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CODE OF PRACTICE FOR MAINTENANCE OF BITUMINOUS SURFACES OF HIGHWAYS

THE INDIAN ROADS CONGRESS

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FOR
MAINTENANCE OF BITUMINOUS SURFACES OF HIGHWAYS

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CODE OF PRACTICE FOR MAINTENANCE OF BITUMINOUS SURFACES OF HIGHWAYS

1. INTRODUCTION

1.1. Highway maintenance is an important activity of every Highway Department. The safety and convenience of traffic using the road are governed to a large extent by the quality of maintenance. The operation-economics of road transport is influenced by the degree of maintenance imparted to the road. The life of an asset can be preserved and prolonged if adequate maintenance measures are undertaken in proper time. In developing countries, stage construction of pavements is often resorted to, with lesser pavement thickness and lower specifications than needed for a full design. The proper maintenance of roads, therefore, assumes greater significance in such situations. The financial resources at the command of a maintenance engineer are always short of demands, and it becomes necessary to utilise the same in the most judicious manner, applying the best engineering practices and managerial skill.

1.2. This Code of Practice deals with the maintenance of bituminous surfaces of highways. This Code was prepared by the Bituminous Pavements Committee (composition given below) and finalised in its meeting held on the 20th August, 1980.

A.Y. Gupte	P.K. Lauria
D.P. Jain	M.R. Malya
M.B. Jayawant	S.N. Sinha
R.S. Jindal	G.M. Shonthu
L.R. Kadiyali	K. Yegnanarayana
K.L. Kapoor	Director, Highways Research
D.N. Khurana	Station, Madras
N.H. Keshwani	(S. Natarajan)
S.B. Kulkarni	

Director General (Road Development) & Addl. Secretary to the Govt. of India-Ex-officio.

It was approved by the Specifications and Standards Committee at its meeting held on the 28th May, 1981.

It was then approved by the Executive Committee through circulation and by the Council in its meeting held at Amritsar on the 28th December, 1981.

2. SCOPE

2.1. Maintenance operations can be classified in three groups:

(*i*) *Routine maintenance*, embracing work items such as filling of potholes, and repairing of cracks which are required to be carried out by the maintenance staff almost round the year;

(*ii*) *Periodic maintenance*, covering more extensive maintenance operations such as applying a seal or renewal coat which are required to be done periodically every few years; and

(*iii*) *Rehabilitation and strengthening*, which refers to major restoration or upgrading of the pavement through reconstruction or application of overlays to rectify structural deficiencies.

2.2. This Code of Practice deals only with the "routine" and "periodic" maintenance activities. By early detection and repair of defects at initial stages the rapid deterioration of the pavement can be prevented. Such surveys and evaluations should be carried out periodically so as to plan necessary preventive maintenance measures. Operations falling in the category of rehabilitation and strengthening are beyond the scope of this Code; for such operations, reference may be made either to IRC:37-1970 "Guidelines for the Design of Flexible Pavements" or to IRC:81-1981 "Tentative Guidelines for Strengthening of Flexible Road Pavements using Benkelman Beam Deflection Technique."

2.3. Since several phases are involved in the maintenance operations for bituminous surfaces, these are discussed separately

in subsequent sections. In brief, Section 3 deals with the overall approach to the maintenance planning process and Section 4 with the symptoms, causes and treatment of the various types of defects commonly met with the bituminous surfaces. Methods for repairing the defects have been discussed in Section 5. Requirements of periodic renewals are covered in detail in Section 6 and some special problems of maintenance, in Section 7. Last four Sections namely 8, 9, 10 and 11, discuss the materials, tools and plants, arrangements for traffic and overall organisation and management, respectively.

3. PLANNING OF MAINTENANCE OPERATIONS

3.1. The first step to planning of maintenance operation is the evaluation of the existing pavement in terms of its physical condition, structural capacity, roughness etc. For this purpose, condition surveys may be undertaken for the visual assessment of the pavement, which would cover not only the type but also the magnitude of the distress and its location.

Apart from visual surveys, pavement surface evaluation based on riding quality (i.e. road roughness) and skid resistance should also form the basis for taking maintenance decisions.

3.2. Necessary information about the routine maintenance needs will be readily available as the maintenance staff are expected to be continuously in touch with the physical condition of the road. However, for periodic renewal requirements or long-term maintenance strategy, condition surveys carried out at a fixed frequency are a must. Keeping this in view, it is desirable that at least two condition surveys are conducted on each stretch of road every year, one before and the other after the monsoon. Generally the condition surveys are carried out from a vehicle travelling at a slow speed, supplemented by inspection of the more critical spots on foot. The data collected should be recorded methodically kilometerwise. It is desirable that these visual surveys are carried out by an experienced engineer at a responsible level.

3.3. Based on the condition evaluation, the causes for the various defects observed should be examined in detail as discussed in Section 4 and a decision taken whether to initiate a particular maintenance activity, defer the same, or to go in for more detailed investigations to determine the rehabilitation needs precisely. Where distress on the pavement has reached the stage of the pot-hole which affects the smooth operation of traffic, it should be rectified straightaway. For other defects like cracking, ravelling etc.

the optimal strategy should be determined having regard to the various factors involved including the finances available, and a decision taken whether to go in for temporary measures like seal/ renewal coat or to strengthen/reconstruct the pavement. If the latter appears necessary, further investigations about structural deficiencies must be taken up as mentioned in Clause 2.2. In other words the planning of the various maintenance operations should be correlated and looked upon as a total system rather than each activity being considered in isolation.

3.4. Once the overall maintenance plan has been drawn up, attention should be given to the proper organisation and management of the whole programme including deployment of various resources, i.e. men, materials and equipment, in an efficient manner. For each maintenance activity the work at site should be carefully controlled so that the optimum output and quality are achieved.

4. SYMPTOMS, CAUSES, AND TREATMENT OF DEFECTS

4.1. General

4.1.1. 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.

4.1.2. This Section describes the symptoms and causes of these defects and indicates the possible types of treatment. The next Section gives the details of specifications and construction methods for each type of treatment.

4.1.3. 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 material 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.

4.2. Surface Defects

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

4.2.2. Fatty surface

Symptoms

Fatty surface, Photo 1 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 leading to their fracture, breakdown and eventual loss.

(vi) Graded cover aggregates with particles so small that they are covered by the binder.

(vii) Too heavy a prime or a tack coat.

(viii) Excessively heavy axle loads causing compression of a surfacing, forcing the bitumen to the top.

Treatment

(i) If the bleeding is fairly uniform and the surface is free from irregularities, application of cover aggregates or sand (sand-blotting or 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.

4.2.3. **Smooth surface**

Symptoms

A smooth surface, Photo 2 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.

4.2.4. **Streaking**

Symptoms

Streaking is characterised by the appearance of alternate lean and heavy lines of bitumen either in longitudinal, Photo 3 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

