

Highway Maintenance

Notes

Introduction

- By early detection & repair of defects at initial stages the rapid deterioration of the pavement can be prevented. Such surveys & evaluations should be carried out periodically so as to plan necessary preventive maintenance measures.

Maintenance of Highway

Various maintenance operations are

- (1) **Routine Maintenance:** These includes filling up of pot holes and patch repairs, maintenance of shoulders and the cross slope and repairing of cracks which are required to be carried out by the maintenance staff almost round the year.
- (2) **Periodic Maintenance:** These include renewals of wearing course of pavement surface and preventive maintenance of various items.
- (3) **Special Repairs:** These include major restoration or upgrading of the pavement through reconstruction or application of overlays to rectify structural deficiencies.

Symptoms, Causes, and Treatment of Defects

The types of defects in bituminous surfacing are grouped under four categories:

- (i) **Surface defects :** which include fatty surfaces, smooth surfaces, streaking, and hungry surfaces;
 - (ii) **Cracks :** under which hair-line cracks, alligator cracks, longitudinal cracks, edge cracks, shrinkage cracks, and reflection cracks are dealt with ;
 - (iii) **Deformation:** under this are grouped slippage, rutting, corrugations, shoving, shallow depressions, and settlements and upheavels; and
 - (iv) **Disintegration:** covering stripping, loss of aggregates, ravelling, pot-holes, and edge breaking.
- We will 1st of all describes the symptoms and causes of these defects and indicates the possible types of treatment.
 - In each case of pavement distress, the cause or causes of .the distress should first be determined. It will be possible to provide suitable maintenance measures which will not only correct the damage but also prevent or delay its recurrence.

In many situations; lack of proper drainage is the principal cause for stripping loss of materials from the pavement and shoulder, weakening of the pavement layers and subgrade, resulting in the failure of the pavement.

- In such situations, the cause should be completely eliminated before taking any maintenance measure.

SURFACE DEFECTS

These are associated with the surfacing layers and may be due to excessive or deficient quantities of bitumen in these layers

(1) Fatty Surface

Symptoms

- Fatty surface, results when the bituminous binder moves upward in the surfacing and collects as a film on the surface.
- The binder so collected becomes generally soft in hot weather and may be picked up and spread by the traffic. In cold or wet weather, the surface is likely to be slippery and this can cause accidents.

Causes

The causes for a fatty surface are :

- (i) Excessive binder in a premix surfacing over-filling the voids.
- (ii) Loss of cover aggregates in surface dressing.
- (iii) Non-uniform spreading of cover aggregates in surface dressing.
- (iv) Excessive application of binder in surface dressing.
- (v) Poor quality of aggregates with lead in to their fracture, breakdown and eventual loss.
- (vi) Graded cover aggregates with 6aiticleg so, Small that they are covered by the binder.

Treatment

- (i) If the bleeding is fairly uniform and the surface is free from irregularities, application of cover aggregates or sand (sand-blotting sand-blinding) would be successful. The aggregate or sand used shall be of small size, clean and angular, and may be heated, if necessary.
- (ii) An open-graded premix surfacing with a low bitumen content can absorb the excess binder.
- (iii) A liquid seal coat, with special care taken to select the rate of application of the binder and the quantity and size of cover aggregates, can also be effective.
- (iv) Special methods such as the burning of the excess binder.
- (v) In case of large areas of fatty surface having irregularities, removal of the affected layer in the area and replacing it with a layer having a properly designed mix, may be necessary.

(2) Smooth surface

Symptoms

A smooth surface, has a very low skid resistance value and becomes very slippery when wet. Such a condition invites hazards, especially on gradients, bends, and intersections.

Causes

A primary cause for a smooth surface is the polishing of aggregates under traffic. Also excessive binder can result in a smooth surface.

Treatment

The rectification consists of resurfacing with a surface dressing course or a premix carpet. Care should be taken to select hard and angular aggregates which have proven non-polishing characteristics. The carpet can be an open-graded mix. A slurry seal can also be used to impart anti-skidding texture.

(3) Streaking

Symptoms

Streaking is characterized by the appearance of alternate lean and heavy lines of bitumen either in longitudinal, or in transverse direction.

Causes

- Longitudinal streaking results when alternate longitudinal strips of surface contain different quantities of bitumen due to non-uniform application of bitumen across the surface.
- Some of the more common causes of this type of streaking are mechanical faults, improper or poor adjustment and careless operation of bitumen distributors.
- These streaks can also be formed as a result of applying the bituminous binder at too low a temperature; a temperature at which bitumen is not fluid enough to fan out properly from the nozzles on the spray bars.
- All these causes can result in transverse streaking also transverse streaking may also be caused by spurts in the bitumen spray from the distribution spray bar.
- Transverse streaking may result in corrugation in the pavement surface.

