Pavement analysis & Design

Problems and Questions of Chapter 1

Submitted To:

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Question 3:

Answer: This method is used to determine the thickness of the pavement so that shear failure does not occur. This method is not used now a day because with the increasing traffic volume, pavements are designed for riding comfort rather than preventing shear failure.

Question 4:

Answer: The mechanistic -empirical method of design is based on the mechanics of materials that relates an input, such as a wheel load, to an output or pavement response, such as stress or strain. Dependence on observed performance is necessary because theory alone has not proven sufficient to design pavements realistically.

Question 5:

Answer: Seal coat is thin asphalt surface treatment used to waterproof the surface. Seal coat also provides skid resistance where the aggregates in surface course could be polished by traffic.

Question 6:

Answer:

Tack Coat	Prime Coat
Tack coat is very light application of asphalt usually asphalt emulsion diluted with water used to ensure a bond between the surface being paved and overlying course.	A Prime coat is application of low viscosity cutback asphalt to an absorbent surface such as an untreated granular base on which an asphalt layer will be placed. Its basic purpose is to bind the granular base to asphalt layer_
The basic difference between the prime and tack coat is that a tack coat does not require the penetration of asphalt into the underlying layer, whereas prime coat penetrates into the underlying layer, plugs the voids and form a water tight surface.	

Question 7:

Answer: Conventional flexible pavements are layered systems with better material on top where the intensity of the stress due to movement of traffic is high and inferior materials at the bottom where the intensity of stress is low. The basic purpose of layered system is to protect the subgrade material from stresses and deflections.

Question 8:

Answer:

Surface coarse	Binder coarse
• **Surface course is the top surface of an asphalt pavement, sometimes called the wearing course. It is usually constructed of dense graded HMA. It must be tough to resist distortion due to loading and to provide smooth and skid resistant riding surface.**	• The binder course, sometimes called the asphalt base course, is the asphalt layer below the surface course.
There are two reasons that a binder course is used in addition to surface course. i. HMA is too thick to be compacted in one layer, so it must be places in two layers. ii. Binder course consists of larger aggregate with less asphalt. So, sometimes it is economical to replace some part of surface course with that of binder course.	

Question 10:

Answer: Pumping is the phenomenon in which due to repeated heavy loading, ejection of water and subgrade soil through joints and cracks and along the pavement edges takes place. Pumping is usually caused by downward movement of slab due to heavy axel loads,

Question 11:

Answer:

- Rigid pavements are constructed of Portland cement concrete. They are placed in the form of slabs jointed together through dowel bars. Pumping occurs mostly under the leading slab when the trailing slab rebounds which creates a vacuum and sucks the fine material from underneath the leading slab.
- Pumping usually does not occur in flexible pavements because they are not constructed in the form of slabs.

Question 12:

Answer: Silt is more frost susceptible because it has high capillary as well as high permeability. On the other hand clay also has a very high capillary but its permeability is so low that very little water can be attracted from the water table to form ice lenses during the freezing period.

Question 13:

Answer: The increase in volume of 9%, when water becomes frozen is not the real cause of frost heave. Frost heave is caused by the formation and continuous expansion of ice lenses, which occurs due to freezing of water in larger voids where the temperature is below normal freezing temperature and the smaller voids remain unfrozen and act as conduits to deliver water to the larger voids. This result in increment of amount of water in freezing zones (Larger voids). The amount of heave is atleast as much as the combined lens thickness.

Question 14:

Answer:

Jointed Plain Concrete Pavement (JPCP)	Jointed Reinforced Concrete Pavement (JRCP)
➢ **All plain concrete pavements should be constructed with closely spaced contraction joints.** ➢ **Depending on the type of aggregate, Climate and prior experience, joint spacing between 15 and 30ft has been used.** ➢ **Dowels or aggregate**	➢ Steel reinforcement in the form of wire mesh or deformed bars does not increase the structural capacity. ➢ Reinforcement allows the use of longer joint spacing. ➢ Joint spacing varies from (30-100ft) but 40ft is more economical. ➢ The number of joints and the dowels costs decreases with the

interlocks may be used for load transfer across the joints.	increase in joint spacing.

Question 15:

Answer:

Jointed Reinforced Concrete Pavement (JRCP)	Continuous reinforced concrete pavement (CRCP)
➢ **Steel reinforcement in the form of wire mesh or deformed bars does not increase the structural capacity.** ➢ **Reinforcement allows the use of longer joint spacing.** ➢ **Joint spacing varies from (30-100ft) but 40ft is more economical.** ➢ **The number of joints and the dowels costs decreases with the increase in joint spacing.**	➢ Due to elimination of joints the thickness of the CRCP reduced by 1 to 2 inch (70-80%) of conventional pavements. ➢ Advantage of CRCP is the elimination of transverse joints. ➢ The formation of transverse cracks at relatively close intervals is the characteristics of the CRCP, which are held tightly by reinforcement.