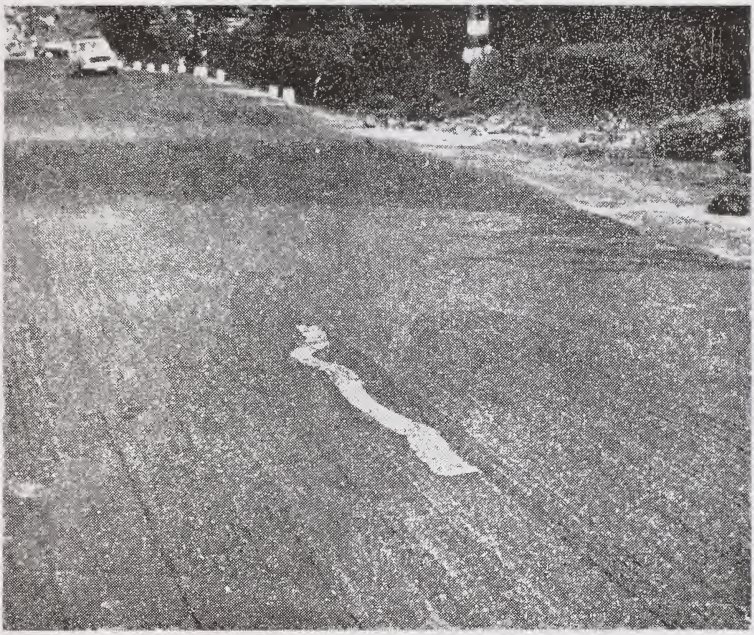

Photo 1. Fatty surface

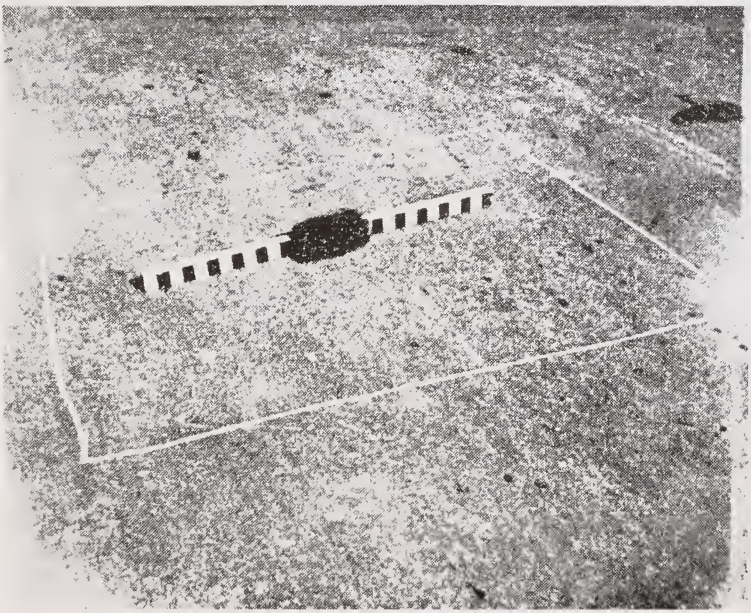

Photo 2. Smooth surface

Photo 3. Streaking

Photo 4. Hungry surface

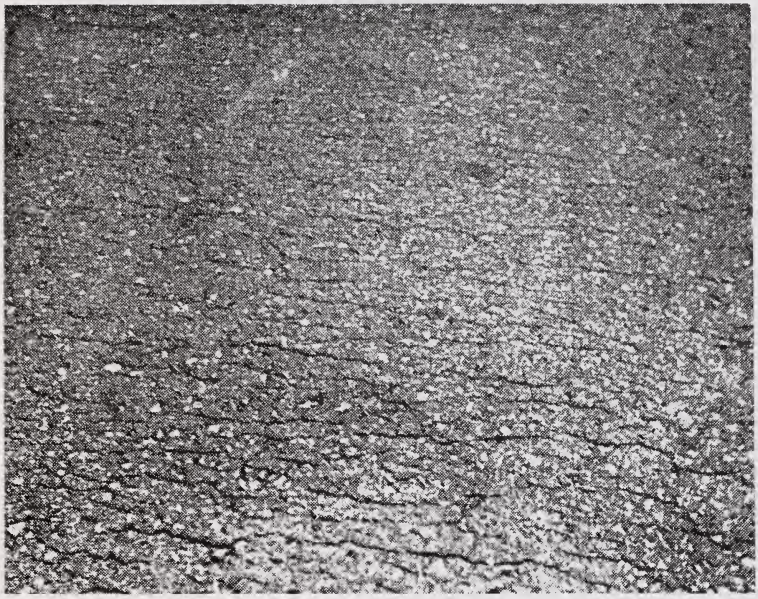

Photo 5. Hair-line cracks

Photo 6. Alligator cracks

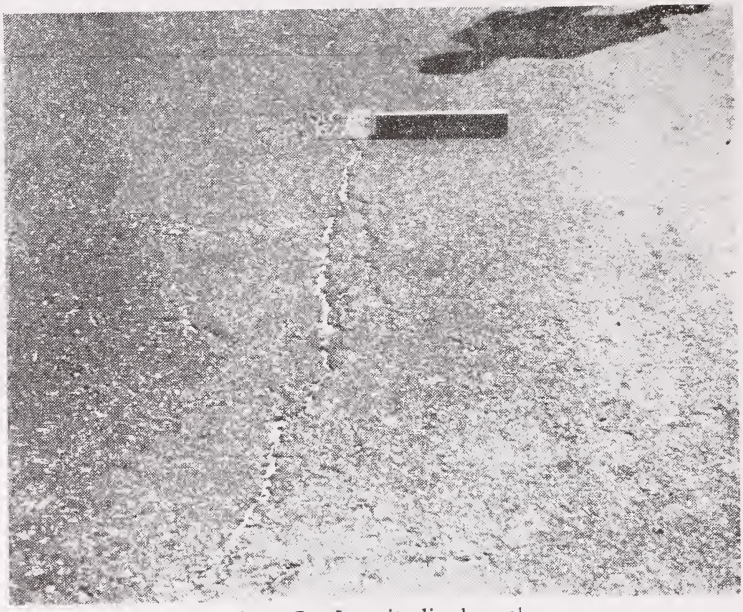

Photo 7. Longitudinal crack

Photo 8. Edge crack

spray from the distribution spray bar. These could be a result of mechanical faults in the distributor. 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. Whenever mechanical equipment is used for spraying of bitumen, manufacturer's recommendations of the bitumen distributor should be carefully adhered to.

4.2.5. **Hungry Surface**

Symptoms

Hungry surface is characterised by the loss of aggregates from the surface or the appearance of fine cracks, Photo 4.

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.

4.3. **Cracks**

4.3.1. **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. As 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.

4.3.2. **Hair-line crack**

Symptoms

These appear as short and fine cracks at close intervals on the surface, Photo 5.

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.

4.3.3. **Alligator crack**

Symptoms

These appear as interconnected cracks forming a series of small blocks which resemble the skin of an alligator, Photo 6.

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'.

4.3.4. **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, Photo 7.

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 or 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.

4.3.5. **Edge crack**

Symptoms

Edge cracks are formed parallel to the outer edge of the pavement usually 0.3 — 0.5 m inside from the edge, Photo 8. 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 the 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.

4.3.6. **Shrinkage crack**

Symptoms

These are cracks appearing in the transverse direction, or as interconnected cracks forming a series of large blocks, Photo 9. 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.

Cause

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.

4.3.7. Reflection crack

Symptoms

Reflection cracks are the sympathetic cracks that appear in the bituminous surfacing over joints and cracks in the pavement underneath, Photo 10. 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 cracks 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 they deteriorate and the riding quality of road is affected. These cracks can allow water to enter the underlying pavement and the subgrade and cause further damage.

Cause

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

4.3.8. 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 materials are removed from the cracks with brooms and, if necessary, with compressed air jetting. The binder is poured with a pouring can and 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 (fog seal) can be broomed