Treatment

- The satisfactory repair for longitudinal and transverse streaking is to remove the streaked surface and apply a new surface treatment.
- It is always desirable to prevent longitudinal and transverse streaking than to correct it.

(4) Hungry Surface

Symptoms

Hungry surface is characterized by the loss of aggregates from the surface or the appearance of fine cracks.

Causes

- One of the reasons for hungry surface is the use of less bitumen in the surfacing. Sometimes this condition may also appear due to use of absorptive aggregates in the surfacing.

Treatment

A slurry seal may be used as a repair measure. It is applied in an average thickness of 2 - 5 mm.

- As an emergency repair, a fog seal may be used.

CRACKS

General : A common defect in bituminous surfaces is the formation of cracks.

- The crack pattern can in many cases, indicate the cause of the defect.
- 16 soon as cracks are observed, it is necessary to study the pattern in detail so as to arrive at the cause.
- Immediate remedial action should be taken thereafter because of the danger of ingress of water through the cracks and of the formation of pot-holes and ravelling.
Cracks can hardly be observed from moving vehicles and inspection on foot is always desirable.
- The common types of cracks are discussed briefly in the following clauses.

(a) Hair-line Cracks

Symptoms

These appear as short and fine cracks at close intervals on-the surface

Causes

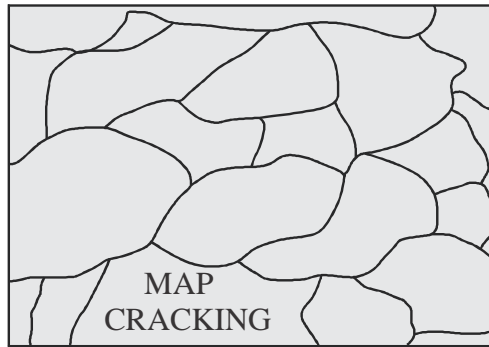
These cracks are caused by

- (i) Insufficient bitumen content.
- (ii) Excessive filler at the surface.
- (iii) Improper compaction — over-compaction, compaction when the supporting layer was unstable, or compaction of too hot a mixture.

(b) Alligator Crack

Symptoms

These appear as interconnected cracking forming a series of small blocks which resemble the skin of an alligator. This pattern is also called in map cracking.



Map Cracking

Causes

Alligator cracks are due to one or more of the following factors :

- (i) Excessive deflection of the surface over unstable subgrade, sub-base or base of the pavement, particularly in the wheel tracks. The unstable conditions in the subgrade or lower layers of the pavement might have arisen from saturation.
- (ii) Excessive overloads by heavy vehicles or inadequate pavement thickness, or both.
- (iii) Brittleness of the binder either due to ageing of binder or initial over-heating might cause fine cracks of the alligator pattern, but there will be no deflection of the surface. These cracks are sometimes called 'crazing'.

(c) Longitudinal Crack

Symptoms

These cracks appear, more or less, on a straight line, along the road. These cracks may appear either at the joint between the pavement and the shoulder, or at the joint between two paving lanes.

Causes

- (i) The cracking at the pavement-shoulder joint may be due to alternate Wetting and drying beneath the shoulder surface owing to poor drainage or due to depressions in the pavement edge which allow water to stand and seep through the joint. Shoulder settlement of trucks passing over the joint, may also cause these cracks.
- (ii) The lane joint crack is caused by a weak joint between adjoining spreads in the layers of the pavement. Differential 'frost heave along the centre line may also be one of the causes.

(d) Edge Crack

Edge cracks are formed parallel to the outer edge of the pavement usually 0.3-0.5 m inside from the edge, at times some transverse cracks are seen to branch out from the edge cracks towards the shoulder.

Causes

These cracks are caused by :

- (i) lack of lateral support from shoulder.
- (ii) Settlement or yielding of the underlying material.
- (iii) Inadequate surface drainage, especially during flooding conditions.
- (iv) Shrinkage due to drying out of the surrounding earth, generally caused by roots of trees or bushes close to the pavement edge. Highly expansive soils are particularly prone to shrinkage when moisture dries out
- (v) Frost heave
- (vi) Inadequate pavement width forcing traffic too close to the edge of the pavement.
- (vii) Non-provision of extra width of pavement on curves.

(e) Shrinkage Crack

Symptoms

These are cracks appearing in the transverse direction, or as interconnected cracks forming a series of large blocks. The pavement itself appears to have suffered no deterioration or deformation, but it is the top surfacing that seems to have become old and cracked.

