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Q No (1)

Part (a)

What is the difference between flexible and rigid pavement?

Ans:- **Flexible pavements:-**

① Grain to grain load transfer
② Initial cost is low
③ Joints are not required
④ Durability is less
⑤ Good subgrade is required
⑥ Temperature variation has no any effect on the stress variation
⑦ Life span is short IS years
⑧ Repair work is easy
⑨ Maintenance cost is high
⑩ Requires less curing time.
⑪ Poor night visibility due to use of bitumen
⑫ No glare due to sunlight.
⑬ Thickness is more
⑭ IRC 37
⑮ Design depends upon the subgrade strength.

Rigid pavements:-

① Slab action takes place
② Initial cost is high
③ Joints are required.
④ Durability is high
⑤ Good subgrade is not required.
⑥ Long life span ~30 years.
⑦ Repair work is tough
⑧ Maintenance cost is low
⑨ Requires much curing time.
⑩ Thickness is less.

(d) Good night visibility
(e) High glare due to sunlight
(f) Design is not depends on subgrade
(g) Difficult to do the underground works
(h) IRC 58.

Part "b"

What are the advantages of water bound over wet mix macadam ?

Ans

Water bound macadam:

→ Water bound macadam may be defined as a dense and compact course of a road pavement composed of stone aggregates bound together by a thin film of cementing medium consisting of fine mineral filler (such as stone screening or gravel) with cementitious properties and containing a minimum laden moisture to impart to the binder necessary cohesive and adhesive properties to enable it to bind the aggregate together.

→ The strength of a water-bound macadam course is thus

① primarily due to the through mechanical interlock in the aggregate particles.

② cohesion between the aggregate particles due to the cementitious film of soil-moisture binder.

→ The water-bound macadam is constructed by spreading loose metal which gives a consolidated thickness of 0.75mm – 100mm

Wet mix macadam:

→ Wet-mix macadam is a specification in which a well-graded aggregate is mixed with water in a mechanical mixer and the resultant

mixture is laid by pavers and compacted.

→ The aggregate is generally crusher-run and includes fines also. Because of the close grading, the course will have good interlock with excellent density.

→ The main **Odantages** of wet-mix macadam over water-bound macadam is that is composed of a well-graded mixture. This ensures good interlock and high stability.

→ Addition of water while mixing facilitates the handling of the mixture. The operation of laying is much simpler than that of water-bound macadam, where the screenings and binding material have to be added in stages and forced into voids. If a crusher-run material is used there is no possibility of plastic fines entering into the mixture.

→ The compaction is greatly facilitated by the moisture added which lubricates the individual particles.

→ One disadvantage of the wet-mix macadam is that it is slightly costlier than water-bound macadam. This is because the specification involves the use of mixing plant and paver. On the other hand, water bound macadam has been traditionally a labour oriented specification.

→ The aggregates for wet mix macadam will have to be crusher-run, whereas the aggregates for water-bound macadam are generally hand-broken.

Part "C"

What is the difference between asphalt and bitumen?

Ans: BITUMEN:

→ A class of black or dark-colored (solid, semi-solid or viscous) cementitious substance, natural or manufactured composed principally of high molecular weight hydrocarbons found in Asphalt, Tars, Pitches, and Asphaltites are typical

→ In some literature Bitumen is actually the liquid binder that holds asphalt together

→ A suspension of minute globules of bituminous material in water or in an aqueous solution

→ A suspension of minute globules of water or of an aqueous solution in a liquid bituminous material

Asphalt:

→ A dark brown to black cementitious material in which the predominating constituents are bitumens which occur in nature or are obtained in fractional distillation of petroleum (crude oil) alongwith certain mineral matter

→ In American Terminology

→ Asphalt is generally used as a term to refer to the combination of bitumen and gravel specifically for road construction.

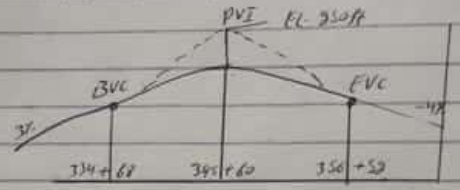
→ Both Asphalt and Bitumen are same and are "ASPHALT"

Composition

→ Carbon (70-85%)
→ Hydrogen (9-13%)
→ Nitrogen (0-1%)
→ Sulfur (1-7%)
→ Oxygen (0-5%)

Q No (2)

A crest vertical curve joining a +3 percent and a -4 percent grade is to be designed for 75 mi/hr. If the tangents intersect at station (345 +60.00) at an elevation of 350 ft, determine the stations and elevations of the BVC and EVC. Also, calculate the elevations of intermediate points on the curve at the whole stations.



Solution:

For a design of 75 mi/h, K = 312.