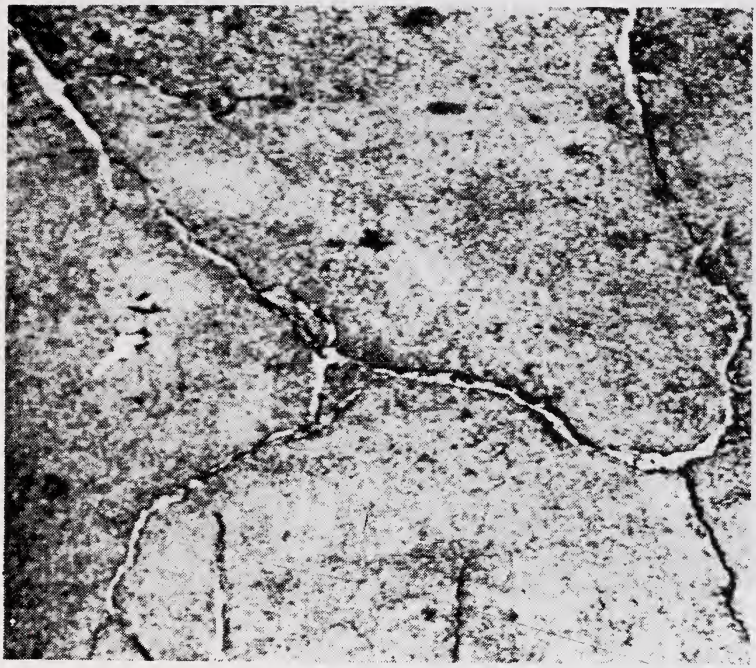

Photo 9. Shrinkage cracks

Photo 10. Reflection crack

Photo 11. Slippage

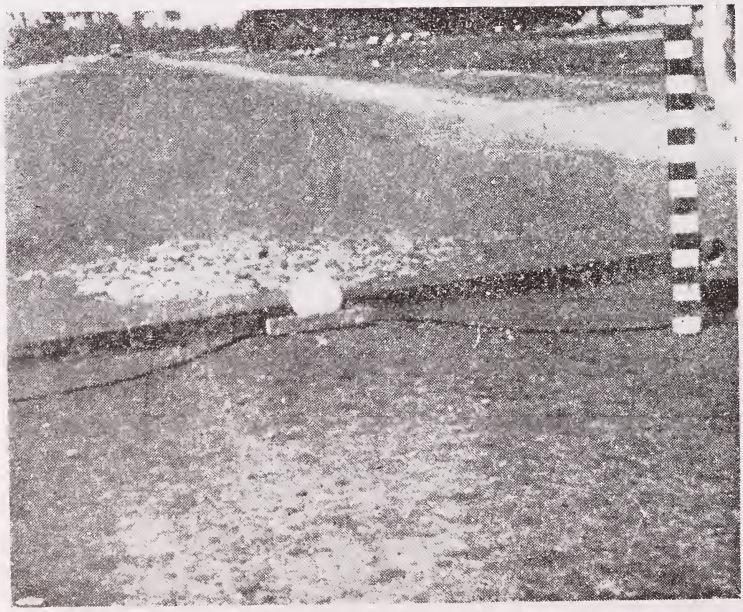

Photo 12. Rutting

Photo 13. Corrugation

Photo 14. Shoving

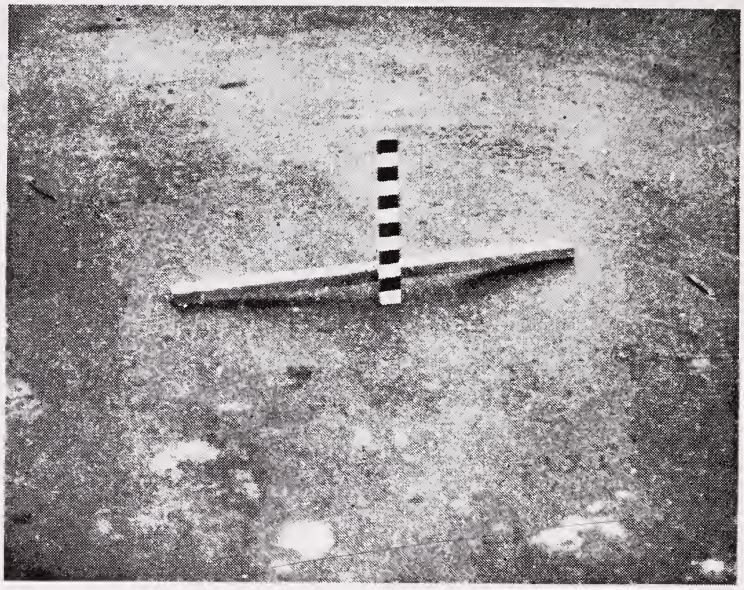

Photo 15. Shallow depression

Photo 16. Settlement

into the cracks and lightly sanded to prevent the picking up of the binder by the traffic.

4.4. Deformation

4.4.1. **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.

4.4.2. Slippage

Symptoms

Slippage is the relative movement between the surface layer and the layer beneath. It is characterised by the formation of crescent-shaped cracks that point in the direction of the thrust of the wheels on the pavement surface, Photo 11. This does not mean that the cracks invariably point in the direction the traffic is going. For example, if brakes 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 layers 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.

4.4.3. Rutting

Symptoms

Rutting is a longitudinal depression or groove in the wheel tracks, Photo 12. 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 accompained by adjacent bulging, it may be a sign of subgrade movement or weak pavement.

Causes

The causes of rutting are the following :

(i) Heavy channelised traffic.

(ii) Inadequate compaction of the mix at the surface or in the underlying 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. Detailed procedure for premix patching is given in Section 5.

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.

4.4.4. **Corrugation**

Symptoms

Corrugation is the formation of fairly regular undulations (ripples) across the bituminous surface, Photo 13. 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 resorted to.

Spreading of sand bituminous premix with a drag spreader with its blade adjusted to just clear the high spots can also be an effective way to make up the corrugations. The area is then thoroughly rolled.

4.4.5. Shoving

Symptoms

Shoving is a form of plastic movement within the layer resulting in localised bulging of the pavement surface, Photo 14. 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.

Causes

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-v olatile 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.

4.4.6. **Shallow depression**

Symptoms

Shallow depressions are localised low areas of limited size, dipping about 25 mm or more below the desired profile, where water will normally collect, Photo 15. 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 depressions are made up by filling with premix materials, open-graded or dense-graded, and compacting to the desired profile as the surrounding pavement.

4.4.7. **Settlement and upheaval**

Symptoms

Setlements and upheavals are characterised by large deformations of the pavement, Photos 16 and 17. 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.

(iv) Frost heave conditions.

Treatment

If settlements 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. Material having good drainage qualities should be preferred. 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 thorough investigations and a complete reconstruction of the pavement.

4.5. **Disintegration**

4.5.1. **General :** There 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.

4.5.2. **Stripping**

Symptoms

This defect is characterised by the separation of bitumen adhering to the surfaces of the aggregate particles, in the presence of moisture, Photo 18. This 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 :

(i) Use of hydrophilic aggregates.

(ii) Inadequate mix composition.

(iii) Continuous contact of water with the coated aggregate.

(iv) Initial over-heating of the binder or the aggregate or both.

(v) Presence of dust or moisture on aggregate when it comes in contact with the bitumen.

(vi) 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.

(vii) Occurrence of rain or dust storm immediately after the construction

(viii) Opening the road to fast traffic before the binder has set.

(ix) Concentration of soil salt in rain water coming in contact with the coated aggregate.

(x) Use of improper grade of bitumen.

(xi) Ageing of the bitumen leading to the embrittlement of the binder film.

Treatment

In the case of surface dressing, hot coarse sand heated to at least 150°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.

4.5.3. **Loss of aggregate**

Symptoms

Loss of aggregate occurs in surfaces which have been provided with surface dressing. The surface presents a rough appearance, with some portions having aggregates intact and others where aggregates have been lost, Photo 19.

Causes

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

(i) Ageing and hardening (oxidation) of the binder whereby 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 aggregate 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.

