Student ID : 13727 | **Program: B.Tech (civil).**

Exam: final Term. | **Subject: Foundation and Pavement.**

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Question # 01: Define pavement distress and their causes

Ans: ***Pavement distress:*** *It is defined as the indication on a performance of unfavorable pavement (unsatisfactory performance of the pavement) and it shows the sign of upcoming failure (impending failures).*

It is the irregularity (uneven) of the road surface which it affects the user comfort and safety. Pavement is a very important factor because it affects maintenance cost of the vehicles, vehicle delay cost, and quality of the ride affects and consumption of fuel.

Pavement distress is like cracking, rutting and distortions are the different type of surface deterioration.it indicates the decline in pavement surface conditions.

Pavement distresses, consider four important measures to characterize –surface roughness, surface deflections, surface distress, and skid resistance.

1) ***Alligator (Fatigue) Cracking:*** *A series of interconnected cracks caused by fatigue failure of the HMA surface under repeated traffic loading. As the number and magnitude of loads becomes too great, longitudinal cracks begin to form (usually in the wheel paths). After repeated loading, these longitudinal cracks connect forming many-sided sharp-angled pieces that develop into a pattern resembling the back of an alligator or crocodile.*

Causes: *Inadequate structural support for the given loading, which can be caused by a myriad of things. A few of the more common ones are:*

- *Decrease in pavement load supporting characteristics.*

a) *Probably the most common reason is a loss of base, subbase or subgrade support from poor drainage. Water under a pavement will generally cause the underlying materials to become weak.*
b) *Stripping on the bottom of the HMA layer. The stripped depth contributes little to pavement strength so the effective HMA thickness decreases.*

- *Increase in loading (i.e., the pavement is being loaded more heavily than anticipated in design)*
- *Inadequate structural design (i.e., the pavement was designed too thin for the anticipated loads)*
- *Poor construction (i.e., inadequate compaction)*

2) ***Block Cracking:*** *Interconnected cracks that divide the pavement up into rectangular pieces. Blocks range in size from approximately 1 ft2 to 100 ft2. Larger blocks are generally classified as longitudinal and transverse cracking. Block cracking normally occurs over a large portion of pavement area but sometimes will occur only in non-traffic areas.*

Causes: *HMA shrinkage and daily temperature cycling. Typically caused by an inability of asphalt binder to expand and contract with temperature cycles because of:*

- *Asphalt binder aging*
- *Poor choice of asphalt binder in the mix design*

3) *Reflection Cracking:* *Cracks in a flexible overlay over an existing crack or joint. The cracks occur directly over the underlying cracks or joints. "Joint reflection cracking" specifically refers to reflection cracks arising from underlying PCC pavement joint movement. Reflection cracks can also occur over existing HMA pavement cracks, cement or lime stabilized base, etc.*

Causes: *Differential movement across the underlying crack or joint. For joint reflection cracking, this is movement of the PCC slab beneath the HMA surface because of thermal and moisture changes. Generally not load initiated, however loading can hasten deterioration.*

4) *Transverse (Thermal) Cracking:* *Cracks perpendicular to the pavement's centerline or laydown direction. Usually a type of thermal cracking.*

Causes:

- *Shrinkage of the HMA surface due to low temperatures or asphalt binder hardening.*
- *Reflective crack caused by cracks beneath the surface HMA layer*
- *Top-down cracking*
- *Expansion and contraction of pavement material*
- *roadbed settlement*
- *poorly constructed paving joints*

5) *Raveling:* *The progressive disintegration of an HMA layer from the surface downward as a result of the dislodgement of aggregate particles.*

Causes: *Loss of bond between aggregate particles and the asphalt binder as a result of:*

- *Asphalt binder aging. Aging is generally associated with asphalt binder oxidation as it gets older. As the asphalt binder gets older, oxygen reacts with its constituent molecules resulting in a stiffer, more viscous material that is more likely to lose aggregates on the pavement surface as they are pulled away by traffic.*
- *A dust coating on the aggregate particles that forces the asphalt binder to bond with the dust rather than the aggregate*
- *Aggregate segregation. If fine particles are missing from the aggregate matrix, then the asphalt binder is only able to bind the remaining coarse particles at their relatively few contact points.*

