# DIRECTORATE GENERAL BORDER ROADS

# TECHNICAL INSTRUCTION NO 2
# (REVISION – 2022)

# MAINTENANCE OF ROADS IN BRO

अजय भट्ट
**AJAY BHATT**

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

रक्षा एवं
पर्यटन राज्य मंत्री
भारत सरकार
Minister of State for
Defence and Tourism
Government of India

## MESSAGE

The revised DGBR Technical Instructions are unique as they combine technical content and codes with practical advice on practice of specific subjects. These Technical Instructions have definite data/content which explicitly bring out tools, process and methodology to be followed for various road construction and infrastructure development associated activities.

The literature is a repository of technical and ground experience amassed by the BRO, working over six decades in inhospitable terrain with harsh climatic conditions as well as latest technical advancements in the field of road communication infrastructure development. I personally find these technical instructors informative, exhaustive and practical in approach. These will mitigate the need for ground executers to refer various books/codes where working on various aspects of road construction and will go a long way in assisting the coming generations of BRO executives.

Jai Hind !

Ajay Bhatt

***(Ajay Bhatt)***

Dated : 20 Dec, 2021

New Delhi

डा. अजय कुमार
रक्षा सचिव
**Dr. Ajay Kumar**
**Defence Secretary**

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

भारत सरकार
रक्षा मंत्रालय
Government of India
Ministry of Defence

## FOREWORD

1. I am pleased to note that the Border Roads Organisation (BRO) has revised its twenty seven Technical Instruction, after a gap of 10 years having updated technical content and IRC codes. These Technical Instructions will positively prove to be very useful and ready reckoner for the BRO ground executives while steering them towards the correct methodology and processes to be followed for diverse road construction and associated activities.

2. Since the past six decades, BRO has been developing road infrastructure in the remote regions of the nation. It has contributed immensely in nation building and ushered in prosperity and development in the border areas. A robust mechanism to channelize the road construction activities is an essential planning process and therefore, the revised Technical Instructions will facilitate in dissemination and application of engineering knowledge with updated codes and provisions, to enable the executives to construct roads with the latest specifications as laid down by IRC.

3. I congratulate Team BRO for their stupendous efforts put in for revision of the twenty seven Technical Instructions which will further strengthen their technical proficiency.

(Ajay Kumar)

New Delhi,

March 3, 2022.

श्रमेण सर्वम साध्यम्

**ले. जनरल राजीव चौधरी,** वी एस एम
महानिदेशक सीमा सड़क एवं कर्नल कमांडेंट
सीमा सड़क संगठन

**Lt Gen Rajeev Chaudhry**, VSM
Director General Border Roads &
Colonel Commandant
Border Roads Organisation

# FOREWORD

1. DGBR Technical Instruction Number 2 (Revision 2022) lays down the procedure and guidelines for Maintenance of Roads by BRO.

2. The Technical Instruction Number 2 has now been updated and revised incorporating the current standards and specifications laid down by Ministry of Road Transport & Highways (MoRT&H) and Indian Road Congress (IRC). The specific requirements of roads under BRO, have also been considered while formulating the Technical Instruction.

3. Proper maintenance of roads is of utmost importance not only for preservation of assets but also for their optimal utilization and traffic safety. The guidelines contained in this Technical Instruction will achieve these objectives with better user satisfaction.

4. This Technical Instruction will come into force with immediate effect.

Station: New Delhi

Dated: Mar 2022

(**Rajeev Chaudhry**)
Lt Gen
Director General Border Roads

# INDEX

# TECHNICAL INSTRUCTION NO 2

# MAINTENANCE OF ROADS IN BRO

## 1. INTRODUCTION

1.1 Construction of roads involves substantial investment and therefore proper maintenance is of paramount importance. The road user cost, comfort and safety are influenced to a large extent by its state of maintenance.

1.2 The Indian Roads Congress defines road maintenance as routine work performed to upkeep pavement shoulders and other facilities provided for road users, as nearly as possible in their constructed conditions under normal conditions of traffic and forces of nature. Maintenance is essential to get optimum service from the pavement structure during its life period.

1.3 These Technical Instructions deal with the procedure to be followed for maintenance of all roads in BRO including National Highways in plains, deserts, hills and high altitude areas. The timely upkeep and maintenance of bituminous surfacing offers numerous benefits for preservation of road asset. As described below:

(a) Reduction in rate of deterioration and improvement in life of road.

(b) Reduction in Vehicle Operation Costs (VOC).

(c) Reduction in rate of accidents.

(d) Keeping roads traffic worthy in all weathers.

(e) Reduction in pollution due to reduced fuel consumption on well maintained pavement surface.

(f) Savings in budgetary expenditure of restoration/reconstruction.

(g) Sustain social and economic benefits of improved road.

1.4 The timely and regular maintenance of roads have been known to provide economic/rate of return as high as 15 to 20 percent depending upon the category of road and traffic volume. Moreover, it helps in deferring the demand for rehabilitation which otherwise is far more costlier than preventive maintenance. Therefore, timely and appropriate maintenance of bituminous surface using sustainable/suitable materials and methods is significant for preservation of road asset and to serve the intended purpose. It is important to make a clear distinction between maintenance and repair works. Effective maintenance is taken well before major damages to road take place.

## 2. CLASSIFICATION OF MAINTENANCE

Maintenance of roads is classified as under:-

2.1 **Regular/Routine Maintenance**. It consists of repairs to road surface including repair of pot holes, clearance of slides to keep the road open for traffic, repairs to drainage works to allow free passage of water, repair of shoulder, side slopes and repair of protective works etc. The expenditure on account of regular maintenance works is to be met out of the allotment of annual maintenance grant for the road.

2.2 **Preventive Maintenance**. The preventive maintenance is performed to improve or extent the functional life of pavement surface while in good condition. It depends on traffic level, type of pavement, geographical and weather condition. This may defer the need of periodical maintenance and rehabilitation.

2.3 **Special Repairs**. This includes restoration of damages to road formation, pavement and protective/drainage works, clearance of heavy slides which cannot be done under normal maintenance, preventive/control measures for landslides etc. Special repairs are undertaken after obtaining necessary sanction.

2.4 **Emergent Repairs**. This includes works undertaken to restore to line of communication disrupted by natural calamities and to prevent further loss/damage to public property. These works are taken up under the provisions of Para 560 of BR Regulations in anticipation of sanction.

2.5 **Renewal of Surfacing**. This is done periodically based on the guidelines issued on life cycle and specifications for renewal of surface course. Separate funds are allotted for this purpose based on life cycle and physical condition of the wearing course.

2.6 Maintenance activities are also done based on where works are carried out: -

2.6.1 On Carriageway repair relates road pavement for smooth riding quality of road, free from any disturbance with proper camber & cross fall for proper surface drainage.

2.6.2 Off Carriageway repair, consist of maintaining shoulders and drains, road signs pavement marking, side slopes, removal of debris, clearing CD structures, cutting bushes. In addition, minor repairs of drainage and other structures in the road side areas. This is part of routine maintenance.

## 3. INSPECTION OF ROAD

3.1 Frequent inspection of the road is essential of identify defects and their causes, determine priorities and take appropriate remedial measures. For this purpose, a Road Inspection Register will be maintained in all Road Maintenance Platoons/Functional platoons entrusted with the Task of Road maintenance. A specimen proforma of this register is given in Table 3.1.

**Table – 3.1: Road Inspection Register**

| Sr No. | Name of Road Section | Date of Inspection | Defects notified and suggested repairs | Sig. of Inspecting officer | Action taken with due | Sig. of PI Cdr/ Supvr I/C |
|---|---|---|---|---|---|---|
| | | | | | | |

3.2 **Periodicity**. The periodicity of inspection will be as under:-

(a) By Platoon Commander – Twice a week.

(b) By Officer Commanding RCC – Twice a month.

(c) By Task Force Commander – Once a month.

3.2.1 While the inspection by various officers may be more frequent wherever required, it should not be less than those specified above. The best time to inspect a road is during the rains/thawing of snow.

3.3 **Check list for Inspection**. A list of important points to be seen during inspection is given in Table 3.2.

**Table - 3.2: Check List of Points to be Examined During Inspection for Maintenance as per TI on the Subject**

| Sr. No. | Items | Points to be examined |
|---|---|---|
| (a) | Safety | Safety at slides/blockage/breaches/deep cuts damages to culvert or bridge; horizontal and vertical clearances in respect of power lines, roadsides trees. |

| Sr No. | Items | Points to be examined |
|---|---|---|
| (b) | Land slide/ Unstable Areas/ Sinking Area/ Avalanche zones | Behavior, effectiveness of control measures already done, likely problems and additional measures required including subsurface drainage system, etc. |
| (c) | Snow fall/ Damages | Advance action required for snow clearance, repair of snow structures, additional requirements. |
| (d) | Pavement | Magnitude and location of potholes, undulations, pavement failures etc. alongwith their causes; camber/cross fall and super elevation. |
| (e) | Shoulders & embankment | Width and crossfall, side slopes, erosion, need for turfing or other protective measures. |
| (f) | Toe Erosion | Where the road alignment follows the course of river, especially in hilly terrain, erosion of the hill slope below the road formation will affect the stability of the road. Control measures required. |
| (g) | Drainage | (i) Adequacy of cross-section, blockage, damage or siltation, bed slopes, need for lining & increase in section etc.<br>(ii) Condition of catch-water/road-side drains, scuppers etc. need for new drains/increase in section of existing drains. |
| (h) | Road furniture | Whether these are there, correctly located, need cleaning/re-painting etc. |
| (j) | Protection Works | The condition of retaining/breast walls, parapet walls, drains, chutes, pitching on slopes etc. |
| (k) | Road Trees | Numbering the trees, disposal of dead trees, etc. |
| (l) | Road Geometrics | Horizontal and vertical alignment, sight distance at curves and intersections. |
| (m) | Roadside Construction Material | Whether aggregates and bitumen are stacked properly; whether these obstruct safe traffic operation; whether the stacks are safe from inundations or washing away during the rains. |

| Sr No. | Items | Points to be examined |
|---|---|---|
| (n) | Encroachments | Encroachments, if any, and action taken for their removal. |
| (o) | Bridges | Bearings, drainage spouts, general cleanliness, cleaning of joints, condition of wearing coat, handrail and approach slab etc. |
| (p) | Culverts | Conditions of abutments slabs and approach |
| (q) | Bailey bridges/ bailey suspension bridges | Bearings, suspenders, cable profile, wooden cleats, decking, anchor blocks, scour near abutment/pier foundation, etc. |
| (r) | User comfort | Design speed and safety |

## 4. PLANNING OF MAINTENANCE ACTIVITIES

4.1 The planning and programming of the various maintenance activities should be done in advance keeping in view the climatic conditions and resources available. A calendar showing the various activities involved is given in Table 4.1, which should be maintained at all Road Maintenance Functional platoons.