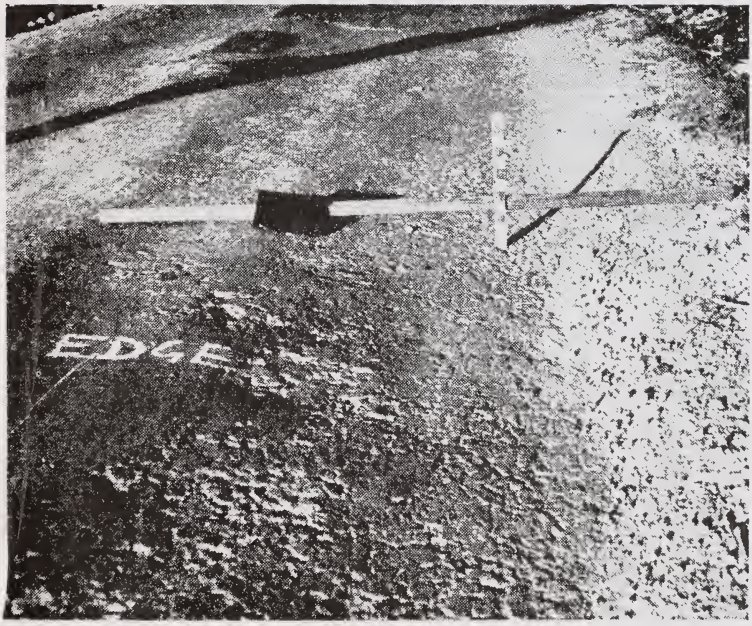

Photo 17. Upheaval

Photo 18. Stripping

Photo 19. Loss of aggregate

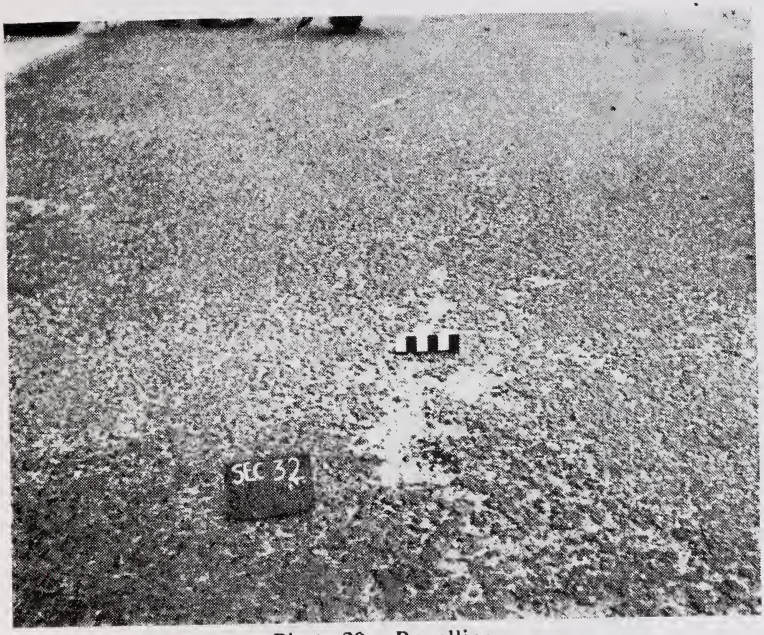

Photo 20. Ravelling

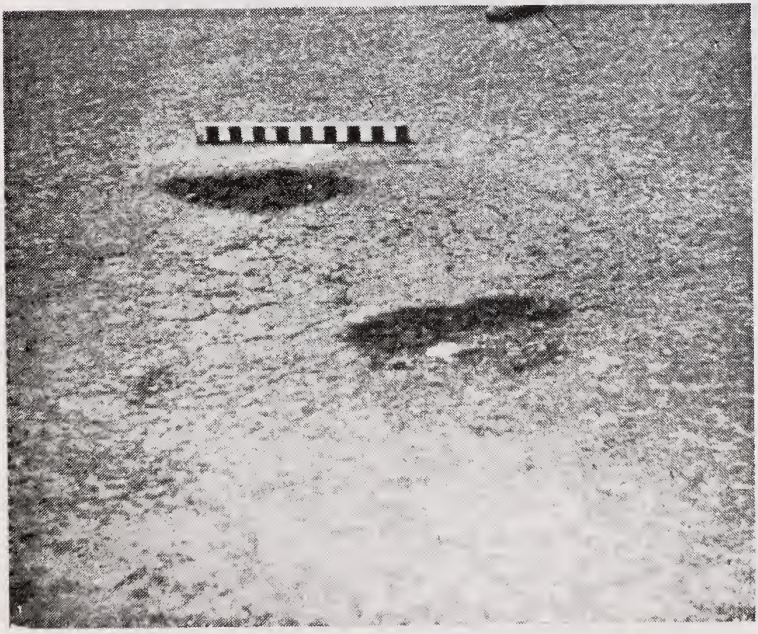

Photo 21. Pot-holes

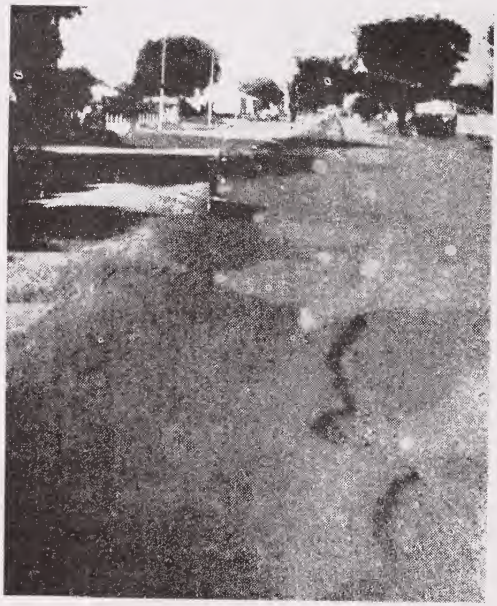

Photo 22. Edge breaking

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.

4.5.4. **Ravelling**

Symptoms

Ravelling is generally associated with premixed bituminous layers. It is characterised 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, Photo 20.

Causes

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

(i) Inadequate compaction during construction.

(ii) Construction during wet weather leading to stripping of binder from aggregates.

(iii) Construction during cold weather resulting in non-uniform binder film.

(iv) Use of inferior quality aggregate resulting in fracture, crushing and opening of new faces.

(v) Insufficient binder in the mix.

(vi) Ageing of binder leading to brittle fracture and disintegration of pavement.

(vii) Excessively open graded mix.

(viii) Poor compatibility of binder and aggregate.

(ix) Over-heating of mix or the binder.

(x) 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.

4.5.5. **Pot-hole**

Symptoms

Pot-holes are bowl-shaped holes of varying sizes in a surface layer or extending into the base course caused by localised disintegration of material, Photo 21. 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 a depression soon gets formed. This is aggravated by use of plastic filler 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 localised inadequacies in these applications can cause pot-holes.

(iii) Insufficient bitumen content in localised 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.

Treatment

The rectification consists of filling pot-holes with premix open-graded or dense-graded patching, or penetration patching.

4.5.6. **Edge-breaking** (Frayed edges)

Symptoms

A common defect in bituminous surfaced roads is edge breaking. The edge of the bituminous surface gets broken in an irregular way, Photo 22, and if not remedied in time, the surfacing may peel off in large chunks at the edges.

Causes

The following are the causes for edge breaking :

(i) Infiltration of water which softens the foundation layers causing the pavement edges to break.

(ii) Worn out shoulders resulting in insufficient side support to the pavement.

(iii) Inadequate strength at the edge of the pavement due to inadequate compaction.

(iv) Lower layer of pavement not being wider than upper layer.

Treatment

The shoulder and the pavement material in the affected area should be entirely removed to a regular section with vertical sides. The pavement and the shoulders should be built up simultaneously with thorough compaction. A bituminous surface similar to that in the adjacent reach should be laid. The shoulder should have adequate slope to drain away the water. A slope one per cent steeper than the camber of the bituminous surface should be found generally necessary for earthen shoulders. In order to prevent the edges from getting broken again, the maintenance operations should include periodic inspection of the shoulder condition and replacement of worn out shoulder material with adequate compaction. In sandy areas where the soil is likely to be eroded by wind and rain, it may be advantageous to have brick paving at least for some width to protect the edges. Surface and subsurface drainage, wherever deficient, should be improved.

5. METHODS FOR REPAIRING THE DEFECTS

5.1. General

5.1.1. The previous Sections have dealt with the identification of the affected area, type of defect and its cause, and the maintenance measure to be taken in each case. This Section describes each of the various maintenance operations which remain grouped under 'Routine Maintenance', in Section 2 of this Code of practice. Maintenance operations of a periodic nature are discussed in Section 6.

5.1.2. The repair methods discussed in this section generally fall under two categories: (i) Seal Coat, and (ii) Patching. The seal coat, is a single, thin application of bitumen which may or may not be covered with aggregate. Patching is the application of bituminous materials either premixed or penetration macadam type,

and is resorted to for filling pot-holes, shallow depressions, rutting and edge irregularities. Patching when used for filling the ruts and depressions, can also be termed as "levelling".

5.2. Liquid Seal

5.2.1 **Description** : Liquid seal consists of an application of liquid bitumen (penetration grade, cut-back or an emulsion) and covering the same with agggregate. This is applicable for the rectification of fatty surfaces, stripping, loss of aggregates, and ravelling.

5.2.2. **Materials** : Penetration grade bitumen should be of suitable grade. A cold application cut-back such as RC-3 or MC-3 is also suitable. If emulsion is to be used, it should be of the rapid setting type. The quantity of binder shall be as follows :

	Binder	*Quantity for 10 sq. m (kg.)*
1.	Penetration grade bitumen	9.8
2.	Cold application cut-back, RC-3 or MC-3 (Quantity in terms of penetration grade bitumen)	9.8
3.	Emulsion, RS	10—12

The cover aggregates should be of a nominal size of 6.3 mm, viz. passing through 10 mm IS Sieve and retained on 2.36 mm IS Sieve. The quantity of cover aggregate should be 0.09 cu. m. per 10 sq. m.

5.2.3. **Construction method** : The area to be treated shall be thoroughly cleaned. If penetration grade or cut-back bitumen is to be used, the wet areas should be allowed to dry. However, if emulsified bitumen is to be used, the surface requires to be dampened. But such patching with emulsified bitumen should not be done when it is raining.

The binder is applied either by a spray nozzle or, only where permitted, by pouring pots at the appropriate temperature and rate. Cover aggregates are then spread at the specified rate and rolled in position with a 6-8 tonne steel wheel roller. When penetration grade bitumen is used, the road can be opened to traffic on the following day or if required to be opened immediately, a speed restriction of 16 km/h shall be enforced till the following day. When cut-back bitumen is used, the finished surface shall be closed

to traffic until it has sufficiently cured to hold the cover aggregate in position. If emulsion is used, the road can be opened to traffic after 4-6 hours.

5.3. Fog Seal

5.3.1. **Description** : Fog seal is a light application of emulsified bitumen, usually without a cover aggregate. It is used to increase the binder content of bituminous surfaces, rejuvenate oxidised and old surfaces, fill in cracks and prevent ravelling. It can also be used as an emergency treatment measure for hungry surfaces.

