01

# FINAL TERM

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Section: "B"

Semester: "6th"

Subject: Highway & Traffic Engineering

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# Question # 01

Part (a)

Answer:

| Flexible Pavements | Rigid Pavements |
|---|---|
| 1: Grain to grain load transfer | 1: Slab action takes place |
| 2: Initial cost is low | 2: Initial cost is high. |
| 3: Joints are not required | 3: Joints are required |
| 4: Durability is less | 4: Durability is high. |
| 5: Good subgrade is required. | 5: Good subgrade is not required. |
| 6: Temprature variation has no any effect on the stress variation | 6: Temprature variation effects the stress variation. |
| 7: life span is short ~15 years | 7: long life span ~30 years. |
| 8: Repair work is easy | 8: Repair work is tough |

03

| Flexible pavements | Rigid pavements |
| --- | --- |
| 9: maintenance cost is high. | 9: maintenance cost is low. |
| 10: Require less curing time. | 10: Requires much curing time. |
| 11: Poor night visibility due to use of bitumen. | 11: Good night visibility. |
| 12: No glare due to sunlight. | 12: High glare due to sunlight. |

04

Part (B)

Answer: One disadvantage of the wet-mix mecadam is that it is slightly costlier than water-bound mecadam. This is because the specifications involves the use of mixing plant and paver.

On the other hand water bound mecadam ~~that is because the specification~~ has been traditionally a labour-oriented specification.

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

05

Part (c)

Answer:

| Asphalt | Bitumen |
| --- | --- |
| * Asphalt pavements are durable: with a layer depth of 25-40 mm and life span of 20+ years. | * Bitumen pavements are less durable; with a layer depth of 10-20 mm and lifespan of 5-10 years. |
| * Surface made of asphalt is smoother and more skid-resistant ensuring the drivers safety and minimal noise. | * The loose fragments on bitumen pavement make the driving experience noiser and can wear down tires, consequently causing safety issues |

06

| Asphalt | Bitumen |
| --- | --- |
| * Reduced friction b/w tire and car: meaning better fuel economy and minimization of carbon dioxide emission. | * Higher frictional resistance of a bitumen pavement means less efficiency in energy utilization |
| * Installation is comparativiely costlier | * cheap to instal compared to asphalt |
| * Less sensitive to temprealure compared to bitumen pavement negative impacts are seen only in extremely high or low temprealure. | * Pavements are susceptible to high temprealure which can make it slick and soft. |

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# Question # 02

Solution:

For a design speed of 75mi/h

K = 312 from table 15.5

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

Station of BVC = (345 + 60) - [21+84 / 2]

= 334 + 68

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

= 356 + 52

Elevation of BVC = 250 - [0.03 × 2184 / 2]

= 217.24 ft

08

| Station | Distance from BVC | Tangent Elevation | Offset $\left[ 1 \cdot \frac{Ax^2}{200L} \right]$ | 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 | 0.09 | 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 | 536 | 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+52 | 2132 | 281.20 | 72.87 | 208.36 |
|  | 2184 | 282.26 | 76.44 | 206.20 |

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## Question # 03

Flexible pavement design problem.

Solution:

- Reliability level (R) = 99%.
- standard deviation (So) = 0.49
- Initial serviceability index $P_i$ = 4.5
- Terminal serviceability index $P_t$ = 2.5
- ΔPSI = 4.5 − 2.5 = 2.0

Finding SN1, and D1 (surface course)

- Step 1.

Draw a line joining the reliability level of 99% and the overall standard deviation So 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 $2 \times 10^6$. and extend this line to intersect the second TL line at point B.

