FINAL. EXAM INU

ID#	7836
SUBMITTED TO	ENGR. FARHAN KTK
SUBJECT	HIGHWAY & TRANSPORTATION ENGINEERING.
SECTION	B
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MODULE	6th

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1.
a) What is the difference between flexible and rigid pavement?

Ans:

FLEXIBLE PAVEMENT	RIGID PAVEMENT
• Bitumen is used a binder in flexible pavement.	• Cement is used as binder in rigid pavements.
• Deformation inthe sub grade is transferred to the upper layer.	• Deformation inthe sub grade is not transferred to subsequent layers.
• Load is transferred by grain to grain contact.	• No concept of grain to grain load transffer.
• It have low initial construction costs but have high maintenance costs.	• It has low maintenance cost but have high initial construction costs.
• The life span is usually 10-15yrs.	• Life span is more than 30yrs.
• Surfacing cannot be laid directly onthe sub grade but sub base is needed.	• Surfacing can be directly laid on the sub grade.
• Road can be used for traffic with 24 hrs.	• Road cannot be used untill 14 days of curing.

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

Ans: Following are the advantages of water bound over wet mix macadam:

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- WBM is slightly cheaper than the wet-mix macadam. The reason is WBM requires general labour while wet-mix macadam requires mixer plant and paver.

- Aggregates of WBM are or can be broken by hands while the WMM needs a crusher for the disintegration of aggregates.

- The interlocking of aggregate particles imparts adequate strength of the materials for filling the voids. These ensure non-entry of the plastic materials of the sub-grade into voids.

c. What is the difference between asphalt and bitumen?

Ans: • Bitumen is actually the liquid binder that holds asphalt togather.

- Asphalt is generally used as a term to refer to the combination of bitumen & gravel for road construction.

- Bitumen is known for being strongly adhesive and resistant to damage from water and oil spills, this makes bitumen the ideal binder for asphalt because asphalt is commonly used as a surface for roads, car parks etc.

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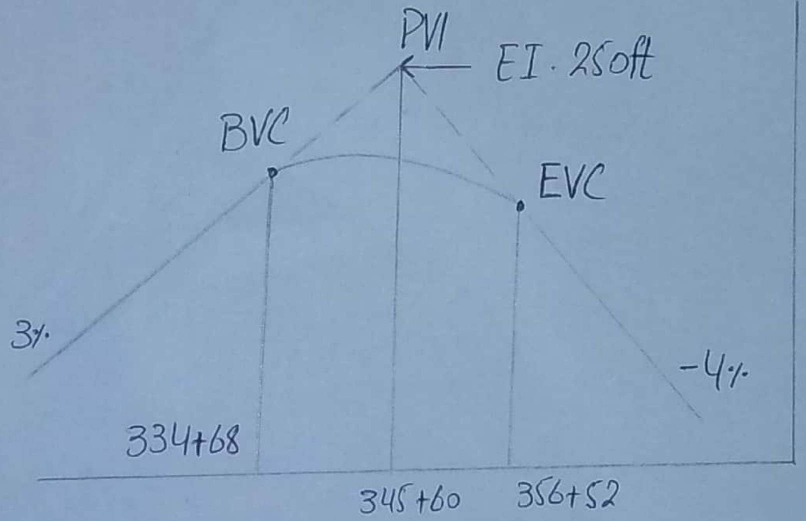
2\. A crest vertical curve joining a +3 percent and a -4 percent grade is to be designed for 75 mi/h. If the tangents intersect at station (345 + 60.00) at an elevation of 250 ft, determine the stations and elevations of the BVC and EVC. Also, calculate the elevation of intermediate points on the curve at the whole stations.



Sol: 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

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

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Station	Distance from BVC (x) (ft)	Tangent Elevation (ft)	Offset $\left[r = \frac{\Delta x^2}{200L} \right]$ (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	42.68	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

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3. 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/in^2
→ CBR value of base course material 100, M_r 31000 lb/in^2
→ CBR value of subbase course material 22, M_r 13,500 lb/in^2
→ CBR value of subgrade material 6
→ M_r of subgrade 6×1500 lb/in^2 = 9000 lb/in^2

Sol:

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 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.

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Step 04:

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

→ loss (PSI) curve at point D, so here

$$\Delta PSI = 4.5 - 2.5 = 2$$

Step 05:

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

Step 06:

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

$$D_1 = SN_1 / a_1$$

$$2.6/0.44 = 5.9''$$

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

$$SN_1 = D_1 \times a_1$$

$$= 6 \times 0.44 = 2.64$$

→ Now find SN_2 and D_2 (Base course)

find the value of a_2 from layer coefficient table and m_2 from drainage co-efficient table.

→ Thickness of Base course (D_2)

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

$$D_2 = (3.8 - 2.64/.14 \times 0.80$$

$$D_2 = 10.36''$$

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Use 12"

So the thickness of base course is 12"

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

$SN_2 = 1.34 + 2.64$

$SN_2 = 3.98$

→ Finding SN_3 and D_3 (Subbase course) and also layer coefficient a_3 and drainage coefficient m_3 from their respective table.

$D_3 = (SN_3 - SN_2) / a_3 m_3$

$= (4.4 - 3.98) / .10 \times 0.80$

$D_3 = 5.24"$

We will use 6" as a sub base

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

$SN_3 = 4.46 > 4.4$ okay!

FINAL DESIGN:

- → Surface course = 6"
- → Base course = 12"
- → Sub base = **6"**
- → Total pavement Thickness = **24"**

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4. What are the different pavement distresses? Explain in detail?

Ans: Following are the different pavement distresses:

1- ALLIGATOR CRACKING:

Possible causes:	Repair
• Over loading. • Inadequate structural design. • Poor construction.	• Crack sealing is in effective • Dig out and replace area of poor subgrade.

2- BLOCK CRACKING:

Problem: Allows moisture infiltration

Possible causes	Repair
• HMA shrinkage. • Asphalt binder aging. • Poor choice of asphalt binder in the mix design	• Low severity cracks (< 1/2" wide). Crack seal to prevent entry of moisture. - High severity cracks (> 1/2" wide) and cracks with raveled 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.

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- Potholes are most likely to occur on roads with thin HMA surface (1"-2") and seldom occurs on road with 4" or deeper HMA surfaces.

Problem: Roughness (serious vehicular drainage can result from driving across potholes at higher speeds), moisture infiltration.

Possible causes	Repair
• Generally, 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.	• Patching techniques.

4. RUTTING:

- Surface depression in the wheel path, are particularly evident after a rain when they are filled with water.

Possible cause	Repair
• Insufficient compaction of HMA layers during construction. • Subgrade rutting (e.g as a result of inadequate pavement structure) • Improper mix design (e.g excessive high asphalt content, excessive mineral filler, insufficient amount of angular aggregate particle).	• Slight ruts (< 1/3" deep) can generally be left untreated. Pavement with deeper ruts should be levelled and overlayed.

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5- **BLEEDING:**

Problem: loss of skid resistance when wet.

Possible causes:

- Excessive asphalt binder inthe HMA.
- Excessive application of asphalt binder during BST application.
- Low HMA air void content.

6- **POLISHED AGGREGATE:**

Possible causes	Repair
• Repeated traffic applications. This can occur quicker if the aggregate is susceptible to abrasion.	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	Repair
• Asphalt binder aging • Aggregate segregation. If fine particles are missing from the aggregate matrix. • Inadequate compaction during construction.	· Fog seal / Slurry seal or Remove the damaged pavement and overlay.

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