5.3.2. **Construction method** : The bituminous binder is a slow setting emulsion. The emulsion is diluted with an equal amount of water and sprayed at the rate of 0.5—1.0 litre/sq. m (of diluted material) depending upon the texture and dryness of the old pavement. The seal sets in about 30 minutes. The traffic can be allowed on the area after the seal has set to a firm condition so that it is not picked-up by the traffic.

5.4. Slurry Seal

5.4.1. **Description**: Slurry seal is a mixture of fine aggregates, mineral filler and emulsified bitumen with water added to achieve slurry consistency. The ingredients are mixed and spread evenly on to bituminous surfaces to fill cracks, repair ravelled pavements, smooth or hungry surfaces, rectify loss of aggregates, rejuvenate oxidised and open-textured old bituminous surfaces, and to provide a skid resistant surface.

5.4.2. **Materials** : The aggregate gradation is very important. The following grading is found suitable :

Gradation of aggregates for slurry seal

Sieve designation	*Per cent by weight passing the sieve*
4.75 mm	100
2.36 mm	80-100
1.18 mm	50-90
300 micron	15-50
150 micron	10-25
75 micron	3-10

In order to obtain the above gradation, fine grit, sand and filler can be mixed in suitable proportions.

The binder is a slow-setting emulsified bitumen. The mix has to be designed to have a consistency such that the slurry when spread, would flow in a wave approximately half a metre ahead of the strike-off squeegee. This would ensure that the slurry would not bridge over the cracks without filling them. About 18-20 per cent emulsion and 10-12 per cent of water by weight of the aggregates would approximately make a satisfactory mix.

5.4.3. **Construction method** : The area is thoroughly cleaned after carrying out patching where necessary, and a tack coat consisting of a light application of bitumen emulsion diluted with three parts of water is applied at the rate of 2.5—3.5 kg/10 sq.m. The slurry seal can be mixed by a continuous machine or a batch type unit. For smaller works batch type unit is preferable. Measured quantity of aggregate is taken in the slurry mixer. Water for pore-wetting is mixed with the aggregates. Bitumen emulsion is added to the mixer and the slurry is then spread on the road. The slurry may be spread and forced into voids by hand squeegees or spreader boxes. Spreader boxes are suitable for controlled laying. The slurry is laid at an approximate coverage rate of 200 sq. m. per tonne giving a thickness of about 2 to 5 mm. No rolling is required. The traffic can be allowed on the area after the slurry seal has set to a firm condition so that the mixture is not picked-up by the traffic.

5.5. Sand Bituminous Premix Patching

5.5.1. **Description :** Sand bituminous premix patching consists of laying a mixture of fine aggregate and bituminous binder to rectify cracks, slippage, corrugations, shoving, shallow depressions and ravelling. The fine aggregate shall be a medium coarse sand (fineness modulus of more than 2.5) or fine grit passing 1.70 mm IS Sieve and retained on 180-micron IS Sieve. The binder can be a paving bitumen of suitable penetration grade, rapid curing cut-back such as RC-3, or a medium curing cut-back such as MC-3.

5.5.2. **Construction method :** The area is thoroughly cleaned and a tack coat with penetration grade bitumen, RC-3 or MC-3 is applied at the rate of 7.5 kg per 10 sq. m. (quantity in terms of penetration grade bitumen). The mix is prepared in suitable mechanical or hand-operated mixers by mixing binder and sand. The quantity of sand and binder shall be 0.06 cu. m. and 6.8 kg (quantity of binder in terms of penetration grade bitumen) per 10 sq. m. area respectively. The mix is spread and laid wherever required. When smoothening a corrugated surface, it may be expedient to use a drag spreader with its blade adjusted

to clear the high spots. The mixture is then rolled thoroughly till it is compacted.

5.6. Premix Open-graded Patching

5.6.1. **Description :** Premix open-graded patching consists of making up the area to be patched by a premix open-graded material consisting of a binder and aggregates, compacting and finishing with a seal coat. This repair method is applicable for fatty surfaces, slippage, rutting, shoving, shallow depressions and pot holes.

5.6.2. **Materials :** Stone aggregates of the following sizes and at the quantities specified below shall be used for premixing :

	Quantity for 10 sq.m. area (For a thickness of 20 mm)
(i) Coarse aggregates—12.5 mm size (passing 20 mm IS Sieve and retained on 10 mm IS Sieve).	0.18 cu.m.
(ii) Coarse aggregates—10 mm size (passing 12.5 mm IS Sieve and retained on 6.3 mm IS Sieve).	0.09 cu.m.
Total :	0.27 cu m.

The binder can be paving bitumen of suitable penetration grade, rapid curing cut-back such as RC-3, medium curing cut back such as MC-3, or a medium setting bitumen emulsion. The quantities of binder for various operations are indicated below :

		Quantity for 10 sq.m. area (kg.)	
		Tack coat	Premix (for a thickness of 20 mm)
1.	Penetration grade bitumen	7.5	14.6
2.	Cold application cut-back, RC-3 or MC-3 (Quantity in terms of penetration grade bitumen)	7.5	14.6
3.	Emulsion, MS	7.5	15-18

The materials for seal coat will depend on the type of seal coat provided ; for a liquid seal coat it shall be as per Clause 5.2.2., and for a premix seal coat it shall be as per Clause 5.5.

5.6.3. **Construction method :** The area to be patched should be thoroughly cleaned. For rectifying unevenness, the uneven

area is first defined by a string line and marked ; the area upto at least 0.3 m beyond the marked area on all sides is thoroughly cleared. A tack coat is applied on the uneven area and then the patching material is applied. For rectifying pot-hole, the edges of the hole are squared and the hole cut to solid material with vertical edges, before applying the tack coat and patching material. The surface is allowed to dry if it is wet and the work is to be done by penetration grade bitumen or cut-back. If a bituminous emulsion is used, slight dampness is required. Patching of permanent nature should be allowed only when it is not raining. However, if it is raining continuously, as an emergency measure, pot-holes can be temporarily filled with stone or brick ballast laid and compacted to WBM specifications using non-plastic filler, till such time when regular maintenance measures can be taken. If an emulsion is used the tack coat is not applied earlier than ten minutes before laying the premix. A mechanical mixer should be preferred. A drier unit for the aggregates will be an added advantage. For use with cold application cut-back and emulsion, a power mixer should be preferred. If no power mixers are available, mixing for small size jobs can be done in hand operated drum mixers. For still smaller jobs, hand mixing by shovels on a platform can be resorted to. When using a cold application cut-back, the premix should be prepared at least 3 days in advance of use. If necessary such a mixture can be stock-piled and covered with a tarpaulin and stored for 2-3 weeks. The patch is filled with the prepared premix, care being taken to see that filling is done in layers not exceeding 40 mm thickness. Each layer is compacted thoroughly either by rolling using a roller or a truck wheel or by means of vibratory tampers. The final surface should be sealed with a liquid seal coat as per Clause 5.2. in areas having rainfall of over 150 cm per year or with a premix seal coat as per Clause 5.5. in areas having rainfall of under 150 cm per year. The resultant surface shall conform to the adjacent levels. Humping for compaction by traffic should not be allowed.

5.7. **Premix Dense-graded Patching**

5.7.1. **Description** : Premix dense-graded patching consists of making up the area to be patched by a dense-graded premix material consisting of a binder, aggregates and filler, compacting and finishing. This is a high quality, thoroughly controlled hot mixture for which the mix design is to be invariably got done before the start of the work in a suitably equipped laboratory. For existing superior types of surfaces, the use of this type of patching may be considered. This type of patching can be used for repairing slippage, rutting, shoving, shallow depressions, or pot-holes.

5.7.2. **Materials:** The coarse aggregates, fine aggregates and filler shall be mixed in suitable proportions to obtain a final composition satisfying any of the two gradings set forth below:

	Gradation of mineral aggregates (Per cent by weight passing the sieve)	
Sieve designation	Grading 1	Grading 2
20 mm	—	100
12.5 mm	100	80-100
10 mm	80-100	70-90
4.75 mm	55-75	50-70
2.36 mm	35-50	35-50
600 micron	18-29	18-29
300 micron	13-23	13-23
150 micron	8-16	8-16
75 micron	4-10	4-10

The binder shall be a paving bitumen of suitable penetration grade. The quantity of binder by weight of total mix shall be 5.7.5 per cent.

5.7.3. **Design requirements** : The design requirements of the mix shall be as under :

Number of compaction blows, on each end of Marshall specimen	50
Marshall stability in lb.	750
Marshall Flow-0.01 in.	8-16
Per cent voids in mix	3-5
Per cent voids in mineral aggregates filled with bitumen	75-85

The design criteria for repair materials should preferably be the same as for the earlier mix.

