Q. No. *(15)*

Define pavement distress and their causes

Pavement distresses

Distressed pavement is often a result of a combination of factors, rather than just one root cause.

Types of Failures in Flexible Pavements due to Structural Distresses

Some of the structural distresses which can cause failures in flexible pavements are

Alligator Cracking

Alligator cracks are also called as map cracking.

Couse

This is a fatigue failure caused in the asphalt concrete. A series of interconnected cracks are observed due to such distress.

Fatigue Cracking.

Fatigue cracking is sometimes called alligator cracking due to the interconnected cracks which resemble an alligatorï¿½s skin.

Couse

Fatigue cracking is caused by load-related deterioration resulting from a weakened base course or subgrade, too little pavement thickness, overloading, or a combination of these factors.

Block Cracking.

Block cracking is a series of large (typically one foot or more), rectangular cracks on an asphalt pavementï¿½s surface. This type of cracking typically covers large areas and may occur in areas where there is no traffic.

Couse

Block cracking is typically caused by shrinkage of the asphalt pavement due to temperature cycles.

Edge Cracking.

Edge cracks are longitudinal cracks which develop within one or two feet of the outer edge of a pavement.

Couse

These cracks form because of a lack of support at the pavement edge.

Longitudinal Cracking.

Longitudinal cracks occur parallel to the centerline of the pavement.

Couse

They can be caused by: a poorly constructed joint; shrinkage of the asphalt layer; cracks reflecting up from an underlying layer; and longitudinal segregation due to improper paver operation. These cracks are not load-related.

Reflection Cracking.

Reflection cracks are cracks that form over joints or cracks in a concrete pavement or in an overlay of a deteriorated asphalt pavement.

Couse

The cracks form because of movement of the old pavement.

Slippage Cracking.

Slippage cracks are crescent-shaped cracks which form because of low-strength asphalt mix or a poor bond between pavement layers.

Couse

The cracks form due to the forces applied by turning or braking motion of vehicles.

Raveling.

Raveling is the wearing away of the aggregate particles from the asphalt cement.

Couse

This condition indicates that the asphalt has hardened or that a poor quality mixture was used. Raveling occurs in the presence of traffic.

Rutting.

Rutting is a linear, surface depression in the wheel path.

Couse

Rutting is caused by deformation or consolidation of any of the pavement layers or subgrade. It can be caused by insufficient pavement thickness, lack of compaction, and weak asphalt mixtures.

Potholes.

Potholes are bowl-shaped holes

Couse

Caused by the localized disintegration of the pavement surface. Potholes typically result from the continued deterioration of another type of distress. Segregation, cracks or failed patches may serve as the start of a pothole. Poor mixtures and weak spots in the base or subgrade accelerate pothole failures.

Shoving.

Shoving is the formation of ripples across a pavement. This characteristic shape is why this type of distress is sometimes called wash-boarding. Shoving occurs at locations having severe horizontal stresses, such as intersections.

Couse

It is typically caused by: excess asphalt; too much fine aggregate; rounded aggregate; too soft an asphalt; or a weak granular base.

Types of Failures in Rigid Pavements

The different types of distresses responsible for failures in rigid pavements are:

Transverse Cracking.

Transverse cracks occur roughly perpendicular to the centerline of the pavement.

Couse

They can be caused by shrinkage of the asphalt layer or reflection from an existing crack. They are not load-related.

Joint Spalling in Rigid Pavements

Excessive compressive stress causes deterioration in the joints, called as the spalling.

This may be related to joint infiltration or the growth of pavement,

Couse

That are caused by the reactive aggregates

The joint that are constructed with weak concrete

Scaling of cement concrete

Peeling off or flaking off of the top layer or skin of the concrete surface.

Couse

It may be due to by improper design mix, excessive vibration during concrete compaction.

Performing finishing operation while bleed water is on surface

Faulting in Rigid Pavements

The difference in elevation between the joints is called as faulting.

Couse

The main causes of failures in rigid pavements due to faulting are:

Settlement of the pavement that is caused due to soft foundation.

