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Section	A
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Question - 1

Part - (a) :- What is the difference b/w flexible and Rigid Pavement ?

Answer:-

Flexible Pavement	Rigid Pavement
⇒ Flexible Pavement typically distribute wheel loads to lower layer of the pavement section and consists generally of bituminous material.	⇒ Rigid Pavement typically distribute wheels loads over a wide area of the subgrade and consists generally of cement concrete and may be reinforced with steel.
⇒ Bitumen is used a binder in flexible pavement	⇒ Cement is used as a binder in rigid pavement.
⇒ Deformation in the subgrade is transferred to the upper layers.	⇒ Deformation in the subgrade is not transffered to the ~~subsq~~ subsequent layers.
⇒ Load is transferred by grain to grain contact.	⇒ No such phenomenon of grain to grain load transfer exists
⇒ Flexible Pavement have low initial construction costs but have high maintenance cost.	⇒ Rigid Pavement have low maintenance cost but have high initial construction costs.
⇒ Have low life span usually 10 - 15 years.	⇒ Life span is more as compare to flexible usually 30+ years.

Flexible ~~Pay~~ Pavement	Rigid Pavement
⇒ Surfacing cannot be laid directly on the subgrade but a sub base is needed	⇒ Surfacing can be laid directly on the sub base.
⇒ Flexible pavements strength of load highly dependent on strength of subgrade	⇒ Strength of road less dependent on strength of subgrade in rigid pavements
⇒ Road can be used for Traffic within 24 hours.	⇒ Road cannot be used until 14 days of curing

Question # 01

Part - B :- What are the advantages of water bond over wet mix macadam.

Advantage of Water Bond over wet mix Macadam

*) Water bound ensures non-entry of the plastic materials of the sub-grade into the voids b/c of the interlocking of aggregate particles that imparts adequate strength of the material selected for filling the voids.

*) Because of the carefully graded materials, water bond is superior in quality and the resulting mass is almost void less compacted mass.

*) The water bond is constructed by spreading loose metal which gives a consolidated thickness of 75 - 100 mm.

*) Water bond is cheaper than wet-mix macadam because of the specification involves the use of mixing plant and power.

*) Water bond has been traditionally a labour oriented specification.

*) The aggregates for water bond macadam are generally hand-broken where for wet mix macadam the aggregates are crushed.

Question - 1

Part - c : What are the difference b/w Asphalt and bitumen ?

Asphalt	Bitumen
⇒ A dark brown to black cementitious material in which the predominating constituents are bitumen which occure in nature or are obtained in fractional distillation of petroleum along with certain mineral matter	⇒ A class of black or dark - coloured cementitious substance natural or manufactured. Composed principally of high molecular weight hydrocarbons found in Asphalts, Tars, pitches and Asphaltites are typical.

Asphalt	Bitumen
⇒ Asphalt is generally used as a term to refer to the combination of bitumen and gravel specifically for road construction	⇒ In some literature Bitumen is actually the liquid binder that holds Asphalt together.
⇒ Asphalt is produced in a plant that heats, dries and mixes aggregate, bitumen and sand into a composite mix.	⇒ The term bitumen is often mistakenly used to describe asphalt. A bitumen-sealed road has a layer of bitumen sprayed and then coved with an aggregate.

Question #02

A crest vertical curve joining a +3 percent and -4 percent grade is to be designed for 75 mi/h. If the tangents intersect at station (345+60.00) at an elevation of 250 ft.

Determine the station and elevation of BVC and EVC. Also calculate the elevation of intermediate point on the curve at the whole stations.

