ROAD MAINTENANCE OR MAINTENANCE OF HIGHWAYS

Introduction

Road maintenance is essential in order to (1) preserve the road in its originally constructed condition, (2) protect adjacent resources and user safety, and (3) provide efficient, convenient travel along the route. Unfortunately, maintenance is often neglected or improperly performed resulting in rapid deterioration of the road and eventual failure from both climatic and vehicle use impacts. It follows that it is impossible to build and use a road that requires no maintenance. Preserving and keeping each type of roadway, roadside, structures as nearly as possible in its original condition as constructed or as subsequently improved and the operation of highway facilities and services to provide satisfactory and safe transportation, is called **Road Maintenance or Maintenance of Highways**.

Road maintenance is the one of the most important components of the road system. It involves the assessment of road condition, diagnosis of the problems and adopting the most appropriate maintenance step. Even if the highways are well designed, they may require maintenance due to its less design life. Various types of failures occur in the pavement which ranges from minor to major distresses.

Fig. Roads Maintenance / Highways Maintenance Definition

Road Maintenance Components

The various road maintenance function includes:

1. Surface maintenance

2. Roadside and drainage maintenance
3. Shoulder and approaches maintenance
4. Snow and ice control
5. Bridges maintenance
6. Traffic service

Highway maintenance is closely related to the quality of construction of original road. Insufficient pavement or base thickness or improper construction of these elements soon results in expensive patching or surface repair. Shoulder care becomes a serious problem where narrow lanes force heavy vehicle to travel with one set of wheels off the pavement.

Improperly designed drainage facilities, mean erosion or deposition of material and costly cleaning operation or other corrective measures. For regular highways maintenance and repair sharp ditches and steep slopes require manual maintenance as compare to cheap repair of flatter ditch and soil by machine.

In snowy country, improper location extremely low fills and narrow cuts leave no room for snow storage, creating extremely difficult snow removal problems.

General Causes of Pavement Failures

Some of the general causes of pavement failures needing maintenance measures may be classified as given below:

(i) Defects in quality of materials used, construction method and quality control during construction.
(ii) Inadequate surface or subsurface drainage
(iii) Increase in the magnitude of wheel loads and the number of load repetitions due to increase in traffic volume.
(iv) Settlement of foundation of embankment
(v) Environmental factors including heavy rainfall, soil erosion, high water table, snow fall, frost action etc.

1. **Poor soil:-** It is the most common problem in the pavement design. The most common soil problem in the Southeast is a highwater table. If not accounted for at the time of construction, a highwater table will erode the soil and eventually lead to pavement failure.

2. **Inferior material quality:-** If the material laid on the ground is not good enough, will be leads to severe defects and failures.

3. **Improper geometry:-** Due to improper geometry of road, lot of factors may arise which keeps the pavement deformation.

4. Overloading of vehicles:- A vehicle is said to be heavy loaded when it is being loaded more than its carrying capacity. Acc. to IRC, the max. wheel load for standard axle is 80 KN. Due to heavy movement of vehicles or overloaded vehicles or increase traffic volume, severe distresses takes place.

5. **Environmental Factors:-** It includes heavy rainfall, soil erosion, high water table, snow fall, frost action etc.

6. **Inadequate drainage:-** Due to improper drainage resulting in stagnation of water in the subgrade which could be the main reason pavement failure in future.

Maintenance of Highway

Various maintenance operations are as follows:

(i) Routine maintenance:

- These include filling up of pot holes and patch repairs, maintenance of shoulders and the cross slope, up-keep of the road side drains and clearing choked culverts, maintenance of miscellaneous items like road signs, arboriculture, inspection bungalows etc.

(ii) Periodic maintenance:

- These include renewals of wearing course of pavement surface and preventive maintenance of various items.

(iii) Special repair:

- These include strengthening of pavement structure or overlay construction, reconstruction of pavement, widening of roads, repairs of damages caused by floods, providing additional safety measures like islands, signs etc.

Basic Maintenance Objective

The basic objective of maintenance functions are to maintain and operate the highway system in a manner such that:

(i) Comfort, convenience and safety are afforded to the public.

(ii) The investment in roads, bridges and appurtenances is preserved.

(iii) The aesthetics and compatibility of highway system with the environment is preserved.

(iv) The necessary expenditure of resources is accomplished with continuing emphasis on economy.

Failure in Flexible Pavement

One of the prime causes of flexible pavement failure is excessive deformation in subgrade soil. This can be noticed in the form of excessive undulations or waves and corrugations in the pavement surface.

The lateral shoving of pavement near the edge along the wheel path of vehicle is due to insufficient bearing capacity or a shear failure in subgrade soil. The failure of subgrade may be attributed due to inadequate stability and excessive stress application.

(i) Failures in subgrade:

Following are the two main reasons for failures in the subgrade:

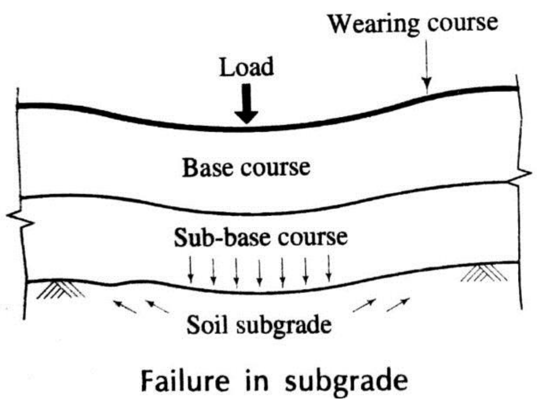


Fig.1. Failure in Subgrade

(a) Excessive stress application: If the pavement thickness is inadequate or the loads are in excess of the design value, the excessive stress is developed and it harms as load repetitions are increased.

(b) Inadequate stability: The resistance to deformation. under stress is known as stability. The inadequate stability of the subgrade is developed due to the inherent weakness of the soil itself or excessive moisture or improper compaction.

(ii) Failures in sub-base or base courses:

The main reasons which contribute to the failures in sub-base or base courses can be mentioned as follows:

(a) Inadequate strength: The poor mix proportioning or inadequate thickness of pavement may lead to the lack of stability or strength of sub-base or base course.

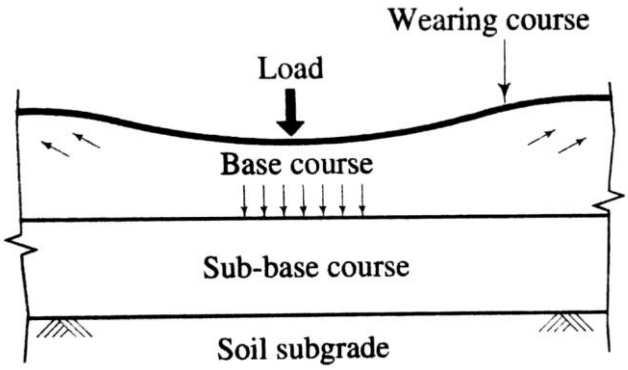


Fig.2. failure in Base course

(b) **Inadequate wearing course:** If the wearing course is of inadequate thickness or if it is totally absent, the sub-base or base courses are exposed to the damaging effects of the climatic agencies and the traffic.

(c) Lack of lateral confinement: If lateral confinement is not provided for granular sub-base or base courses, the action of traffic causes the materials of these courses to spread out.

(d) Loss of binding action: The repeated stress applications lead to the internal movements of aggregate in sub base or base courses and ultimately the composite mass or structure of the layers gets disturbed. Thus, the loss of binding action is developed and it leads to the low stability and poor load transmitting property of the pavement layer.

(e) Loss of materials: If the base course is not covered with a wearing course or if the wearing course has completely worn out, there are chances of loss of base course materials due to action of traffic and it leads to the formation of pot holes on the surface. Use of inferior materials: If the materials employed in the construction of flexible pavements do not comply with the standard requirements, the structural behaviour of the pavement is affected.

(iii) Failures in wearing course:

The failures in wearing course are attributed to the following reasons:

(a) Lack of proper mix design: If the mix design does not provide for adequate binder content, the bituminous surface will exhibit poor performance under the action of traffic.

(b) Quality control: It is necessary to provide a high degree of quality control in bituminous construction. The resulting paving mix should contain just enough binder content only.

