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Q (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 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.
Distress is a condition of the pavement structure that reduces serviceability or leads to a reduction in service life
Distress manifestations are the visible consequences of various distress mechanisms which usually lead to a reduction in serviceability.
Structural failure is a fracture or distortion that may or may not cause an immediate reduction in serviceability but leads to a future loss of serviceability.
Fracture is the state of pavement material that is breaking.

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

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.

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.
Loss of skid resistance when wet, unsightly

Block Cracking:

Shrinkage of the asphalt concrete and daily temperature cycling, which results in daily stress/strain cycling, causes block cracking. These are interconnected cracks that divide the pavement into approximately rectangular pieces. This type of distress usually indicates that the asphalt has hardened significantly.
Block cracking generally occurs over a large portion of the pavement area and may sometimes occur only in non-traffic areas.
Interconnected cracks that divide the pavement up into rectangular pieces. Blocks range in size from approximately 1 ft^2 to 100 ft^2. 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.
Allows moisture infiltration, roughness.

Reflection Cracking:

Vertical or horizontal movements in the pavement beneath an overlay cause this type of distress. These movements may be due to expansion and contraction caused by temperature and moisture changes or traffic loads. The cracks in asphalt overlays reflect the crack pattern in the underlying pavement.

They occur most frequently in asphalt overlays on Portland cement concrete pavements. However, they may also occur on overlays of asphalt pavements wherever cracks in the old pavement have not been properly repaired.

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).

Allows moisture infiltration, roughness

Transverse (Thermal) Cracking:

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

Allows moisture infiltration, roughness 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

Raveling:


The progressive disintegration of an HMA layer from the surface downward as a result of the dislodgement of aggregate particles.
Problem: Loose debris on the pavement, roughness, water collecting in the raveled locations resulting in vehicle hydroplaning, loss of skid resistance.
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 wheel paths under traffic loading.

Mechanical dislodging by certain types of traffic (studded tires, snowplow blades or tracked vehicles).

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.

Roughness (serious vehicular damage can result from driving across potholes at higher speeds), moisture infiltration.

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.

Rutting:

A rut is characterized by a surface depression in the wheel path. In many instances, ruts become noticeable only after a rainfall when the wheel paths fill with water. This type of distress is caused by a permanent deformation in any one of the pavement layers or subgrade, resulting from the consolidation or displacement of the materials due to traffic loads.

Surface depression in the wheel path. 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 wheel path depressions as a result of compaction/mix design problems. Subgrade rutting occurs when the subgrade exhibits wheel path depressions due to loading. In this case, the pavement settles into the subgrade ruts causing surface depressions in the wheel path. Ruts filled with water can cause vehicle hydroplaning, can be hazardous because ruts tend to pull a vehicle towards the rut path as it is steered across the rut.

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).
Roughness.
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.

Above all are flexible pavement distresses causes:

Rigid pavement distresses causes.

Durability “D” Cracking:

“D” cracking usually appears as a pattern of cracks running in the vicinity of and parallel to a joint or linear crack. It is caused by the concrete’s inability to withstand environmental factors such as freeze-thaw cycles because of variable expansive aggregates.
This type of cracking may eventually lead to disintegration of the concrete within 1 to 2 feet (30 to 60 cm) of the joint or crack.

Cracking of Concrete Pavements:

Cracks in concrete pavements often result from stresses caused by expansion and contraction or warping of the pavement. Overloading, loss of subgrade support, and insufficient and/or improperly cut joints acting singly or in combination are also possible causes. Several different types of cracking can occur

Longitudinal, Transverse, and Diagonal Cracks:

A combination of repeated loads and shrinkage stresses usually causes this type of distress. It is characterized by cracks that divide the slab into two or three pieces. These types of cracks can indicate poor construction techniques or weak underlying pavement layers.

Pop-outs:

Pop-outs usually occur as a result of poor aggregates durability.