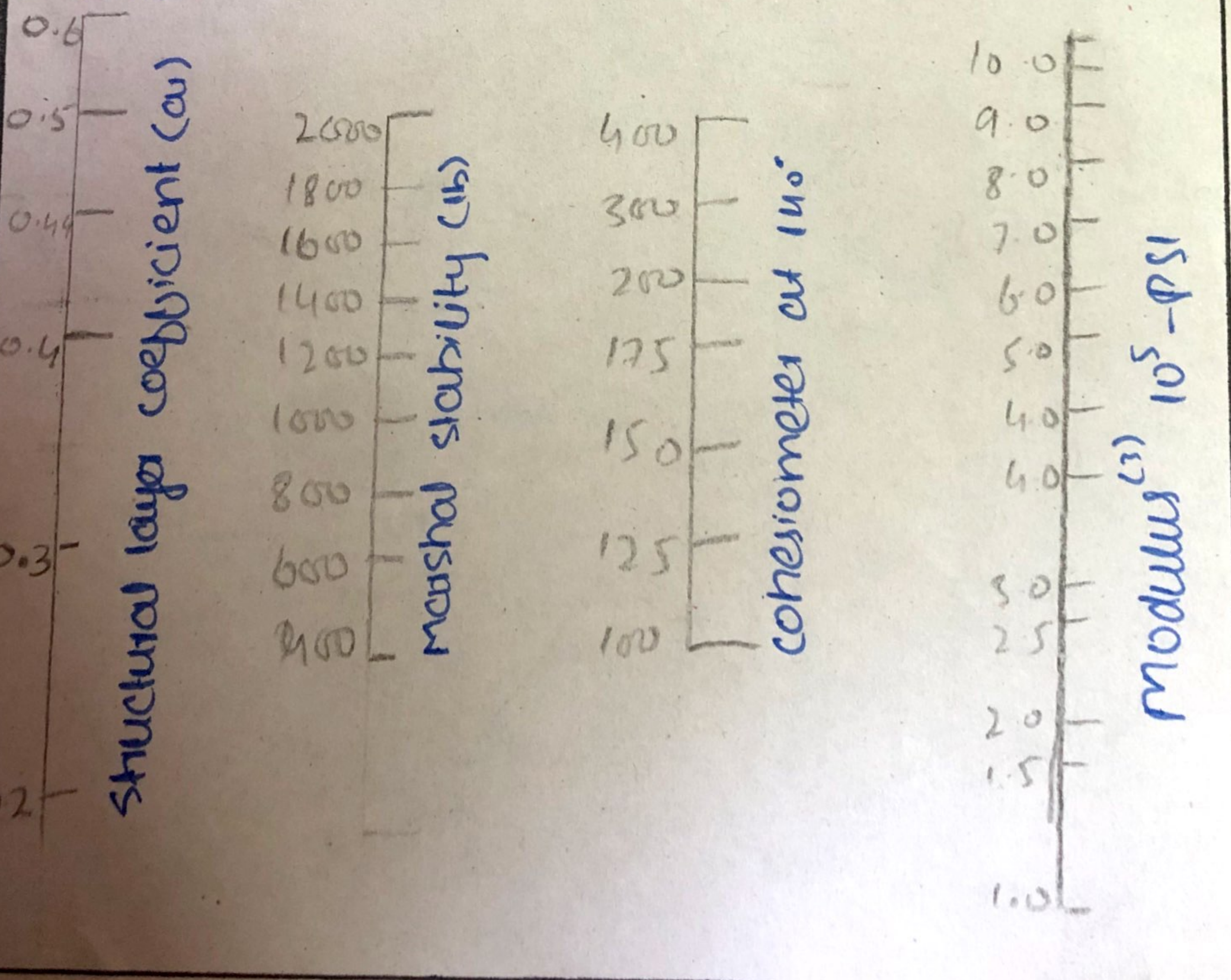
* Step 3: Draw a line joining point B and resilient modulus ($M_R$) of base course and extend this line to intersect the design serviceability loss chart at point C.

Step 4: Draw a horizontal line from point C to intersect the design serviceability loss (PSI) curve at point D.
In this problem, $\Delta PSI = 4.5 - 2.5 = 2$

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

Finding layer coefficient a1.

▷ Step 6: Determine the appropriate structure layer coefficient for each construction material. Resilient value of asphalt = 450,000 Ib/in², therefore a1 0.44.