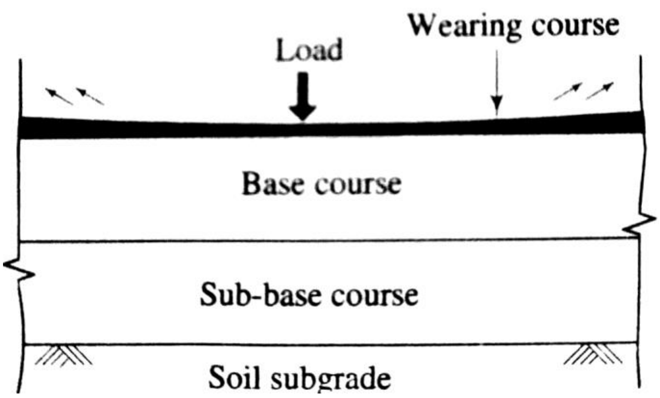


Fig. 3. Failure in wearing course

(c) Volatilization and oxidation of binder: The bituminous surface becomes brittle due to volatilization and oxidation of binder. It results in the cracking of the pavement surface which further permits the seepage of rainwater to cause damage to the underlying layers.

Causes of premature failures:-

- Rutting due to high variation in ambient temperature.
- Uncontrolled heavy axle loads.
- Limitation of pavement design procedures to meet local environmental conditions.

Common Flexible Pavement Failure/ Distresses:-

- Cracking
- Deformation
- Deterioration
- Mat problems
- Problems associated with seal coats

Category	Distress type
1. Cracking	Longitudinal, Fatigue, Transverse, reflective, block, edge
2.Deformation	Rutting, Corrugation, Shoving, depression, overlay bumps
3. Deterioration	Delamination, Potholes, Patching, raveling, stripping, Polished aggregate, Pumping
4.Mat Problems	Segregation, Checking, Bleeding
5.Seal coats	Rock loss, Segregation, bleeding/fat spots, Delamination

Types of Defects in Flexible Pavement

The types of defects in flexible pavement are grouped under four categories:

1. **Surface defect:** These are associated with the surfacing layers and may be due to excessive or deficient quantity of bitumen in these layers. It includes fatty surfaces, smooth surfaces, streaking and hungry surfaces.
2. **Crack:** It contains hair line crack, alligator crack, longitudinal crack, edge crack, shrinkage crack and reflection crack.
3. **Deformation:** It includes slippage, rutting, corrugation, shoving, shallow, depression, settlement and upheaval.
4. **Disintegration:** It covers stripping, loss of aggregates, ravelling, potholes and edge cracking.

A brief description of the defects, symptoms, probable causes, and possible treatment is given in the Table 10.3, extracted from "IRC; 82-1982: 'Code of Practice for maintenance of bituminous surfaces', Indian Roads Congress, New Delhi, 1982"

Table 10.3 Defects, symptoms, causes and treatment of defects in bituminous surfacings

Type of defect	Symptoms	Probable causes	Possible treatment
A. Surface defect 1. Fatty surface	Collection of binder on the surface	Excessive binder; loss of cover aggregates excessively heavy axle load.	Sand-blinding; open-graded premix; liquid seal coat; removal of affected area.
2. Smooth surface	Slippery	Polishing of aggregates under traffic; or excessive binder	Resurfacing with surface dressing or premix carpet.
B. Cracks 1. Alligator cracks	Interconnected cracks forming a series of small blocks	Weak pavement, poor subgrade, excessive loads, or brittle binder	The treatment depends on whether the pavement is structurally sound or unsound. For structurally sound condition, cracks are to be filled with low viscosity binder. Unsound cracked pavement need strengthening or rehabilitation treatment.
2. Longitudinal cracks	Cracks on a straight line along the road.	Poor drainage, shoulder settlement, or differential frost-heave	
3. Shrinkage cracks	Cracks in transverse direction or interconnected cracks forming large blocks	Shrinkage of bituminous layer with age.	
C. Deformation 1. Rutting	Longitudinal depression in the wheel tracks	Heavy channelized traffic inadequate compaction or heavy steel-tyred traffic	Filling the depressions with premix material
2. Corrugations	Formation of regular undulations	Lack of mix stability, oscillations from vehicle spring, faulty laying of surface course	Scarification and relaying of surface.
3. Settlement	Large deformation of pavement	Poor compaction of fills, poor drainage, inadequate pavement or frost heave	Where fill is weak, it should be replaced. If pavement is inadequate, it should be strengthened.
D. Disintegration 1. Stripping	Separation of bitumen from aggregates in the presence of moisture	Use of hydrophilic aggregate, poor mix, continuous contact with water	Spreading and compacting heated sand, replacement with fresh bituminous mix
2. Loss of aggregate	Rough surface with loss of aggregate in some portions	Ageing and hardening of binder, poor bond between aggregate and binder, poor compaction	Application of liquid seal, fog seal or slurry seal depending upon the extent of damage.
3. Ravelling	Failure of binder to hold the aggregates with small eroded areas on the surface.	All the above and insufficient binder, and brittleness of binder	Application of cutback covered with coarse sand, or a premix renewal coat.
4. Pot-holes	Appearance of bowl-shaped holes, usually after rain.	Ingress of water into the pavement, lack of bond between WBM base and surfacing, insufficient bitumen content.	Filling pot-holes with premix material or penetration patching.

Renewal of surface is needed every 4 to 5 years for national and state highways.
The renewal can be with metal (75 mm), surfacing dressing, premix chipping carpet with seal coat, semi-dense bituminous concrete, or bituminous concrete.

Table-8.1 : Symptoms, Causes and Treatment of defects in bituminous surfacings

Types of distress	Symptoms	Probable causes	Possible types of treatment
A. Surface defect			
1. Fatty surface	Collection binder on the surface	Excessive binder in premix, spray or tack coat; loss of cover aggregates, excessively heavy axle load.	Sand-blinding; open graded premix; liquid seal coat; burning of excess binder; removal of affected area.
2. Smooth surface	Slippery	Polishing of aggregates under traffic, or excessive binder.	Resurfacing with surface dressing or premix carpet.
3. Streaking	Presence of alternate lean and heavy lines of bitumen.	Non-uniform application of bitumen, or at a low temperature.	Application of a new surface.
4. Hungry surface	Loss of aggregates or presence of fine cracks.	Use of less bitumen of absorptive aggregates.	Slurry seal or fog seal.
B. Cracks			
1. Hair-line cracks	Short and fine cracks at close intervals on the surface.	Insufficient bitumen, excessive filler or improper compaction.	The treatment will depend on whether pavement is structurally sound or unsould.
2. Alligator cracks	Inter-connected cracks forming series of small blocks.	Weak pavement, unstable conditions of sub-grade or lower layers, excessive over-loads or brittleness of binder.	Where the pavement is structurally sound, the cracks should be filled with a low viscosity binder or a slurry seal or fox seal depending on the width of cracks. Unsound cracked pavements will need strengthening or rehabilitation treatment.
3. Longitudinal cracks	Cracks on a straight line along the road.	Poor drainage, shoulder settlement, weak joint between adjoining spreads of pavement layers or differential frost heave.	
4. Edge cracks	Cracks near and parallel to pavement edge.	Lack of support from shoulder, poor drainage, frost heave, or inadequate pavement width.	
5. Shrinkage cracks	Cracks in transverse direction or inter-connected cracks forming a series of large blocks	Shrinkage of bituminous layer with age.	
6. Reflection cracks	Sympathetic cracks over joints and cracks in the pavement underneath.	Due to joints and cracks in the pavement layer underneath.	
C. Deformation			
1. Slippage	Formation of crescent shaped cracks pointing in the direction of the thrust of wheels.	Unusual thrust of wheels in a direction, lack or failure of bond between surface and lower pavement courses.	Removal of the surface layer in the affected area and replacement with fresh material.
2. Rutting	Longitudinal depression in the wheel tracks.	Heavy channelised traffic, inadequate compaction of pavement layers, poor stability of pavement material or heavy bullockcart traffic.	Filling the depressions with premix material.
3. Corrugations	Formation of regular undulations	Lack of stability in the mix, oscillations set up by vehicle springs, or faulty laying of surface course.	Scarification and relaying of surfacing, or cutting of high spots and filling of low spots.
4. Shoving	Localised bulging of pavement surface alongwith crescent-shaped cracks.	Unstable mix, lack of bond between layers, or heavy start-stop type movements and those involving negotations of curves and gradients	Scarification and relaying of surfacing, or cutting of high spots and filling of low spots.
5. Shallow depression	Localised shallow depressions	Presence of indequately compacted pockets.	Filling with premix materials.
6. Settlement and upheaval	Large deformation of pavement.	Poor compaction of fills, poor drainage, inadequate pavement or frost heave.	Where fill is weak the defective fill should be excavated and redone. Where inadequate pavement is the cause, the pavement should be strengethened.