Causes:
Poor aggregates freeze-thaw resistance
Alkali-aggregate reactions

Shallow Reinforcing:

Cause:

Reinforcing steel too close to surface.

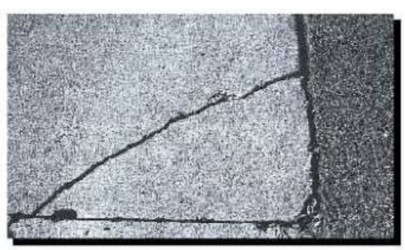
Cure:

Asphalt overlay or patch
Replacing steel and partial or full depth repair.

Corner Breaks:

Load repetition, combined with loss of support and curling stresses, usually causes cracks at the slab corner. The lack of support may be caused by pumping or loss of load transfer at the joint. This type of break is characterized by a crack that intersects the joints at a distance less than or equal to one-half of the slab length on both sides, measured from the corner of the slab.
A corner crack differs from a corner spall in that the crack extends vertically through the entire slab thickness; a corner spall intersects the joint at an angle.

- Causes:
  - Insufficient soil support
  - Temperature related
- Cures:
  - Partial or full-depth patch
  - Replace slab
  - Stabilize subsurface


Faulting:

The difference in elevation between the joints is called as faulting. The main causes of failures in rigid pavements due to faulting are:
Settlement of the pavement that is caused due to soft foundation
The pumping or the erosion of material under the pavement, resulting in voids under the pavement slab causing settlement

The temperature changes and moisture changes that cause curling of the slab edges.

Sever scaling and spalling:

Scaling is the disintegration and loss of the wearing surface. A surface weakened by improper curing or finishing and freeze-thaw cycles can lead to scaling. Map cracking or crazing refers to a network of shallow hairline cracks that extend only through the upper surface of the concrete.

Crazing usually results from improper curing and/or finishing of the concrete and may lead to scaling of the surface. Alkali-Silica Reactivity (ASR) is another source of distress associated with map cracking. ASR is caused by an expansive reaction between aggregates containing silica and alkaline pore solutions of the cement paste.

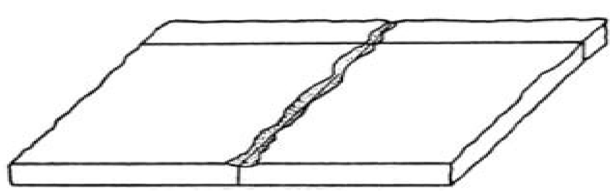
Transverse Joint Spalling:

Excessive compressive stress causes deterioration in the joints, called as the spalling. This may be related to joint infiltration or the growth of pavement that are caused by the reactive aggregates.

Poor quality concrete or construction technique will also result in joint spalling. Small edges to large spalls in the back of the slab and down to the joints can be observed.

Main causes of joint spalling in rigid pavements are:

- Joints subjected to excessive stress due to high traffic or by infiltration of any incompressible materials
- The joint that are constructed with weak concrete
- Joint that is accumulated with water that results in rapid freezing and thawing. The joint spalls can be avoided by using good construction techniques, or by sealing the joints.



Polished Aggregate:

The repeated traffic application leads to this distress. 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.
The polishing degree should be specified before the construction is carried out. This study is included in the condition survey, where it is mentioned as a defect.

Pumping:

The expulsion of water from the under a layer of the pavement is called as pumping. This distress is caused due to the active vehicle loads coming over the pavement in a repetitive manner. This will result in the fine materials present in the sub base to move along with water and get expelled out with the water.

Larger voids are created under the pavement due to repeated expulsion. The stains on the pavement or on the shoulder surface are the method through which this type of failure of rigid pavement is evidenced.
Pumping can be avoided by prevention of water accumulation at the pavement sub-base interface. This can be achieved by reducing the deflection to a minimum value and by the provision of a strong well-constructed sub-base.
The constructed sub-base must have sufficient drainage facility so that the subgrade below is not saturated. Modern pavement construction makes use of underground drainage system that is the best solution for pumping distress.

