IQRA NATIONAL UNIVERSITY PESHAWER

PAPER

Foundation and pavement

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Q: No. (01)

Define pavement distress and their causes.

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 i s 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.

Types Pavement Distress

1. Alligator (Fatigue) Cracking
2. Bleeding
3. Block Cracking
4. Corrugation and Shoving
5. Depression
6. Joint Reflection Cracking
7. Longitudinal Cracking
8. Patching
9. Potholes
10. Raveling
11. Rutting
12. Slippage Cracking
13. Stripping
14. Transverse (Thermal) Cracking

Distressed pavement is often a result of a combination of factors, rather than just one root cause. There are always exceptions to the rule – the exact condition you are looking for may not be here. Please contact your state DOT or Pavement Association for assistance.

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 wheelpaths). 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.

Possible 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.
  - 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.
  - 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. Bleeding

A film of asphalt binder on the pavement surface. It usually creates a shiny, glass-like reflecting surface that can become sticky when dry and slippery when wet.

Possible Causes:

Bleeding occurs when asphalt binder fills the aggregate voids during hot weather or traffic compaction, and then expands onto the pavement surface. Since bleeding is not reversible during cold weather or periods of low loading, asphalt binder will accumulate on the pavement surface over time. Likely causes are:

- Excessive asphalt binder in the HMA (either due to a poor mix design or manufacturing problems)
- Excessive application of asphalt binder during BST application
- Low HMA air void content (e.g., not enough void space for the asphalt to occupy), likely a mix design problem

3. 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.

Possible 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

4. Corrugation and Shoving

A form of plastic movement typified by ripples (corrugation) or an abrupt wave (shoving) across the pavement surface. The distortion is perpendicular to the traffic direction. Usually occurs at points where traffic starts and stops (corrugation) or areas where HMA abuts a rigid object (shoving).

Possible Causes:

- Usually caused by traffic action (starting and stopping) combined with:
  - An unstable (i.e. low stiffness) HMA layer (caused by mix contamination, poor mix design, poor HMA manufacturing, or lack of aeration of liquid asphalt emulsions)
- Excessive moisture in the subgrade

5. Depression

- Localized pavement surface areas with slightly lower elevations than the surrounding pavement. Depressions are very noticeable after a rain when they fill with water.

Possible Causes:

Subgrade settlement resulting from inadequate compaction during construction.

6. Joint Reflection Cracking

Cracks in a flexible overlay of a rigid pavement. The cracks occur directly over the underlying rigid pavement joints. Joint reflection cracking does not include reflection cracks that occur away from an underlying joint or from any other type of base (e.g., cement or lime stabilized).

Possible Causes:

Movement of the rigid pavement slab beneath the HMA surface because of thermal and moisture changes. Generally not load initiated, however loading can hasten deterioration

7. **Longitudinal Cracking**

Cracks parallel to the pavement's centerline or laydown direction. Usually a type of fatigue cracking.

Possible 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

8. **Patching**

An area of pavement that has been replaced with new material to repair the existing pavement. A patch is considered a defect no matter how well it performs.

Possible Causes:

- Previous localized pavement deterioration that has been removed and patched
- Utility cuts

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9. **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 (1 to 2 inches) and seldom occur on roads with 4 inch or deeper HMA surfaces.

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. The remaining hole after the pavement chunk is dislodged is called a pothole.

10. **Raveling**

The progressive disintegration of an HMA layer from the surface downward as a result of the dislodgement of aggregate particles.

Possible 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.
  - Inadequate compaction during construction. High density is required to develop sufficient cohesion within the HMA. Often, inadequate compaction will also result in rutting because once the pavement is opened to traffic, it will continue to compact in the wheelpaths under traffic loading.
- Mechanical dislodging by certain types of traffic (studded tires, snowplow blades or tracked vehicles).

11. 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.

Possible 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)

12. Slippage Cracking

Crescent or half-moon shaped cracks generally having two ends pointed into the direction of traffic.

Possible Causes:

Braking or turning wheels cause the pavement surface to slide and deform. The resulting sliding and deformation is caused by a low-strength surface mix or poor bonding between the surface HMA layer and the next underlying layer in the pavement structure.

13. Stripping

The loss of bond between aggregates and asphalt binder that typically begins at the bottom of the HMA layer and progresses upward. When stripping begins at the surface and progresses downward it is usually called raveling.

Possible Causes:

Bottom-up stripping is very difficult to recognize because it manifests itself on the pavement surface as other forms of distress including rutting, shoving/corrugations, raveling, or cracking. Typically, a core must be taken to positively identify stripping as a pavement distress. Stripping is typically caused by:

- Poor aggregate surface chemistry
- Water in the HMA causing moisture damage

14. Transverse (Thermal) Cracking

Cracks perpendicular to the pavement's centerline or laydown direction. Usually a type of thermal cracking.