**Table-4.1: Annual Calendar of Road Maintenance Activities**

| Sr No. | Item of Work | Planned for | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| (a) | Repairs of road berms including Jungle clearance. | | | | | | | | | | | | |
| (b) | Repairs to side drains/catch water Drains/culverts etc. | | | | | | | | | | | | |
| (c) | Collection of patch repair material for WBM roads. | | | | | | | | | | | | |
| (d) | Collection of patch repair material for B/T roads | | | | | | | | | | | | |
| (e) | Patch repair works for WBM roads. | | | | | | | | | | | | |
| (f) | Patch repair works for B/T roads. | | | | | | | | | | | | |

| Sr No. | Item of Work | Planned for | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| (g) | Repairs to sign and caution boards. | | | | | | | | | | | | |
| (h) | Painting of km. stones, Road markings and white washing of parapet walls | | | | | | | | | | | | |
| (j) | Maintenance of T&P. | All round the year | | | | | | | | | | | |
| (k) | Removal of encroachment. | All round the year | | | | | | | | | | | |
| (l) | Clearance of slides. | Immediately on occurrence | | | | | | | | | | | |

The programming of the various activities should be indicated in this calendar by the RCC/RMP/functional platoons, depending upon terrain & availability of materials.

4.2 All types of pavement maintenance need a comprehensive maintenance program. Following guidelines are to be considered in planning of routine, preventive and periodic maintenance activities.

4.2.1 Pavement condition survey may be undertaken by visual assessment to evaluate existing condition of pavement and structural capacity. The rating of pavement may be arranged as per criteria given on table 4.2 to 4.4 for different categories of roads.

4.2.2 Apart from visual survey, functional evaluation survey based on riding quality should also form basis for maintenance for roads. Skid resistance is an important parameter to enhanced safety of road commutes specially in wet weather condition. Lower skid number is more hazardous & need immediate corrective action. Table 4.5 & 4.6 indicates the level of serviceably to be considered in conjunction of distress given in table 4.2 to 4.4.

4.2.3 Site staff shall have details of physical condition, location of slips, slides and defects can be undertaken under routine maintenance. However for preventative and periodic maintenance, condition survey twice a year to be carried out i.e before and after monsoon. The condition survey is carried out either by a vehicle travelling a speed of 5 Km/ Hr or by walking on critical locations. The details of distress/ defects to be recorded kilometer wise by an experienced engineer. Further, type of maintenance be decided upon condition rating as given on table 4.2 to 4.4 & 4.5 & 4.6. The plan of the various maintenance operation should be correlated and to be taken up as a total system rather than taking each activity in isolation.

4.2.4 Based on the ground data obtained from physical condition survey a plan for maintenance activity to be drawn for routine, periodic, emergent and special repair of the road and to be recorded properly at RCC level. Further follow up action for deployment of manpower material and resources in an efficient manner to be taken up to ensure optimum use of resources and optional output and quality is achieved.

**Table 4.2: Pavement Distress Based Rating for Highways**

| **Defects (type)** | **Range of Distress** | | |
|---|---|---|---|
| Cracking(%) | >10 | 5to 10 | <5 |
| Raveling(%) | >10 | 1to10 | <1 |
| Potholes(%) | >1 | 0.1to1 | <0.1 |
| Shoving(%) | >1 | 0.1to1 | <0.1 |
| Patching(%) | >10 | 1to10 | <1 |
| Settlement and Depression (%) | >5 | 1to5 | <1 |
| Rut depth (mm) using 3 m straight edge | >10 | 5to 10 | <5 |
| Rating | 1 | 1.1- 2 | 2.1 –3 |
| Condition | Poor | Fair | Good |

Note: The various distress/defects types as mentioned above to be observed visually as described in Appendix-1 and to be noted in a standard format as given in Proforma1.

**Table 4.3: Pavement Distress Based Rating for MDR(s) and Rural Roads (ODR and VR)**

| **Defects (type)** | **Range of Distress** | | |
|---|---|---|---|
| Cracking (%) | > 20 | 10-20 | <10 |
| Raveling (%) | > 20 | 10-20 | <10 |
| Potholes (%) | > 1 | 0.5to1 | <0.5 |
| Patching (%) | > 20 | 5-20 | <5 |
| Settlement and Depression (%) | > 5 | 2to5 | <2 |
| Rating | 1 | 1.1- 2 | 2.1 –3 |
| **Condition** | **Poor** | **Fair** | **Good** |

**Table 4.4: Pavement Distress Based Rating for Urban Roads**

| **Serviceability Indicators** | **Level 1 (Good)** | **Level 2 (Fair)** | **Level 3 (Poor)** |
|---|---|---|---|
| Roughness (Max permissible) | 1800 mm/km | 2400 mm/km | 3200 mm/km |
| Skid Resistance (Skid Number, SN by ASTM-274) Minimum Desirable | 60 SN | 50 SN | 40 SN |

**Table 4.5: Serviceability Indicators for Highways**

| **Defects (type)** | **Range of Distress** | | |
|---|---|---|---|
| Cracking(%) | > 15 | 5-15 | <5 |
| Raveling(%) | >10 | 5 to 10 | <5 |
| Potholes(%) | >0.5 | >0 and <0.5 | NIL(0) |
| Settlement (%) | >05 | 1-5 | <1 |
| Rut depth (mm) using 3 m straight edge | >10 | 5-10 | <5 |
| Rating | 1 | 1.1-2 | 2.1 –3 |
| **Condition** | **Poor** | **Fair** | **Good** |

**Table 4.6: Serviceability Indicators for Urban Roads**

| **Serviceability Indicators** | **Level 1 (Good)** | **Level 2 (Fair)** | **Level 3 (Poor)** |
|---|---|---|---|
| Roughness (Max permissible) | 1800 mm/km | 2600 mm/km | 3400 mm/km |
| Skid Resistance (Skid Number, SN by ASTM-274) Minimum Desirable | 65 SN | 55 SN | 45 SN |

*Note: Level 1 is expected to match with new pavement condition, level 2 is the in-service minimum desirable level and level 3 is the warrant for intervention to restore the pavement condition to level 1.*

## 5. SYSTEM APPROACH TO PAVEMENT MAINTENANCE

5.1 Pavement Maintenance Management System (PMMS) is a technical or operational methodology for managing or directing and controlling maintenance resources, in a scientific manner, for optimum benefits. It is a complex problem of matching of resources, time, materials, labour, equipment, funds, design and above all decision making. A major objective of PMMS is to assist the highway engineer in making consistent and cost effective decisions related to the construction, maintenance and rehabilitation of pavements.

5.2 The Pavement Maintenance Management System performs the following functions:-

(a) Identify projects in need of Maintenance & Repairs (M&R) and to establish priorities.

(b) Identification of the type of maintenance and/or rehabilitation required.

(c) Requirement of type and timing of future M&R.

(d) To minimize life-cycle costs or maximize benefits.

(e) To predict performance of pavement in future.

5.3 The prime purpose of maintenance phase in a Pavement Management System is to determine the cost associated with providing various level-of-serviceability for any given pavement. This is an important feedback to planning, design and construction. The type and degree of maintenance can also influence the rate and serviceability loss for a pavement. It is clear that maintenance management requires careful planning and implementation, efficient reporting of maintenance practices and problems. Hence, maintenance management is primarily managing the resources to provide an agreed level-of-service.

## 6. TYPES OF PAVEMENT DISTRESS, IDENTIFICATION, SYMPTOMS, LOCATION, CAUSES, SEVERITY LEVELS AND TREATMENT

6.1 General. The types of defects in bituminous surfacing are grouped under following categories.

(a) **Surface Defects**. These include fatty surface, smooth surface, streaking, and hungry surface.

(b) **Cracks**. These include all types of cracks, viz, hair-line cracks, alligator cracks, longitudinal cracks, edge cracks, shrinkage cracks, reflection cracks etc.

(c) **Deformation**. These include rutting, corrugations, shoving including those caused by layer slippage, shallow depressions, settlements, upheavals etc.

(d) **Disintegration**. These include stripping, loss of aggregates, raveling, potholes, edge breaking etc.

The location and severity of distress are important to select appropriate maintenance treatments, materials and technique.

6.2 **Surface Defects**. These are confined to surfacing and may be due to inappropriate quality and quantity of bitumen.

6.2.1 **Bleeding of Fatty Surface**

6.2.1.1 **Symptoms.** A surface having a thin film of excess or free bituminous binder on it, which creates a shiny, glass like reflecting surface tending to become soft in hot weather and slippery in cold and wet weather, eventually developing low skid resistance is referred to as bleeding or fatty bituminous surface.

6.2.1.2 **Location.** Generally, such defects develop along the wheel path but sometimes these are restricted to isolated locations and specific lanes. Many a time, these defects are seen on the entire carriageway.

6.2.1.3 **Causes.** Bleeding occurs in hot weather, when the bituminous binder after filling the available voids in compacted bituminous layer moves upward under traffic movement and collects as a thick film on the surface. The process is not reversible during cold weather, leading to permanent accumulation of binder on the surface with passage of time making the surface fatty, slippery and skid prone. This can be caused by one or combination of the following factors:

(a) Excessive binder in hot mix due to faulty mix design or lapses in quality control.

(b) Lower voids in hot mix.

(c) Use of softer grade binder.

(d) Too heavy tack coat or prime coat.

(e) Loss of cover aggregates in surface dressing.

(f) Excessive application of binder or non-uniform spreading of cover aggregate or flaky/elongated cover aggregate in surface dressing.

6.2.1.4 **Severity levels.** A fatty surface may have different degree of severity depending upon reasons thereof. The severity of fatty surface and bleeding may be classified as low, medium and extensive. The isolated spots measuring less than 5 $m^2$ area in a lane km and restricted to only specific lane with total area less than 1% may be considered as bleeding/ fatty surface of low severity. Sometimes bleeding/fatty surface is confined to entire lane along with wheel path. In case the area is in the range of 1 to 5%, it may be treated as fatty surface/ bleeding of medium severity. Extensive bleeding and fatty surface showing initiation of shoving shall be treated as fatty surface of "High Severity". Photos 6.2.1, (a, b, c) indicate low, medium and high severity level of bleeding and fatty surface respectively.