Blowups:

Blowups usually occur at a transverse crack or joint that is not wide enough to permit expansion of the concrete slabs. . Insufficient width may result from infiltration of incompressible materials into the joint space or by gradual closure of the joint caused by expansion of the concrete due to ASR.
When expansive pressure cannot be relieved, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blowups normally occur only in thin pavement sections, although blowups can also appear at drainage structures (manholes, inlets, etc.).
The frequency and severity of blowups may increase with an asphalt overlay due to the additional heat absorbed by the dark asphalt surface. They generally occur during hot weather because of the additional thermal expansion of the concrete.

Q (02): Discuss the process of sub-base and sub-grade preparation in detail

Sub-Base Preparation:

Definition:

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:

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 with 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 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 of6 or less.
- If over-size is encountered, screening of material at source, shall invariably be done, no hand picking shall be allowed, and 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:

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,

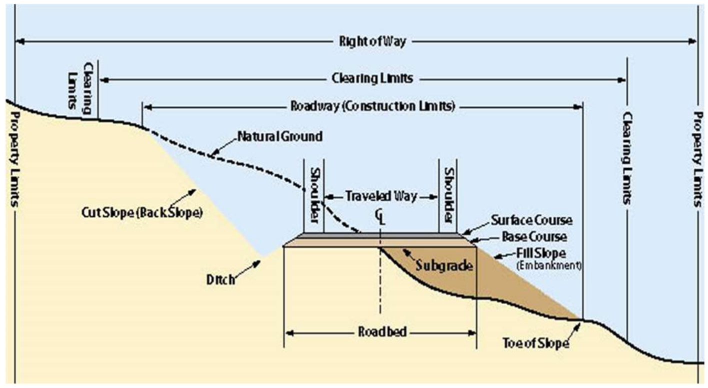
and the relationship between the number of compaction passes and the resulting density of the material.
The subbase material shall be compacted by means of approved vibrating rollers or steel wheel rollers (rubber tired rollers may be used as a supplement), progressing gradually from the outside towards 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,

Sub-Grade Preparation:

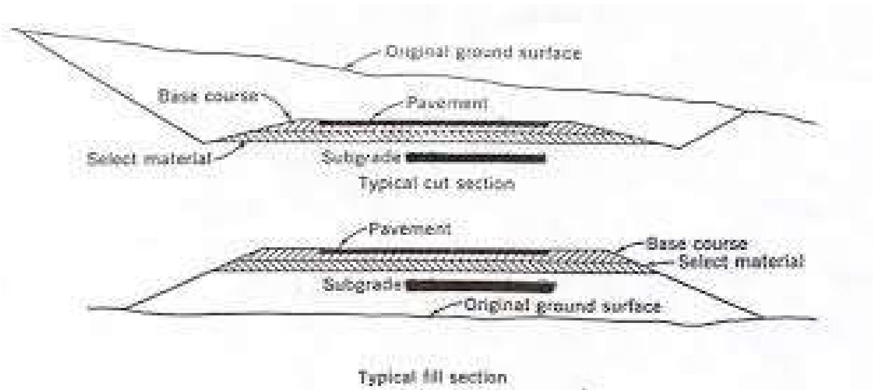
Definition:

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.
- Subgrade 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.

Q (03): Discuss the process of leaning of prime coat?

PROCESS of 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	Liter Per Square Meter	
Subgrade, subbase, water bound base courses, and Crushed stone base course.	Min	Max
	o.65	1.75
Bridge, wearing surfaces, concrete Pavement however, the exact rate shall be specified by the Engineer determined from field trials.	0.15	0.4

Q (04): Discuss pavement types (surface/layers)?

