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QUESTION-01
(PART-A)

Q:- What is the difference between flexible and Rigid Pavement?

Ans:- Following are the differences b/w Rigid and flexible Pavement.

FLEXIBLE PAVEMENT	RIGID PAVEMENT
=> It consists of 4 Layers, Sub-grade, Sub-base, base and wearing Course	=> It consists of 3 Layers Sub-grade, Sub-base and wearing Course.
=> A Layer of Bitumen is used as a wearing Course in flexible Pavement.	=> RCC (slab) is laid directly on Sub-base as a wearing Course.
=> It functions by a way of load distribution through the Component Layers.	=> It distributes load over a wide area of Sub-grade because of its rigidity and high modulus of elasticity.
=> Load is transferred by grain to grain Contact.	=> No grain to grain load transfer exists.
=> Pavement design is greatly influenced by Sub-grade strength.	=> Flexural strength of Concrete is a major factor for design.
=> Flexible pavements have self healing properties due to havier wheel loads are recoverable due to some extent.	=> Any excessive deformations occuring due to havier wheel loads are not recoverable i.e Settlements are permanent.
=> These pavements have Low initial construction costs but have high maintenance cost.	=> These pavements have low maintenance cost but high initial construction costs.
=> Road can be used for traffic within 24 hours.	=> Road cannot be used until 14 days of curing.

(PART-B)

b:- What are the advantages of waterbound over wet mix macadam?

Ans:- Following are the advantages of waterbound over wet mix macadam.

ADVANTAGES OF WATERBOUND OVER WET MIX MACADAM:-

1- Because of the carefully graded materials, water bound is superior in quality and the resulting mass is almost void less compacted mass.

2- Waterbound ensures non-entry of the plastic materials of the sub-grade into the voids because of the interlocking of aggregate particles that imparts adequate strength of the materials selected for filling the voids.

3- The water bound is constructed by spreading loose metal which gives a consolidated thickness of 75-100 mm.

4- Water bound is cheaper than wet-mix macadam because of the specifications involves the use of mixing plant and paver.

5- The aggregates for water bound macadam are generally hand-broken whereas for wet mix macadam, the aggregates are crushed.

6- Water bound has been traditionally a labour oriented specifications, where as wet mix macadam uses energy for their process.

(PART-C)

C:- What is the difference between Asphalt and Bitumen?

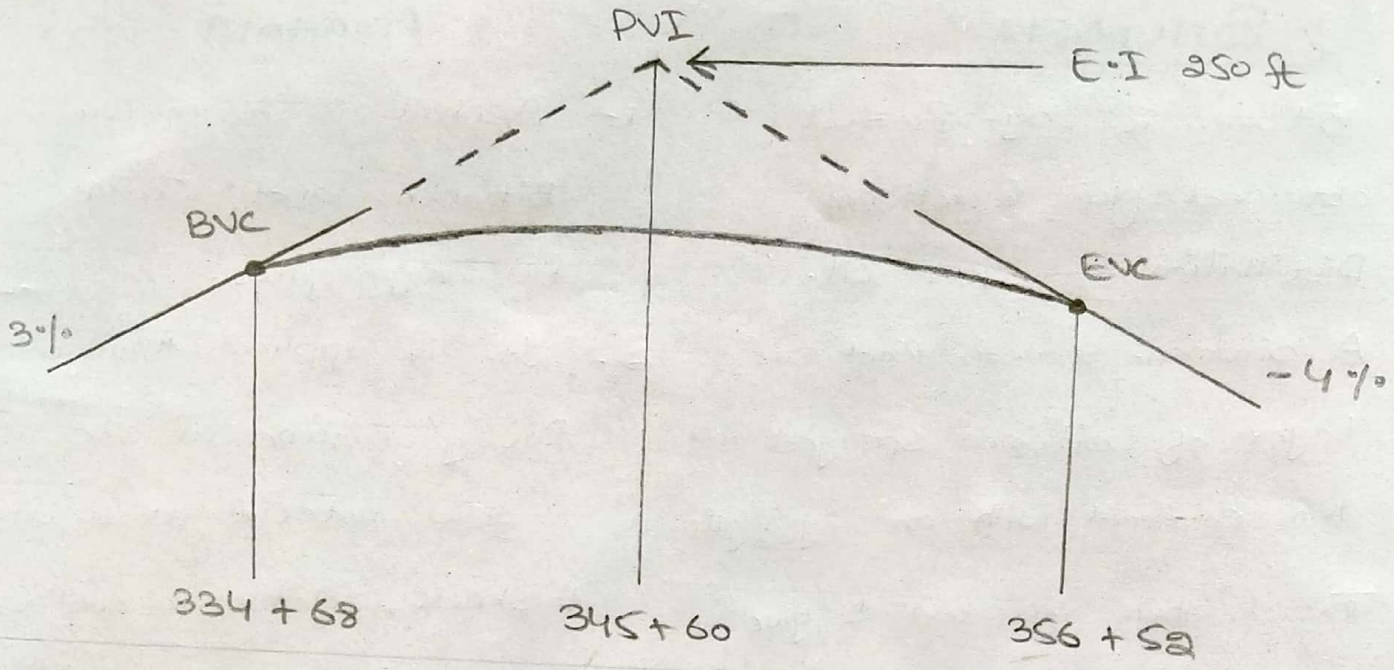
Ans:- Following are the differences b/w Asphalt and Bitumen.