D. Disintegration			
1. Stripping	Separation of bitumen from aggregates in the presence of moisture.	Use of hydrophilic aggregate, inadequate mix composition, continuous contact with water, poor bond between aggregate and bitumen at the time of construction, etc.	Spreading and compacting heated sand over the affected area in the case of surface dressing; replacement with added anti-stripping agent in other cases.
2. Loss of aggregate	Rough surface with loss of aggregate in some portions	Ageing and hardening of binder, stripping, poor bond between binder and aggregate, insufficient binder, brittleness of binder etc.	Application of liquid seal, fog seal or slurry seal depending on the extent of damage.
3. Ravelling	Failure of binder to hold the aggregates shown up by pock marks of eroded areas on the surface.	Poor compaction, poor bond between binder and aggregate insufficient binder, brittleness of binder etc.	Application of cutback covered with coarse sand, or slurry seal, or a premix renewal coat.
4. Pothole	Appearance of bowl-shaped holes, usually after rain.	Ingress of water into the pavement, lack of bond between the surfacing and WBM base, insufficient bitumen content etc.	Filling pot-holes with premix material, or penetration patching.
5. Edge-breaking	Irregular breakage of pavement edges.	Water infiltration, poor lateral support from shoulders, inadquate strength of pavement edges, etc.	Cutting the affected area to regular sections and rebuilding with simultaneous attention paid to the proper construction of shoulder.

DESIGN OF PAVEMENT

The surface of the roadway should be stable & non-yielding, to allow the heavy wheel load of road traffic to move with least possible rolling resistance. The road surface should also be even along the longitudinal profile to enable the design speed. The earth road may not be able to fulfill any of the above requirement, especially during the varying conditions of traffic loads & the weather. At high moisture contents, the soil becomes weaker & soft & starts yielding under heavy wheel loads, thus increasing the tractive resistance discomfort & fatigue to the passengers of fastmoving vehicle & cyclists thus a pavement consisting of a few layers of pavement materials is constructed over a prepared soil sub grade to serve as a carriageway.

- Based on the vertical alignment & the environmental conditions of the site, the pavement may be constructed over an embankment, cut or almost at the ground level of the ground water to keep the sub grade relatively dry even during monsoons.

Failures in flexible pavement

A flexible pavement failure is defined by formation of pot holes, ruts, cracks, localized depressions and settlements. The localized depression normally is followed with heaving in the vicinity.

The failure of any one or more components of the pavement structure develops the waves and corrugations on the pavement surface or longitudinal ruts and shoving. Pavement unevenness may itself be considered, as a failure, when it is excessive.

The aging and oxidation of bituminous films lead to the deterioration of bituminous pavements. Deterioration actions in pavements are rapidly increased when excess water is retained in the void spaces of bituminous pavements or in the cracks and joint of the cement concrete pavements.

The cement concrete pavement may develop cracks and deteriorate due to repeated loads and fatigue effects. A rigid pavement failure is observed by the development of structural crack of break resulting in progressive subsidence of some portions of pavement.

Pavements are therefore capable of withstanding slight variations in the underlying support and they bridge the localized gaps moderately.

It is the combination of many factors that induce the failure conditions in the rigid pavement. Due to the temperature effects, the newly constructed cement concrete pavement may also crack even if no vehicle moves on them.

Failures in Flexible Pavements:

The localized settlement of any one component layer of the flexible pavement structure could be enough to cause pavement failure. This demands that each one of the layers should be carefully designed and laid.

Thus, to maintain the stability of the pavement structure as a whole, each layer should be stable within itself and thereby make the total pavement mainta9n its stability.

In this fig shows the failures in soil subgrade, base course and the surface wearing course. It may see that ultimately there is surface deformation when failure takes place either in sub grade or base or surface.

Failures in sub grade:

One of the prime causes of flexible pavement failure is excessive deformation in sub grade soil. It is the form of excessive undulation or waves and corrugations in the pavement surface and also depressions followed by heaving of pavement surface.

The lateral shoving of pavement near the edge along the wheel path of vehicles is due to insufficient bearing capacity or a shear failure in sub grade soil.

The failure of sub grade maybe attributed due to two basic reasons:

i) Inadequate stability

ii) Excessive pavement thickness

Inadequate stability may be due to inherent of the soil and excessive moisture condition and improper compaction. Stability is the resistance to deformation under the stress.

Excessive stress application is due to inadequate pavement thickness or loads in excess of design value.

The deformation due to the load would be elastic or fully recovered when the load is released. In part of the compaction of the layers is not adequate with reference to subsequent loading part of the deformation may be permanent due to compaction of soil this may be called as consolidation deformation.

The applied stress is excessive with respect to the stability and plastic flow takes place as in the case of we t clay soil, this deformation is called plastic deformation.

The type of damage in flexible pavement than can be caused by traffic due to sub grade failure due to inadequate and improper compaction of sub grade and other pavement layers.

Failures in sub base or base course:

Following are the chief types of sub-base or base course failures:

i) Inadequate stability or strength

ii) Loss of binding action.

iii) Loss of base course materials

iv) Inadequate wearing course

v) Use of inferior materials and crushing of base course materials

vi) Lack of lateral confinement for the granular bass course.

Failures of wearing course:

Failure of wearing course is observed due to lack of proper mix design. Improper gradation of aggregates, inadequate binder content and inferior type of binder result in a poor bituminous surfacing.

Besides the design project the bituminous construction requires a high degree of quality control since over or under estimated binder content are both greatly damaging to the resulting paving mix including temperature controls.

Vocalization and oxidation of binder also makes the bituminous surfacing brittle and cause cracking of the pavement surface which further allows seepage of rain water to harm the underlying layers.

Following are the some of the flexible pavement failures:

Alligator (map) cracking

Consolidation of pavement layers

Shear failure

Longitudinal cracking

Frost heaving

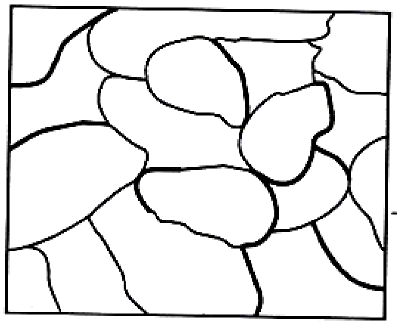
Lack of binding to the lower course

Reflection cracking

Formation of waves and corrugation.

Alligator (map) cracking

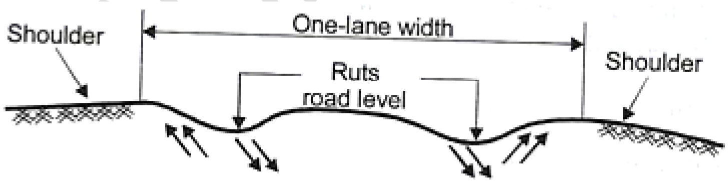
This is the most common type of failure and occurs due to relative movement of pavement layer materials. This may be caused by the repeated application of heavy wheel load resulting in fatigue failure or due to the moisture variations resulting in swelling and shrinkage of sub grade and other pavement materials. Localized weakness in the under laying base course would also cause a cracking of the surface course in this pattern.



Map cracking

Consolidation of pavement layers

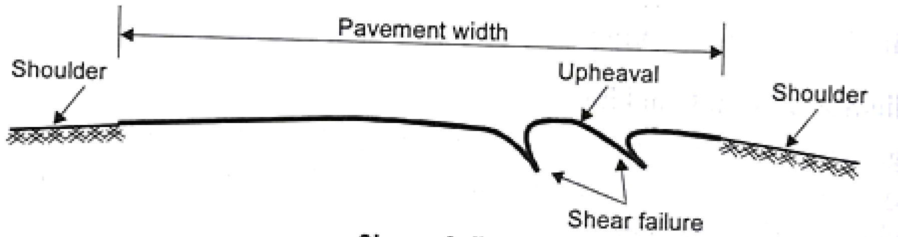
Formations of ruts are mainly attributed to the consolidation of one or more layers of pavement. The repeated application of loads along the same wheel path cause cumulative deformation resulting in consolidation deformation or longitudinal ruts. Shallow ruts on the surfacing course can also be due to wearing along the wheel path. Depending upon the depth and width of ruts, it can be estimated whether the consolidation deformation has been caused in the sub grade or in subsequent layers.