5.7.4. **Construction method** : The area to be patched should be thoroughly cleaned. For rectifying unevenness, the uneven area is first defined by a string line and marked; the area upto at least 0.3 m beyond the marked area on all sides is thoroughly cleared. A tack coat is applied at the rate of 7.5 kg per 10 sq. m. on the uneven area and then the patching material is applied. For rectifying pot-hole, the edges of the hole are squared and the hole cut to solid material with vertical edges, before applying the tack coat and patching material. The surface is allowed to dry, if it is wet. Patching work of permanent nature shall be allowed only when it is not raining. However if it is raining continuously, as an emer-

gency measure, pot-holes can be temporarily filled with stone or brick ballast laid and compacted to WBM specifications using non plastic filler till such time when regular maintenance measures can be taken. The mixing shall be done in a hot mix plant. A small capacity portable hot mix plant will be very convenient for small patching jobs. The patch is filled with the prepared mix, care being taken to see that filling is done in layers not exceeding 40 mm thickness. Each layer is compacted thoroughly either by rollers or by means of vibratory tampers before the mix cools below 100°C. The resultant surface shall conform to the adjacent levels. Humping for compaction by traffic should not be allowed. Adequate quality control shall be exercised at every stage of the work as per IRC:29-1968 and IRC Special Publication: 11-1977.

5.8. **Penetration Patching**

5.8.1. **Description**: Penetration patching consists of making up the area to be patched by a course of aggregates, compacting the same, applying bitumen and key aggregates and finishing off with a seal coat. The patch is used for surface disintegration over 12 mm deep. The patching may be done in layers, but the depth of the individual layers should not exceed 50 mm.

Although it is known from experience that penetration patching does not produce as good a patch as premix material due to lack of accurate control of the amount of bitumen to be used, emergency patches of this type may be necessary as a last resort in the absence of premix material. Hence use of penetration patch should be very limited.

5.8.2. **Materials**: The coarse aggregates should conform to the following grading requirements:

Sieve designation	*Per cent by weight passing the sieve* (for 50 mm compacted thickness)
50 mm	100
25 mm	35-70
12.5 mm	0-15
2.36 mm	0-5

The key aggregates should conform to the following grading

requirements :

Sieve designation	*Per cent by weight passing the sieve* (for 50 mm compacted thickness)
20 mm	100
12.5 mm	35-70
4.75 mm	0-15
2.36 mm	0-5

The quantities of the aggregates for 50 mm compacted thickness should be as under :

	Quantity for 10 sq. m. area
Coarse aggregates	0.60 cu.m.
Key aggregates	0.15 cu.m.

The binder shall be a paving bitumen of suitable penetration grade, rapid curing cut back such as RC-3, or medium curing cut-back such as MC-3. The quantities of binder are indicated below:

	Quantity for 10 sq. m. area (kg.)	
	Tack coat	Grouting (for 50 mm compacted thickness)
1. Penetration grade bitumen	7.5	50
2. Cold application cut-back, RC-3 or MC-3 (Quantity in terms of penetration grade bitumen)	7.5	50

The materials for seal coat will depend on the type of seal coat provided; for a liquid seal coat it shall be as per Clause 5.2.2. and for a premix seal coat, it shall be as per Clause 5.5.

The gradation and quantities of the materials shall be modified depending on the thickness of the layers to be achieved.

5.8.3. **Construction method** : The area to be patched should be thoroughly cleaned. If it is a pot-hole, the edges of the hole should be squared and the hole cut to solid material with vertical edges. All loose materials are removed. The surface should be allowed to dry if it is wet. Patching of permanent nature shall be done only if the weather is dry and free from dust storm. However if it is raining continuously, as an emergency measure, pot-holes can be temporarily filled with stone or brick ballast laid and compacted to WBM specifications using non-plastic filler, till such time when regular maintenance measures can be taken. A tack coat with

bitumen is applied over the sides and bottom of the hole and the entire area to be patched at the rate specified in Clause 5.8.2. Coarse aggregates conforming to gradation and quantities specified in Clause 5.8.2. are spread. The aggregates are dry rolled either by a steel wheel roller or a vibratory compactor. Bituminous binder is then applied at the appropriate temperature either by a nozzle or, only where permitted, by pouring pots, at the rate specified in Clause 5.8.2. Immediately, thereafter key aggregates conforming to gradation and quantities specified in Clause 5.8.2. are spread uniformly and rolled into position. The final surface should be sealed with a liquid seal coat as per Clause 5.2. in areas having rainfall of over 150 cm per year or with a premix seal coat as per Clause 5.5. in areas having rainfall of under 150 cm per year. The resultant surface shall conform to the adjacent levels. Humping for compaction by traffic should not be allowed.

Care should be taken to see that excessive amount of bitumen is not used as this causes the patch to shove and become rough, to bleed or to be slippery when wet. Also too small amount of bitumen will cause the patch to ravel. Penetration patches should be checked frequently. If found to be ravelling, they should be resealed; if they are bleeding additional seal coat aggregate should be applied. If they show signs of shoving they should be removed and replaced with premix material.

5.8.4. For penetration patching above 50 mm thickness and upto 75 mm thickness, built-up spray grout specifications conforming to IRC : 47-1972 may be adopted.

6. PERIODIC RENEWALS

6.1. Need and Importance of Periodic Renewals

Periodic renewals consist of the provision of a surfacing layer over the pavement at regular intervals of time, so as to preserve the required characteristics of the pavement and offset the wear and tear caused by traffic, weathering, etc. In effect, periodic renewals represent preventive maintenance which is needed to prevent deterioration of the pavement characteristics and to ensure that initial qualities are kept up for the future requirements of traffic during the design life of the pavement. Early detection and repair of noticeable defects can prevent a major break-down of the surface. For example, if symptoms like hungry surface, ravelling etc. are noticed at an early stage and suitable preventive action by way of renewal of surface is taken to arrest further deterioration, the life of the pavement can be prolonged.

6.2. Planning and Programming of Renewals

The general practice in the country is to finalise renewal programme on an annual basis. In order that necessary steps leading to the laying of renewal layer on the road could be taken in proper time, the renewal programme for each section of a road should be decided well in advance. Once the programme is finalised, steps could be taken to secure the required allocations and start the preliminary field action such as collection of materials etc.

While the nomenclature "Periodic Renewal" would imply that the renewal treatment be carried out at a fixed and pre-determined frequency, it would neither be practicable nor desirable to follow implicitly any specified frequency irrespective of the condition of the road surface proposed to be renewed. The most effective way to plan a renewal programme is to carry out inspections of the road surface at suitable intervals. Visual inspection of the road as detailed in Section 3 of this Code should be carried out. In addition, special inspections also are necessary before and after the rains so as to assess the need for patching and other remedial measures required to be carried out either in advance or together with the renewal treatment.

6.3. Identification of Length to be Renewed

The lengths of the road showing signs of distress such as hungry surface/hair-line cracking, ravelling etc., should invariably be included in the renewal programme. This would ensure that the surface of the road and the pavement structure do not deteriorate further. The lengths of the road which would be due for renewal treatment on the basis of the prescribed periodicity should be inspected closely and decision whether to include these in the renewal programme or to postpone the renewal for a specified period should be taken depending upon the condition of the road surface. In cases where the nature of distress/failure seen on the road is severe and of considerable extent and the cause may be deep-seated and where it is considered the pavement cannot be improved with renewal treatment, detailed investigations should be carried out and special measures would have to be taken for correcting the same.

6.4. Types of Renewal

The types of bituminous surfaces prevalent in India are surface dressing (one or two coats), thin premix chipping carpet, thin mix seal carpet, hot mix semi-dense and dense carpets. These surfaces have different life spans depending upon traffic and environmental conditions. Periodic renewals in these cases would generally provide

for the application of a surfacing layer upto 20 mm thickness so that the superficial wear and weathering of the surface is covered up and the pavement lasts for the full intended life span. The specifications adopted for the renewal layer on a particular road would depend upon the type of the original surface and its condition at the time of renewal. The specifications generally adopted for periodic renewals in this country are :

(i) Single coat of surface dressing as per IRC : 17-1965 (SD).

(ii) 20 mm thick premix chipping carpet as per IRC : 14-1977 (PC).

(iii) Mix seal surfacing as per Ministry of Shipping and Transport (Roads Wing) Specification for Road and Bridge Works Clause 508 (MS).

The specification and the thickness of the renewal course should be such that as far as possible the road surface is restored close to its original condition. For example, renewal over an original hot mix dense carpet (asphaltic concrete) surface would have to be hot mix paver-laid mix seal surfacing while on an original surface of premix chipping carpet, the renewal layer could either be single coat surface dressing or 20 mm thick premix carpet depending upon the condition of the worn-out surface.

