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Section: "B"

Submitted to: Sir Engr. Farhan Khan

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Question no: 01

Part (a): What is difference between flexible and rigid Pavement?

	Flexible Pavement	Rigid Pavement
(1)	Bitumen is used as Binder in flexible pavement	Cement is used as binder in rigid Pavements.
(2)	Deformation in the subgrade is transferred to the upper layers	Deformation in layers is not transferred to subsequent layers.
(3)	Load is transferred by grain to grain Cortact.	No such phenomenon of grain to grain load transferring enists.
(4)	It have low initial construction cost but have high maintenance cost.	It have low maintenance cost but have high initial Construction cost.
(5)	Have low life span usually 10-15 years.	It have more lifespan as compared to flexible Pavement usually 30+ years.
(6)	Surfacing cannot be laid directly on the sub-grade but a sub-base is needed.	Surfacing can be directly laid on the subgrade.

⑦	In flexible pavements strength of road is highly dependant on strength of subgrade.	Strength of road is less dependent on strength of sub grade in rigid pavements.
⑧	Road can be used for traffic within 24hrs	Road cannot be used until 14 days of curing.

Question no: 01

Part (b): what are the ~~d~~advantages of water bound over wet mix macadam?

Ans: The main advantages of water bound over wet mix macadam are the following:

① The water bound macadam is slightly cheaper then wet mix-macadam, this is because the specification of ~~wet mix-macadam~~ involves the use of mixing plant and Paver.

② water bound macadam is superior in quality because the materials are carefully graded and the resulting mass is almost voidless compacted mass.

③ The interlocking of aggregate particles imparts adequate strength of materials selected for filling the voids.

④ The aggregates for water bound macadam are generally hand broken whereas for wet-mix the aggregates are crushed.

⑤ waterbound has been traditionally a labour oriented specifications.

⑥ waterbound macadam roads are constructed as faster rate.

Question no: 01

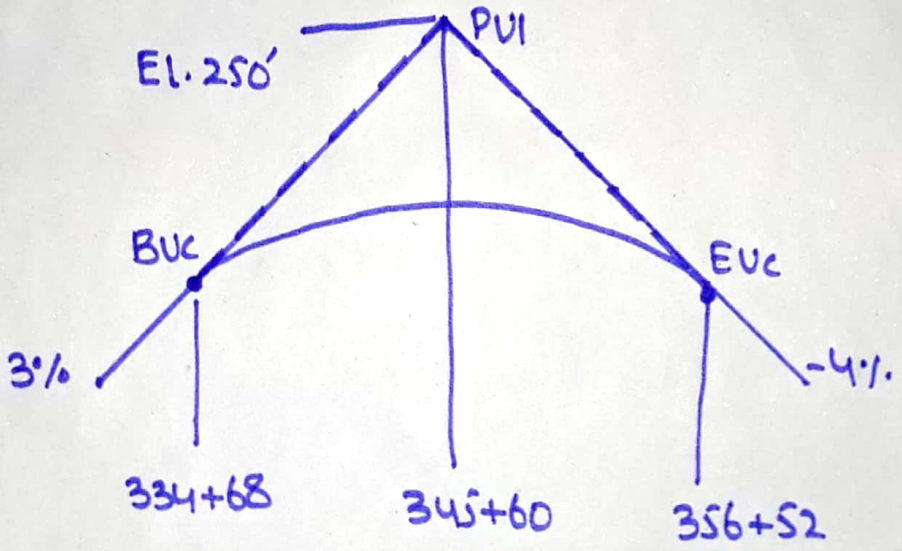
Part (c): what is the difference between Asphalt and bitumen?

	Asphalt	Bitumen
①	A dark brown to black cementatitious 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.	A class of black or dark colored cementitious substances, natural or manufactured, composed principally of high molecular weight hydrocarbons found in asphalts, Tars, Pitches, and Asphalties are typical.
②	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.
③	The asphalt is a composite mixture that provides a durable and flexible surface for cars, heavy vehicles, and machinery.	Bitumen is only used by commercial suppliers as a binder or sealant for other products. It is used in roads to seal other layers.

④	Asphalt is a composite mix of aggregate, sand, stone dust, Bitumen.	Bitumen is the liquid binder that holds the asphalt together, and is composed of partially hydrogenated Polycyclic aromatic compound ($C_{10} \cdot H_8$).
⑤	Density = 2330 kg/m³	Density = 1040 kg/m³

Question no: 02

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



Solution: * For a design speed of 75mi/h, K = 312

* Minimum length = 312 * (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 = $250 - (0.03 * \frac{2184}{2})$ = 217.24ft

Question no: 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 level 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, Mr 31,000 lb/in^2.

⇒ CBR value of subbase course material 22, Mr 13,500 lb/in^2

⇒ CBR value of subgrade material 6.

⇒ Mr of subgrade $6 * 1500\ lb/in^2 = 9000\ lb/in^2$.

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 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 = 0.49 and extend this line to intersect the first TL line to 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 (Mr) 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, $\Delta PSI = 4.5 - 2.5 = 2$

Step:05 So the structure number required to protect the base course and to find the thickness D1 of the surface course is 2.6.

Step: 06 Determine the appropriate structure layer coefficient for each construction material. Resilient value of asphalt = 450,000 lb/in², therefore a1 = 0.44.

* **Thickness of Surface Course D1:**

$$D1 = SN1/a1$$

$$2.6/0.44 = 5.9''$$

* Thickness should be taken to the nearest 0.5 inches.