Polished Aggregate in Rigid Pavements

The repeated traffic application leads to this distress.

Couse

These are the failures in rigid pavements caused when the aggregates above the cement paste in the case of PCC is very small or the aggregates are not rough or when they are angular in shape, that it cannot provide sufficient skid resistance for the vehicles.

Shrinkage Cracking in Rigid Pavements

These are hairline cracks that are less than 2m in length. They do not cross the entire slab. The setting and curing process of the concrete slab results in such cracks.

Couse

These are caused due to higher evaporation of water due to higher temperature cracks. Improper curing can also create shrinkage cracks in rigid pavements.

Corner Breaks in Rigid Pavements

These are the failures in rigid pavements

Couse

That is caused due to pumping in excessive rate. When the pumping completely remove the underlying support that no more support exists below to taken the vehicle load, the corner cracks are created.

Q.No.(02) *(15)*

Discuss the process of sub-base and sub-grade preparation in detail

<u>Sub Base:</u>

Definition:

The work is consist of spreading, and compacting sub base 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.

<u>Material Requirements:</u>

Granular sub base 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 .

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

Grading Requirements of Sub base 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 of6 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 Requirement:

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.

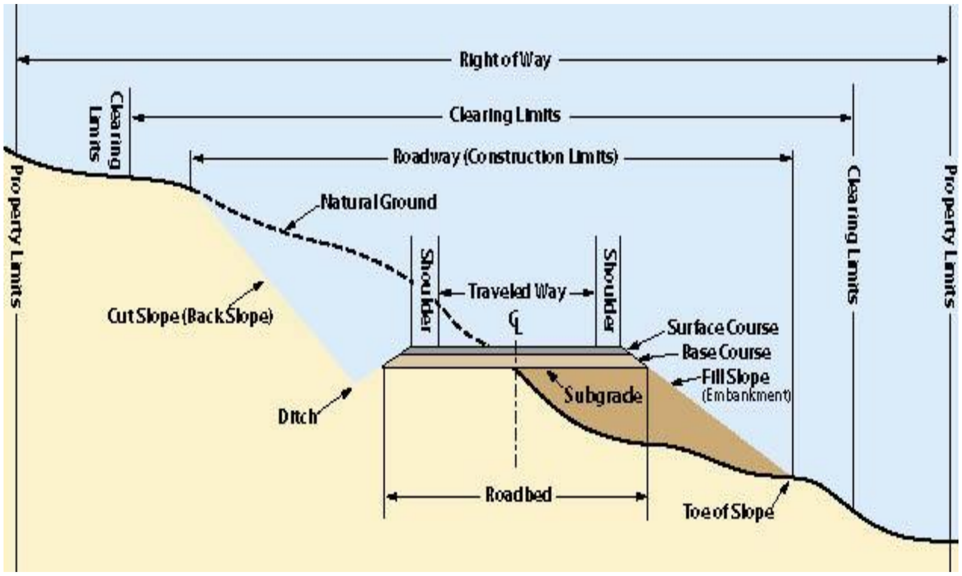
While the rolling progresses the entire surface of each layer shall be properly shaped and dressed with a motor grader, to attain a smooth surface free from ruts or ridges and having proper section and crown. Rolling shall continue until entire thickness of each layer is thoroughly and uniformly compacted 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,

SUBGRADE PREPARATION:

- Definition:

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.

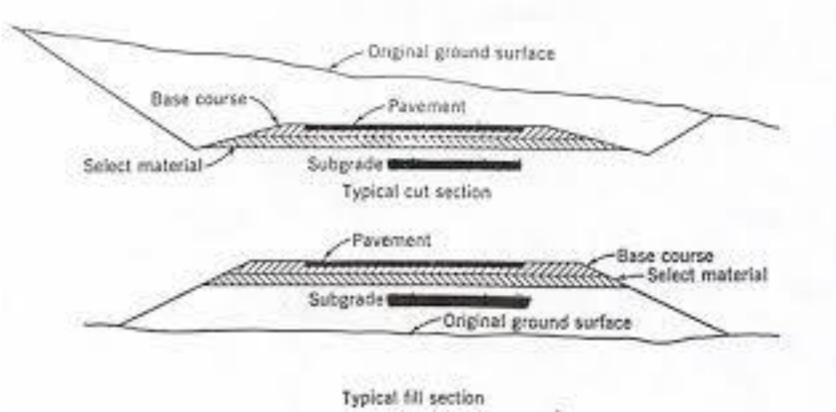


Construction Requirement:

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.