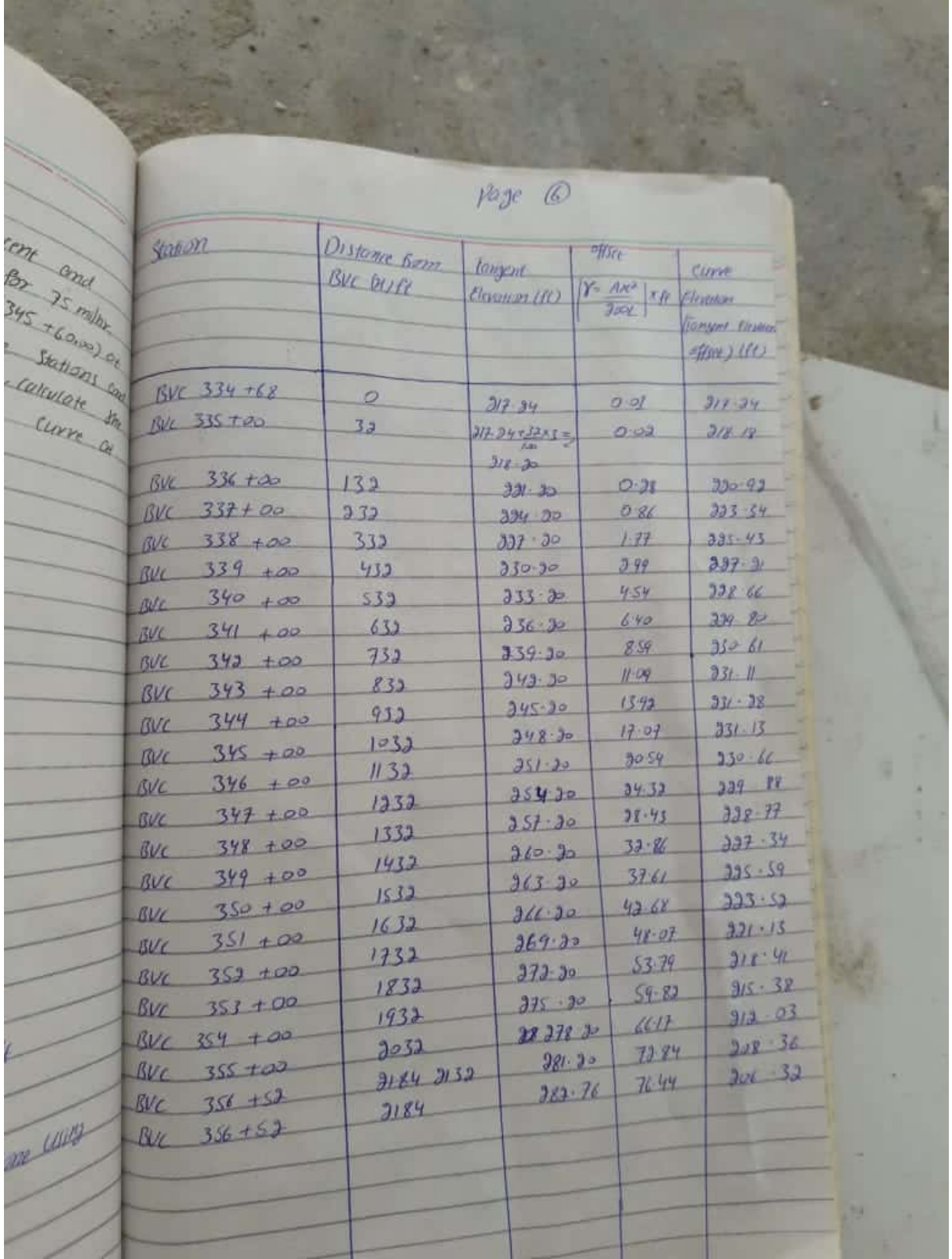
Minimum length = 312 x [3 - (-4)] = 2184ft

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

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

Elevation of BVC = 350 - (0.03 x $\frac{2184}{2}$) = 317.24 ft

The remainder of the computation is efficiently done using the format shown in table.



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Station	Distance from BVC (ft)	tangent Elevation (ft)	offset $\left\lvert \frac{Y = Ax^2}{2L} \right\rvert \times ft$	Curve Elevation (tangent Elevation − offset) (ft)
BVC 334 +68	0	317.34	0.01	317.34
BVC 335 +00	32	317.34 + 32 × 5 / 100 = 318.20	0.02	318.18
BVC 336 +00	132	321.30	0.28	320.92
BVC 337 +00	232	324.20	0.86	323.54
BVC 338 +00	332	327.20	1.77	325.43
BVC 339 +00	432	330.20	2.99	327.21
BVC 340 +00	532	333.20	4.54	328.66
BVC 341 +00	632	336.20	6.40	329.80
BVC 342 +00	732	339.20	8.59	330.61
BVC 343 +00	832	342.20	11.09	331.11
BVC 344 +00	932	345.20	13.92	331.28
BVC 345 +00	1032	348.20	17.07	331.13
BVC 346 +00	1132	351.20	20.54	330.66
BVC 347 +00	1232	354.20	24.32	329.88
BVC 348 +00	1332	357.20	28.43	328.77
BVC 349 +00	1432	360.20	32.86	327.34
BVC 350 +00	1532	363.20	37.61	325.59
BVC 351 +00	1632	366.20	42.68	323.52
BVC 352 +00	1732	369.20	48.07	321.13
BVC 353 +00	1832	372.20	53.79	318.41
BVC 354 +00	1932	375.20	59.82	315.38
BVC 355 +00	2032	378.20	66.17	312.03
BVC 356 +52	2184 2132	381.20	73.84	308.36
BVC 356 +52	2184	383.76	76.44	306.32