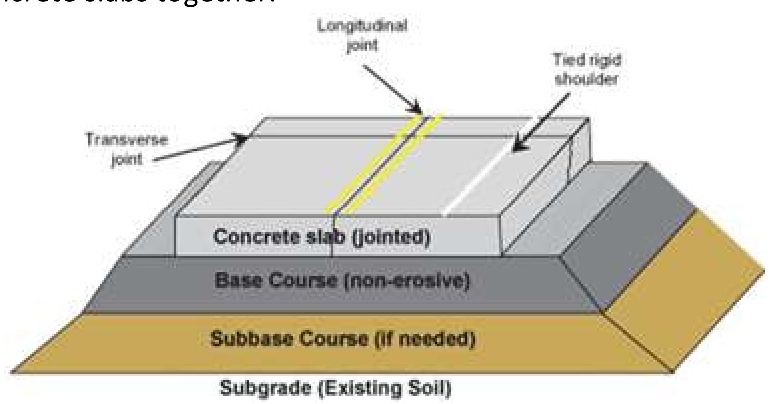
There are two types of Pavement:

Flexible Pavement:

A typical flexible pavement consists of a bituminous surface course over base course and sub-base course. The surface course may consist of one or more bituminous or Hot Mix Asphalt (HMA) layers. These pavements have negligible flexure strength and hence undergo deformation under the action of loads. The structural capacity of flexible pavements is attained by the combined action of the different layers of the pavement. The load from trucks is directly applied on the wearing course, and it gets dispersed (in the form of a truncated cone) with depth in the base, sub base, and subgrade courses, and then ultimately to the ground. Since the stress induced by traffic loading is highest at the top, the surface layer has maximum stiffness (measured by resilient modulus) and contributes the most to pavement strength. The layers below have lesser stiffness but are equally important in the pavement composition. The subgrade layer is responsible for transferring the load from the above layers to the ground. Flexible pavements are designed in such a way that the load that reaches the subgrade does not exceed the bearing capacity of the subgrade soil. Consequently, the thicknesses of the layers above the subgrade vary depending upon strength of soil affecting the cost of a pavement to be constructed.

Rigid Pavement:

Rigid pavements are named so because of the high flexural rigidity of the concrete slab and hence the pavement structure deflects very little under loading due to the high modulus of elasticity of their surface course. The concrete slab is capable of distributing the traffic load into a large area with small depth which minimizes the need for a number of layers to help reduce the stress. The most common type of rigid pavement consists of dowel bars and tie bars. Dowel bars are short steel bars that provide a mechanical connection between slabs without restricting horizontal joint movement. Tie bars on the other hand, are either deformed steel bars or connectors used to hold the faces of abutting slabs in contact. Although they may provide some minimal amount of load transfer, they are not designed to act as load transfer devices and are simply used to 'tie' the two concrete slabs together.



Difference between Flexible Pavements and Rigid Pavements:

	Flexible Pavement	Rigid Pavement
1.	It consists of a series of layers with the highest quality materials at or near the surface of pavement.	It consists of one layer Portland cement concrete slab or relatively high flexural strength.
2.	It reflects the deformations of subgrade and subsequent layers on the surface.	It is able to bridge over localized failures and area of inadequate support.
3.	Its stability depends upon the aggregate interlock, particle friction and cohesion.	Its structural strength is provided by the pavement slab itself by its beam action.
4.	Pavement design is greatly influenced by the subgrade strength.	Flexural strength of concrete is a major factor for design.
5.	It functions by a way of load distribution through the component layers	It distributes load over a wide area of subgrade because of its rigidity and high modulus of elasticity.
6.	Temperature variations due to change in atmospheric conditions do not produce stresses in flexible pavements.	Temperature changes induce heavy stresses in rigid pavements.
7.	Flexible pavements have self healing properties due to heavier wheel loads are recoverable due to some extent.	Any excessive deformations occurring due to heavier wheel loads are not recoverable, i.e. settlements are permanent