Causes

The primary cause for such cracks is the shrinkage of the bituminous layer itself with age. The Bituminous binder loses its ductility as it ages and becomes brittle

(f) Reflection Crack

Symptoms

Reflection cracks are the sympathetic cracks that appear in the bituminous surfacing over joints and cracks in the pavement underneath. The pattern may be longitudinal. Transverse, diagonal or block.

- They occur most frequently in overlays on cement concrete pavements or on cement-soil bases.
- They may also occur in overlays or surfacings on flexible pavements where crack in the old pavement have not been properly repaired.
- Another condition under which reflection cracks can occur is when a pavement is widened and the entire pavement is surfaced
- The location of the crack will then be exactly on the junction between the old pavement and the widened strip.
- In some cases reflection cracks are merely unsightly, but frequently the deteriorate and the riding quality of roads is affected.
- These cracks can allow water to enter the under lying pavement and the subgrade and cause further damage.

Cause

Reflection cracks are due to joints and crack in the pavement layer underneath

Treatment

The treatment, for all types of cracks discussed above, would depend on whether the pavement remains structurally sound, or has become distorted or unsound.

- In case the pavement remains structurally sound, then the cracks should be filled with a bituminous binder having a low viscosity so that it can be poured and worked into the cracks.
- Cut-back bitumen and emulsions are generally suitable
- All loose material are removed from the cracks with brooms and, if necessary, with compressed air jetting.
- The binder is poured with a pouring can a hand squeegee is used to assist the penetration of the binder into the cracks
- Light sanding of the cracks is then done to prevent traffic picking up the binder'
- If the cracks are wide enough a slurry seal or sand bituminous premix patching can be used to fill the cracks
- If the cracks are fine (crazing) and extend over large areas, a light cut-back or an emulsified bitumen (for seal) can be broomed into the cracks and lightly sanded to prevent the picking up of the binder by the traffic.

DEFORMATION

General : Any change in the shape of the pavement from its original shape is a deformation. It may be associated with slippage, rutting, etc., discussed below. The treatment measures aim at the removal of the cause, and bringing it to the original level by fill material or by removing the entire affected part and replacing it with new material.

(a) Slippage

Symptoms

- Slippage is the relative movement between the surface layer and the layer beneath.
- It is characterized by the formation of crescent-shaped cracks that point in the direction of the thrust of the wheels on the pavement surface.
- This does not mean that the cracks invariably point in the direction the traffic is going.
- For example, if breakers are applied on a vehicle going down a hill the thrust of the wheels will be pointing uphill. The cracks in this case will, therefore, point uphill.

Causes

Slippage is caused by:

- (i) Unusual thrust of wheels in a particular direction
- (ii) Omission or inadequacy of tack coat or prime coat
- (iii) Lack of bond between the surface and the lower course caused by a layer of fine dust, moisture or both.
- (iv) Failure of bond between two layer due to excessive deflection of the pavement

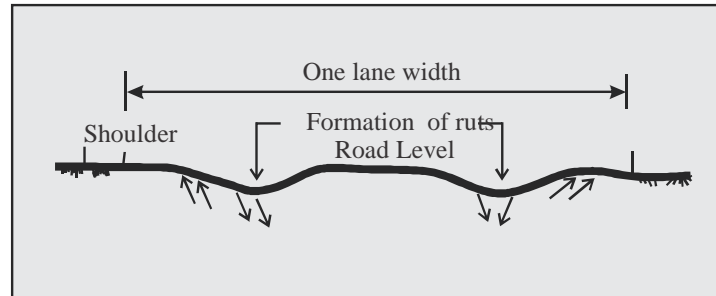
Treatment

Rectification consists of removing the surface layer around the area affected upto the point where good bond between the surfacing and the layer underneath exists and patching the area with premix material after a tack coat.

(b) Rutting

Symptoms

Rutting is a longitudinal depression or groove in the wheel. The ruts are usually of the width of a wheel path. Swerving from a rutted wheel path at high speed can be dangerous. Accumulation of water in the depressions can cause skidding. If rutting is accompanied by adjacent bulging, it may be a sign of subgrade movement or weak pavement.



Cause

The cause of rutting are the following :

- (i) Heavy channelized traffic.
- (ii) Inadequate compaction of the mix at the surface or in the under lying courses during construction.
- (iii) Improper mix design, lacking in stability of the mix to support the traffic and leading to plastic movement laterally under traffic.
- (iv) Weak pavement.
- (v) Incidence of high stress caused by heavy bullock cart traffic.
- (vi) Intrusion of subgrade clay into base course.
- (vii) Aggregates of surface dressing being pressed into the lower supporting bituminous layer.