Question 16:

Answer:

Pre-stressed Concrete Pavement

Advantages	Disadvantages
➢ **Concrete is weak in tension but strong in compression** ➢ **The pre application of a compressive stress to the concrete greatly reduces the tensile stress caused by traffic and thus decreases the thickness of the concrete required.** ➢ **The pre-stressed concrete pavements have less probability of cracking and fewer transverse joints and therefore results in less maintenance and longer pavement life.**	➢ It is very difficult to repair the services beneath the slab, since if a trench is cut across the pre-stressed slab the whole of the pre-stressing in the vicinity of the slab is lost; this is the matter of particular importance in case of urban roads. ➢ The constructions of pre-stressed slabs require expert supervision by experienced personnel. ➢ It poses certain constructional difficulties at bends and curves.

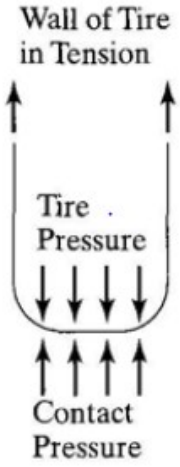
Question 17:

Answer: Fatigue cracking of cement-treated bases, instability rutting, top-down cracking, shrinkage cracking, reflective cracking and thermal fatigue cracking have been identified as the most common distresses affecting the service life of composite pavements, which consist of an asphalt course on top of a cement-treated base. These distresses prevent composite pavements from being considered long-life pavements, which are defined as pavements in which the structural elements may last indefinitely.

Remedial Measures:

These distresses can be avoided by using asphalt mixes with less aging susceptibility, gradations more resilient to fractures along with avoiding high air to void ratios.

Question 18:



Answer: this type of pavement is more costly to construct because of the grading operations required at the thickened edge. Thickened edge pavements were popular in the old days when pavement widths were less (18-20ft) and most trucks traveled very close to the pavement edge. With current (24ft) wide pavements traffic concentration is between (3-4ft) from the edge, thus significantly reducing the stress at the edge.

Question 19:

Answer:

Maryland Road Test	AASHO Road Test
➢ **Pumping occurred on plastic clay soils but not on granular subgrades with low percentages of silt and clay.** ➢ **With the exception of the corner case of loading for pumping soils, the stress and deflection resulting at vehicle speed of 40 mph (64 km/h) averaged approximately 20% less than those at creep speed.** ➢ **The stresses and deflections caused by loads acting at the corners and edges of slabs were influenced to a marked degree by temperature curling. For the corner loading, the stresses and deflections for a severe downward curled condition were observed to be only approximately one-third of those for the critical upward curled condition.**	➢ Pumping of sub-base material, including the coarser fractions, was the major factor causing failures of sections with sub-base. The amount of materials pumped through joints and cracks was negligible when compared with the amount ejected along the edge. ➢ Corner deflections of a 40-ft (12 . 2-m) reinforced panel usually exceeded those o f a 15-ft (4 .6-m) non-re-enforced panel, if all other conditions were the same. Edge deflections and strains were not affected significantly by panel length or re-enforcement. An increase in vehicle speed from 2 to 60 mph (3 .2 to 96 km/h) resulted in a decrease in strain or deflection of about 29%.

Question 22:

Answer: The contact pressure is smaller than the tire pressure for high-pressure tires, because the wall of tires is in tension. However, in pavement design, the contact pressure is generally assumed to be equal to the tire pressure.

Question 23:

Answer:

- Method used for the design of rigid pavements is based on the finite element procedure, and a rectangular area is assumed with length **0.8712L** and width **0.6L**, which has the same area of **$0.5227L^2$.**
- Method used for the design of flexible pavement is based on layered theory. Areas mentioned for the rigid pavements are not axisymmetric and cannot be used for the layered theory.

Question 24:

Answer: Pumping phenomenon occurs frequently in highway pavements more than airport pavement because the number of load repetitions in airport pavement is usually smaller that on highway pavements.

Question 25:

Answer: The design of highway pavements is based on moving loads with the loading duration as an input for viscoelastic behaviors and the resilient modulus under repeated loads for elastic behaviors. The design of airport pavements is based on moving loads in the interior of runways but stationary loads at the end of runways. As a result, thicker pavements are used at the runway end than in the interior.

Question 26:

Answer: The design principles used for highway pavements can be equally applied to airport pavements with only a few exceptions, such as the consideration of aircraft wandering on the number of load repetitions and the use of stationary loads at the end of runways.

Question 27:

Answer: The major difference between a highway pavement and a railroad track bed, namely, the distribution of wheel loads to the layered system. On highway pavements, wheel loads are applied over small areas and the magnitude of loads on each area is a constant independent of the stiffness of the layered system. On railroad track beds, wheel loads are distributed through rails and ties over a large area and the load on the most critical tie under the heaviest wheel load depends strongly on the stiffness of the layered system.

Question 28:

Answer:

- Full-depth asphalt pavements are constructed by placing one or more layers of HMA directly on the subgrade or improved subgrade. This concept was conceived by the Asphalt Institute in 1960 and is generally considered the most cost-effective and dependable type of asphalt pavement for heavy traffic.
- The use of full-depth asphalt, which is popular for highway pavements, is ineffective for railroad track- beds. It is more economical to place the HMA under the ballast rather than over the ballast.