* So thickness of surface course is 6".

$$SN1^* = D1 * a1$$

$$SN1^* = 6 \times 0.44$$

$$SN1^* = 2.64$$

* Thickness of Base Course D2:

$$D2 = (SN2 - SN_1^*) / a2\,m2$$

$$D2 = (3.8 - 2.64) / 0.14 * 0.80$$

$$\boxed{D2 = 10.36''}$$

⇒ Use 12":

So thickness of base course is 12"

$$SN2^* = 0.14 * 0.80 * 12 + SN_1^*$$

$$SN2^* = 1.34 + 2.64$$

$$\boxed{SN2^* = 3.98}$$

* Thickness of Subbase Course D3:

$$D3 = (SN3 - SN_2^*) / a3.m3$$

$$D3 = (4.4 - 3.98) / 0.10 * 0.80$$

$$\boxed{D3 = 5.25''}$$

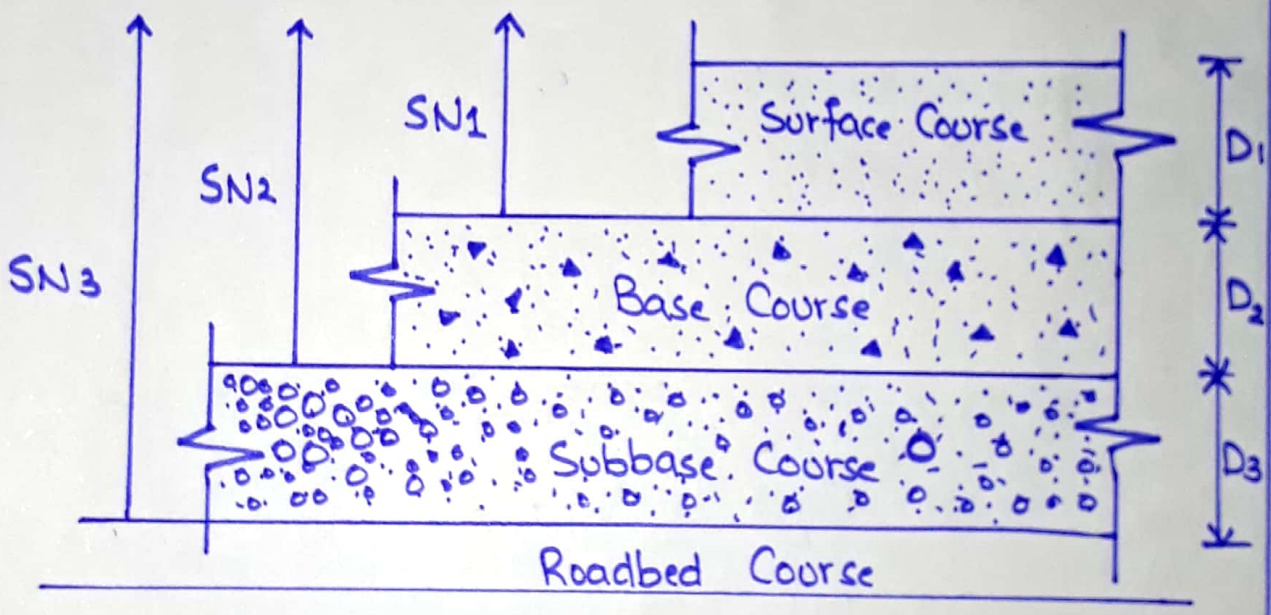
⇒ we will use 6" as a subbase.

$$SN3^* = 2.64 + 1.34 + 6'' * 0.10 * 0.80$$

$$\boxed{SN3^* = 4.46 > 4.4}$$ okay!

Final Design:

* Surface Course = 6"
* Base Course = 12"
* Sub base = 6"
* Total Pavement Thickness = 24"



Question no: 04 What are the different pavement distresses? Explain in detail?

Distress: Pavement structures often have distresses and 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 then those considered in design.

Types of Pavement distresses:

① **Alligator (Fatigue) cracking:** It is a series of interconnected cracks of various types/stages of development. It is considered as the combination of fatigue and block cracking. It occurs due to repeated traffic loadings.

Possible Causes: It is caused due to Overloading, Inadequate structual design and poor Construction.

Repair:

① Crack Sealing is in effective.

② Digout and area replacement of poor subgrade.

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② **Block Cracking:** It is a pattern of cracks that divides the pavement into approximately rectangular pieces with sides generally longer then one foot. Its main problem is that it allows moisture infiltration.

Possible Causes: It is caused by HMA shrinkage, asphalt binder aging, poor choice of asphalt binder in the mix design.

Repair:

① low Severity Cracks (< ½ inch wide). Crack Seal to prevent entry of moisture.

② High Severity Cracks (> ½ inch wide and cracks with raveled edges). Remove and replace the cracked pavement layer with an overlay.

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③ **Potholes:** It is small, bowl shaped depression 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 2 inches) and seldom occur on roads with 4" or deeper HMA surfaces.

Problem: Roughness (serious vehicular damage can result from driving accross potholes at higher speeds, moisture infiltration.

Possible Causes: Generally it is the end result of fatigue cracking. As it become severe, the interconnected cracks create small chunks of pavement, which can be dislodged as vehicles drive over them.

Repair: ① Patching techniques.

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

Possible Causes:

① Insufficient compaction of HMA layers during constructions.
② Subgrade rutting
③ Improper mix design.

Repair:

① slight ruts (< 1/3 inch deep) can generally be left untreated. Pavement with deeper ruts should be levelled and overlayed.

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⑤ **Bleeding:** It is a shiny, black suface of asphalt on the road surface caused by upward movement of asphalt in the pavement surface.

Problem: loss of skid resistance when wet.

Possible Cause: ① Excessive asphalt binder in HMA.

② Excessive asphalt application during BST application.

③ low HMA air void content.

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⑥ **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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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 aggrigate matrix.

③ Inadequate compaction during construction

Repair: ① Fog seal / slurry seal

② Remove the damaged pavement and overlay.