Formation of ruts due to consolidation

Shear failure and cracking

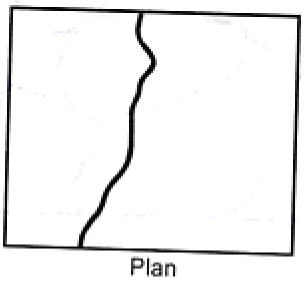
Shear failures are associated with the inherent weakness of pavement mixtures, the shearing resistance being low due to inadequate stability or excessively heavy loading. The shear failure causes upheaval of pavement materials by forming a fracture or cracking.



Shear failure cracking

Longitudinal cracking

Due to frost action and differential volume changes in sub grade longitudinal cracking is caused in pavement traversing through the fall pavement thickness. Settlement of fill and sliding of side slopes also would cause this type of failure.



Longitudinal cracking due to differential volume change

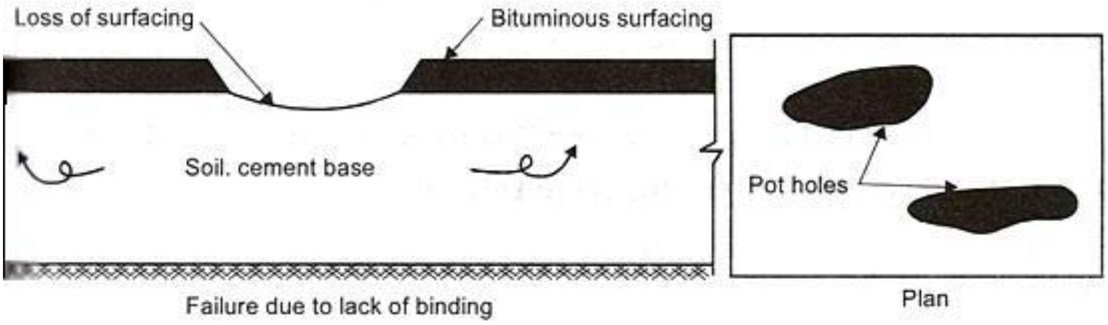
Frost heaving

Frost heaving is often misunderstood for shear or other types of failure. In shear failure, the upheaval of portion of pavement is followed with a depression. In the case of frost heaving, there is mostly a localized heaving up pavement portion depending upon the ground water and climate conditions.

Failure due to frost heave

Lack of binding with lower layer

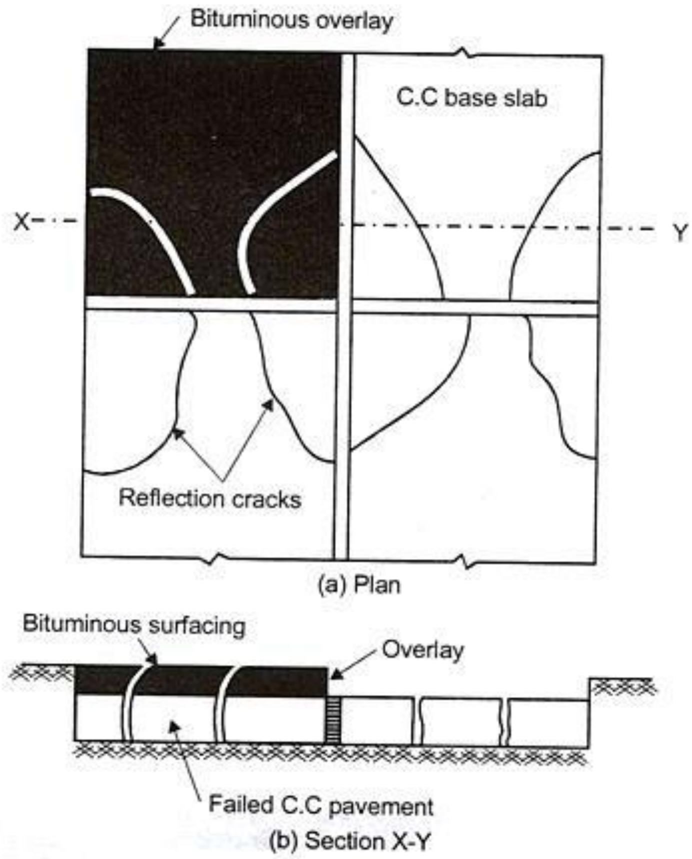
Slipping occurs when the surface course is not keyed/bound with the under laying base. This results in opening up and loss of pavement materials forming patches or pot holes. Such conditions are more frequent in case when the bituminous surfacing is provided over the existing cement concrete base course or soil cement course. This condition is more pronounced when the prime/tack coat in between two layers is lacking.



Reflection cracking

This type of cracking is observed in bituminous overlays provided over existing cement concrete pavements. The crack patterns as existing in cement concrete pavements are mostly reflected on bituminous surfacing in the same pattern. Structural action of the total pavement section is not much influenced by the presence of reflection cracks but since the cracks appear at the surface, these allow surface water to seep through and cause damage to the soil sub grade or resulting in mud pumping.

(a) and (b) show the pattern of reflection cracking.



Reflection cracking

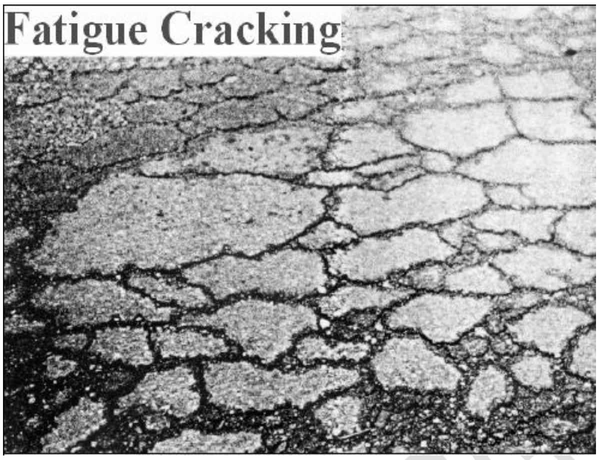
PAVEMENT FAILURE

Pavements fail prematurely because of many factors. When boiled down to the basics, there are four primary reasons pavements fail prematurely:

- Failure in design
- Failure in construction
- Failure in materials
- Failure in maintenance

DIFFERENT TYPE OF PROBLEM

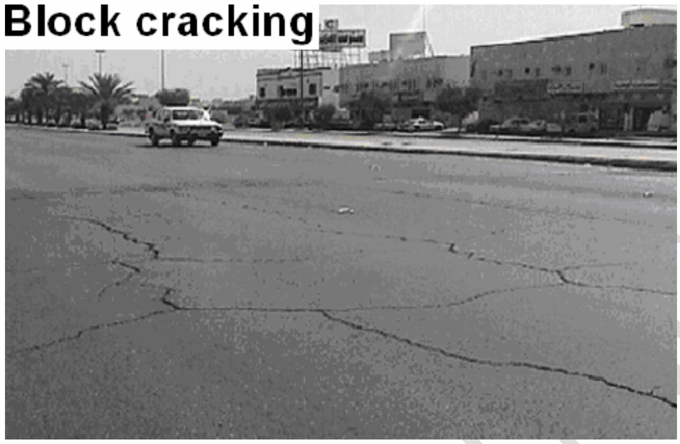
1. **Fatigue Cracking (Alligator Cracking):-** Fatigue cracking is commonly called alligator cracking. This is a series of interconnected cracks creating small, irregular shaped pieces of pavement. It is caused by failure of the surface layer or base due to repeated traffic loading (fatigue).



2. **Longitudinal Cracking:-** Longitudinal cracks are long cracks that run parallel to the canter line of the roadway. These may be caused by frost heaving or joint failures, or they may be load induced. Understanding the cause is critical to selecting the proper repair.

3. **Transverse Cracking:-** Transverse cracks form at approximately right angles to the centre line of the roadway. They are regularly spaced and have some of the same causes as longitudinal cracks. Transverse cracks will initially be widely spaced (over 20 feet apart). They usually begin as hairline or very narrow cracks and widen with age.

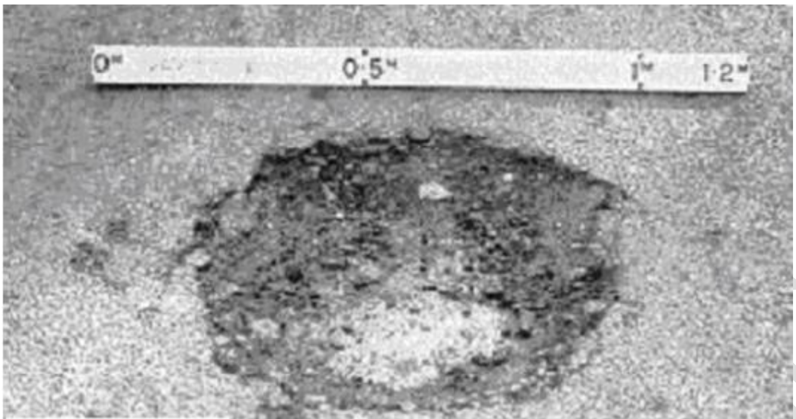
4. **Block Cracking:-** Block cracking is an interconnected series of cracks that divides the pavement into irregular pieces. This is sometimes the result of transverse and longitudinal cracks intersecting. They can also be due to lack of compaction during construction. Low severity block cracking may be repaired by a thin wearing course.