6.5. Periodicity of Renewal and Annual Budgetting

Based on the experience in this country, the following broad guidelines are recommended for the type and periodicity of renewals. This may be utilised as a guide for working out the requirement of funds for the annual renewal programme on different sections of roads.

Class of road	Lane width	Traffic (Commercial vehicles per day)	Type of renewal and periodicity of the renewal treatment for		
			Low rainfall upto 150 cm per year	Medium rainfall 150—300 cm per year	High rain fall above 300 cm per year
National Highways and State Highways	Single	(i) Less than 450	$\frac{SD}{4}$	$\frac{SD}{4}$	$\frac{SD}{4}$
		(ii) 450—1500	$\frac{SD}{4}$	$\frac{SD}{3}$	$\frac{SD}{3}$

		(iii) More than 1500	$\frac{PC}{6}$ or $\frac{MS}{8}$	$\frac{PC}{5}$ or $\frac{MS}{7}$	$\frac{PC}{4}$ or $\frac{MS}{6}$
	Double	(i) Less than 450	$\frac{SD}{5}$	$\frac{SD}{4}$	$\frac{SD}{4}$
		(ii) 450—1500	$\frac{SD}{4}$	$\frac{SD}{3}$	$\frac{SD}{3}$
		(iii) More than 1500	$\frac{PC}{6}$ or $\frac{MS}{8}$	$\frac{PC}{5}$ or $\frac{MS}{7}$	$\frac{PC}{4}$ or $\frac{MS}{6}$
Major District Roads, Other Ddistrict Roads and Village Roads)	Irrespective of lane width	(i) Less than 150	$\frac{SD}{6}$	$\frac{SD}{6}$	$\frac{SD}{6}$
		(ii) 150—450	$\frac{SD}{6}$	$\frac{SD}{5}$	$\frac{SD}{5}$
		(iii) More than 450	$\frac{SD}{5}$	$\frac{SD}{4}$	$\frac{SD}{3}$

Notes: (1) The treatment symbols SD, PC and MS have been explained in Clause 6.4 above.

(2) The denominator refers to the periodicity of renewal in years.

(3) For areas subject to snowfall and hilly areas with steep side slopes and heavy rainfall the periodicity of renewal may be at closer interval.

(4) The periodicity of the renewal indicated in the table above should only be taken as a general guideline for the purpose of budgetting and determining the extent of renewal prograimme. It does not indicate either the expected life of the partcular type of treatment or the imperative need for renewals after the period indicated.

6.6. Rectification of Profile at the Time of Renewal

The camber and superelevation provided initially on a road tend to get flattened out due to traffic. Before the renewal of surface is done, the cross profile should be corrected by means of a suitable levelling course.

7. SPECIAL PROBLEMS

7.1. Construction and Maintenance during Wet Weather Conditions

7.1.1. **Nature of problem** : It is well known that the chippings which are damp or wet due to storage in the open stacks, do not adhere to bituminous binder so long as the film of water persists on the stone. Also majority of wet weather failure of surface dressings are caused by rain during or within a few days after construction. Even after the chippings have adhered to the binder there is a period varying from an hour or two to seven days or more when the adhesive bond between the stone and the binder is susceptible to displacing action of water. This phenomenon is relevant not only to surface dressing but also to open-graded surfacings as well, although the aggregates in this case are heated and then coated with the bituminous binder. The effect of water manifests in the form of all round ravelling of the affected area, loss of cover aggregate and development of pot-holes.

7.1.2. **Preventive Measures** : The damage by wet weather can be prevented by the use of surface active agents (adhesion agents). The adhesion agent promotes the adhesion of binder to wet aggregates or prevents the loss of adhesion under the influence of subsequent rains. Creoste oil, hydrated lime, turkey red oil, or amines (mono, di or polyamine of fatty acids) can be used as an adhesion agent. Under wet conditions, adhesion agents may be added at the rate of 1 to 1.5 per cent by weight of binder.

7.1.3. **Maintenance measures**

(A) **Use of bitumen emulsions**

The bitumen emulsions not only flow well at atmospheric temperature but can also be applied to damp road surfaces and used for coating damp aggregates. The presence of emulsifying agent helps in improving the adhesion characteristics of the binder.

Two types of bitumen emulsion namely the anionic type and the cationic type are generally used. The basic difference between the two lies in their method of breaking. Anionic bitumen emulsions break only when sufficient water has evaporated from the system to leave the emulsion unstable. With cationic bitumen emulsion the break is chemical, i.e., the positively charged emulsifier is chemically attracted to negative surface on the aggregate. This

causes the emulsion to break and the emulsifier then acts as an adhesion agent. The cationic emulsifiers are especially useful with siliceous aggregate and may be effectively used in slurry sealing and preparation of patching mixtures.

(B) Storable bituminous mixes for maintenance during rainy season

In bituminous pavements the maximum damage is caused by water and that too during the rainy season. Stagnation of water and movement of traffic induces stripping and ruptures the binder film on aggregate and eventually leads to ravelling and potholing on the road pavement. For meeting such a situation storable bituminous mixtures stockpiled in advance offer a ready solution. Such mixes may be stored for a week or ten days. The manufacturing details of such mixes are as follows :

(i) *BINDER :* The cut-back bitumen of the consistency of MC—3 (Bitumen 80/100+16 per cent flux) or a slow setting emulsion may be used. In case the maintenance is to be undertaken during rainy season the cut-back bitumen should be treated with one per cent antistripping agent. No treatment is warranted in the case of cationic bitumen emulsion.

(ii) *AGGREGATE :* The mineral aggregates shall be crushed rock, sand, or mineral dust conforming to the required gradings.

(iii) *PREPARATION OF THE MIXTURES :* Coarse and fine aggregate shall be fed into the plant in a proportion conforming to the grading requirements. The cut-back bitumen or emulsion shall be applied at appropriate temperature at 4-6 per cent by weight of total mix. The mineral aggregates and the binder shall be mixed until all aggregates are thoroughly coated.

(iv) *STOCK PILING :* The mixture shall be stored in a cool dry place and shall be used as and when required.

7.2. Road Cuts Resorted to for Installation or Maintenance of Utilities

7.2.1. **Nature of the problem :** It often becomes necessary to cut the road pavement to install an utility (sewer, waterline, electric cable etc.) or repair it. This requirement is very frequent in urban streets, though rural roads also need such cuts. The number and frequency of these cuts should be kept to a minimum by proper coordination with the utilities services organisations. In some Highway Departments, the method of driving or jacking the pipeline under the pavement is adopted wherever feasible. Wherever these cuts are made, the important thing is to ensure that they are restored properly. Otherwise, they tend to be a

constant source of annoyance and danger to traffic, apart from the recurring trouble to maintenance personnel.

7.2.2. **Hints for better maintenance practices** : The cut should be of rectangular shape with vertical sides. As far as possible, the accumulation of water in the trenches should be avoided. Collection of water renders it difficult to dry the trenches and is also detrimental to the stability of the trench fill.

The trench fill material must be carefully selected and it should be thoroughly compacted. The use of mechanical rammers and the control of moisture and layer thickness should receive attention. The different layers of the pavement should similarly be built-up under controlled conditions. It is suggested that bituminous macadam may be adopted in lieu of water-bound-macadam where it is not possible to consolidate water-bound macadam in narrow trenches. The top 150 mm of the pavement should preferably be of bituminous construction, irrespective of the existing crust.

The final surface should be of material similar to that in the existing pavement. The final surface should be laid in a manner similar to the restoration of a pot-hole. The resultant surface should be flush with the adjacent surface. Humping, for compaction by traffic, should not be allowed. Since many repaired road-cuts continue to give trouble for quite some time, sustained attention is necessary.

8. MATERIALS

8.1. Binder

The bituminous binder should be one of the following :

(1) Paving bitumen, penetration grade 30/40, 60/70 or 80/100 conforming to IS:73-1961.

(2) Cut-back bitumen of the Rapid curing (RC-3) and Medium curing (MC-3) Type conforming to IS:217-1961 and 454-1961.

(3) Bitumen emulsions of the Rapid setting (RS) or Medium setting (MS) or Slow setting (SS) type.