(a) Low severity (b) Medium severity (c) High severity

**Photo 6.2.1 Bleeding**

6.2.1.5 **Treatment**

(a) **Low Severity**. Minor bleeding/low severity fatty surface can be corrected by applying heated coarse sand (passing 1.18 mm sieve) to blot up excess bitumen in affected area followed by light rolling.

(b) **Medium Severity**. Medium severity bleeding and fatty surface may be corrected by application of pre-coated chips; Passing 4.75 mm and retained over 1.18 mm using 1% bitumen and generally applied in a single layer followed by light rolling. In case the layer of bleeding is less than 1 mm, treatment described for low severity would be sufficient.

(c) **High Severity**. The affected portion shall be milled out and repaired with mix of desired quality. The milled material i.e. Recycled Asphalt Pavement (RAP) mixed with fresh aggregates may be laid followed by application of slurry seal/ microsurfacing treatment. An open-graded premix carpet with low bitumen content can also be applied to absorb the excess binder. In the case of large areas of fatty surface, having irregularities, removal of the affected layer and replacing it with a layer of properly designed mix, may be necessary.

6.2.2 **Smooth Surface**

6.2.2.1 **Symptoms.** A smooth surface has a low skid resistance and becomes very slippery when it is wet. Such a condition invites safety hazards, especially on gradients, bends and intersections, Photo 6.2.2 indicates a smooth surface.

**Photo 6.2.2 A View of Smooth Surface**

6.2.2.2 **Location.** Smooth surface may be restricted to a lane/carriageway.

6.2.2.3 **Causes.** A primary cause for a smooth surface is the polishing of aggregates under traffic. Excessive binder can also contribute to formation of smooth surface.

6.2.2.4 **Severity Levels.** The severity level of smooth surface may be defined by skid number. A surface with skid number in the range of 30 to 40 indicates low severity smooth surface while skid number below 30 indicates high severity smooth surface.

6.2.2.5 **Treatment.** The rectification consists of resurfacing with a surface dressing course or a premix carpet or microsurfacing depending upon the

type of existing surface. Care should be taken to select 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 skid texture on a smooth surface.

6.2.3 **Streaking**

6.2.3.1 **Symptoms**. Streaking is characterized by the appearance of alternate lean and heavy lines of bitumen either in longitudinal direction or a transverse direction. Photo 6.2.3 shows streaking.

**Photo 6.2.3 Streaking of Bituminous Pavement**

6.2.3.2 **Location.** Streaking may occur in a lane or a carriageway.

6.2.3.3 **Cause.** Longitudinal streaking results when alternate longitudinal strips of surface contain differ quantities of bitumen due to non-uniform application of bitumen across the surface. Some the more common causes of streaking are mechanical faults, improper or poor adjust and operation of bitumen distributors. These streaks can also be formed as a result applying the bituminous binder at too low temperature; a temperature at which bitumen not fluid enough to be delivered in a uniform and smooth flow from the nozzles on the spray bars. All these causes can result in transverse streaking also. Transverse streaking may be caused by spurts in the bitumen spray from the distribution spray bar. These could be a result of mechanical faults in the bitumen distributor. Transverse streaking may result corrugation in the pavement surface.

6.2.3.4 **Treatment.** The satisfactory repair for longitudinal and transverse streaking is to remove the streak surface and apply a new surface. It is always desirable to prevent longitudinal and transverse streaking than to

correct it. Whenever mechanical equipment is used for spraying of bitumen distributor should be carefully operated.

6.2.4 **Hungry Surface**

6.2.4.1 **Symptoms.** Hungry surface is characterized by the loss of fine aggregates from the surface or appearance of dry surface with fine cracks; Photos 6.2.4 indicate a dry and hungry surface.

**Photo 6.2.4 View of Dry and Hungry Surface**

6.2.4.2 **Location**. Hungry surface may be in full lane or carriageway.

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

6.2.4.4 **Treatment.** Fog seal / liquid rejuvenating materials may be used for correction of dry and hungry surface. Slurry seal or microsurfacing may also be used as a repair measure, when applied in an average thickness of 2-4 mm.

6.3 **Cracks.**

6.3.1 **General.** Cracking of bituminous surfacing is a common distress seen on majority of roads in India (with the passage of time). Cracks in bituminous surface are classified into various types depending upon severity. Immediate attention must be given for sealing of cracks, and prevention of their further widening as ingress of water through cracks is detrimental to pavement structure and performance of bituminous surfacing.

6.3.2 **Hairline Cracks.**

6.3.2.1 **Symptoms.** Hairline cracks are present in narrow area and their width is less than one mm (Photo 6.3.1). Hairline cracks are generally isolated and normally these are not interconnected. These appear as short and fine cracks at close intervals on the surface. Many a time, such cracks can disappear in hot summer.

**Photo 6.3.1 Hairline Cracks**

6.3.2.2 **Location.** These cracks may be at isolated places or in a lane/ carriageway.

6.3.2.3 **Causes.** These cracks develop due to either insufficient bitumen content, excessive filler, improper compaction, oxidation of bitumen in surface or sometimes excessive moisture in granular. layers. These may occur due to rolling of mix while it is still tender or due to excess compaction.

6.3.2.4 **Treatment.** These cracks may be treated by fog seal, application of liquid rejuvenating agents, slurry sealing and microsurfacing.

6.3.3 **Alligator and Map Cracking**

6.3.3.1 **Symptoms.** Alligator or map cracking is characterized as a series of interconnected cracks, having small irregular blocks in pavement surface which resemble the skin of an alligator. These cracks may be of different types depending upon extent and severity. The size of irregular shape blocks of cracks vary from less than 30 cm to more.

6.3.3.2 **Location.** Alligator or map cracks normally appear along the wheel path.

6.3.3.3 **Causes.** The causes of alligator cracking are many. These are developed due to one or more of the following reasons.

(a) Excessive deflection of pavement surface normally in wheel paths.

(b) Inadequate pavement thickness.

(c) Weakening of sub-grade or lower layers of the pavement due to ingress of excessive moisture to pavement and saturation.

(d) Overloading of heavy commercial vehicles.

(e) Brittleness of binder due to ageing of binder and lowering of surface temperature due to weather conditions.

(f) Stripping of underlying bituminous courses.

6.3.3.4 **Severity Level.** Alligator cracking may be classified as low severity, medium severity and high severity. (Photos 6.3.3-a.b.c.)

(a) **Low Severity**. Low severity cracks are characterized by an area of cracking with very narrow cracks with almost no additional deterioration of the surface. The cracking is often isolated and many times, the cracking may not be interconnected to other areas and there is not much distortion. The depth and width of such cracks is in the range of 1 to 3 mm.

(b) **Medium Severity**. Medium severity-cracking is characterized by interconnected cracks forming a small area similar to the skin of an alligator. The cracks may have signs of slight spalling, with no pumping visible. The depth and width of such cracks lies between 3 to 6 mm.

(c) **High Severity**. High Severity alligator cracking is characterized by an area of moderate to severely spalled interconnected cracks creating a full pattern of cracking similar to the skin of an alligator. The width and depth in this case may be more than 6 mm. Pieces of bituminous surface may be loose or missing. The pumping of water and fine material below the pavement may be seen on the surface.


**Photo 6.3.3 Alligator Cracks**

6.3.3.5 **Treatment.** In order to repair a pavement affected by alligator cracking, the main cause of the cracking should be determined. However, often the specific cause is fairly deep seated. Any investigation should involve digging a pit or coring the pavement to determine the pavements structural adequacy/ability as well as determining whether or not subsurface moisture is a contributing factor. The repair needed is also based on the severity and extent of cracking. Treatment of alligator cracking may be done by following the methods depending upon their severity.

(a) Crack sealing by bitumen emulsions.
(b) Crack sealing by rubberized and modified.
(c) Bitumen Milling and surface recycling.

In case of a pavement being structurally inadequate or weak, a properly designed overlay based on evaluation shall be provided.

6.3.4 **Longitudinal Cracking**

6.3.4.1 **Symptoms.** Cracks that appear parallel to the centerline or along the road are called longitudinal cracks. These cracks are also sometimes source of onset of alligator cracking.

*a) Low severity* *b) Medium severity* *c) High severity*

**Photo 6.3.4 Longitudinal Cracking**

6.3.4.2 **Location.** These cracks may appear at joints between two paving lanes or between pavement and Paved shoulders.

6.3.4.3 **Causes.** Longitudinal cracks in bituminous pavement are usually caused by alternate wetting and drying beneath the shoulder surface or by improper/weak joint between adjoining layers of pavement.

6.3.4.4 **Severity Level.** Severity of longitudinal cracks may be defined as low, medium and high. (Photos 6.3.4: a, b and c). The low severity is assigned to 1-3 mm wide and infrequent cracks medium severity is assigned to 3-6 mm wide. High Severity is assigned to cracks greater than 6 mm wide and are frequent (numerous).

6.3.4.5 **Treatment.** Treatment for longitudinal cracks depend upon the severity and extent of the cracking :

(a) **Low and medium Severity Cracks**. Crack sealing, preferably using rubberised bitumen.

(b) **High Severity Cracks**. Remove and replace the cracked pavement layer with fresh overlay.

6.3.5 **Transverse Cracks**

6.3.5.1 **Symptoms.** These cracks appear in the transverse directions or as interconnected cracks forming series of large blocks perpendicular to the direction of the road.