5. **Edge cracking:-** Edge cracks typically start as crescent shapes at the edge of the pavement. They will expand from the edge until they begin to resemble alligator cracking. This type of cracking results from lack of support of the shoulder due to weak material or excess moisture.
6. **Rutting:-** Rutting is the displacement of pavement material that creates channels in the wheel path. Very severe rutting will actually hold water in the rut. Rutting is usually a failure in one or more layers in the pavement. The width of the rut is a sign of which layer has failed. A very narrow rut is usually a surface failure, while a wide one is indicative of a sub grade failure.

7. **Potholes:-** Potholes are bowl-shaped holes similar to depressions. They are a progressive failure. First, small fragments of the top layer are dislodged. Over time, the distress will progress downward into the lower layers of the pavement. Potholes are often located in areas of poor drainage, as seen in Figure Potholes are formed

when the pavement disintegrates under traffic loading, due to inadequate strength in one or more layers of the pavement, usually accompanied by the presence of water.



Pothole

8. **De-lamination:-** De-lamination is a failure of an overlay due to a loss of bond between the overlay and the older pavement. Common causes of de-lamination include: wet or dirty surface during paving of the overlay, failure to use a tack coat, or poor compaction of the overlay. Proper paving techniques, including cleaning the surface and use of tack coat, will reduce the chances of de- lamination.

Other issues that need treatment before maintenance: Oil Spots – oil spots are a common problem in parking lots and driveways. These areas must be treated before sealcoating or the oil and chemicals will seep up through the newly applied material and render your sealed surface ineffective. There are number of great products for treating these types of issues. Ask your material supplier what they offer. Grass – Poorly maintained parking lots will often have grass growing up through the cracks. Cleaning the cracks should be standard practice before sealing them. Use a heat lance to burn out the crack and/or blow out the cracks depending on the severity of the problem. Mud, tree sap, berry stains, etc. Anything that would sit between the asphalt and the sealer must be removed. Without removing it the sealer cannot properly adhere to the asphalt and will eventually (sooner than later most likely) peel off. Blowers, push brooms, pressure washers, and gas powered brooms are all tools you should have in your pavement maintenance arsenal.

FAILURE OF RIGID PAVEMENT

Failure in rigid pavement (or cement concrete pavement) can be identified by formation of cracks on the pavement surface. The two prime factors responsible for rigid pavement failure are

1. Use of poor quality material
2. Inadequate stability of the pavement structure

Poor quality of material consist of following items

- Using soft aggregate
- Poor quality of sub-grade soil
- Poor joint filler R sealer materials

Inadequate stability of the pavement structure can be due to following reason

- Inadequate pavement thickness
- Lack of sub-grade support
- Improper compaction of sub-grade
- Improper spacing of joints

TYPES OF FAILURE IN RIGID PAVEMENT

The following 5 form of failures are commonly found in rigid pavement

1. Scaling of cement concrete
2. Shrinkage cracks
3. Joint spalling
4. Warping cracks
5. Pumping

1. SCALING OF CEMENT CONCRETE

Scaling of rigid pavement simply means, peeling off or flaking off of the top layer or skin of the concrete surface. This may be due to the following reasons

- Improper mix design
- Excessive vibration during compaction of concrete
- Laitance of concrete
- Performing finishing operation while bleed water is on surface

2. SHRINKAGE CRACKS

Formation of hairline shallow cracks on concrete slab is the indication of shrinkage cracks. Shrinkage cracks develop on concrete surface during the setting & curing operation. These cracks may form in longitudinal as well as in transverse direction.

3. JOINT SPALLING

Joint spalling is the breakdown of the slab near edge of the joint. Normally it occurs within 0.5 m of the joints. The common reasons for this defect are

- Faulty alignment of incompressible material below concrete slab
- Insufficient strength of concrete slab near joints
- Freeze-thaw cycle
- Excessive stress at joint due to wheel load

4**. WARPING CRACKS**

In hot weather, concrete slab tends to expand. Therefore the joints should be so designed to accommodate this expansion. When joints are not designed properly, it prevents expansion of concrete slab and therefore results in development of excessive stress. This stress cause formation of warping cracks of the concrete slab near the joint edge. This type of crack can be prevented by providing proper reinforcement at the longitudinal and transverse joints. Hinge joints are generally used to relieve the stress due to warping.

5. PUMPING

When material present below the road slab ejects out through the joints or cracks, it is called pumping. When soil slurry comes out it is called mud pumping. The common reasons for this defect are

- Infiltration of water through the joints, cracks or edge of the pavement forms soil slurry. Movement of heavy vehicles on pavement forces this soil slurry to come out causing mud pumping.
- When there is void space between slab and the underlying base of sub-grade layer
- Poor joint sealer allowing infiltration of water
- Repeated wheel loading causing erosion of underlying material

Pumping can also lead to formation of cracks. This is because; ejection of sub-grade material below the slab causes loss of sub-grade support.

When traffic movement occurs at these locations, it fails to resist the wheel load due to reduction of sub-grade support and develops cracks. This type of defect can be identified when there is presence of base or sub-grade material on the pavement surface close to joints or cracks.

PAVEMENT FAILURE & MAINTENANCE

The no. of factors that causes pavement failure are

- Increase in traffic
- Environmental charges
- Design and construction deficiency
- Maintenance deficiency

Pavement failures:

Unsatisfactory performance of a pavement such that it can no longer be serviceable.

Pavement failure may be structural and functional failures.

- Structural failure means the collapse of the pavement
- Functional means the pavement is not able to discharge the traffic freely.

Maintenance of pavements:

Maintenance is the process which tends to keep the pavement in serviceable condition as long as possible.

- For proper inspection & maintenance each state should have a highway maintenance cell which will focus on construction, repair, maintenance & inspection works.

Earth roads:

The usual damages caused in the earth roads needing frequent maintenance are:

i) Formation of dust in dry weather.

ii) Formation of longitudinal ruts along wheel path or vehicles
iii) Formation of cross ruts along the surface after monsoons due to surface water.

Thus, dust nuisance may be remedied y the following methods:

a) Frequent sprinkling of water
b) Treatment with calcium chloride
c) Use of other dust palliatives.

Application of calcium chloride retains some water due to the hygroscopic nature of mix. Oiled earth roads are also common these days.

Periodical maintenance by spreading moist soil along ruts and reshaping of the camber is necessary. Formation of cross ruts may be due to excessive cross slope.

Hence either these ruts should be repaired from time to time during and after the monsoon or a surface treatment or stabilized layer be provided on the top.

Maintenance of earth roads:

- Sprinkling water
- Rolling
- Adding new material over the older one followed by compaction.

Maintenance of WBM roads:

- Spreading a thin binder layer after monsoon.
- Applying surface dressing.
- Using filling materials such as dust.

Maintenance of bituminous road such as patch work and resurfacing

In addition to standard causes such as traffic, weather and ingress of water for the deterioration of earth, gravel and WBM roads, loss of volatiles, oxidation of the binder material and inadequacy of the specification and construction standards also could be the reasons for distress and disintegration of bituminous pavements.

Depending upon the degree of deterioration of the highway facility, the nature of the maintenance operations for bituminous pavements could be: (a) Patch repair (b) Surface treatment (c) Resurfacing

Maintenance of bituminous surfaces:

Mainly the maintenance works of bituminous surfacing consists of:

i) Patch repairs
ii) Surface treatments
iii) Resurfacing

Patch repairs:

Patch repairs are carried out on the damaged or improper roads surface. Localized depression and pot holes may be formed in the surface layers due to defects in materials and construction.

An inadequate or defective binding material causes removal of aggregates during monsoons. Patching may be done on affected localized area or sections using a cold premix.

Pot holes and repairs:

Pot holes are cut to rectangular shape and the affected materials in the section is removed until the sound materials are encountered.

The excavated patches are cleaned and painted with bituminous binder. A premixed material is then placed in the sections. Generally, cutback or emulsion is used as binder.

Bituminous emulsions could be used even when the pavement surface and the aggregates are wet during monsoons.