BITUMEN	ASPHALT
1- Bitumen is by-Product obtained from Fractional Distillation of Crude oil.	1- Asphalt is a mixture of Bitumen and Coarse & Fine Aggregates.
2- A bitumen-sealed road has a layer of bitumen sprayed and then covered with an aggregate. This is then repeated to give a two-coat seal.	2- It is applied through a Paving machine on site as a solid material at required thickness, relative to end use. It is smoother and more durable surface than a bitumen-sealed road.
3- Bitumen is Actually the liquid binder that holds Asphalt together.	3- Asphalt is a strong cement that is readily adhesive and highly water proof and durable making it particularly useful in road construction.

(QUESTION-02)

A Crest Vertical curve joining a +3% and a -4% grade is to be designed for 75 mi/h. If the tangents intersect at station (345+60.00) at an elevation of 950 ft. Determine the Stations and elevation of BVC and EVC. Also Calculate

the elevations of intermediate points on the curve at the whole stations.



Solution :-

For a design speed of 75 miles/hour the value of "k" will be choosed from the table (on next Page) i.e $\boxed{K = 312}$

Now,

1- Minimum length $= 312 \times (3 - (-4)) = \boxed{2184 \text{ ft}}$

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

3- Station of EVC $= (334 + 68) + (21 + 84) = \boxed{356 + 52}$

4- Elevation of BVC $= 250 - \left(0.03 \times \frac{2184}{2}\right) = \boxed{217.94 \text{ ft}}$

Station	Distance from BVC (x) (ft)	Tangent Elevation (ft)	Offset $\left[y = \frac{Ax^2}{200L} \right]$ (ft)	Curve Elevation (Tangent Elevation offset) (ft)
BVC 334+68	0	217.24	0.01	217.24
BVC 335+00	32	$217.24 + \frac{32}{100} \times 3 = 218.20$	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	239.20	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	42.86	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
BVC 356+52	2184	282.76	76.44	206.32

(QUESTION - 03)

A flexible highway is to be designed to carry a design ESAL of 2×10^6. It is estimated that it takes about a week for water to be drained from within the pavement and the pavement structure will be exposed to moisture levels approaching saturation for 30% of the time. The following additional information is available:

- Resilient Modulus of Asphalt Concrete at 68°F 450,000 lb/in²
- CBR value of base course material 100, M_r 31,000 lb/in²
- CBR value of Sub-base course material 22, M_r 13500 lb/in²
- CBR value of Sub-grade material 6
- M_r of Subgrade 6×1500 lb/in² = 9000 lb/in²

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

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

STEP #1 :-

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 #2 :-

Draw a line joining Point A to the ESAL of 2×10^6, and

extend this line to intersect the Second TL Line at point B.

STEP # 3 :-

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 # 4 :-

Draw a horizontal line from point C to intersect the design Serviceability loss (PSI) curve at point D. In this Problem, $\Delta PSI = 4.5 - 2.5 = 2.0$

=> So the structure number required to protect the base course and to find the thickness D1 of the surface course is 2.6.

STEP # 5 :-

Determine the appropriate structure layer co-efficient for each construction material. Resilient value of Asphalt = 450,000 lb/in², therefore $a_1 = 0.44$

THICKNESS OF SURFACE COURSE (D_1) :-

By formula, $D_1 = SN_1/a_1$

$= 2.6/0.44 = 5.9'' \rightleftharpoons 6''$

As thickness should be taken to nearest 0.5", So the thickness of the Surface Course is 6".