Treatment

The rectification consists of filling with premix open-graded or dense-graded patching materials and compacting to the desired levels. The limits of the depression are first determined with a string line and marked on the surface. After applying a suitable tack coat, the premix is spread and compacted.

Situations indicative of shear failure or subgrade Movement generally require excavation. The job should be carefully assessed. The area to be opened up should as far as possible be limited to that which can be completed and made safe in a day's working.

(c) Corrugation

Symptoms

Corrugation is the formation of fairly regular undulations (ripples) across the bituminous surface. They are usually shallow (about 25 mm) and are different from the larger depressions caused by weakness in the lower layers of the pavement or the subgrade. The spacing of the waves is around 3 m. The corrugations can be a source of discomfort to the motorists and can become a hazard if allowed to become severe.

Causes

Corrugations are due to the following causes:

- (i) Lack of stability in the mix (excessive binder, high proportion of fines, too round or too smooth textured coarse or fine aggregate, too soft a binder).
- (ii) Oscillations set up by the vehicle springs can cause alternative valleys and ridges.
- (iii) Faulty laying of surface course.

Treatment

If the surface is thin, the same is scarified, including some portions of the underlying water-bound macadam base, and the scarified material is recompacted. A new surfacing layer is then laid.

Cutting of high spots with a blade with or without heating and addition of levelling course materials can also be an effective way to make up the corrugations. The area is then thoroughly rolled.

(d) Shoving

Symptoms

Shoving is a form of plastic movement within the layer resulting in localized bulging of the pavement surface. Shoving occurs characteristically at points where traffic starts and stops (intersections, busy bus-stops), on hills where vehicles accelerate or brake on grades and

on sharp curves. The first indication of shoving is the formation of slippage cracks which are crescent shaped cracks with the apex of the crack pointing in the direction of the shove.

Cause

Shoving can be caused by :

- (i) Lack of stability in the mix (excessive binder, high proportion of fines, too soft a binder) in the surface or base course.
- (ii) Lack of bond between bituminous surface and underlying layer.
- (iii) Heavy traffic movement of a start and stop type or involving negotiation of curves and gradients.
- (iv) Use of non-volatile oil on roller wheels.

Treatment

The rectification consists of removing the material in the affected area down to a firm base and laying a stable premix patch.

(e) Shallow depression

Symptoms

Shallow depressions are localized low areas of limited size, dipping about 25 mm or more below the desired profile, where water will normally collect. The depressions may or may not be accompanied by cracking. If not rectified in time, they may lead to further deterioration of the surface and cause discomfort to traffic.

Cause

Shallow depressions are caused by the settlement of lower pavement layers due to a pocket of inadequately compacted subgrade or pavement layers.

Treatment

Shallow depression are made up by filling with premix materials, open-graded or dense graded, and compacting to the desired profile as the surrounding pavement.

(f) Settlement and upheaval

Symptoms

Settlement and upheavals are characterized by large deformations of the pavement. They are extremely uncomfortable to traffic and cause serious reduction in speed. They are generally followed by extensive cracks in the pavement surface in the affected region.

Causes

The following are the causes for settlements and upheavals :

- (i) Inadequate compaction of the fill at locations behind bridge abutments, over utility cuts, etc.
- (ii) Excessive moisture in subgrade and permeable layer of sub-base and base caused by capillary action or poor drainage.
- (iii) Inadequate pavement thickness.

Treatment

If settlement and upheavals indicate an inherent weakness in the fill, it may be necessary to excavate the defective fill and do the embankment afresh under properly controlled conditions. Under-drains may become necessary in locations where lack of drainage has been identified as the cause of failure. Where the cause of deformation is inadequate pavement thickness, then properly designed pavement shall be provided. Frost-affected regions may need through investigations, and a complete reconstruction' of the pavement.

DISINTEGRATION

General : These are some defects which if not rectified immediately, result in the disintegration of the pavement into small, loose fragments. Disintegration, if not arrested in the early stages, may necessitate complete rebuilding of the pavement.

(a) Stripping

Symptoms

This defect is characterized by separation of bitumen adhering to the surfaces of the aggregate particles, in the presence of may lead to loss of bond and subsequently to loss of strength and materials from the surface.