1. 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.

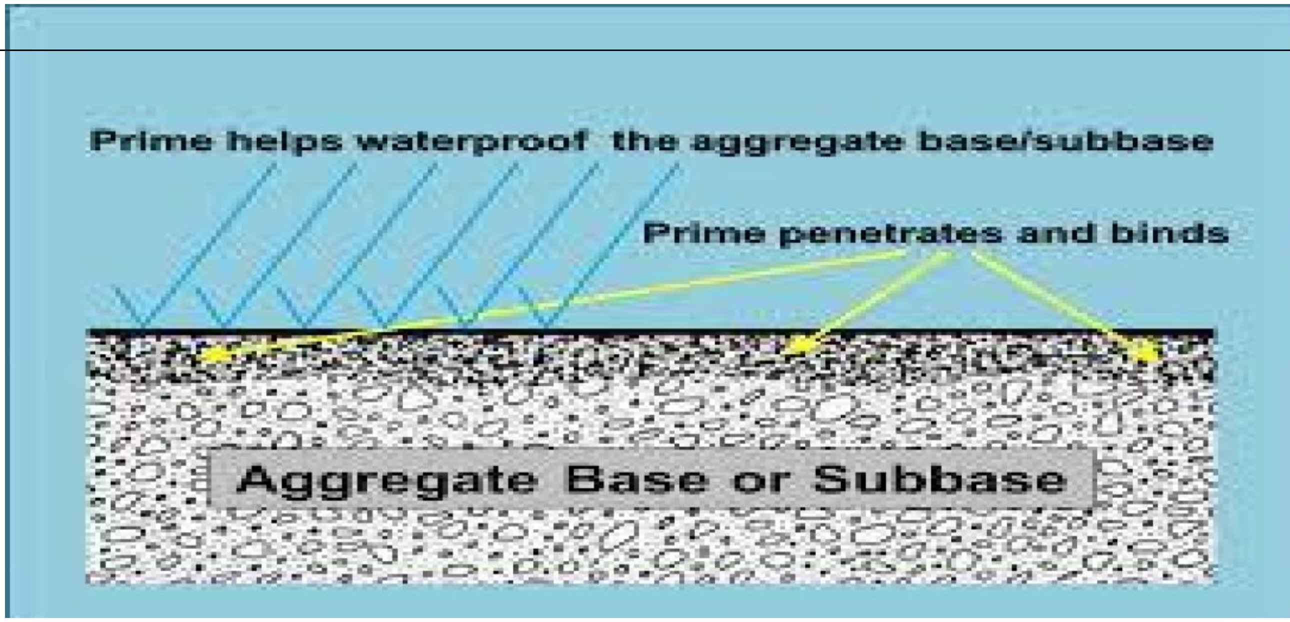
Q .No. *(10)*

Discuss the process of leaning of prime coat

Process of leaning of Bituminous Prime Coat:

<u>Definition:</u>

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.



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	Liters per Square, Meter	
	Min	**max**
2. Subgrade, sub base, Water bound base courses, and Crushed stone base course.	0.65	1.75
2. Bridge, wearing surfaces, concrete Pavement	0.15	0.4

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

Q .No. *(10)*

Discuss pavement types (surface/layers)

Types of Pavements

There are two types of pavements based on design considerations i.e. flexible pavement and rigid pavement. Difference between flexible and rigid pavements is based on the manner in which the loads are distributed to the subgrade.

Flexible Pavements

Flexible pavement can be defined as the one consisting of a mixture of asphaltic or bituminous material and aggregates placed on a bed of compacted granular material of appropriate quality in layers over the subgrade. Water bound macadam roads and stabilized soil roads with or without asphaltic toppings are examples of flexible pavements.