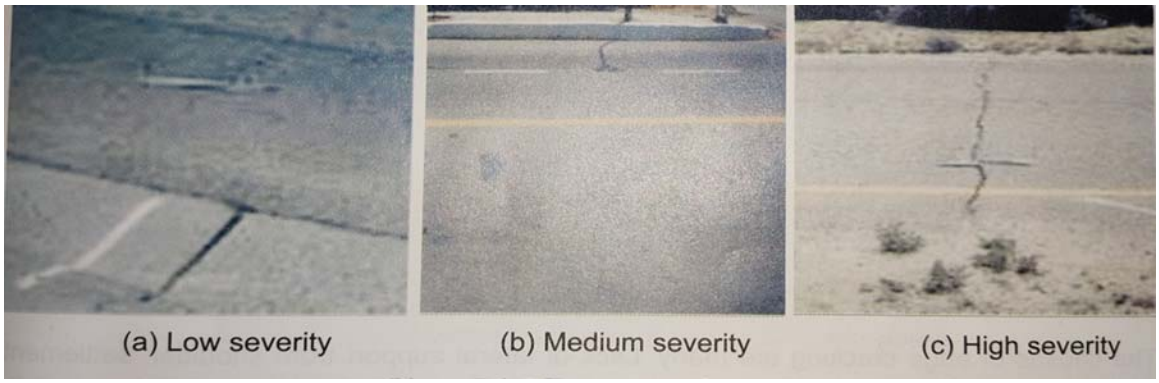


**Photo 6.3.5 Transverse Cracks**

6.3.5.2 **Location.** Transverse cracks may occur at isolated locations or in a lane/ carriageway.

6.3.5.3 **Causes.** Transverse cracking may occur due to reflection of crack

or joint in an underlying pavement layer. The low temperature brittleness or oxidation of bitumen and also structural failure at concrete base course are also causes of such cracking. Transverse cracks are usually formed due to shrinkage of bituminous mix on account of low temperature.

6.3.5.4 **Severity Level.** Severity of transverse cracks may be defined as low, medium and high (Photos 6.3.5: a, b and c). The low severity is assigned to 1-3 mm wide and infrequent cracks. Medium severity is assigned to 3-6 mm wide cracks. High Severity is assigned to cracks greater than 6mm wide and are frequent (numerous).

6.3.5.5 **Treatment.** Transverse cracks may be treated using slurry seal or rubberised bitumen.

6.3.6 **Edge Cracking**

6.3.6.1 **Symptoms.** Edge cracking is defined as cracks which develop parallel to outer edge of the pavement.

6.3.6.2 **Location.** The location of edge cracking is normally 0.3 to 0.5 m inside of pavement edge.


**Photo 6.3.6 Severity level of Transverse Cracks**

6.3.6.3 **Causes.** The causes of edge cracking are many. Lack of lateral support from shoulder, settlement underlying the bituminous layers, inadequate surface drainage, shrinkage in sub-grade soil, inadequate pavement width near curves, inferior quality material in shoulders and thinner bituminous surface at edge of the pavement and wet sub-grade are some of the reasons for edge cracking.

6.3.6.4 **Severity Level.** The severity levels of edge cracks are low, medium and high (Photos 6.3.6 a, b and c). Low severity is with no breakup or loss of material, medium severity is with some breakup and loss of material

(upto 10% of the affected length) while high severity is with considerable breakup and loss of material (more than 10% of the affected length).

6.3.6.5 **Treatment**. The following procedure techniques are used for prevention or treatment of edge cracking:

(a) Promote good drainage along the edge of the road. Make sure that surface water will run to the nearby drain and not pond along the pavement edge.

(b) Remove the dirty, poor draining shoulder material and replace it with a more permeable material.

(c) If truck traffic is substantial, place a considerably thick structural overlay on the road surface of the order of 75-100 mm of hot mix to provide adequate support for heavier vehicle loads.

6.3.7 **Reflection Cracking**

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

**Photo 6.3.7 Reflection Cracking**

6.3.7.2 **Location.** Reflection cracking occurs most frequently in bituminous overlays on cement concrete pavements, or on cement soil bases. They may also occur in overlays or surfacing on flexible pavements where cracks in the old existing pavement have not been properly rectified Another condition under which reflection cracks can occur is when a pavement is

widened The location of the cracks will then be exactly on the junction between the old pavement and the widened portion. Reflection cracks may allow water to enter the underlying pavement and the sub grade and cause further damage to pavement.

6.3.7.3 **Causes.** Differential movement across the underlying crack or joint is responsible for development of reflection cracking. For joint reflection cracking, this is movement of the cement concrete slab beneath the bituminous surface because of the thermal and moisture changes.

6.3.7.4 **Severity Levels.** Not applicable.

6.3.7.5 **Treatment**

6.3.7.5.1 The treatment, for all types of cracks discussed above would depend on whether the pavement is structurally sound, or has become distorted or unsound. In case the pavement is 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. Rubberised bitumen meeting the requirements of ASTM D 5078 may also be used. 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 of the binder.

6.3.7.5.2 If the cracks are wide enough, a slurry seal or sand bituminous premix patching can be used to seal the cracks. If the cracks are fine and extend over large areas, a light cut-back or an emulsified bitumen (fog seal) can be broomed into the cracks and lightly sanded to prevent the picking up of the binder by the traffic. Stress Absorbing Membrane (SAM) or Stress Absorbing Membrane Interlayer (SAMI) may be used to seal reflection cracking and prevention of occurrence.

6.4 **Deformation**. Deformation may be restricted to one or more layers of bituminous courses or may extend to entire pavement and sub-grade. A change in the original shape of the pavement surface is known as deformation. It may be reflected in the form of slippage, rutting, corrugation shoving, shallow depression and settlement.

6.4.1 **Slippage**

6.4.1.1 **Symptoms.** Slippage is the relative movement between the wearing

course and the layer beneath the bituminous surface. 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 of the traffic. 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.


**Photo 6.4.1 Slippage of the Bituminous Wearing Coat**

6.4.1.2 **Location.** Slippage of bituminous surface normally occurs along the wheel path of heavy vehicles.

6.4.1.3 **Causes.** Slippage is causes by unusual thrust of wheels in a specific direction due to omission or inadequacy of have coat, lack of bond between the wearing coat and the lower layer caused by a layer of fine dust, moisture or both. Failure of bond between two layers due to excessive deflection of the pavement may also be responsible for slippage of wearing coat or successive layer.

6.4.1.4 **Severity Level.** Slippage may be classified as low severity and high severity slippage (Photos 6.4.1 : a and b). In case, slippage is at isolated locations in a lane, it is classified as low severity slippage. In case, slippage is along the wheel path in the entire lane or carriageway, it is classified as high severity slippage.

6.4.1.5 **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 applying a tack coat.

6.4.2 **Rutting**

6.4.2.1 **Symptoms.** Rutting is longitudinal depression or groove in the pavement along the wheel path. Rutting is categorized into three types

and defined by the cause and layers in which rutting occurs, and it can be characterized by two components of the original (initial) pavement profile change which are direct consequences of permanent deformation such as uplift and downward deformation.

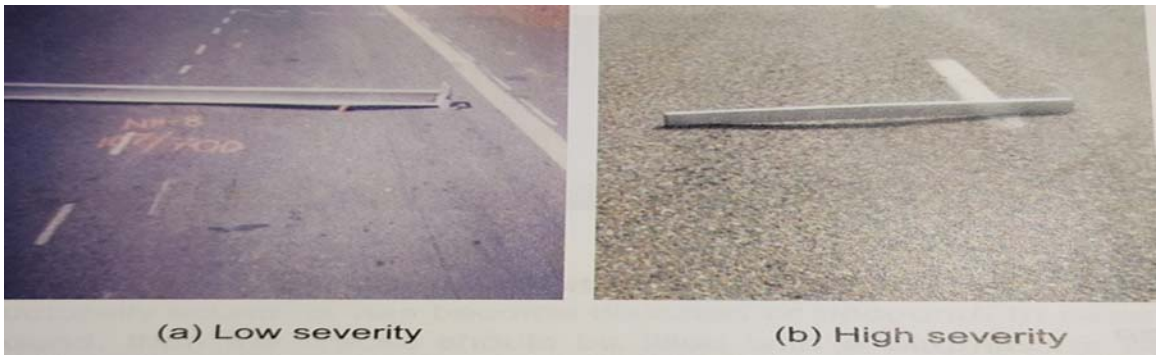


**Photo 6.4.2 Rutting in Bituminous Surface**

6.4.2.2 **Location.** Rutting generally appears along the wheel path.

6.4.2.3 **Causes.** The causes of rutting are the following:

(a) Heavy channelized traffic and overloading of vehicles.

(b) Inadequate compaction of the mix at the surface or in the underlying bituminous courses during construction.

(c) Improper mix design, lacking in stability to support the traffic.

(d) Weak pavement due to poor sub grade and inadequate design.

(e) Use of soft bitumen or waxy bitumen.

(f) Intrusion of sub grade clay into granular base course or use of plastic filler in GSB/WBM/WMM.

6.4.2.4 **Severity.** Rutting may be classified as low severity when 4-10 mm deep and high severity when more than 10 mm (Photos 6.4.2 a and b).

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

6.4.3 **Corrugation**

6.4.3.1 **Symptoms.** Corrugation is the formation of regular undulations (ripples) across the bituminous surface. These 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 sub-grade. The spacing of the waves is 2-3 m. The corrugations can be a source of discomfort during driving and can become a safety hazard if allowed to become severe. A view of corrugated surface is shown in Photo 6.4.3

**Photo 6.4.3 Corrugation of Bituminous Surface**

6.4.3.2 **Location.** Corrugations may occur near wheel path or in the entire lane or carriageway.

6.4.3.3 **Causes.** Corrugations occur due to the following reasons:

(a) Lack of stability in the mix (excessive binder, high proportion of fines, too round or too smooth textured coarse or fine aggregate, too soft binder).

(b) Oscillations set up by the vehicle springs can cause alternative valleys and ridges.

(c) Faulty laying of surface course.

(d) Insufficient rolling or rolling a tender mix.

(e) Braking action of vehicles on grade especially near intersections.

6.4.3.4 **Treatment.** If the surface is thin, the same is scarified; including some portions of the underlying 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 leveling 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 corrugation. The area is then thoroughly rolled.

6.4.4 **Shoving**

6.4.4.1 **Symptoms.** Shoving is a form of plastic movement within the bituminous layers resulting in bulging of the pavement surface. Photo 6.4.4 shown shoving of bituminous layers

**Photo 6.4.4 shoving of Bituminous Surface**

6.4.4.2 **Location.** Shoving occurs characteristically at points, where traffic starts and stops (intersections, bus- stops), on hills roads or where vehicles accelerate or brake on grades and on sharp curves. The first indication of shoving appears in the form of slippage cracks which are crescent shaped cracks, with the apex of the crack pointing in the direction of the shove. Photo 6.4.4 shows shoving of bituminous layers. Shoving occurs near the wheel path.

6.4.4.3 **Causes**

(a) Lack of stability in the mix (excessive binder, high proportion of fines, soft binder) in the bituminous surface or base course.