Thickness of surface cource D1

$D1 = SN_1 / a_1$

$2.6 / 0.44 = 5.9''$

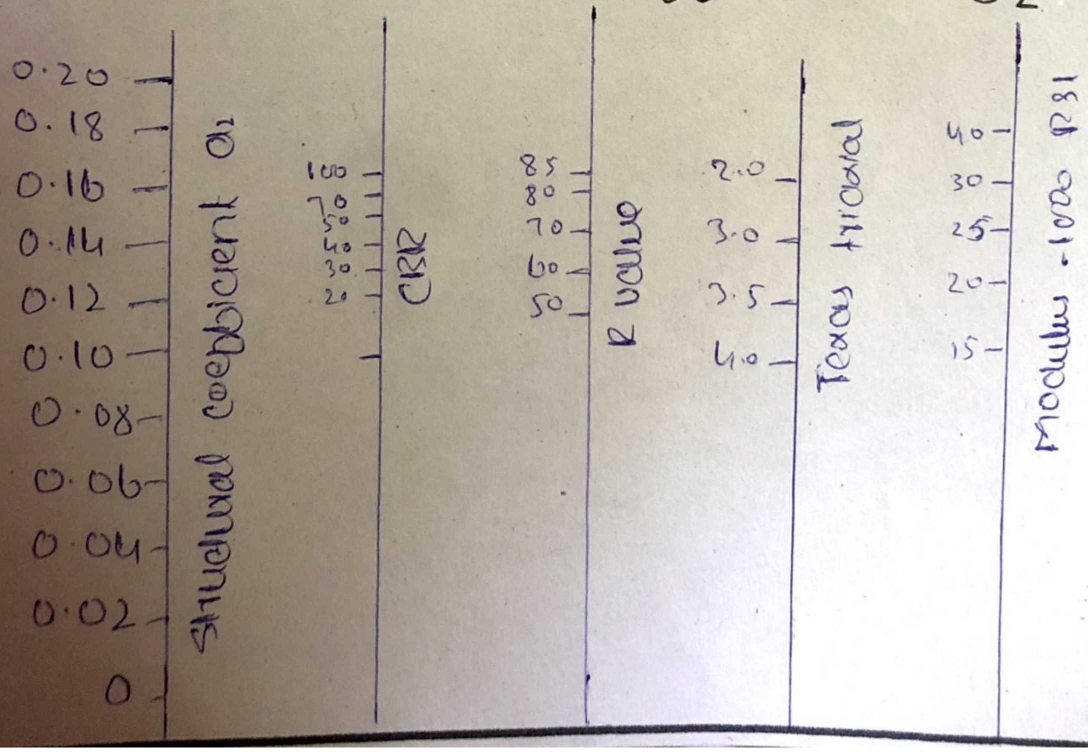
Thickness should be taken to the nearest 0.5 inches.

So the thickness of the surface cource is 6.

$SN_1^* = D_1'' \times a_1$

$SN_1^* = 6 \times 0.44 = 2.64$

Finding layer coefficient $a_2$



13
a

Thickness of base course $D_2$

$D_2 = (SN_2 - SN_1^*)/a_2m_2$

$D_2 = (3.8 - 2.64)/0.14 \times 0.80$

$D_2 = 10.36''$

use 12''

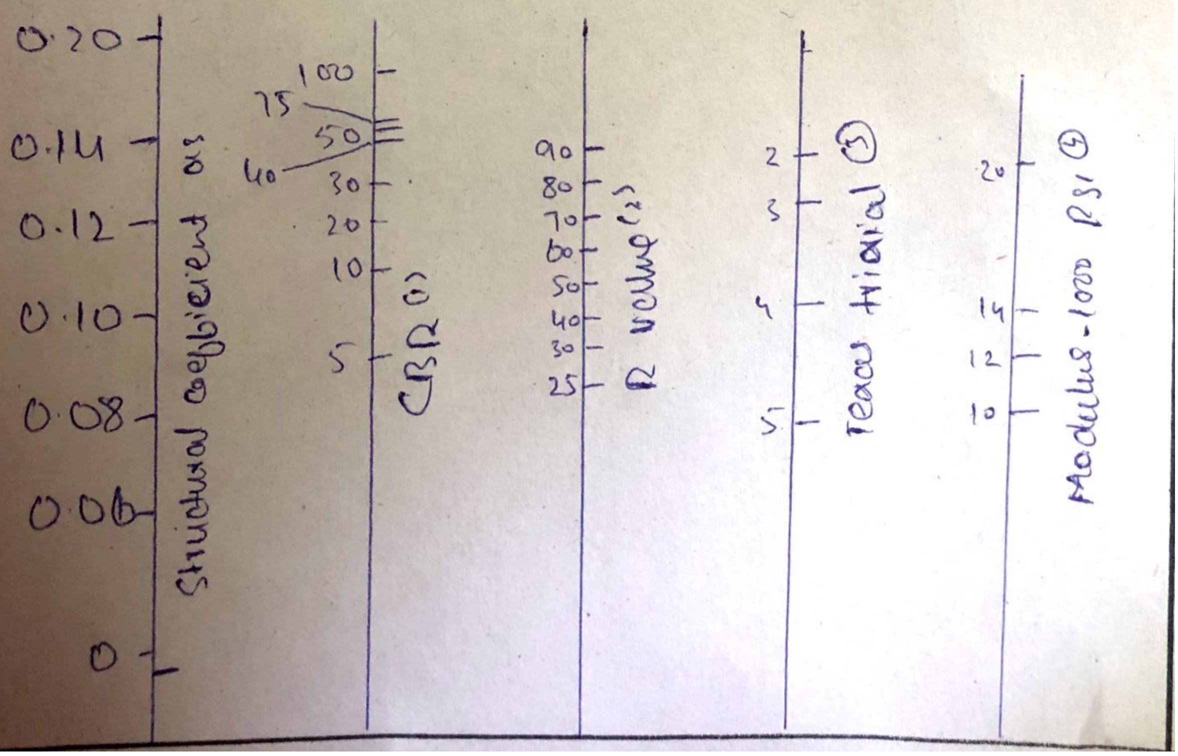
So thickness of base course is 12''