Causes

Stripping may be caused by the following :

1. Use of hydrophilic aggregates.
2. Inadequate mix composition.
3. Continuous contact of water with the coated aggregate.
4. Initial over-heating of the binder or the aggregate or both.
5. Presence of dust or moisture on aggregate when it comes in contact with the bitumen.
6. In the case of surface dressing, poor bond with the surface existing below, delay in spreading the cover aggregate over the sprayed bitumen, or insufficient compaction.
7. Occurrence of rain or dust storm immediately after the construction.
8. Opening the road to fast traffic before the binder has set.
9. Concentration of soil salt in rain water coming in contact with the coated aggregate.
10. Use of improper grade of bitumen.
11. Ageing of the bitumen leading to the embrittlement of the binder film.

Treatment

In the case of surface dressing, hot coarse and heated to at least 159°C and spread over the affected areas, may be used to replace the lost aggregates. After spreading, it should be rolled immediately so that it will be seated into the bitumen. If aggregates are only partially whipped off, a liquid seal may be the solution.

In other cases the existing bituminous mix should be removed and a fresh one laid. As a precautionary measure, a suitable anti-stripping agent should be added to the bitumen, at the time of construction.

(b) Loss of aggregate

Symptoms

Loss of aggregate occurs in surfaces which have been provided with surface dressing. The surface presents a round appearance, with some portions having aggregates intact and other where aggregates have been lost,

Causes

The loss of aggregates can occur due to the following causes:

- (i) Ageing and hardening (oxidation) of the binder where by its adhesive property is lost.
- (ii) Stripping of binder from aggregates due to cold or wet weather before, during or soon after surface dressing.
- (iii) Wet or dusty aggregate to which binder has not adhered.
- (iv) Insufficient binder for the size of the aggregates used or for the existing absorptive surface.
- (v) Aggregate having no affinity to the binder.
- (vi) Insufficient rolling before opening to traffic.
- (vii) Fast traffic over new work whipping off the aggregates.
- (viii) Cold-spraying of bitumen or delaying the spreading of aggregates over sprayed bitumen.

Treatment

If the loss of aggregates is due to ageing and hardening of the binder, the condition may be rectified by applying liquid seal, fog seal or slurry seal.

If the loss of aggregates has occurred over large isolated areas, the best thing to do would be to provide another surface dressing layer, after carefully cleaning the surface.

If the loss of aggregates has taken place in small isolated patches a liquid seal would be sufficient.

(c) Ravelling

Symptoms

Ravelling is generally associated with premixed bituminous layers. It is characterized by the progressive disintegration of the surface due to the failure of the binder to hold the materials together. The ravelling process generally starts from the surface downwards or from edge inward. It usually begins with the blowing off of the fine aggregates leaving behind pock marks on the surface. When larger particles are broken free, the surface appears eroded.

Causes

Ravelling is due to one or more of the following reasons :

1. Inadequate compaction during construction.
2. Construction during wet weather leading to stripping of binder from aggregates.
3. Construction during cold weather resulting in non-uniform binder film.
4. Use of inferior quality aggregate resulting in fracture, crushing and opening of new faces.
5. Insufficient binder in the mix.
6. Ageing of binder leading to brittle fracture and disintegration of pavement.
7. Excessively open graded mix.
8. Poor compatibility of binder and aggregate.
9. Over-heating of mix or the binder.
10. Improper coating of aggregates by binder.

Treatment

Ravelled surface is corrected by adding more quantity of binder, the rate of application depending upon the condition of existing surface and degree of hardening occurred to the binder. If the ravelling has not developed too far, the condition may be corrected by a simple application of a cut-back bitumen covered with coarse sand, or a slurry seal can be applied, Where the ravelling has progressed far, a renewal coat with premix material Would be necessary.

Symptoms

Pot-holes are bowl-shaped holes of Varying sizes in a surface layer or extending into the base course caused' by localized disintegration of Material. They usually appear after rain.

Causes

- (i) The most common cause of pot-hole formation is the ingress of water into the pavement through the surfacing course. This can happen if the surfacing is open-textured and lacks proper camber. Water can enter the pavement also through the cracks in the bituminous surface. The pavement gets softened as a result and under the action of traffic depression soon gets formed. This is aggravated by use of plastic filter in WBM If not attended to properly, the aggregates in the surface get progressively loosened and a regular pot-hole forms.

- (ii) Lack of proper bond between the bituminous surfacing and the underlying water bound macadam base can also cause pot-holes. The bond is usually supplied by a tack coat, and any localized inadequacies in these applications can cause pot-holes.
- (iii) Insufficient bitumen content in localized areas of the surfacing layer can cause pot-holes.
- (iv) Too thin a bituminous surface which is unable to withstand the heavy traffic can also cause pot-holes, when associated with improper or inadequate camber.
- (v) In dense-graded mixtures, pot-holes can be caused by too much fines or too few fines.