(b) Lack of bond between bituminous surface and underlying layer.

(c) Heavy traffic movement involving negotiation of curves and gradients.

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

6.4.5 **Shallow Depression**

6.4.5.1 **Symptoms.** Shallow depressions are isolated low areas of limited size, dipping about 25 mm or more below the Profile, where water will normally become stagnant. The shallow depressions may or may not be eventually accompanied by cracking of surface. These may also lead to further deterioration of the surface and cause discomfort and unsafe surface to traffic. A view of shallow depression is shown in Photo 6.4.5.

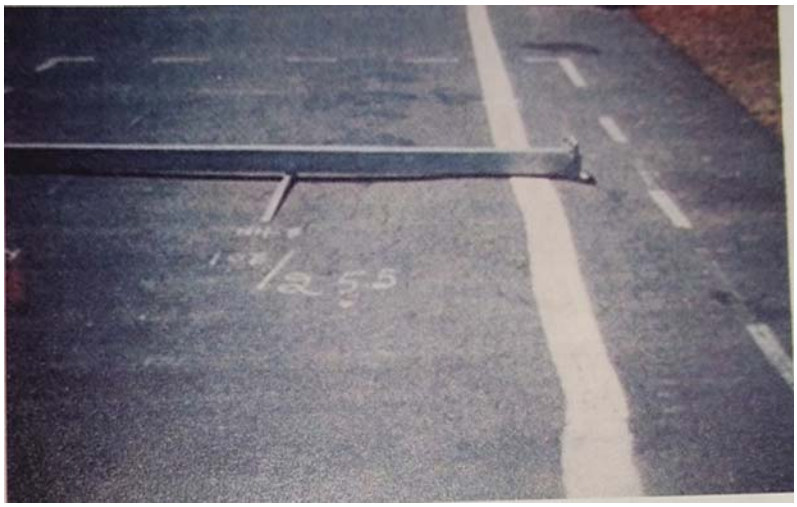

**Photo 6.4.5 Shallow Depression in Bituminous Surface**

6.4.5.2 **Location.** Shallow depressions are generally restricted to wheel path/heavy traffic lanes.

6.4.5.3 **Causes.** Shallow depressions are caused by isolated settlement of lower pavement layers due to pockets of inadequately compacted sub grade or subsequent pavement layers.

6.4.5.5 **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.

6.4.6 **Settlements and Upheaval**

6.4.6.1 **Symptoms.** Settlements and upheavals are characterized by relatively large deformations of the pavement compared to shallow depressions. These are dangerous to traffic and cause reduction in speed of traffic. These are generally followed by extensive cracks over the pavement surface in the affected region. Settlements and upheavals are shown in Photo 6.4.6 and 6.4.7, respectively.

**Photo 6.4.6 Settlement in Bituminous Surfacing**

**Photo 6.4.7 Upheaval in Bituminous Surfacing**

6.4.6.2 **Location.** Settlement may be along the wheel path or at isolated locations in a lane or carriageway.

6.4.6.3 **Causes.** The following are the causes for settlements and upheavals in bituminous pavements:

(a) Inadequate compaction of the fill at locations behind bridge abutment, over utility cuts, etc.

(b) Excessive moisture in sub-grade and permeable layer of sub-base and base caused by capillary action or poor drainage.

(c) Inadequate pavement thickness.

6.4.6.4 **Treatment.** If settlements and upheavals indicate any 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.

6.5 **Disintegration**. There are some defects which, if not rectified immediately, result in the disintegration of the pavement into small and, loose fragments. Disintegration, if not arrested in the early stages, may necessitate complete reconstruction of the pavement.

6.5.1 **Stripping.**

6.5.1.1 **Symptoms.** This defect is characterized by the separation of bitumen film from the surfaces of the aggregate particles, due to the presence of moisture. This may lead to loss of bond between bitumen and aggregate and subsequently to loss of cohesion in mixture. A view of stripped aggregate surface is shown in Photo 6.5.1

**Photo 6.5.1 Stripping of Bituminous Surface**

6.5.1. **Location.** Stripping is either localized or extended to lane or the entire carriageway.

6.5.1.3 **Causes.** Stripping may be caused by the following reasons:-

(a) Use of hydrophilic aggregates.

(b) Inadequate mix composition.

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

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

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

(f) Occurrence of rain or dust storm immediately after construction.

(g) Higher concentration of salt in soil and rain water.

(h) Use of improper grade of bitumen.

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

6.5.1.4 **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. Rejuvenating sealants, slurry seal or microsurfacing can be used to treat stripped surface.

6.5.2 **Raveling.**

6.5.2.1 **Symptoms.** Raveling is defined as progressive separation and dissociation of fine aggregate particles and binder from the bituminous surface. Normally, fine aggregates wear away first followed by coarse aggregates. The raveling process generally starts from the surface downward or from the edge inward. Pavement surface is led to rough and jagged appearance after occurrence of raveling. Raveling differs from fretting that it involves plucking out of surface aggregate by traffic without loss of cohesion.

6.5.2.2 **Location.** Raveling may occur on any part of a lane or carriageway.

6.5.2.3 **Causes.** Raveling is likely to occur on a surface due to one or more of the following reasons:

(a) Inadequate bitumen content in a mix.

(b) Overheating of bitumen during mixing process.

(c) Inadequate compaction during construction.

(d) Stripping of bitumen from aggregates due to water at interface.

(e) Construction during cold and wet weather.

(f) Use of inferior quality aggregates prone to fracture, crushing and opening of new faces.

(g) Use of absorptive aggregates.

(h) Excessive ageing of binder.

(j) Lack of performance related contract specifications.

(k) Improper filler/bitumen ratio.

(l) High intensity hydrostatic pressure due to combined effects of traffic and water.

(m) Development of inclement weather (moisture, freezing) immediately after construction.

(n) Traffic stresses exceed breaking strength of mix.

6.5.2.4 **Severity Level.** Raveling may be classified into three severity levels, viz., low severity, medium severity and high severity (Photos 6.5.2.: a, b and c). Low severity is when some loss of fines is associated with initial stage of binder wearing out, medium is when loose particles exists with some loss having binder wearing out to a rough surface and high severity is when surface is too rough with loss of aggregates.

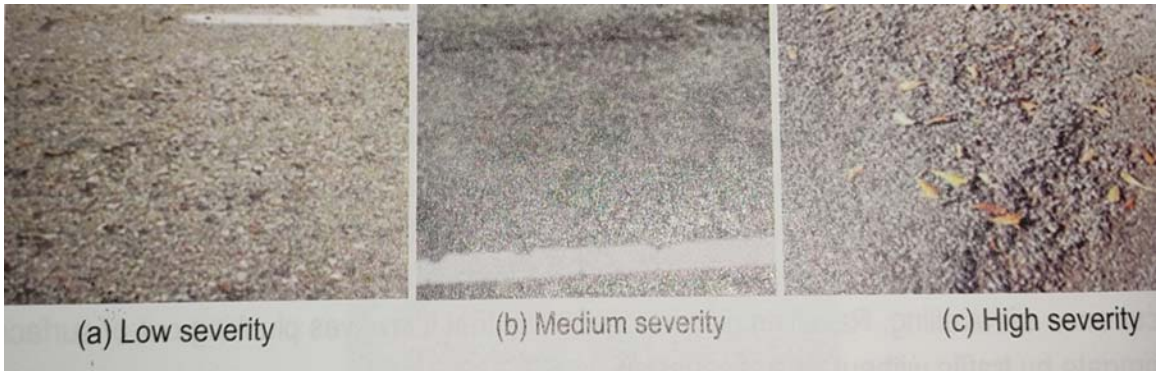


**Photo 6.5.2 View of Raveling**

6.5.2.5 **Treatment.** The treatment of raveled surface shall depend upon severity of raveling.

(a) **Low Severity Raveling**. The low severity raveling may be corrected by application of fog seal, sand seal, seal coat, slurry seal or microsurfacing

(b) **Medium Severity Raveling**. This may be corrected by application of seal coat, slurry seal or microsurfacing treatment in affected area

(c) **High Severity Raveling**. Depending upon the condition of raveled surface and specification of existing surface, the high severity raveling may be corrected by single or multiple applications of liquid seal coat, slurry seal, microsurfacing and surfacing of thin overlay of appropriate mix specification like mix seal surfacing or open graded premix carpet.

6.5.3 **Potholes**

6.5.3.1 **Symptoms.** Potholes are bowl shaped cavities of varying sizes in a bituminous surface or extending into the binder/ base course, caused by localized disintegration of material.

6.5.3.2 **Location.** Potholes may occur in any part of road surface.

6.5.3.3 **Causes.** The most common cause of pothole formation is loss of adhesion in bituminous wearing coat due to the ingress of water into the pavement or due to higher voids in surface. The pavement gets softened as a result of loss of cohesion, and under the action of traffic. The formation of pothole is aggravated due to use of plastic filler in granular base. If not attended to in time and properly, aggregates in the surface get progressively loosened to result in a pothole. Lack of proper bond between the bituminous surfacing and the underlying water bound macadam base layer can also cause formation of potholes. Insufficient bitumen content in localized areas of the surfacing layer can also cause formation of potholes. A thin bituminous surface, which is unable to withstand the heavy traffic, can also cause formation of pot-holes, when associated with improper or inadequate camber. In dense-graded mixtures, pot-holes can be caused by too much fines or too few fines.

6.5.3.4 **Severity.** Potholes may be classified as small, medium and large (Photos 6.5.3 : a, b and c). A small pothole is defined as 25 mm deep and 200 mm wide. The medium pothole is defined as 25 to 50 mm deep and 500 mm wide. The large potholes are those greater than 50 mm deep and 500 mm width.