The choice of a particular type of binder will depend upon the maintenance specifications for which the binder is required, the climatic conditions, traffic and durability. The following broad indications may be tentatively taken as a general guide :

Type of Binder	*Uses in Maintenance operations*
A. Penetration Grade :	
1. 30/40 Pen (S 35)	(i) Premix dense-graded patching, penetration patching, premix open-graded patching/ premix carpet, sand bituminous premix/ premix seal coat, liquid seal, mix seal surfacing and semi-dense carpet.
	(ii) Generally favoured in regions with comparatively high atmospheric temperature throughout the year with slight variation between day and night temperatures.
	(iii) Being a harder grade, recommended for heavy traffic, bus stops, parking places, etc.
2. 60/70 Pen (S 65)	(i) Premix dense-graded patching, penetration patching, premix open-graded patching/ premix carpet, sand bituminous premix/ premix seal coat, liquid seal, mix seal surfacing and semi-dense carpet.
	(ii) Generally favoured for high summer temperatures and low winter temperatures, moderate variation between day and night temperatures.
	(iii) Being a reasonably hard grade, preferred for heavy traffic, bus stops, parking places, etc.
3. 80/100 Pen (S 90)	(i) Premix dense-graded patching, penetration patching, premix open-graded patching/premix carpet, surface dressing, premix seal coat, liquid seal coat, mix seal surfacing and semi-dense carpet.
	(ii) Generally favoured for areas with extremes in summer and winter temperatures and where the difference between day and night temperature is large ; and also for the low temperature regions at high altitudes.
B. Cut-backs:	
1. MC-3 (Medium curing)	(i) Premix open-graded patching/premix carpet, semi-dense carpet, sand bituminous premix patching, penetration patching, single or two coat surface dressing, and liquid seal patching.
	(ii) Generally favoured for maintenance operations where cold-mixing is an advantage.
	(iii) Intended for immediate use after mixing as well as for stockpiling.
2. RC-3 (Rapid curing)	(i) Liquid seal, premix open-graded patching/ premix carpet, surface dressing, sand bituminous premix patching, penetration patching, and mix seal surfacing.

ii) Generally favoured for maintenance operations where cold-mixing is an advantage.

iii) Intended for immediate use after mixing.

C. Emulsions (anionic and cationic)

Emulsions may be the anionic, electro-negatively charged asphalt globules, or cationic, electro-positively charged asphalt globules, depending upon the emulsifying agent. Anionic emulsion combines well with positive surface charged carbonate rocks, while cationic emulsions are more suitable with negative surface charged siliceous rocks.

1. Rapid setting :
   i) Surface dressing, liquid seal.
   ii) Cationic emulsions can be used with wet aggregates (very useful for maintenance operations during rainy seasons).
2. Medium setting :
   i) Premix open-graded patching
   ii) Cationic emulsions can be used with wet aggregates (very useful for maintenance operations during rainy seasons).
3. Slow setting:
   i) Slurry seals, fog seals.

8.2. Stone Aggregates

The stone aggregates shall consist of crushed stone, crushed slag, crushed gravel (shingle) and sand and shall be clean, hard, tough, durable and of uniform quality. They shall be free of elongated or flaky pieces, soft and disintegrated material, and organic or other deleterious matters. They should satisfy the following general requirements :

	Value	*Method of Test*
1. Los Angeles Abrasion Value	Max. 35%	IS : 2386 (Part IV)
or		
Aggregate Impact Value	Max. 30%	IS : 2386 (Part IV)
2. Flakiness Index		
i) Surface dressing and premix carpet	Max. 30%	IS : 2386 (Part I)
ii) Bituminous macadam and asphaltic concrete	Max. 35%	IS : 2386 (Part I)
3. Stripping Value	Max. 25%	IS : 6241
4. Water absorption	Max. 2%	IS : 2386 (Part III)
5. Soundness: Loss with sodium sulphate—5 cycles (in case of slag only).	Max. 12%	IS : 2386 (Part V)
6. Unit weight or bulk density (in case of slag only)	Min. 1120 kg per cu.m.	IS : 2386 (Part III)

8.3. For general specifications for the different types of work, the following specifications may be referred to :

1. IRC : 14-1977 Recommended Practice for 2 cm thick Bitumen and Tar Carpets.
2. IRC : 17-1965 Tentative Specification for Single Coat Bituminous Surface Dressing.
3. IRC : 19-1977 Standard Specifications and Code of Practice for Water Bound Macadam.
4. IRC : 20-1966 Recommended Practice for Bituminous Penetration Macadam (Full Grout).
5. IRC : 23-1966 Tentative Specification for Two Coat Bituminous Surface Dressing.
6. IRC : 27-1967 Tentative Specification for Bituminous Macadam (Base and Binder Course).
7. IRC : 29-1968 Tentative Specification for 4 cm (1½ in) Asphaltic Concrete Surface Course.
8. IRC : 47-1972 Tentative Specification for Built-up Spray Grout.
9. IRC Special Publication 11 Handbook of Quality Control for Construction of Roads and Runways (First Revision).
10. Ministry of Shipping & Transport (Roads Wing) Specification for Road and Bridge Works (First Revision).

9. TOOLS AND PLANT

9.1. A list of equipment that will be needed for various types of bituminous work is given in IRC : 72-1978 "Recommended Practice for use and upkeep of equipment, tools and appliances for bituminous pavement construction"

9.2. In addition, it may be necessary to have mobile units located at key places so that the repair work may be centralised and handled expeditiously. For this purpose, a truck wherein a small hand operated drum mixer, vibratory tamping equipment, and some small essential tools are provided, can be very useful.

10. ARRANGEMENTS FOR TRAFFIC

10.1. Since maintenance operations involve considerable hardship, inconvenience and hazard to traffic and also hazards to maintenance workmen, all possible precautions should be taken to make safe arrangements for traffic. These include erection of barriers, signs, red flags and lights. Efforts should be made to confine work in half the pavement width at a time, leaving the other half

for use by the traffic. Where this is not possible, diversion roads may have to be constructed or the traffic diverted to some other alternative routes. The maintenance operation itself can be conveniently confined to a small length at a time, say 30 m.

10.2. The appropriate warning sign to be used is the "Man at work" sign, vide Code of Practice for Road Signs (IRC: 67-1977). If half the road width alone is available for traffic, the "Narrow Road Ahead" sign should also be displayed. During night, there should be adequate lighting with a red lantern/red reflectors.

11. ORGANISATION AND MANAGEMENT

11.1 Maintenance of a road requires proper supervision of skilled workmen who are adequately trained in various aspects of maintenance. The supervisory staff, generally known as Road Inspectors in this country are, therefore, to be given training in various aspects of bituminous work. They should be conversant with the specifications for various types of repair works, the choice of binder for different types of repair work, the quality control measures needed to achieve good workmanship, use and upkeep of equipment and tools and safety measures to be adopted during the maintenance operations.

11.2. Routine maintenance work in this country is generally carried out through gang labour. For National Highways and State Highways, it is customary to base the optimum requirement of labour at a rate of 0.3 gangman per km in the case of single-lane road and 0.45 gangman per km in case of two lane road. A group of 5-6 gangmen is supervised by a mate. In order to optimise the output of the labour employed and to ensure that the job carried out are at locations fixed by the supervisory officer, partial mechanisation of the maintenance operations is quite necessary. The system of making an individual gang responsible for a particular section of the road should be adopted and these gangs should be made mobile with the provision of a mechanical transport (truck/pick-up vans for longer beats, and tricycles for shorter beats) provided with necessary tools and equipment (see clause 9.2. of the Code).

11.3. Maintenance of bituminous pavement is a skilled operation. The labour engaged for this job should be properly trained. Such trained labourers should move about in the mechanical transport carrying essential tools, implements and materials while the premix material could be prepared and stored

at a central location. This would ensure required mobility of the labour force and result in timely and proper completion of repair works.

11.4. The headquarters of one or more mobile gangs should be fixed at a convenient location on the road where the necessary store-sheds for tools, plants and implements and for premix and other materials should be available together with a rest-shed. Preferably, these locations should be connected with the headquarters of the Assistant Engineer/Executive Engineer either by means of a public telephone or a departmental telephone line so that in case of emergency, serious accidents on the road, dislocation of traffic due to flooding, damage to structures etc., immediate contact could be established with the concerned officer for initiating the remedial measures and giving necessary publicity to the road user.

11.5. Planning and scheduling of the maintenance operations should be given due importance. The annual renewal programme should be drawn up well in advance keeping in view the condition of the surface, prescribed renewal cycle and any improvement work carried out recently or scheduled to be taken up in the near future. It is useful for easy comprehension to depict the renewal programme on a bar chart indicating the renewals carried out in the last eight years. The budgetting for maintenance expenditure should also be done well in advance and the allocation of resources to the different operations of maintenance should be finalised simultaneously. This would facilitate the field engineer to plan and implement his programme effectively.

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