Possible 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

Q:No. (02)

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

Sub grade

Preparation of sub grade by excavating earth to depth equal to the pavement thickness, consolidation with roller, disposal of surplus earth up to 50m

Preparation of sub-grade:

The surface of the formation for a width of sub-base, which shall be 15 cm more on either side of base course, shall first be cut to a depth equal to the combined depth of sub-base and surface courses below the proposed finished level (due allowance being made for consolidation). It shall then be cleaned of all foreign substances. Any ruts or soft yielding patches that appear due to improper drainage conditions, traffic hauling or from any other cause, shall be corrected and the sub-grade dressed off parallel to the finished profile.If sub-grade composed of clay, fine sand or other soils that may be forced up into the coarse aggregate during rolling operations, an insulation layer of granular materials or over size brick aggregate not less than 10 cm thick of suitable thickness shall be provided for blanketing the sub-grade. In slushy soil or in areas that are water logged, special arrangements shall be made to improve the sub-grade and the total pavement thickness shall be designed after testing the properties of the sub-grade soil. Necessary provision for the special treatment required shall be made in the project and paid for separately.

Consolidation:

The sub-grade shall be consolidated with a power road roller of 8 to 12 tones. The roller shall run over the subgrade till the soil is evenly and densely consolidated and behaves as elastic mass (the roller shall pass a minimum of 5 runs on the sub-grade). All the undulations in the surface that developed due to rolling shall be made good with material or quarry spoils as the case may be and the sub-grade is re-rolled.

Surface Regularity:

The finished surface shall be uniform and conform to the lines, grades and typical cross-sections shown in the drawings.

Preparation of Sub-base

Sub-base shall be spread in layers of nearly equal thickness either by hand or by using a grader or paving machine, with an uncompacted thickness up to 150 mm, subject to the approval of the Engineer. Where sand and aggregates are combined together to meet the specified grading, care shall be taken to prevent segregation of the material into fine and coarse parts. All areas of segregated coarse or fine material shall be corrected, or removed and replaced with material, which conforms to the Specification.

Where the material for shoulders is the same as that used for the sub-base course, the material shall be evenly spread in layers, as herein specified, for the full width of the sub-base course and the shoulders simultaneously. Where the shoulders are not of the same material as the sub-base course, then the sub base shall be spread to give the required compacted depth and the edge detail shown on the Drawings. When the sub base is spread contiguous to concrete kerbs or gutters, extreme care shall be exercised not to damage them. Any damage of kerbs or gutters resulting from carelessness or negligent construction methods by the Contractor shall warrant their removal and replacement at the Contractor's sole expense.

Sprinkling, Rolling and Compacting

Immediately after each layer has been spread and shaped to the cross section required each layer shall be compacted with suitable and adequate compaction equipment approved by the Engineer. Rolling operations shall begin from the outer edge of roadbed toward the centre, gradually in a longitudinal direction; except on super-elevated curves, where rolling shall begin at the low side and progress towards the high side.
If water is required, to bring the sub base to the correct moisture content, it shall be sprinkled on the surface. The contractor shall supply and sprinkle the necessary water at his own expense.
Sub-base material containing excess moisture shall be dried prior to or during compaction.
Drying of wet material shall be performed by methods approved by the
Sub-base which does not conform to the above requirements shall be corrected by scarifying the full depth of the affected areas, adding or removing materials and rerolling, watering if necessary, until the entire surface conforms to the correct levels and cross-falls. The prepared sub-base layer shall be protected against damage until covered by the base course.

Q.No. (03)

Discuss the process of leaning of prime coat

Bituminous 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.

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.

- 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
1. Subgrade, subbase, water bound base courses	0.65	1.75
2. Bridge, wearing surfaces ,concrete	0.15	0S.4

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

Q: No. (04)

Discuss pavement types (surface/layers

Types of Pavement (surface/layers)

1. **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.

2. **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.

3. **Portland Cement Concrete (PCC)**
   lmost all rigid pavement is made with Portland Cement Concrete (PCC). Rigid pavements are differentiated into three major categories by their means of crack control:
   1. **Jointed plain concrete pavement (JPCP**)

      This is the most common type of rigid pavement. JPCP controls cracks by dividing the pavement up into individual slabs separated by contraction joints. Slabs are typically one lane wide and between 3.7 m (12 ft.) and 6.1 m (20 ft.) long. JPCP does not use any reinforcing steel but does use dowel bars and tie bars.

   2. **Jointed reinforced concrete pavement (JRCP)**

      As with JPCP, JRCP controls cracks by dividing the pavement up into individual slabs separated by contraction joints. However, these slabs are much longer (as long as 15 m (50 ft.)) than JPCP slabs, so JRCP uses reinforcing steel within each slab to control within-slab cracking. This pavement type is no longer constructed in the U.S. due to some long-term performance problems.

Continuously reinforced concrete pavement (CRCP)

This type of rigid pavement uses reinforcing steel rather than contraction joints for crack control. Cracks typically appear ever 1.1 – 2.4 m (3.5 – 8 ft.) are held tightly together by the underlying reinforcing steel.

4. 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. This pavement type can also be used in conjunction with roller-compacted concrete (RCC\) pavements, where the RCC pavement provides the structural capacity that the conventional concrete pavement base would.