Solution:-

For a design speed of 75 mi/h $K = 312$ From table

Minimum length $= 312 \times [3-(-4)] = 2184$ ft

Station of BVC $= (345+60) - \left(\frac{21+84}{2}\right) = 334+68$

Station of EVC $= (334+68) + (21+84) = 356+52$

Elevation of BVC $= 250 - \left(0.03 \times \frac{2184}{2}\right) = 217.24$ ft

Station	Distance from BVC (x)(ft)	Tangent elevation (ft)	$\left[y = \frac{Ax^2}{200L}\right]$ (ft)	Curve elevation (Tangent elevation - offset) (ft)
BVC 334 + 68	0	217.24	0.01	217.24
BVC 335 + 00	32	$217.24 + \frac{32}{100} \times 3 =$ 218.2	0.02	218.18
BVC 336 + 00	132	221.20	0.28	220.92
BVC 337 + 00	232	224.20	0.86	223.34
BVC 338 + 00	332	227.20	1.77	225.43
BVC 339 + 00	432	230.20	2.99	227.21
BVC 340 + 00	532	233.20	4.54	228.66
BVC 341 + 00	632	236.20	6.40	229.80
BVC 342 + 00	732	238.20	8.59	230.61
BVC 343 + 00	832	242.20	11.09	231.11
BVC 344 + 00	932	245.20	13.92	231.28
BVC 345 + 00	1032	248.20	17.07	231.13
BVC 346 + 00	1132	251.20	20.54	230.66
BVC 347 + 00	1232	254.20	24.32	229.88
BVC 348 + 00	1332	257.20	28.43	228.77
BVC 349 + 00	1432	260.20	32.86	227.34
BVC 350 + 00	1532	263.20	37.61	225.59
BVC 351 + 00	1632	266.20	42.68	223.52
BVC 352 + 00	1732	269.20	48.07	221.13
BVC 353 + 00	1832	272.20	53.79	218.41
BVC 354 + 00	1932	275.20	59.82	215.38
BVC 355 + 00	2032	278.20	66.17	212.03
BVC 356 + 00	2132	281.20	72.84	208.36
EVC 356 + 52	2184	282.76	76.44	206.32

Question No # 03

Solution :-

* Reliability level = R = 99%
* Standard deviation (S_o) = 0.49
* Initial Serviceability index P_i = 4.5
* Terminal Serviceability index P_t = 2.5
* ΔPSI = 4.5 - 2.5 = 2.0

⇒ Finding SN_1 and D_1 (Surface course)

Step # 01 :- Draw a line joining the reliability level of 99% and the overall standard deviation S_o of 0.49 and extend this line to intersect the first TL line at point A.

Step # 02 :- Draw a line joining point A to the ESAL of 2×10^6, and extend this line to ~~increase~~ intersect the second TL line at point B.

Step # 03 :- Draw a line joining point B and resilient modulus (M_r) of base course and extend this line to intersect the design serviceability loss chart at point C.

Step #04 :-

⇒ Draw a horizontal line from point C to intersect the design serviceability

⇒ loss (PSI) curve at point D. In this problem

$$\Delta PSI = 4.5 - 2.5 = 2.0$$

Step = 05

⇒ So the structure number required to protect the base course and to find the thickness D_1 of the surface course is 2.6.

Finding layer co-efficient a_1

Step #06 :- Determine the appropriate structure layer co-efficient for each construction material

Resilient value of asphalt = 450000 lb/in²

therefore $a_1 = 0.44$

Thickness of surface course D_1

$$D_1 = \frac{SN_1}{a_1} = \frac{2.6}{0.44}$$

$D_1 = 5.9$ inch

Thickness should be taken to the nearest 0.5 inches so the thickness of surface course is 6 inch

$SN_1 = D_1 \times a_1$

$SN_1 = 6 \times 0.44$

$SN_1 = 2.64$

Thickness of Base course D_2

$$D_2 = \frac{SN_2 - SN_1}{a_2 m_2} = \frac{3.8 - 2.64}{0.14 \times 0.80}$$

$$\boxed{D_2 = 10.36 \text{ inches}}$$

Use 12"

So Thickness of base course 12"

$$SN_2 = 0.14 \times 0.80 \times 12 + SN_1$$

$$SN_2 = 1.34 + 2.64$$

$$\boxed{SN_2 = 3.98}$$

Thickness of Subbase Course D_3

$$D_3 = \frac{SN_3 - SN_2}{a_3 m_3} = \frac{4.40 - 3.98}{0.10 \times 0.80}$$

$$\boxed{D_3 = 5.25 \text{ inches}}$$

Use 6" sub base.