The **design of flexible pavement** is based on the principle that for a load of any magnitude, the intensity of a load diminishes as the load is transmitted downwards from the surface by virtue of spreading over an increasingly larger area, by carrying it deep enough into the ground through successive layers of granular material.

Thus for flexible pavement, there can be grading in the quality of materials used, the materials with high degree of strength is used at or near the surface. Thus the strength of subgrade primarily influences the thickness of the flexible pavement.

Rigid Pavements

A rigid pavement is constructed from cement concrete or reinforced concrete slabs. Grouted concrete roads are in the category of semi-rigid pavements.

The design of rigid pavement is based on providing a structural cement concrete slab of sufficient strength to resists the loads from traffic. The rigid pavement has rigidity and high modulus of elasticity to distribute the load over a relatively wide area of soil.

Minor variations in subgrade strength have little influence on the structural capacity of a rigid pavement. In the design of a rigid pavement, the flexural strength of concrete is the major factor and not the strength of subgrade. Due to this property of pavement, when the subgrade deflects beneath the rigid pavement, the concrete slab is able to bridge over the localized failures and areas of inadequate support from subgrade because of slab action.

Types of Layer

Surface Course.

The layer in contact with traffic loads. It provides characteristics such as friction, smoothness, noise control, rut resistance and drainage. In addition, it prevents entrance of surface water into the underlying base, subbase and subgrade (NAPA, 2001{{1}}). This top structural layer of material is sometimes subdivided into two layers: the wearing course (top) and binder course (bottom). Surface courses are most often constructed out of HMA.

Base Course.

The layer immediately beneath the surface course. It provides additional load distribution and contributes to drainage. Base courses are usually constructed out of crushed aggregate or HMA.

Subbase Course.

The layer between the base course and subgrade. It functions primarily as structural support but it can also minimize the intrusion of fines from the subgrade into the pavement structure and improve drainage. The subbase generally consists of lower quality materials than the base course but better than the subgrade soils. A subbase course is not always needed or used. Subbase courses are generally constructed out of crushed aggregate or engineered fill.

Types of surface for pavements

Asphalt:

One of the most popular types of construction ever since its inception in the early 1920s is asphalt paving. In this construction technique, a layer of asphalt is laid on top of an equally thick gravel base. Advantages of this form of road construction are that the pavement produces relatively little noise, its relative low cost compared to other materials, and that it is relatively easy to repair and maintain as well. However, asphalt is known to be significantly less durable and strong than most other choices, and isn't the best for the environment either.

Concrete:

Concrete is another popular choice for roadways, though it is typically only used for local roads and not other types of construction. There are three major types of concrete road surfaces, JPCP, JRCP, and CRCP; the distinguishing feature between the three being the joint system that is used to help prevent cracks from forming. Concrete is more long-lasting than asphalt and significantly stronger as well, but is quite expensive to lay and maintain.

Composite:

Composite materials are often used in types of construction that are more related to maintenance, recycling, and rehabilitation. Composite materials are combinations of both asphalt and concrete, and are typically employed in one of two methods. Asphalt overlays literally are placed over a damaged surface, or alternatively pavement may be cracked and seated instead, forming a true new surface.

Recycling:

There are three typical types of construction techniques related to recycling the surface of distressed or damaged pavement. Rubblizing, Cold/Hot in-place Recycling, and Full-depth Reclamation. Rubblizing involves reducing the road to gravel and then applying a new surface, both hot and cold in-place recycling relies on using bituminous pavement to reinforce the road (at different temperatures and admixtures, of course), and Full-depth reclamation involves both total pulverization and the addition of binding agents or other additives.

Bituminous Solutions

– Bituminous and other temporary solutions are types of construction that are only suitable for use on very low-traffic thoroughfares. Chipsealing techniques, thin membrane surfacing, and Otta sealing are all examples of bituminous surface options. These are all more commonly employed as sealing coats or finishes than as full road surfaces