Q.NO "3"

A flexible highway is to be designed to carry a design ESAL of 3×10^6. 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 subbase course material 22, M_r 13,500 lb/in²
→ CBR value of subgrade 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

$\Delta PSI = 4.5 - 2.5 = 2.0$

Finding SN1 and D_1 (Surface course)

Step#01

Draw the line joining the reliability level of 99% and the over all Standard deviation S_o of 0.49

Step #2 :

Draw a line joing point A to the ESAL of 2x10

Step #3 :: Draw a line joing point B and resilined modulus (Mr) 0.6 Base course and extend this line.

Step # 4 : Draw a horizontal line from the point C to intersect the design serviceability → loss (PSI) curve at point D

$\Delta PSI = 4.5 - 2.5 = 2$

→ D_1 of surface coarse is 2.2

Step # 5 :

Resilined value of Asphat = 450000 lb/in²

Therefore $\boxed{a_1 = 0.44}$

Thickness of surface coarse D_1

$D_1 = SN / a_1$

$D_1 = 2.4 / 0.44$

$\boxed{D_1 = 5.4''}$

Thickness should be taken to the nearest 0.5'

So thickness of surface coarse is 6"

$SN_1' = D_1' \times a_1$

$SN_1 = 6 \times 0.44 = \boxed{2.64}$

Finding SN_2 and D_2 (Base coarse)

$D_2 = (SN_2 - SN_1')/a_2 m_2$

$D_2 = \frac{3.8 - 2.64}{0.14 \times 0.80}$

$\boxed{D_2 = 10.36''}$

use 12"

So thickness of base coarse is 12"

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

$SN_2' = 1.34 + 2.64$

$\boxed{SN_2' = 3.98}$

Finding SN_3 and D_3 (Subbase coarse)

$D_3 = \frac{(SN_3 - SN_2')}{a_3 \times m_3}$

$D_3 = (4.4 - 3.98) \, 0.10 \times 0.80$

$D_3 = 5.25''$

We will use 6" as a slab base

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

$SN_3^* = \boxed{4.46 > 4.4}$ correct

Final Design

Surface coarse = 6"
Base coarse = 12"
Subbase coarse = 6"

Total pavement thickness = 24"

Q.No (4)

What are the different pavement distresses? Explain in detail?

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

→ Distresses could occurs in a pavement due to
① Unstable mixes
② Higher wheel loads than those considered in design

① Alligator or (Fatigue) Cracking:

(A) Possible causes:
① Overloading
② Inadequate structural design
③ Poor construction

(B) Repair:
① Crack Sealing is in effective
② Dig out and replace area of poor subgrade.

② Block Cracking:
(A) Problem: Allows moisture infiltration
(B) Possible causes:
① Thin Shrinkage
② Asphalt binder aging
③ Poor choice of asphalt binder in the mix design.

(C) Repair
① Low severity cracks (< 1/2 inch wide). Crack Seal to prevent entry of moisture
② High severity cracks (>1/2) inch wide and cracks with raveled edges).
Remove and replace the cracked pavement layer with an overlay.

⑤ Potholes:
→ Small bowl-shaped depressions in the pavement surface that penetrate all the way through the HMA layer down to the base course.
→ Potholes are most likely to occur on roads with thin HMA surfaces (1 to 3 inches) and seldom occur on roads with 4 inch or deeper HMA surfaces.

Problem:
Roughness (Serious vehicular damage can result from driving across potholes at higher speeds), moisture infiltration

Possible causes: Commonly, potholes are the end result of fatigue cracking. As fatigue cracking becomes severe, the interconnected cracks create small chunks of pavement, which can be dislodged as vehicles drive over them.
→ Repairs
→ Patching techniques
→ Patching techniques

⑥ Rutting:
→ Surface depression in the wheel path. Are particularly evident after a rain when they are filled with water.
→ Surface depression in the wheel path, are particularly evident after a rain when they are filled with water.

Possible causes:
→ Insufficient compaction of HMA layer during construction
→ Subgrade rutting (e.g as a result of inadequate pavement structure)

Scanned with CamScanner

→ Improper mix design (eg excessively high asphalt content, excessive mineral filler, insufficient amount of angular aggregate particles)

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 cause:
→ 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 traffic application. This can occur 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:
① Asphalt binder aging
② Aggregate segregation, if fine particles are missing from the aggregate matrix.

3. Inadequate compaction during construction.

Repair:

Fog seal/ Slurry seal or Remove the damaged pavement and overlay.