6) *Potholes:* *Small, bowl-shaped depressions in the pavement surface that penetrate all the way through the HMA layer down to the base course. They generally have sharp edges and vertical sides near the top of the hole. Potholes are most likely to occur on roads with thin HMA surfaces (25 to 50 mm (1 to 2 inches)) and seldom occur on roads with 100 mm (4 inch) or deeper HMA surfaces*

Causes: *Generally, potholes are the end result of fatigue cracking. As alligator cracking becomes severe, the interconnected cracks create small chunks of pavement, which can be dislodged as vehicles drive over them. The remaining hole after the pavement chunk is dislodged is called a pothole.*

7) *Rutting:* *Surface depression in the wheelpath. Pavement uplift (shearing) may occur along the sides of the rut. Ruts are particularly evident after a rain when they are filled with water. There are two basic types of rutting: mix rutting and subgrade rutting. Mix rutting occurs when the subgrade does not rut* *yet the pavement surface exhibits wheelpath depressions as a result of compaction/mix design problems. Subgrade rutting occurs when the subgrade exhibits wheelpath depressions due to loading. In this case, the pavement settles into the subgrade ruts causing surface depressions in the wheelpath.*

Causes: *Permanent deformation in any of a pavement's layers or subgrade usually caused by consolidation or lateral movement of the materials due to traffic loading. Specific causes of rutting can be:*

- *Insufficient compaction of HMA layers during construction. If it is not compacted enough initially, HMA pavement may continue to densify under traffic loads.*
- *Subgrade rutting (e.g., as a result of inadequate pavement structure)*
- *Improper mix design or manufacture (e.g., excessively high asphalt content, excessive mineral filler, insufficient amount of angular aggregate particles)*

8) *Longitudinal Cracking:* *Cracks parallel to the pavement's centerline or laydown direction. Usually a type of fatigue cracking.*

Causes:

- *Poor joint construction or location. Joints are generally the least dense areas of a pavement. Therefore, they should be constructed outside of the wheelpath so that they are only infrequently loaded. Joints in the wheelpath will general fail prematurely.*
- *A reflective crack from an underlying layer (not including joint reflection cracking)*
- *HMA fatigue (indicates the onset of future fatigue cracking)*
- *Top-down cracking*

9) *Spalling:* *Cracking, breaking or chipping of joint/crack edges. Usually occurs within about 0.6 m (2 ft.) of joint/crack edge.*

Causes

- *Excessive stresses at the joint/crack caused by infiltration of incompressible materials and subsequent expansion (can also cause blowups).*
- *Disintegration of the PCC from freeze-thaw action or "D" cracking.*
- *Weak PCC at a joint caused by inadequate consolidation during construction. This can sometimes occur at a construction joint if (1) low quality PCC is used to fill in the last bit of slab volume or (2) dowels are improperly inserted.*
- *Misalignment or corroded dowel.*
- *Heavy traffic loading.*

10) *Polished Aggregate:* *Areas of HMA pavement where the portion of aggregate extending above the asphalt binder is either very small or there are no rough or angular aggregate particles.*

Causes: *Repeated traffic applications. Generally, as a pavement ages the protruding rough, angular particles become polished. This can occur quicker if the aggregate is susceptible to abrasion.*

Question # 02: Discuss the process of sub-base and sub-grade preparation in detail

Ans:

Process of Sub-Base preparation

- ***Sub-Base:*** *The work is consist of spreading, and compacting subbase constructed on a prepared bed in accordance with the specification in conformity with the lines, grade thickness and typical cross-section shown on the drawing .The material shall consist of sand, gravel or a sand gravel mixture obtained from the source approved by the Engineer.*

- ***Material Requirements for the process of sub-base preparation:***

Granular subbase shall consist of natural or processed aggregates such as gravel, sand or stone fragment and shall be clean and free from dirt, organic matter and other deleterious substances, and shall be of such nature that it can be compacted easily under watering and rolling to form a firm, stable pavement layer.

The material shall comply to the following grading and quality requirement .

The subbase material shall have a gradation curve within the limits for grading A and B given below. However grading A may be allowed by the Engineer in special circumstances.