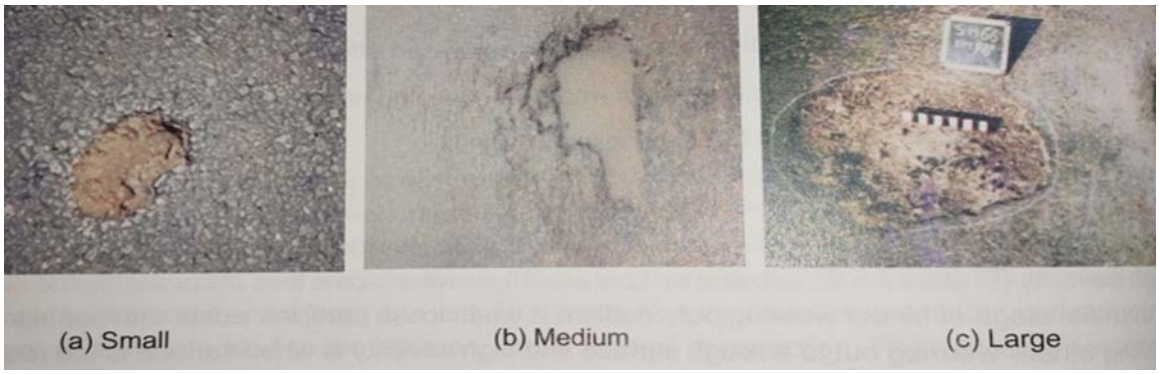


**Photo 6.5.3 Potholes of Different Severity**

6.5.3.5 **Treatment.** The rectification consists of filling pot-holes with open graded or dense graded premix. Potholes can be repaired by various methods

(a) Mixes (cold mixed/hot mixed) for immediate use.

(b) Storable cold mixer.

(c) Readymade mixes.

(d) Cold mixes by patching machines.

6.5.4 **Edge-Breaking**

6.5.4.1 **Symptoms.** A common defect in bituminous surface is edge breaking wherein the edge of the bituminous surface gets broken in an irregular way. Photo 6.5.4 shows this type of defect. In case distress in not attended to in time, the surfacing may peel off in chunks at the edges.

**Photo 6.5.4 Edge Break-up**

6.5.4.2 **Location.** Distress is restricted to edges upto 30 cm from the edge.

6.5.4.3 **Causes.** The following are the causes for edge breaking:-

(a) Infiltration of water which make the foundation layers weak causing the pavement edges to break.

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

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

(d) Lower layer of pavement being wider than upper layers.

(e) Too narrow width.

6.5.4.5 **Treatment.** The shoulder and the pavement materials in the affected area should be fully 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 to 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 was for some width to protect the edges. Surface and subsurface drainage, wherever deficient, should be improved.

## 7. WARRANTS FOR PREVENTIVE MAINTENANCE

7.1 The description and warrants for preventive maintenance treatments are given in Tables 7.1 to 7.4

**Table 7.1: Crack Filling or Crack Sealing**

| Crack Filling or Crack Sealing | Warrant | | | |
|---|---|---|---|---|
| | **Climate** | **Traffic** | **Addressed** | **Limitations** |
| These treatments are intended primarily of moisture through existing cracks. Crack sealing refers to a sealing operation that addressed "working cracks, i.e., those that open and close with changes in temperature. It typically implies high quality materials and good preparation. Crack filling is for | Treatment can perform well in all climatic conditions | Performance is not significantly affected by varying traffic | • Longitudinal cracking<br>• Minor block cracking<br>• Transverse cracking<br>• No structural benefits,<br>• Acceptable if the extent of cracking is minimal (little to no structural cracking) | • Structural failure (i.e., extensive fatigue cracking or high severity rutting)<br>• Extensive pavement deterioration little remaining life |

| Crack Filling or Crack Sealing | Warrant | | | |
|---|---|---|---|---|
| | Climate | Traffic | Addressed | Limitations |
| cracks that undergo little movement. Sealants used are typically elastomers modified bituminous materials that soften upon heating and harden upon cooling | | | | |
| Site Restrictions | None | | | |
| Construction Considerations | Placement should be done during warm and dry weather conditions. Proper crack cleaning is essential to achieve a good bond and maximum performance. | | | |

**Table 7.2: Surface Dressing**

| Crack Filling or Crack Sealing | Warrant | | | |
|---|---|---|---|---|
| | Climate | Traffic | Conditions Addressed | Limitation |
| Bitumen emulsion is applied directly to the pavement surface (1.2 to 1.7 kg/m$^2$) followed by the application of aggregate chips (0.004 to 0.015 cum/m$^2$ which are then immediately rolled to embed chips. Application rates depend upon aggregate | Treatment performance will in all climatic conditions | With proper design and placement, chip seals can perform well on high-volume roads.<br>However, use is primarily limited to lower- | • Longitudinal and transverse<br>• Raveling/ weathering (loose material must be removed)<br>• Bleeding<br>• Friction loss<br>• Roughness<br>• Friction loss | • Structural failure (i.e., extensive fatigue cracking)<br>• Extensive pavement deterioration, little remaining life<br>• Thermal cracking |

| Crack Filling or Crack Sealing | Warrant | | | |
|---|---|---|---|---|
| | Climate | Traffic | Conditions Addressed | Limitation |
| gradation and maximum size. Treatment seals pavement surface and improves friction. | | speed, lower volume roads because of the propensity for loose chips to crack windshields. | • Moisture infiltration<br>• Adds limited structural capacity.<br>However, effective at sealing fatigue cracks in comparison with other treatments | • Extensive pavement deterioration, little or no remaining life<br>• Can accelerate the development of stripping in susceptible bituminous pavements |
| Site Restrictions | High-speed, high-volume roadways are often avoided, although a number of approaches are being used to extend the applicability of these treatments. | | | |

**Table 7.3: Thin Hot-Mix/Cold ix Bituminous Overlays**

| Description | Warrant | | | |
|---|---|---|---|---|
| | Climate | Traffic | Conditions Addressed | Limitation |
| Plant-mixed combinations of asphalt cement and aggregate applied to the pavement in Thicknesses between about 15 and 25 mm Dense-graded, open-graded, premix and stone matrix mixes are used | Treatment performance will in all climatic conditions | Performance should not be affected by different traffic condition. Thin overlays are not structural layers and as such should not be | • Functional/ Other<br>• Longitudinal and transverse<br>• Raveling/ weathering (loose material must be removed)<br>• Bleeding | • Structural failure (i.e., extensive fatigue cracking)<br>• Extensive pavement deterioration, little remaining life<br>• Thermal cracking |

| Description | Warrant | | | |
|---|---|---|---|---|
| | **Climate** | **Traffic** | **Conditions Addressed** | **Limitation** |
| | | subjected to strain from loadings. Such layers may be subject to top down cracking under certain combinations of loadings, environmental conditions, and pavement structures. | • Friction loss<br>• Roughness<br>• Block cracking may perform better with additional milling)<br>**Structural**<br>Rutting (assumes rutting has stopped; requires use of separate rut-fill application | |
| Site Restrictions | High-speed, high-volume roadways are often avoided, although a number of approaches are being used to extend the applicability of these treatments. | | | |
| Construction Considerations | Surface must be clean. Treatment should be placed during warm weather with chip spreader immediately behind asphalt distributor and rollers close behind the spreader. Approximately 2 hours required before roadway may be re-opened to normal speed traffic. Brushing is usually required to remove loose chips. | | | |

**Table 7.4: Ultrathin Friction Courses**

| Description | Warrant | | | |
|---|---|---|---|---|
| | **Climate** | **Traffic** | **Conditions Addressed** | **Limitation** |
| Relatively new treatment and consists of a gap-graded, polymer modified 10 to 20 mm layer placed on a tack coat formed by the application of a heavy, polymer-modified bitumen emulsion. Treatment effectively addresses minor surface distresses and increases surface friction. | Treatment performance will in all climatic conditions | Capable of with standing high ADT volumes and truck traffic better than other thin treatments | • Longitudinal and transverse and block cracking. Higher severities can be addressed with cold milling<br>• Raveling/ weathering (loose material must be removed)<br>• Bleeding<br>• Friction loss<br>• Roughness<br>• Provides some increased capacity and retards fatigue cracking. Not suited for rutted pavements. | • Structural failure (i.e., significant fatigue cracking and/or deep rutting)<br>• Extensive pavement deterioration, little remaining life<br>• Thermal cracking |
| Site Restrictions | Ultrathin overlays should only be placed on structurally sound pavements. Localized structural problems should be repaired prior to overlay application. | | | |
| Construction Considerations | Requires special paving equipment to place the mix. | | | |

## 8. PERIODIC RENEWALS

8.1 **Need and importance of Periodic Renewals.** Periodic renewals consist of the provision of a surfacing layer at regular intervals of time or at a specified condition, so as to preserve the required serviceability level of the pavement surface and offset the wear and tear caused by traffic and weathering. Periodic renewals represent the maintenance, which is needed to prevent deterioration of the pavement 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 distress/defects can prevent a major damage of the surface.

8.2 **Planning and Programming of Renewals.** The general practice in the country is to finalize renewal programme on an annual basis. The renewal programme for each section of a road should be decided well in advance. Once the programme is finalized, steps could be taken to secure the required allocations and start the preliminary field action such as mobilization of resources. While the nomenclature "Periodic Renewal" would imply the renewal treatment to be carried out at a fixed and pre decided frequency, it would neither be practicable nor desirable to follow implicitly of 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 periodic inspections of the road surface at suitable intervals in order to assess its condition and needs for providing renewal treatment. Visual inspection and actual measurements, if required (Appendix 1 and 2) of the roads as detailed in Section 5 should be carried out manually or through automated machine (Appendix 3). In addition, special inspections are also necessary before and after the rains so as to assess the need for pothole repair and patching and other remedial measures required to be carried out either in advance or together with the renewal treatment.

8.3 **Identification of Stretches to be Renewed.** The stretches of the road showing signs of distress such as hungry surface/hair-line cracking, Raveling 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 stretches of the road which would be due for periodic renewal on the basis of the pavement condition index and 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, the nature of distress/failure seen on the road is severe and of

considerable extent and the causes are deep-seated; and where it is considered that the pavement cannot be improved with renewal treatment, detailed investigations shall be carried out and special measures shall be taken for correcting same.

8.4 **Types of Renewal Treatments.**

8.4.1 The types of bituminous surfaces those can be adopted are surface dressing (one or two coats), thin premix carpet, mixed seal, stone matrix asphalt, hot/cold mix semi- dense and dense bituminous concrete. Microsurfacing in one layer or two layers can also be used for renewals. These surface nave different life spans depending upon traffic and environmental conditions.

8.4.2 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. Following standards/ specifications may be referred for periodic renewals:-

(a) IRC:14-2004 "Recommended Practice for Open Graded Premix Carpet".

(b) IRC:107-2013 "Specifications for Bitumen Mastic Wearing Courses".

(c) IRC:110-2005 "Standard Specifications and code of Practice for Design and Construction of Surface Dressing".

(d) IRC:111-2009 "Specifications for Dense Graded Bituminous Mixes".