The materials so places in the pot hole, is well compacted by ramming to avoid any raveling. The materials in out holes are places in layers of thickness of 6 cm.

it is however necessary to replace the base course materials with similar new materials if the failure has been detected in the base curse layer. The finished level of the patched is kept slightly above original level to allow for subsequent compaction under traffic.

Surface treatment:

Excess of bitumen in the surface materials bleeds and the pavement becomes patchy and slippery. Corrugations or rutting or shoving develop in such pavement surface. It is customary to spread blotting materials such as aggregate chips of maximum size of about 10mm or coarse sand during summer.

Resurfacing:

In the event when the pavement surface is totally worn out and develops a poor riding surface, it may be more economical to provide an additional surface course on the existing surface.

In case of the pavement is of inadequate thickness due to increase in traffic loads and strengthening is necessary, than an overlay of adequate thickness should be designed and constructed.

A brief description of the defects, symptoms, probable causes, and possible treatment is given in the Table 10.3, extracted from “IRC; 82-1982: ‘Code of Practice for maintenance of bituminous surfaces’, Indian Roads Congress, New Delhi, 1982”: Defects, Symptoms, Causes and Treatment of Defects in Bituminous Surfacings.

Maintenance of Bituminous pavements:

- Cutting the defective areas in rectangular shape.
- Cleaning & applying primer.
- Filling the excavated area with premixed material by applying emulsions and compacted.
- Bituminous surface with minute cracks are treated by providing a completely new surface over it.

Maintenance of concrete roads – filling cracks, repairing joints, maintenance of shoulders (berm), maintenance of traffic control devices

A cement concrete pavement needs very little maintenance if it is well-designed and properly constructed. In fact, this is considered to be the most important advantage which offsets the high initial cost. However, defects are likely to occur due to ingress of water, especially through ill-maintained joints and cracks, inadequate pavement thickness and poor workmanship.

Maintenance of cement concrete roads:

Various types of cracking have been explained:

Treatment of cracks:

The cracks are developed in cement concrete (CC) may be classified into two groups:

i) Temperature cracks which are initially fine cracks or hair cracks formed across the slab in between a pair of transverse or longitudinal joints, dividing the slab length into two or more approximately equal parts due to the temperature stresses like the shrinkage stress warping stress etc.

ii) Structural cracks formed near the edge and corner regions of the slabs, due to combined wheel load and warping stresses in the slab.

The repeated application of heavy wheel loads and the variations in temperature and moisture conditions the cracks get widened and further deterioration becomes repaid.

Once the surface water starts getting into the pavement and the sub grade through the widened cracks, progressive failure or the pavement is imminent.

Therefore, before these cracks get wide enough to permit infiltration of water, they should be sealed off to prevent rapid deteriorations

The formation of structural rocks in CC slabs should be viewed seriously and needs immediate attention as these indicate possible beginning of pavement failure. The maintenance work in such a case involves first remedy of the basic cause of the failure and then recasting the failed slabs.

Maintenance of joints:

Joints are the weakest pars in CC pavements. The efficiency of the pavement is determined by the proper functioning of the joint.

During the summer the joint sealer material is squeezed out of the expansion joints due to the expansion of the slabs. Subsequently as the slabs contract during winter, the joint gap opens out and cracks are formed in the old sealer material.

The joint filler material at the expansion joints may get damaged or deteriorated after several years of pavement life. The repair consists of removal of the sealer and deteriorated filler and sealer materials from the expansion joints cleaning up replacement with new filter board a sealing the top of the joints with suitable sealer materials.

Patch Repair of Slabs:

Sealing, spalling, depressions and irregularities can occur in a slab locally. Immediate patching up of such defective slabs can arrest further deterioration. Premix bituminous materials are commonly used for this purpose, but they do not provide a satisfactory result. The best materials are epoxy resin mortars and concrete for such patch repair work. The sides of the area of the slab to be patched are trimmed, made vertical, and fresh concrete is laid and tamped; the areas are usually made of regular geometrical shapes like rectangles.

Mud-Pumping:

When water gets collected in the subgrade, heavy axle loads cause ejection of mud through joints, cracks and edges. This phenomenon is commonly known as mud-pumping and blowing. When this is observed, defective joints and wide cracks should be refilled and sealed. To prevent further damage and recurrence, grouting of the slab is done through holes drilled in it; the grout can be of cement mortar (1:3.5 mix) or of bituminous material (the latter is preferred since it is effective in filling the void spaces between the slab and the subgrade), and raising the slab to the desired level. This process is called mud-jacking and is popularly used in advanced countries.

Restoration of Anti-Skid Surface:

When the surface becomes smooth and slippery, anti-skid surface can be restored by cutting grooves by grooving machines or by grinding machines.

Crack Repair:

A patching mix of epoxy mortar can be filled and compacted after chipping off the area and cleaning it thoroughly by using compressed air. This is adequate only when the crack depth is not more than one-third of the depth of the slab. However, when the crack extends almost to the entire depth of the slab, cross-stitching with inclined tie-bars or stapling with U-bars may be adopted; the former is shown schematically in Fig. 10.9.

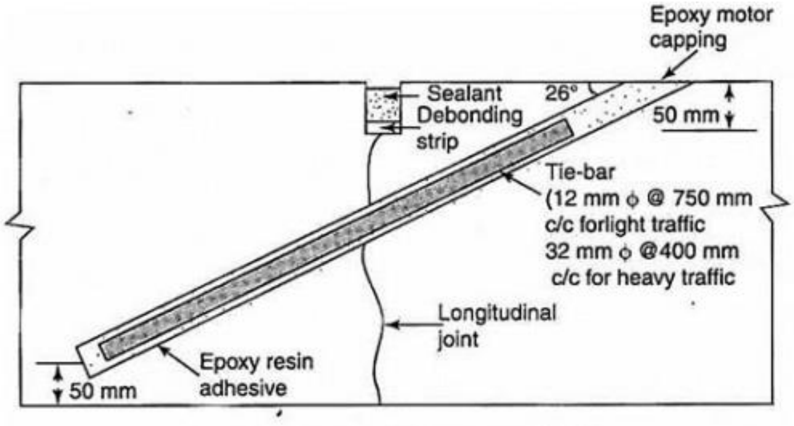


FIG. 10.9 *Crack repair by cross-stitching*

Mechanised Maintenance of Roads:

In India, road maintenance is mostly labour-oriented; however, mechanical maintenance of roads also can be practised with indigenous equipment for speedy implementation and better-quality control.

Maintenance of concrete roads:

- Wide pavement cracks can be maintained by first cleaning the cracks & applying a coat of kerosene then filled with suitable fillers.
- Slabs may be repaired using epoxy rasin sand ratio of 1:8 to 1:10 to a desired level.

Methods of Repairing the Defects

The repair methods are generally fall under two categories

(i) Seal coat:

Seal coat is a single thin application of bitumen which may or may not be covered with aggregate.

Sealing can take the form of the following treatments:

(a) Liquid seal:

It is an application of binder at 9.8 kg/10m^2 followed up with a spread of cover aggregates (6.3 mm nominal size) at a rate of 0.09cu-m/10m^2 and rolling in position.

(b) **Fog seal:**

It is a spray of slow setting emulsion diluted with equal amount of water at a rate 0.5-1 litre/m^2.Traffic is allowed after the seal sets in. It is used to increase the binder content of bituminous surface. It can also be used as an emergency treatment measure for hungry surfaces.

(c) **Slurry seal:**

It is an application of a slurry composed of slow setting emulsion, water and aggregates to a thickness of 5 -10 mm. The emulsion and water are 18-20 % and 10-12 % respectively of the weight of aggregate. The slurry is spread at the rate of 200m^2 per tonne.

Table-8.2 : Specification for sealing materials

Treatment	Binder	Aggregate	Specification in brief
Liquid seal	Penetration grade, or cut-back emulsion	6.3 mm size	Spray binder uniformly at 9.8 kg/ 10 sqm spread aggregate at 0.09 cu m/ 10 sq m and roll.
Fog seal	Slow setting emulsion RS diluted with equal amount of water.		Spray at 0.5 to 1 litre/sq m. Allow traffic after the seal sets.
Slurry seal	Slow setting emulsion	Well graded material between 4.75 mm and 75 micron (grading specified).	Apply tack coat with diluted emulsion at 2.5 to 3.5 kg/ 10 sq m. Apply slurry mix consisting of 18 to 20% water by weight of aggregate at the rate of 200 sq m per tonne.

(ii) Patching:

Patching is the application of bituminous materials for filling potholes, shallow depressions, rutting and edge irregularities.