Grading Requirements of Subbase Material			
Sieve Designation		*Mass percent passing Grading*	
mm	*Inch*	*A*	*B*
60.0	*(2.1/2)*	*100*	*-*
50.0	*(2)*	*90-100*	*100*
25.	*(1)*	*50-80*	*55-85*
9.5	*(3/8)*	*-*	*40-70*
4.75	*No.4*	*35-70*	*30-60*
2.0	*No.10*	*-*	*20-50*
0.425	*No.40*	*-*	*10-30*
0.075	*No.200*	*2-8*	*5-15*

- *The Material shall have a CBR value of at least 50% determined according to AASHTO T-193. the CBR value shall be obtained at a density corresponding to Ninety eight (98) percent of the maximum dry density determined according to AASHTO T-180.*

- *The coarse aggregate material retained on sieve No. 4 shall have a percentage of wear by the Los Angeles Abrasion (AASSHTO T-96) of not more than fifty (50) percent.*
- *The fraction passing the 0.075 mm (No.200) sieve shall not be greater than two third of the fraction passing the 0.425 mm (No.40) sieve. The fraction passing the 0.425 mm sieve shall have a liquid limit of not greater than 25 and a plasticity index of 6 or less.*
- *If over-size is encountered, screening of material at source, shall invariably be done, no hand picking shall be allowed, however hand picking may be allowed by the Engineer, if over-size quantity is less than 5% of the total mass.*
- *Sand equivalent for all classes shall be 25min*

➢ ***Construction Requirements for the process of sub-base preparation:***

Spreading:

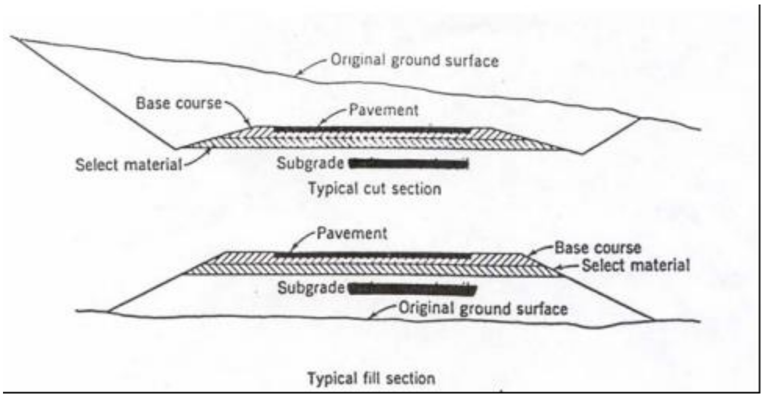
- *Granular subbase shall be spread on approved subgrade layer as a uniform mixture. Segregation shall be avoided during spreading and the final compacted layer shall be free from concentration of coarse or fine materials.*
- *Granular subbase shall be deposited on the roadbed or shoulders in a quantity which will provide the required compacted thickness without resorting to sporting, picking up or otherwise shifting the subbase material. In case any material is to be added to compensate for levels, the same shall be done after scarifying the existing material, to ensure proper bonding of additional material.*
- *When the required thickness is fifteen (15) cm or less, the aggregates may be spread and compacted as one layer, but in no case shall a layer be less than seven and a half (7.5) centimeters thick. Where the required thickness is more than 15cm, the aggregates shall be spread and compacted in 2or more layers of approximately equal thickness ,but in any case the maximum compacted thickness of one layer shall not exceed 15cm. All subsequent layers shall be spread and compacted in a similar manner.*

➢ ***Compaction Trials:***

- *Prior to commencement of granular subbase operation, contractor shall construct a trial length, not to exceed, five hundred (500) meters and not less than two hundred (200) meters with the approved subbase material as will be used during construction to determine the adequacy of the constrictor's equipment, loose depth measurement necessary to result in the specified compacted layer depths, the field moisture content, and the relationship between the number of compaction passes and the resulting density of the material.*
- *The subbase material shall be compacted by means of approved vibrating rollers or steel wheel rollers (rubber tired rollers may be used as a supplement), progressing gradually from the outside towards the centre, except on super elevated curves, where the rolling shall begin at the low side and progress to the high side. Each succeeding pass shall overlap the previous pass by at least one third of the roller width.*
- ***Rolling:*** *While the rolling progresses the entire surface of each layer shall be properly shaped and dressed with a motor grader, to attain a smooth surface free from ruts or ridges and having proper section and crown. Rolling shall continue until entire thickness of each layer is thoroughly and uniformly compacted to the specified density. any area inaccessible to rolling equipment shall be compacted by means of hand guided rollers, plate compactors or mechanical tampers, where the thickness in loose layer shall not be more than 10cm.*