$$SN_3 = 2.64 + 1.34 + 6" \times 0.10 \times 0.80$$

$$\boxed{SN_3 = 4.46 > 4.4} \text{ Okey}$$

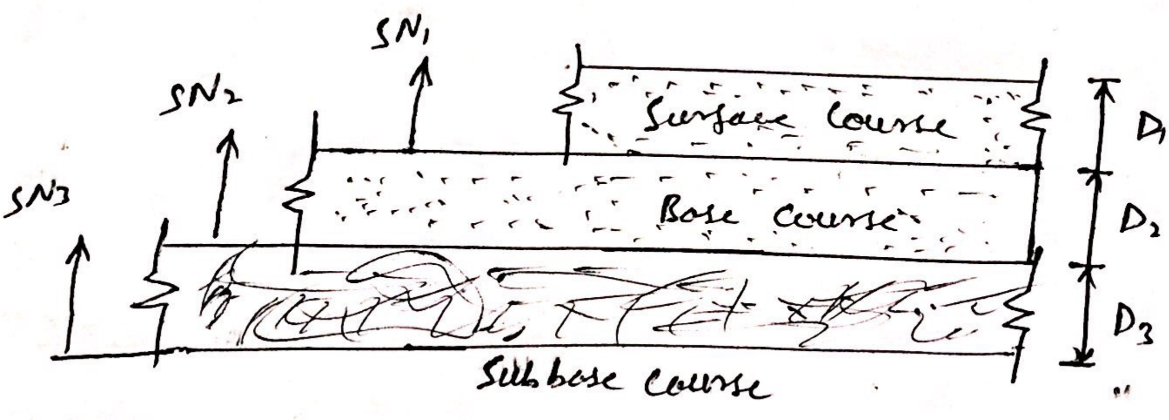
Final Design

⇒ Surface course = 6"

⇒ Base course = 12"

⇒ Sub base = 6"

⇒ Total pavement thickness = 24"



Question No # 04

What are different pavement distresses? Explain in detail?

PAVEMENT DISTRESSES :

⇒ Distresses is a condition of the pavement structure that reduces serviceability or lead to a reduction in service life

⇒ Distresses could occure in a pavement due to.

* ★ Unstable mixes
* ★ Higher wheel load than those considerade in design

Different Pavement Distresses

① Alligator Cracking :-

A form of plastic movement typified by ripples or an abrupt wave across the pavement surface. the distortion is perpendicular to the traffic direction.

★ **Problem :-** Roughness

★ **Possible causes :-**
- ★ Over loading
- ★ Inadequate structure design
- ★ Poor construction.

★ **Repair :-**
- ★ Crack sealing is in effective
- ★ Dig out and replace area of poor subgrade.

② Block Cracking :-

Block cracking in a parking lane.
Parking lanes see little if any traffic, Therefore the only likely distresses that will occure are ravelling and block cracking.
These cracke are probably too wide to be effectively crack sealed.

Problem :- Allows moisture infiltration.

Possible causes :-
* ★ HMA shrinkage
* ★ Asphalt binder aging
* ★ poor choice of asphalt binder in the mix design

Repair :-

★ Low severity cracks (< ½ inch wide).
Crack seal to prevent entry of moisture.

★ High severity crack (> ½ inch wide and crack with raveled edges)
Remove and replace the cracked pavement layer with an overlay.

③ **Potholes :-**

Potholes are most likely to occure on road with thin HMA surface (1 to 2 inch) and seldom occure on road with 4 inch or deeper HMA surface.

Problem:- ⊛ Roughness (serious vehicular damage can result from driving across potholes at higher speed)
⊛ Moisture infiltration.

Possible causes:- ~~Gener~~ Generally, potholes are the end result of fatigue cracking.
As fatigue cracking become severe, the interconnected cracks create small chunks of pavement, which can be dislodged as vehicles drive over them.

Repair : Patching Techniques.

④ **Rutting :-** Surface depression in the wheel path are particularly evident after a rain when they are filled with water.

Possible causes :
⊛ Insufficient compaction of HMA layers during construction
⊛ Subgrade rutting
★ Improper mix design.

Repair :- Slight ruts (< 1/3 inch deep) can generally be left untreated.
Pavement with deeper ruts should be leveled and overlayed.

(5) Bleeding :-

Problem :- Loss of skid resistance when wet

Possible causes :-

- ★ Excessive asphalt binder in the HMA
- ★ Excessive application of asphalt binder during BST application.
- ★ Low HMA air void content.

(6) Polished Aggregate :-

Possible causes :- Repeated trafic application.
This can occure quicker if the aggregate is susceptible to abrasion

Repair :- Apply a skid-resistant slurry seal BST or non-structural overlay.

⑦ Raveling :-

Loose debris on the pavement which increases pavement roughness and loss of skid resistance.

Possible causes :-

* Asphalt binder aging
* Aggregrate segregation. if fine particles are missing from the aggregrate matrix.
* Inadequate compaction during construction

Repair :- Fog seal or slurry seal or Remove the damaged pavement and overlay.

The END