\pi p}}$

$$a = \sqrt{\frac{6000}{\pi\, 6}} \Rightarrow \boxed{a = 17.84cm}$$

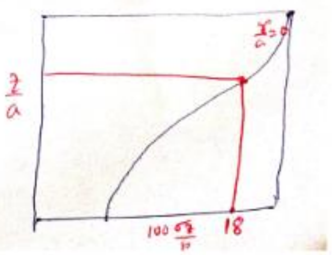
step② To determine maximum material stress at a depth of 50cm

$z = 50cm$, $a = 17.84cm$

$\therefore \frac{z}{a} = \frac{50}{17.84} = 2.8$ take $\frac{r}{a} = 0$ r = offset distance

from graph $100 \frac{\sigma_z}{p} = 18$

$\Rightarrow \sigma_z = \frac{18}{100} \times 6 = 1.08 kg/cm^2$



b) $z = 2a = 2 \times 17.84 = 35.68\,cm$

$\therefore \frac{z}{a} = \frac{2a}{a} = 2$

i) for $\frac{r}{a} = 1$, $\frac{z}{a} = 2$ from graph

$100 \frac{\sigma_z}{p} = 19 \Rightarrow \sigma_z = \frac{19 \times 6}{100} = 1.14\,kg/cm^2$