Now,

$$SN_1^* = D_1 \times a_1$$
$$= 6 \times 0.44$$
$$\boxed{SN_1^* = 2.64}$$

THICKNESS OF BASE COURSE (D_2) :-

Also by formula,

$$D_2 = \frac{(SN_2 - SN_1^*)}{a_2 m_2}$$
$$= \frac{(3.8 - 2.64)}{0.14 \times 0.80} \Rightarrow \boxed{D_2 = 10.36"}$$

Rounding D_2 to nearest whole number, ie 12"

So thickness of Base Course is 12".

$$\Rightarrow SN_2^* = 0.14 \times 0.80 \times 12 + SN_1^*$$
$$= 1.34 + 2.64$$
$$\boxed{SN_2^* = 3.98}$$

THICKNESS OF SUB-BASE COURSE (D_3) :-

$$\Rightarrow D_3 = \frac{(SN_3 - SN_2^*)}{a_3 m_3} = \frac{(4.4 - 3.98)}{0.10 \times 0.80}$$

$$\boxed{D_3 = 5.25}$$

we take 6" instead of 5.25" $\Rightarrow \boxed{D_3 = 6"}$

$$\Rightarrow SN_3^* = 2.64 + 1.34 + 6" \times 0.10 \times 0.80$$
$$SN_3^* = 4.46$$

As, $4.46 > 4.4 \longrightarrow$ OK!

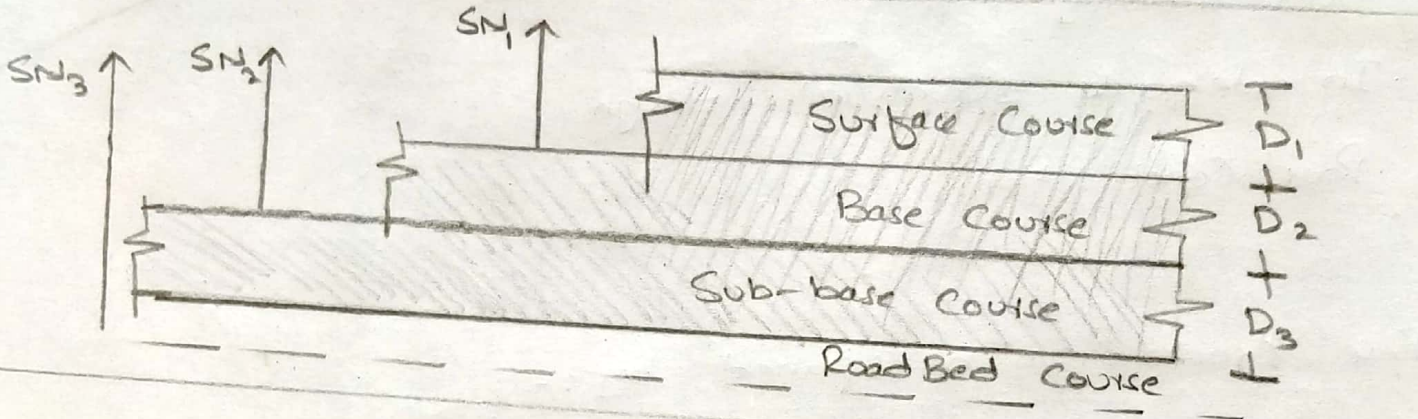
FINAL DESIGN :-

=> Surface Course = 6"

=> Base Course = 12"

=> Sub Base = 6"

=> Total Pavement Thickness = 24"



QUESTION- 4

What are the different Pavement Distresses? Explain in Detail.

Ans:- **PAVEMENT DISTRESSES :-**

Distress is a condition of the pavement structure that reduces serviceability or leads to a reduction in service life.

=> Distresses that occur in a pavement are due to the following reasons :

- Unstable Mixes
- Higher Wheel loads than those considered in design.

Pavement Distresses Types:-

Following are different categories of Pavement distresses

1- Alligator (Fatigue) Cracking:-

It is a type of Cracks that occur in a pavement due to the following Causes :

=> Over loading

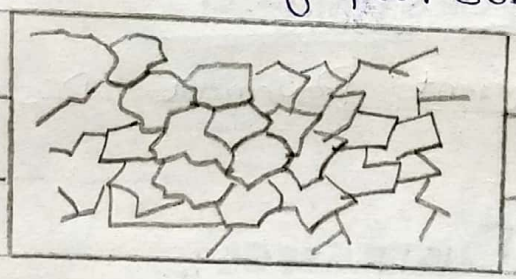
=> In adequate structural design

=> Poor Construction.

These Cracks can be repaired by :-

=> Crack Sealing is in effective

=> Dig out and replace area of Poor Sub-grade.



2- Block Cracking:-

=> These Cracks are Blocks in shape.