Table- 8.3 : Specification for patching material

Treatment	Binder	Aggregate	Specification in brief
Sand premix	Penetration grade, or cut-back RC or MC	Fine grit 1.7 mm to 180 micron	Apply tack coat at 7.5 kg per 10 sq.m. Spread mix consisting of 0.06 cu m of grit and 6.8 kg of binder per 10 sq m and roll.
Open-graded premix	Paving grade, RC or MC cut-back, MS emulsion	12.5 mm and 10 mm size aggregate	Apply tack coat, prepare the mix as per IRC: 14-2004, spread and roll. Where cutback is the binder, the premix should be prepared at least 3 days in advance of use. The final surface should be provided with seal coat.
Dense graded premix	Paving grade	Well graded as per IRC: 16-2008	Apply tack coat and prepare, spread and compact mix as per IRC: 16 2008.
Penetration patching	Penetration grade RC or MC cut-back	Coarse and key aggregates as per IRC:20-1996	Apply tack coat, spread course aggregate and dry roll; apply binder and key aggregate and roll as per IRC:20. For patching 50-75 mm thickness, use built up spray grout as per IRC: 47-1972.

Special Repairs in Flexible Pavement

(i) **Waves and Corrugations:** Following are the factors which contribute to the formation of waves and corrugations:

(a) Defective Rolling: If the rolling during construction stage in improper thus leaving the formation of waves, then the process being progressive, the wave formation would continue indefinitely. However, the subsequent traffic operations would also cause similar effects if the rolling is inadequate during the construction stage.

(b) Poor subgrade conditions: Subgrade consisting of poor soils including highly plastic or organic soils and highwater table close to subgrade surface may cause nonuniform and inadequate subgrade stability. When boulders are used as soling course in such subgrade there is differential settlement or sinking of these stones. All these would contribute to formation of corrugated pavement surface.

(c) Poor gradation: Defective gradation or mix for the surface layer is another factor which gives rise to the wave formation pushing and pulling caused due to the vehicular movement enhance the defect further more.

(d) Compaction temperature: Viscous state of the bitumen binder greatly depends upon the temperature and thus very high temperature during mixing and compaction of bituminous mix would make the resulting pavement surface layers with low stability and wavy surface is formed during rolling.

(e) **Unstable underlaying layers:** Weak underlying layers also cause the formation of waves due to repeated lying of vehicles on such road. Failure of any one of the pavement layers can cause surface deformations.

Remedial measures to be taken for the wave and corrugations are:

(a) There appears to be no way to improve the road surface once the waves and corrugations are already formed. Usually, another layer of surface course is laid after laying a levelling course. but often waves and corrugation again develop, unless the basic reason for this problem is investigated and proper measure is taken.

(b) If the instability of underlying layer is due to excessive moisture conditions suitable subsurface drainage system is warranted to remedy the defect permanently.

(c) If the failure is due to improper compaction of the lower layers this would need complete reconstruction.

(d) If the failure is due to subgrade soil which may be a highly plastic expansive clay the solution may be by subgrade treatment using a modifying agent for stabilization.

(ii) Skidding of pavement surface:

(a) Skid resistance property of pavement surface is essential requirement for highway safety. The skid resistance or the friction of pavement surface may be measured by using any one of the devices such as the pendulum type friction recorded or the skid testing device attached to test vehicle or the instrument mounted dynamic skid resistance tester towed by another vehicle.

(b) Water, clay, dust, dry sand, oil ad grease on the pavements are few factors which cause skidding. These materials on the pavement surface cause a reduction in grid between tyre and the pavement surface.

(c) Skidding is of three types straight skidding, impending skidding and sideway skidding. The straight skidding occurs in the direction of travel when the sudden brakes are applied. Impending skidding is encountered when the braking is gradual and wheel continues to revolve. Sideway skidding occurs on curves where sufficient superelevation is not provided or when the coefficient of friction is inadequate.

(d) Highways can develop sufficient skid resistance if they are maintained clean and dry. But the presence of water film, debris and polishing characteristics of aggregate influence the skid resistance properly. Rough surfaces or textures like those of gravel road, WBM and cement concrete roads offers sufficient amount of skid resistance. Bituminous pavements are more prone to skidding.

EVALUATION AND STRENGTHENING

• Evaluation: Evaluation of pavement is done under following categories:

i. Functional Evaluation
ii. Structural Evaluation
iii. Material durability
iv. Shoulder condition
v. Extent of maintenance activity performanced in last
vi. Variation of pavement condition

The structural evaluation of pavement can be broadly classified into two major categories, namely, Destructive Evaluation and Nondestructive (NDT) Evaluation. In Non-destructive evaluation the structural strength of the pavement is evaluated without causing any damage to the pavement or disruption of traffic. A number of Non-destructive devices have been developed for the structural evaluation of pavement. The Non-destructive equipment is used to determine the;

(i) In -situ module of pavement layers,
(ii) Load transfer efficiency at joints in the concrete pavements, and
(iii) Location and extent of void in a pavement structure.

Destructive Evaluation:

Pavement is cut open for in-situ and lab tests (e.g. density, moisture, strength)

Non-destructive Evaluation:

Pavement subjected to applied loading and the structural response is measured (e.g. Benkelman Beam, Dynaflect, FWD, GPR).

Non destructive tests (NDT) – The application of load can be in different modes

(i) Static load (Plate Load Test)
(ii) Slow moving or creep load (Benkelman Beam Deflection Test)
(iii) Vibratory load (Dynaflect)
(iv) Impulse load (Falling Weight Deflectometer) Electromagnetic wave transmission and reflection in layered media
(v) Ground Penetrating Radar (GPR).

METHODS OF EVALUATION OF MATERIAL PROPERTIES

a. Plate – loading test

b. Triaxial compression test
c. California Bearing Ratio Test
d. Test of Bituminous Mixtures
e. Resilient Modulus test
f. Dynamic modulus test
g. Poission's ratio
h. Fatigue testing

Pavement Evaluation:

Pavement evaluation involves a thorough study of various factors such as:

(i) Subgrade support
(ii) Pavement composition and its thickness
(iii) Traffic loading
(iv) Environmental conditions

The various methods of pavement evaluations may be broadly classified into two groups

(i) Structural evaluation of pavement
(ii) Evaluation of pavement surface condition

Structural Evaluation of Pavement:

Structural evaluation of both flexible and rigid pavements may be carried out by plate bearing test. Benkelman Beam measurements are preceded by a rating survey of the road so as to divide it into homogeneous section of approximately similar serviceability. A few numbers of nondestructive testing techniques are used for assessing the load carrying capacity of the pavements.

Evaluation of pavement surface condition:

The pavement unevenness may be measured using unevenness indicator. The pavement serviceability concept was introduced at the AASHTO road test for comparing relative performance of various test sections during different periods.

The present serviceability rating (PSR) is the mean opinion of the members of the rating panel and this is correlated with the physical measurements such as longitudinal and transverse profile of the pavement degree of cracking and patching etc. affecting pavement serviceability.

Table-8.4 : Riding quality of pavements

Unevenness index, cm/km	Riding quality
In old pavements	
< 95	Excellent
95 to 119	Good
120 to 144	Fair
145 to 240	Poor (possible resurfacing)
> 240	Very poor(resufacing required)
In new pavements	
< 120	Good (acceptable)
120 to 145	Fair (acceptable)
>145	Poor (not acceptable)

Strengthening of Existing Pavement:

Strengthening may be done by providing additional thickness of the pavement of adequate thickness in one or more layers over the existing pavement which is called **overlay**. If the existing pavements have completely deteriorated on overlay would not serve the purpose and hence to remove the existing damaged pavement structure and rebuild it. In partially damaged pavement sections, patch repair works are carried out before constructing the overlay.

Types of Overlay:

The overlay combinations are divided into four categories based on the type of existing pavement and the overlay :

a) Flexible overlay over flexible pavement
b) Flexible overlay over rigid pavement
c) Rigid overlay over rigid pavement
d) Rigid overlay over flexible pavement

Note: The choice of overlay type depends upon the number of factors including total thickness of overlay required, local material, wheel load, cost etc.

Design of overlay:

The overlay thickness required over a flexible pavement may be determined either by one of the conventional pavement design methods or by a nondestructive testing method like Benkelman beam deflection method.

Benkelman Beam Deflection method:

Benkelman Beam is a device which can be conveniently used to measure the rebound deflection of a pavement due to a dual wheel load assembly or the design wheel load. The design wheel load is a dual wheel load assembly of gross weight 4085 kg with an inflation pressure of 5.6 kg/cm^2. The beam is 3.66 m long and is pivoted at a distance of 2.44 m from the contact point. The other end of the beam activates a dial gauge.