(e) IRC:SP:78-2008 "Specifications for Mix Seal Surfacing (MSS), Close Graded Premix Surfacing (CGPS)".

(f) IRC:SP:79-2008 "Tentative Specifications for Stone Matrix Asphalt".

(g) IRC:SP:81-2008 "Tentative Specifications for Slurry Seal and Microsurfacing".

8.4.3 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 bituminous concrete surface would have to be bituminous concrete.

8.5 **Periodicity of Renewal.** Based on the experience and condition of pavement broad guidelines for the type of renewals are given in Table 8.1. This may be utilized as a guide for working out annual renewal programme on different sections of roads.

**Table 8.1: Suggested Renewal Treatment on Flexible Pavement**

| Road Category | Condition Rating* | Roughness, mm/km | Suggested Treatment** (Thickness, mm) |
|---|---|---|---|
| NH | 2 | 2400 | 30-40 BC |
| SH | 2 | 2800 | 30 BC/30 SDBC |
| MDR/RR | 2-1 | 4000 | SD/PC/MSS/SDBC(20-25) |
| Urban Road | 2 | 2600 | 30-40 BC/SDBC/<br>2 Coat Microsurfacing |

* When the condition of road is rated as 1, it is recommended that a detailed investigation is carried out to assess the strengthening requirement, if any. In case, the pavement is found to be structurally adequate, then the periodic renewal will suffice.

** Wherever feasible, recycling of wearing course may be preferred.

8.6 **Rectification of Profile at the Time of Renewal.** The camber and super elevation 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 profile correction course/leveling course, which may be compatible with existing surface specification.

## 9. MATERIALS AND METHODS FOR RECTIFICATION OF DISTRESS ON BITUMINOUS SURFACE

### 9.1 General

9.1.1 The Section 6 has dealt with the identification of the distress, measurement of distressed area, types of defects and their causes, and the maintenance measures to be taken up in each case. This Section describes various materials required for maintenance methods, which are applicable to “Routine, Preventive and Periodic Maintenance”. Routine maintenance is covered in Section 7. Preventive type of maintenance activities are covered in Section 8. Maintenance operations of periodic nature are described in Section 9. Repair materials and methods discussed

in this Section fall under three categories:

(a) Rejuvenation.

(b) Seal and.

(c) Patching.

9.1.2 Rejuvenation of oxidized and hungry bituminous surface can be done by application of liquid bituminous materials. The seal coat is a thin application of bitumen, which shall be covered with fine aggregate/ sand. Seal coat may be premixed material or a spray application. Patching is an application of premixed bituminous mixture. Patching is done to fill pot-holes, correct shallow depressions, rutting and correct edge irregularities.

## 9.2 Bituminous Materials

9.2.1 **Paving Bitumen.** Paving Bitumen conforming to IS:73:2012 is recommended for road maintenance works, unless otherwise specified. Paving bitumen is classified into four grades based on viscosity, viz. VG-10, VG-20, VG-30 and VG-40.

9.2.2 **Cut-back Bitumen.** Cut-back bitumen of different grades are required for cold weather construction as well as maintenance under all-weather conditions. Medium curing cut-back bitumen MC-800 conforming to IS: 217 is recommended for preparation of storable bituminous pothole/ patching mix.

9.2.3 **Bitumen Emulsion.** Bitumen emulsion is a two-phase system consisting of bitumen, water and one or more additives to assist in formation and stabilization and to modify the properties of the emulsion. The bitumen is dispersed throughout the water phase in the form of discrete globules, typically km 1.0 to 25 km in diameter, which are held in suspension by electrostatic charges stabilized by an emulsifier. Bitumen emulsions conforming to IS: 8887 are recommended for various maintenance applications including preparation of cold mixes and patching mixes.

9.2.4 **Foam Bitumen.** Foaming of bitumen is a means of reducing the binder viscosity and increasing the binder volume. Foam bitumen is produced in an expansion chamber in which cold water, between 1 and 5% by weight of bitumen, is injected under pressure into hot bitumen to produce foam. Expansion ratio and half life are two important properties

of foam bitumen. The expansion ratio is defined as the ratio of the volume of foam produced to the volume of liquid bitumen injected. The life time of foam is expressed as the 'half-life, defined as the time after which the maximum volume of foam is reduced by a factor of two. It is measured in seconds. The foam bitumen is used for stabilization of recycled asphalt pavement.

9.2.5 **Modified Bitumen.** Modified bitumen is the binder whose properties have been modified by the use of polymers and rubbers. IRC:SP:53-2010 and IS:15462 specify different grades of modified bitumen for construction and maintenance of bituminous roads.

9.2.6 **Modified Emulsions.** Modified emulsions are defined as bitumen emulsions whose aqueous phase is generally modified by latex of the rubber. Sometimes, bitumen is also modified before emulsification. These emulsions are used for microsurfacing applications. The specification of modified emulsion for microsurfacing is given in IRC:SP:81-2008.

9.2.7 **Rejuvenating Agents/Sealants.** Rejuvenating agents are used for restoration of physico - chemical properties of oxidized bitumen of dry and hungry surface or oxidized bitumen in recycled asphalt pavement. Sometimes, these rejuvenating agents are used as sealants. The viscosity value of these rejuvenating agents lies between 100-300 seconds at 60°C by Say bolt Fural viscometer.

9.2.8 **Anti-Stripping Agents.** Anti-stripping agents are organic surf act ants which are used to prevent stripping of bitumen from aggregate and to improve adhesion between wet aggregate and bitumen. Specifications of anti-stripping agent are given in IS:14982.

9.2.9 **Warm Mix Additives.** A warm mix asphalt technology utilizes chemical additives that have little effect on theological properties of the binder. These additives reduce mixing, laying and compaction temperature of bituminous mixes. The guidelines for warm mix asphalt are given in IRC:SP:101-2019.

## 9.3 Maintenance Techniques

### 9.3.1 Rejuvenating Seal

9.3.1.1 Rejuvenating seals are applications of thin layer of liquid bituminous material such as low viscosity grade bitumen like VG-10, cut-back bitumen, bitumen emulsion or bituminous sealants (Rejuvenating

Agents). A number of proprietary rejuvenating agents are also available. This process comprises application of a liquid bitumen material with or without cover aggregate of fine grading. The application of cover aggregate may be required or may not be required.

9.3.1.2 Rejuvenator shall be used as a maintenance measure under the following conditions.

(a) The area to be treated needs to be in air to good condition and not approaching the end of its life.

(b) When the road surface is in a condition which does not show significant cracking, raveling or rutting.

(c) Where the road is structurally adequate i.e. major patching or reconstruction is not required.

9.3.1.3 Rejuvenation functions by introducing an extremely resilient membrane on the top layer of surface course. Such membranes are impervious to water and the chemicals used to de-icing and as such it prevents their ingress which would normally cause further deterioration of the binder. It also halts the loss caused through oxidization of maltenes present in the bitumen, which are necessary for flexibility of bituminous layer. The viscosity of such binders shall be in the range of 100-300 seconds at 50° C when measured by Say bolt furol viscometer. Bitumen to be used for such treatment shall be of VG-10 grade confirming to IS:73. Cut-back bitumen may also be suitable. If emulsion is to be used, it should be of the Rapid Setting type (RS-I) or slow setting (SS-2) grade. The quantity of binder for such treatment shall be as follows:

**Table 9.1: Rejuvenation Seal**

| **Binder** | **Quantity** |
|---|---|
| Rejuvenator | 0.4 to 0.6 kg/m$^2$ |
| Emulsion* | 0.8 to 1.2 kg/m$^2$ |
| VG-10 Bitumen* | 0.5 to 1.0 kg/m$^2$ |
| Cut - back Bitumen* | 0.75 to 1.0 kg/m$^2$ |

* Either of the three, as required

9.3.1.4 The cover aggregates, if needed, shall be of a nominal size of 6.3 mm, viz. passing through 9.5 mm IS Sieve and retained on 2.36 mm IS sieve. The quantity of cover aggregates shall be 0.09 $m^3$ per 10 sq. m. area. The area to be treated shall be thoroughly cleaned. If viscosity grade or cut-back bitumen is to be used, the wet surface should be allowed to dry. However, if cationic bitumen emulsion is to be used, the surface may or may not be required to be wet or dry depending upon quality of emulsion. Some tailor-made emulsions may not require damping of surface. The binder shall be applied either by a spray nozzle or a pressure distributor. Cover aggregates are then spread at the specified rate and rolled in position with suitable steel wheel roller. When viscosity grade bitumen is used, the road can be opened to traffic on the following day. However, if the road is required to be opened immediately, a speed restriction of 10 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 2-3 hours.

9.3.2 **Fog Seal**

9.3.2.1 Fog seal is defined as "a light application of dilute (SS-2 or tailor made) bitumen emulsion which is used primarily to seal an existing bitumen surface to reduce raveling and enrich dry and weathered surfaces. Fog seal is a method of incorporation of bituminous binder to an existing Pavement to improve its waterproofing characteristics, prevent further stone loss by holding aggregate in place, rejuvenating surface and improving the surface appearance. However, its inappropriate use can result in a slick pavement. During application, bitumen emulsion wets the surface of the aggregate. Cationic emulsion can displace water from the surface of aggregate and existing binder film. The rate of breaking emulsion is dependent on several factors including weather conditions (e.g. wind, rain, temperature, etc.). Rejuvenating emulsion has oils which help in softening of the oxidized binder in existing surface, thus reducing its viscosity. This also improves the flexibility of the binder, which reduces the possibility of cohesive failure. This may be beneficial in situations where the surface has an open texture and the existing binder has become hard and brittle due to aging. As with conventional emulsions, if these do not penetrate the surface, they may create a surface prone to skidding after they break.

9.3.2.2 Properly calibrated truck mounted distributors shall be used to apply the emulsion. Spray nozzles with 4 to 5 mm openings are

recommended. The emulsion may be heated to maximum 30"C. although, the emulsion is generally sprayed at ambient temperature. The emulsion is sprayed at a rate that is dependent on the surface conditions. A test section representative of the entire surface should be chosen to decide application rate. The total quantity of emulsion in fog seal is normally from 0.5-1.0 I/$m^2$ of diluted SS emulsion (1:1 dilution). The surface condition or texture, dryness and degree of cracking of the pavement determine the quantity required. Excessive application of the fog seal must be avoided as this will result in pickup of bitumen by vehicles leading to a slippery surface. When excess emulsion is applied, a light application of fine sand on the affected area may be applied to prevent formation of sliding surface. The detail of fog seal applications, its benefits and limitation are given in IRC:SP:100-2014.