(Process of sub-grade preparation)

- ***Sub-grade:*** *The sub grade preparation is the process through which a surface is prepared on which, the sub base is placed or, in the absence of sub base, act as the base of the pavement structure. It shall extend to the full width of the Road bed including the shoulders.*
- ***Construction Requirement:***
  - *All materials down to a depth of 30 cm below the sub grade level in earth cut or embankment shall be compacted to at least 95 percent of the maximum dry density as determined according to AASHTO T-180 Method .The Road geometric should be established and finalized on the top of Sub grade.*
  - ***Sub grade preparation in earth cut:*** *In case bottom of sub grade level is within thirty (30) cm of the Natural ground, the surface shall be scarified, broken up, adjusted to moisture content and compacted to minimum density of ninety five (95) percent of the maximum dry density as determined by AASHTO T-180. Subsequent layer of approved material shall be incorporated to ensure that the depth of sub grade layer is thirty (30) cm.*
  - *In case, the bottom of sub grade is below the natural ground by more than thirty (30) cm, the material above the top of sub grade shall be remove and subsequent layer of thirty(30) cm shall be scarified, broken up, adjusted to moisture content and compacted to the same degree of compaction as described above.*
  - *In case, unsuitable material is encountered at the sub grade level within a depth of thirty (30) cm, the same shall be removed in total and replaced by the approved material.*



- ***Subgrade Level in Existing Road:***
  Where indicated on the Drawings or directed by the Engineer that the existing road surface is to be used as the sub grade, the correct elevation on which the base or sub base is to be laid shall be obtained, where necessary, either by means of leveling course or by excavation. The leveling course shall be constructed to the requirements of the Engineer and paid for under the appropriate pay Item involved.

Question # 03: Discuss the process of leaning of prime coat

Ans: Prime coat:

This work shall consist of furnishing all plant, labor, equipment, material and performing all operations in applying a liquid asphalt prime coat on a previously prepared and untreated, earth sub grade, water bound base course, crushed aggregate base course, tops or roadway shoulders.

Leaning of prime coat:

Material Requirements: *Prime coat shall be applied when the surface to be treated is dry. The application is prohibited when the weather is foggy or rainy, or when the atmospheric temperature is below fifteen (15) degree C unless otherwise directed by the Engineer.*

- *Prior to the application of the prime coat, all loose materials shall be removed from the surface and the same shall be cleaned by means of approved mechanical sweepers or blowers and/or hand brooms, until it is as free from dust as is deemed practicable. No traffic shall be permitted on the surface after it has been prepared to receive the bituminous material.*
- *Primed surface shall be kept undisturbed for least 24 hours, so that the bituminous material travels beneath and leaves the top surface in non-tacky condition. No asphaltic operations shall start on a tacky condition.*
- *The rate for application of asphaltic material shall be as under:*

Type of Surface	***Litres per Square, Meter***	
	Min	*max*
Subgrade, subbase, water bound base courses and Crushed stone base course	*0.65*	*1.75*
Bridge, wearing surfaces, concrete Pavement	*0.15*	*0.4*

However, the exact rate shall be specified by the Engineer determined from field trials.

Question # 04: Discuss pavement types (surface/layers).

Ans: *Hard surfaced pavements are typically categorized into flexible and rigid pavements*

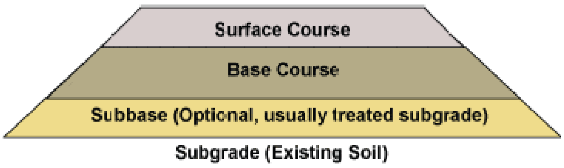
Flexible pavements: *Those which are surfaced with bituminous (or asphalt) materials. These types of pavements are called "flexible" since the total pavement structure "bends" or "deflects" due to traffic loads. A flexible pavement structure is generally composed of several layers of materials which can accommodate this "flexing".*

Rigid pavements: *Those which are surfaced with portland cement concrete (PCC). These types of pavements are called "rigid" because they are substantially stiffer than flexible pavements due to PCC's high stiffness.*