Principle of Overlay Design:

A well compacted pavement section or one which has been well conditioned by traffic deforms elastically under each wheel load application such that when the load moves away, there is an elastic recovery or rebound deflection of the deformed pavement surface.

The amount of deflection depends upon a number of factors such as:

(i) Wheel load

(ii) Pavement thickness

(iii) Soil strength

(iv) Surface temperature

Larger rebound deflection indicates weaker pavement structure which may require earlier strengthening or higher overlay thickness.

Procedure of Benkelman Beam Deflection method:

(i) A minimum of 10 points are selected along the outer wheel path for each lane.

(ii) A single rear axled truck is selected with the rear axle loaded of 81.7 kN, the tyre pressure being 5.6 kg/cm^2. The probe is inserted in between the two wheels, the wheel position representing the point where the deflection is desired. The contact point is also the same point. The dial gauge reading is noted i.e. D_0.

(iii) The truck is moved forward slowly and the dial gauge readings are taken when the truck is 2.7 m and 9.0 m away from the initial position to given the intermediate (D_i) and final readings (D_f).

(iv) Pavement temperature is recorded.

(v) The intermediate and final readings are subtracted from the initial reading. If the deflections so obtained compare within 0.025 mm, the actual deflection is twice the difference between the initial reading and the final reading.

(vi) If the deflection obtained from the two positions do not compare within 0.025 mm, twice the difference between the final and initial readings gives the apparent deflection, this is known as leg correctio.

(vii) The three dial gauge readings D_0, D_i and D_f from a set of readings at one deflection point under consideration. The deflection observations are continued at all desired points.

(viii) The mean and standard deviation of the measurements are determined. The characteristics deflection is taken as summation of mean and twice of standard deviation.

(ix) The allowable deflections are given in Table below:

Table-8.5 : Allowable deflections

Design Traffic Intensity (commercial vehicles/day)	Allowable Deflection (mm)
150 - 450	1.50
450 - 1500	1.25
1500 - 4500	1.00

Flexible overlay over Flexible pavement

Overlay thickness over Flexible pavements generally determined by means of deflection measurements. Measurements are made using Benkelman beam. The analysis of data for overlay design and the determination of overlay thickness as given in IRC:81 1997 (first Revision).

Analysis of data for Overlay design

The rebound deflection values D_1, D_2, D_3 are determined in mm after applying corrections, if necessary, to the observed values of D_0, D_f and D_i in each case.

The mean value of the deflections at n points is given by, $D = \Sigma D/n$

The standard deviation of the deflection values is given by,

$$\sigma = \sqrt{\frac{\Sigma(\bar{D} - D)^2}{(n-1)}}$$

Characteristic deflection D_c is given by, $D_c = \bar{D} + t \times \sigma$

Where, $t = 1.0$, $D_c = \bar{D} + \sigma$ covers about 84 % of the cases

$t = 2.0$, $D_c = \bar{D} + 2\sigma$ covers about 97.7 % of the cases of deflection values on the pavement section, assuming normal distribution of rebound deflection values

NOTE: IRC recommends the former case, $D_c = \bar{D} + \sigma$

Temperature correction: IRC suggests measurements of deflection at a standard temperature of 35^0C. If the temperature is different than 35^0C, then the correction is applied to deflection value.

$D_t = D_c – (t^0C – 35^0C) \times 0.0065$

Subgrade moisture correction: Generally, deflection are recorded after rainy season but if they are taken in dry seasons, they should by multiplied by 2 for clayey soils and 1.2 to 1.3 for sandy soils.

NOTE: For higher altitudes, measurements are recommended at 20^0C with no corrections.

Overlay thickness Design

The overlay thickness required h_0 may be determined after deciding the allowable deflection D_a in the pavement under the design load. According to Ruiz’s equation, overlay thickness h_0 in cm is given by:

$$h_0 = \frac{R}{0.434} \log_{10} \frac{D_c}{D_a}$$

Where, h_0 = Thickness of bituminous overlay in cm

R = Deflection reduction factor depending on the overlay material

= 10 to 15 (for Bituminous overlay)

D_a = Allowable deflection which depends upon the pavement type and the desired design life

The formula suggested by IRC for the design of overlay thickness equivalent to granular material of WBM layer,

$$h_0 = 550 \log_{10} \frac{D_c}{D_a}$$

Where, h_0 = Thickness of granular or WBM overlay in mm

$D_c = \bar{D} + \sigma$ after applying the corrections for pavement temperature and subgrade moisture

When bituminous concrete or bituminous macadam with bituminous surface course is provided as the overlay, an equivalency factor of 2.0 is suggested by the IRC to decide the actual overlay thickness required. Thus, the thickness of bituminous concrete overlay in mm will be $h_0/2$ when the value of h_0 is determined from the above equation.

Flexible overlay over Rigid pavement:

The required thickness of flexible overlays on rigid pavements can be determined from the following equation:

$t_0 = 2.5(F\,h_n - h_e)$

Where, t_0 = Required thickness of flexible overlay

h_n = Required thickness of equivalent single slab placed directly on subgrade or sub-base.

h_e = Thickness of existing slab

F = Factor which is function of the subgrade or sub-base

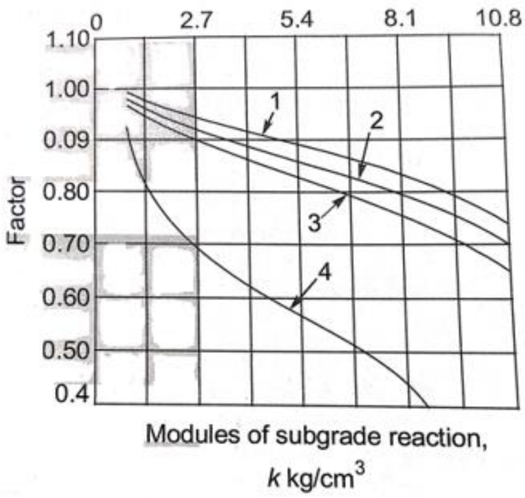


Figure-8.14: *Non-rigid overlay design*

Rigid overlay over Rigid Pavement:

The required thickness of rigid overlays over existing rigid pavements can be determined from the following equation:

$h_0 = (h_n^x - C\,h_e^y)^z$

Where, h_0 = Thickness of concrete overlay in slab in cm

h_e = Thickness of existing slab in cm

h_n = Thickness of equivalent single slab placed directly on the subgrade with a working stress equal to that of the overlay slab

C = Coefficient depending upon the condition of existing pavement

= 1 when existing pavement in good condition

= 0.75 when existing pavement with initial corner cracks due to loading but no progressible crack

= 0.35 when existing pavement badly cracked or crushed

Recommended value of x, y and z are given in Table below

Table-8.6 : Values of *x*, *y* and *z*

Agency	Condition	*x*	*y*	*z*
U.S. corps of engineers	Overlay placed directly on existing pavement	1.4	1.4	1/1.4
	Levelling course used	2.0	2.0	0.5
PCA, FAA	Overlay placed directly on existing pavement	1.87	2.0	0.5
	Levelling course used	2.0	2.0	0.5

Rigid overlay over existing Flexible Pavement:

In this case, the original flexible pavements is considered as sub- base course and the rigid overlay thickness can be determined by using design criteria for rigid pavements. The value of subgrade reaction k of existing flexible pavement can be determined and this value can be used for the design of overlay.

The normal deflection to be expected of a flexible pavement is about 6.25mm, where as the deflection of a rigid pavement sufficient to cause the pavement to break is about 2.5 mm. unless this deflection is limited, the rigid pavement will crack and lose its effectiveness.

Maintenance management system

The type and extent of maintenance requirement for a road depend on the serviceability standard laid down, the maintenance needs funds available and the priorities for the maintenance operations. As several interlinked factors are involved in the maintenance works of road network consisting of different categories of road, a system approach is appropriate for the road maintenance management.

The various factors to be included in the maintenance management system are:

- Minimum acceptable serviceability standards for the maintenance of different categories of roads.
- Field surveys for the evaluation of maintenance requirements.
- Various factors influencing the maintenance needs such as sub grade soil, drainage, climate, traffic, environmental conditions.

- Estimation of rate of deterioration of the pavement under the prevailing set of conditions.
- Type and extent of maintenance requirements and various possible alternatives and their economic evaluation.
- Availability of funds.
- Maintenance cost, availability of materials, man power and equipment.