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

$SN_2^* = 1.34 + 2.64$

$SN_2^* = 3.98$

Finding layer coefficient $a_3$



Thickness of subbase course $D_3$

- $D_3 = (SN_3 - SN_2^*)/a_3 m_3$
- $D_3 = (4.4 - 3.98)/0.10 \times 0.80$
- $D_3 = 5.25$

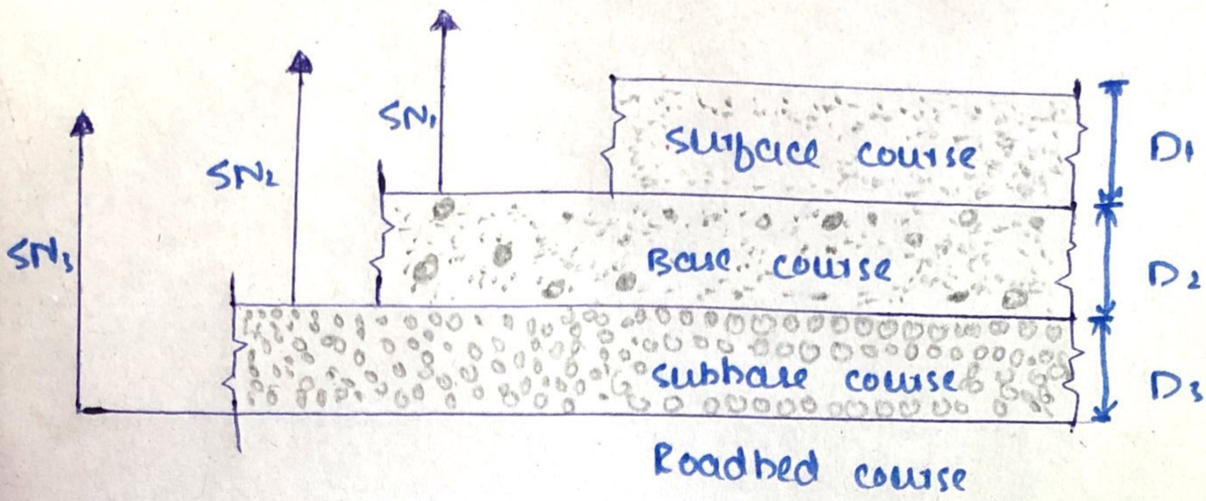
We will use 6" as a sub base

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

$SN_3 = 4.46 > 4.4$ okay

Final Design

- Surface course = 6"
- Base course = 12"
- Sub base = 6"
- Total Pavement Thickness = 24"




AASHTO Design Equation for SN

$$\log_{10} W_{18} = Z_R S_0 + 9.36 \log_{10} [SN+1] - 0.20$$

$$+ \frac{\log_{10} [\Delta PSI / (4.2 - 1.5)]}{0.40 + [1094 / (SN+1)^{5.19}]}$$

$$+ 2.32 \log_{10} M_r - 8.07$$

# Question # 04

Answer: Pavement Distresses:

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

▷ Distresses could occur in a pavement due to:

* Unstable mixes
* Higher wheel loads than those considered in design.

Different pavement distresses.

* Alligator (Fatigue) cracking.

▷ Possible causes

- overloading
- inadequate structural design
- poor construction.

▷ Repair

• Crack sealing is an effective

• Dig out and replace area of poor subgrade.

★ Block cracking:

▷ Problem: Allows moisture infiltration.

▷ Possible causes

• HMA shrinkage

• Asphalt binder aging.

• Poor choice of asphalt binder in the mix design.

▷ Repair

• Low severity cracks (< 1/2 inch wide). Crack seal to pavement entry of moisture.

• High severity cracks (< 1/2 inch wide and cracks with reveled edges): Remove and replaced the cracked pavement layer with an overlay.

## * Potholes:

▷ Small, bowl-shaped depressions in the pavement surface that penetrate all the way through the HMA layer down to the base course.

Problem:

Roughness (serious vehicular damage can result from driving across potholes at higher speeds). moisture infiltration.

Possible causes: 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.

Repair:

Patching techniques.

**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 (e.g as a result of inadequate pavement structure)
- Improper mix design (e.g 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.

## 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.

## Polished Aggregate:

▷ Possible causes: Repeated traffic applications. This can occur quicker if the aggregate is susceptible to abrasion.

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

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## Raveling:

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

### Possible causes:

- Asphalt binder aging.
- Aggregate segregation. If fine particles are missing from the aggregate matrix.
- Inadequate compaction during construction.

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