Layers in Flexible pavements

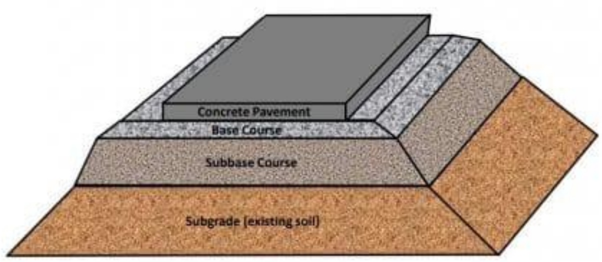
- ***Surface course***
  Surface course is the layer directly in contact with traffic loads and generally contains superior quality materials. They are usually constructed with dense graded asphalt concrete (AC).
- ***Base course***
  The base course is the layer of material immediately beneath the surface course and it provides additional load distribution and contributes to the sub-surface drainage. It may be composed of crushed stone, crushed slag, and other untreated or stabilized materials.
- ***Sub-Base course***
  The sub-base course is the layer of material beneath the base course and the primary functions are to provide structural support, improve drainage, and reduce the intrusion of fines from the sub-grade in the pavement structure If the base course is open graded, then the sub-base course with more fines can serve as a filler between sub-grade and the base course. A sub-base course is not always needed or used. For example, a pavement constructed over a high quality, stiff sub-grade may not need the additional features offered by a sub-base course. In such situations, sub-base course may not be provided.

- ***Sub-grade***
  The top soil or sub-grade is a layer of natural soil prepared to receive the stresses from the layers above. It is essential that at no time soil sub-grade is overstressed. It should be compacted to the desirable density, near the optimum moisture content.



<u>Layes in Rigid Pavements:</u>

- ***Concrete Slab:***
  The concrete slab is the top most layer of rigid pavement which is in direct contact with the vehicular loads. This is also called as surface course. It is water resistant and prevents the water infiltration into the base course. It offers friction to the vehicles to provide skid resistance. The thickness of concrete slab is kept between 150 mm to 300 mm.
- ***Granular Base or Stabilized Base Course***
  The base course or granular base or stabilized base is the second layer from the top and is constructed using crushed aggregates. This course helps the surface course to take additional loads. It provides stable platform to construct rigid pavement It is also useful to provide sub surface drainage system. The base course thickness should be minimum 100mm.
- ***Granular Subbase or Stabilized Subbase Course***
  It is the third layer from the top and is in contact with the subgrade soil and base course. It is constructed by using low quality aggregates than the base course but they should be better quality than subgrade.
- ***Subgrade Soil***
  The subgrade is nothing but the existing soil layer which is compacted using equipment to provide stable platform for rigid pavement. The subgrade soils are subjected to lower stresses than the top layers since the stresses will reduce with depth.



Types of sufaces:

- ***Asphalt Concrete Pavement.***
  Asphalt concrete pavements consist of a combination of layers, which include an asphalt concrete surface constructed over a granular or asphalt concrete base and a subbase. The entire pavement structure, which is constructed over the subgrade, is designed to support the traffic load and distribute the load over the roadbed.
- ***Composite pavement.***
  A composite pavement is a type of pavement that utilizes both asphalt and concrete. Typically, a concrete base layer provides structural capacity while an asphalt surface layer provides a wearing surface course.

- ***Continuously reinforced concrete pavements (CRCP).***
  Continuously reinforced concrete pavements (CRCP) is a type of concrete pavement that does not require any transverse contraction joints. Transverse cracks are expected in the slab, usually at intervals of 1.5 - 6 ft (0.5 - 1.8 m). CRCP is designed with enough embedded reinforcing steel (approximately 0.6-0.7% by cross-sectional area) so that cracks are held together tightly
- ***Jointed Plain Concrete Pavement.***
  Jointed plain concrete pavement (JPCP) uses contraction joints to control cracking and does not use any reinforcing steel. Transverse joint spacing is selected such that temperature and moisture stresses do not produce intermediate cracking between joints. This typically results in a spacing no longer than about 6.1 m (20 ft.).
- ***Jointed Reinforced Concrete Pavement.***
  Jointed reinforced concrete pavement (JRCP) uses contraction joints and reinforcing steel to control cracking. Transverse joint spacing is longer than that for JPCP and typically ranges from about 7.6 m (25 ft.) to 15.2 m (50 ft.).

THE END