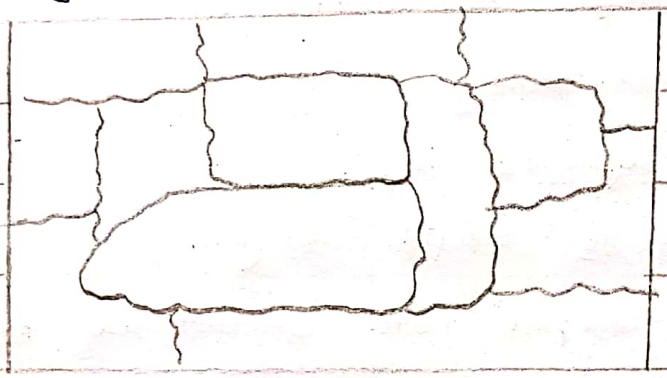
=> It allows moisture infiltration.

=> Possible Causes include

- HMA Shrinkage
- Asphalt Binder Aging
- Poor choice of Asphalt Binder in mix design

=> These Cracks can be repaired by :-

- Low Security Cracks ($< \frac{1}{5}$" wide) . Crack Seal to Prevent entry of moisture.
- High Security Cracks ($> \frac{1}{5}$" wide & and Cracks with reveled edges). Remove and replace the Cracked Pavement Layer with an overlay.



3- POTHOLES :-

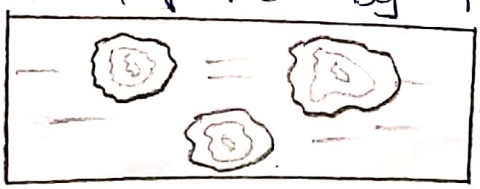
=> These are Small, bowl shaped depressions in the Pavement Surface that penetrate all the way through the HMA Layer down to the base Course.

=> Potholes Causes Roughness (Serious vehicular damage can result from driving across potholes at higher Speeds).

=> Potholes are Caused in the Pavement due to :-

- Potholes are the end result of fatigue Cracking. As fatigue cracking becomes severe, the inter-connected Cracks Create small chunks of pavement that forms potholes.

=> Potholes Can be Repaired by Patching techniques.



4- RUTTING:-

=> Rutting is the surface depression in the wheel path, are particularly evident after a rain when they are filled with water.

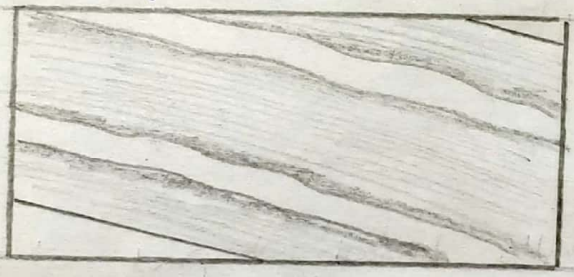
=> Possible causes of Rutting in Pavement are;-

- Insufficient Compaction of HMA Layers during Construction.
- Subgrade rutting (as a result of inadequate pavement structure)
- Improper Mix design (e.g high Asphalt content etc).

=> These can be repaired by :-

Slight ruts ($< 1/3$" deep) can generally be left untreated.

Pavement with deeper ruts should be leveled & overlayed.

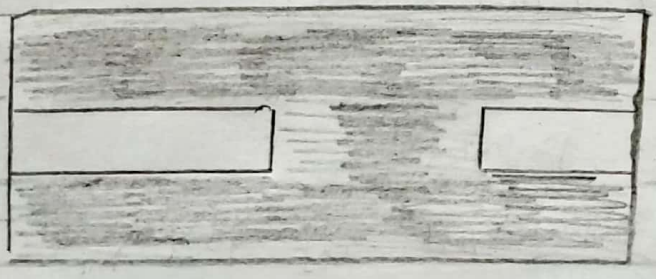


5- BLEEDING:-

=> Bleeding causes loss of skid resistance when wet.

=> Possible causes of bleeding are :-

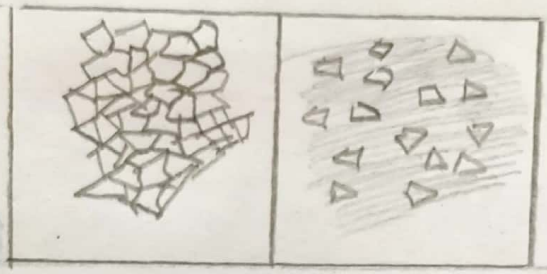
- Excessive asphalt binder in the HMA.
- Excessive Application of Asphalt binder during BST.
- Low HMA air void content.



6- POLISHED AGGREGATE:-

=> Possible causes of the polished Aggregate of pavement surface are Repeated traffic applications. This can occur quicker if the aggregate is susceptible to abrasion

=> These can be repaired by applying 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 of raveling are:-

- Asphalt Binder Aging
- Aggregate Segregation
- Inadequate Compaction during Construction

=> Raveling in a pavement can be repaired by:- Fog Seal / Slurry Seal or Remove the damaged pavement and over-lay.

END