**Table 9.2: Fog Seal**

| **Description** | **Warrant** | | | |
|---|---|---|---|---|
| | **Climate** | **Traffic** | **Conditions Addressed** | **Limitation** |
| Fog seals are placed primarily to seal the pavement inhibit raveling rejuvenate hardened/ Oxidized bitumen surface, and provide some pavement edge-shoulder delineation. Fog seals are very light applications of a diluted bitumen emulsion | Treatment performance will in all climatic conditions | Increased traffic can increase surface wear | • Longitudinal<br>• Transverse, and block cracking<br>• Raveling/ weathering(loose material must be removed)<br>• Bitumen aging, oxidation and hardening<br>• No structural improvement, but can help reduce moisture infiltration | • Structural failure (such as significant fatigue cracking)<br>• Friction loss<br>• Thermal cracking |

| Description | Warrant | | | |
|---|---|---|---|---|
| | Climate | Traffic | Conditions Addressed | Limitation |
| placed directly on the pavement surface with no aggregate. Typical application rates range from 0.23 to 0.45 kg. per $m^2$ | | | through fatigue cracks (if their severity is low) | |
| Site Restrictions | Not appropriate for surfaces with poor skid resistance, as it will lower the skid resistance further. | | | |
| Construction Considerations | Typically, a slow-setting emulsion is used which requires time to "break", the pavement is sometimes closed for two hours for curing before being re-opened to traffic. | | | |

9.3.3 **Slurry Seal**

9.3.3.1 Slurry seal is a mixture of dense graded mineral aggregate, emulsified bitumen, filler, additive and water. The mixture is applied as surface treatment on the existing surface. Slurry seal can be used for both preventive and corrective maintenance needs. This treatment does not increase the structural strength of a pavement. A pavement which is structurally weak, should be repaired first before applying slurry seal. Ruts, humps, distressed pavement edges, crown deficiencies, or other surface irregularities that affect riding quality should be corrected before placing slurry seal, which is considered to be a very effective maintenance technique for the surfaces of older pavements. It will fill the surface cracks, stop raveling and loss of matrix, improve skid resistance, generally protect the pavement, reduce water and oxidative deterioration, and finally extend the overall pavement service life. Slurry seal has the following major advantages:-

(a) Rapid application and early open to traffic.

(b) Excellent surface texture and friction resistance.

(c) Ability to correct minor surface irregularities.

(d) Minimum loss of kerb height.

(e) No need for manhole and other structure adjustments.

(f) Excellent low-cost treatment for urban streets.

9.3.3.2 Slurry seal is applied in a very thin layer of 3 to 6 mm. The grade of emulsion to be used SS-2. The machine used for mixing and application is a self-contained, continuous-flow mixing unit which accurately delivers to the mixing chamber the pre-determined amount of aggregate, mineral filler, additive, water, and bitumen emulsion. Specifications for slurry seal are given in Table 9.3. The details of this treatment are given in IRC: SP:100-2014.

**Table 9.3: Slurry Seal**

| **Description** | **Warrant** | | | |
|---|---|---|---|---|
| | **Climate** | **Traffic** | **Conditions Addressed** | **Limitation** |
| A mixture of well- graded aggregate (fine sand and mineral filler) and bitumen emulsion that is spread over the entire pavement surface with either a squeegee or spreader box attached to the back of a truck.It is effective in sealing low-severity surface cracks, waterproofing the pavement surface, and | Treatment performance will in all climatic conditions | Performance in terms of surface wear is affected by increasing traffic. Accommodate the higher traffic volumes. | • Transverse, and block cracking<br>• Raveling/ weathering (loose material must be removed)<br>• Bitumen aging, oxidation and hardening<br>• Friction loss<br>• Moisture infiltration<br>• Adds no structural capacity; however, can temporarily seal cracks (if | • Structural failure (such as significant fatigue cracking and deep rutting)<br>• Thermal cracking |

| Description | Warrant | | | |
|---|---|---|---|---|
| | Climate | Traffic | Conditions Addressed | Limitation |
| improvingskid resistance at speeds below 60 km/hr. Thickness is generally less than 10 mm | | | severity is low) or serve as a rut-filler (if the ruts are not severe and are stable) | |
| Site Restrictions | Pavement is often closed for several hours to allow the emulsion to cure. | | | |
| Construction Considerations | Surface must be clean. Aggregates must be clean, angular, durable, well-graded, and uniform (prefer 100% crushed). Avoid placement in hot weather (potential flushing problems) and premature opening to traffic. Do not place when freezing temperatures are expected. | | | |

**Table 9.4: Specifications for Different Types of Slurry Seal Treatments**

| Items | Type I | Type II | Type III |
|---|---|---|---|
| Applications | For filling hair cracks on surface cracks less than1mm | For filling surface cracks (1-3 mm), and preventive/ renewal treatment (upto 450 CVPD) | For filling surface cracks (3-6 mm), and preventive/ renewal treatment (upto 1500 CVPD) |
| Quantity or Slurry ($kg/m^2$) | 4.3 to 6.5 | 8.4 to 9.8 | 10.1 to 12 |
| Residual binder (percent by weight of dry aggregate) | 10 to 16 | 4.5 to13.5 | 6.5 to 12 |

* By weight of dry aggregate only, **Indicative only, CVPD- Commercial Vehicles per day.

9.3.4 **Microsurfacing**

9.3.4.1 Microsurfacing shall consist of mixture of modified (Polymer or Rubber Latex) bitumen emulsion, well graded mineral aggregate, water, filler and additive (if needed) proportioned, mixed and uniformly spread over a properly prepared surface. The finally laid microsurfacing shall have a homogeneous mat, adhere firmly to the prepared surface and provide friction resistant surface texture throughout its service life. The mix is to be a quick setting system i.e. it should be able to receive traffic after 1-2 hours depending upon weather conditions. This may be used for a variety of purposes such as surface sealing treatment to improve skid resistance, and longevity/ of surfacing, durability and to seal fine and medium cracks. It is applied on an existing pavement surface which is structurally adequate but is showing signs of distress such as premature aging, aggregate loss, cracking, high degree of polishing etc. Generally, microsurfacing is laid in single layer, but when the existing surface is highly polished and/ or cracked, it is advisable to apply it in two or more layers. As a surface treatment, micro-surfacing imparts protection to the underlying pavement and provides renewed surface friction values. Special emulsifiers in micro-surfacing emulsions contribute to the quick setting characteristics. Minor re-profiling can be achieved with multiple applications. Special equipment permits the filling of wheel ruts up to 40 mm deep in one pass. The major benefits of microsurfacing are given as under:

(a) Quick application (One lane – km in 35 minutes).

(b) Minimum traffic hold up (Work is done in lane wise manner) Quick opening to traffic.

(c) Life span exceeds the life span of ordinary Bituminous Concrete.

(d) Non-polluting for environment since no heating or hot paving is required.

(e) Does not require sensor paver or compaction equipment.

(f) Longer life since oxidation is reduced.

(g) Waterproof Surface — Protection from rains.

(h) Ideal for surface sealing treatment since it improves skid resistance and provides surface durability.

(j) Does not increase pavement elevation significantly (This saves from water logging, drainage and other associated problems).

(k) Cost effective as compared to Hot-Mix.

(l) Reduces noise caused by movement of traffic.

(m) Environment friendly (reduced emissions) and savings in natural resources.

9.3.4.2 Microsurfacing helps in preservation of pavement strength and can be used both as a preventive maintenance treatment and/or periodic renewal treatment on low, medium or heavy traffic. It can be used for pavements in urban and rural areas, primary and inter-state routes, residential streets, highways, and toll roads. It can also be used on the top of single coat surface dressing (Cape Seal), on open graded premix carpet without seal coat and also on Dense Bituminous Macadam/Bituminous Macadam. Various types of microsurfacing that can be used for different applications; quantity of microsurfacing mix and the residual binder content in each type are presented in Table 9.5.

**Table 9.5: Microsurfacing**

| **Description** | **Warrant** | | | |
|---|---|---|---|---|
| | **Climate** | **Traffic** | **Conditions Addressed** | **Limitation** |
| Microsurfacing consists of a mixture of polymer-modified emulsified asphalt, mineral aggregate, mineral filler, water, and additives applied in a process similar to slurry seals. Used primarily to inhibit Raveling and oxidation of | Effective in all climate conditions. | Successful on both low-and high-traffic volume | • Longitudinal and transverse<br>• Raveling/ weathering (loose material must be removed)<br>• Bleeding<br>• Friction loss<br>• Roughness<br>• Friction loss<br>• Moisture infiltration<br>• Adds limited structural | • Structural failure (i.e., extensive fatigue cracking)<br>• Extensive pavement deterioration, little remaining life<br>• Thermal cracking<br>• Can accelerate |

| Description | Warrant | | | |
|---|---|---|---|---|
| | Climate | Traffic | Conditions Addressed | Limitation |
| the pavement surface. Also effective at improving surface friction and filling minor irregularities and wheel ruts (up to 40 mm | | | capacity Temporarily seals fatigue cracks (if severity is low) and can serve as a rut-filler (if the existing ruts are stable) | the development of stripping in susceptible bituminous pavements |
| Site Restrictions | None | | | |
| Construction Considerations | Avoid placement in hot weather if there is potential for flushing problems. Placement in cool weather can lead to early reveling, not to be placed when freezing temperatures are expected. | | | |

**Table 9.6: Different Types and Specifications for Microsurfacing**

| Items | Type II | Type III |
|---|---|---|
| Applications | For roads in urban and rural areas, residential streets, as preventive and renewal treatment (< 1500 CVPD) | For primary and inter-state routes, highways and runways to give maximum skid resistance, preventive and renewal treatment (1500 to 4500 CVPD) |
| Quantity* of Microsurfacing (kg/m*) | 8.4 to 10.8 | 11.1 to 16.3 |
| Residual binder (percent by weight of dry aggregate) | 6.5 to 10.5 | 5.5 to 10.5 |

*By weight of dry aggregate

9.3.4.3 Details of microsurfacing application are given in IRC:SP:81-2008 and IRC:SP:100-2014.

9.3.5 **Cape Seal.** Cape seal involves application of a slurry seal or micro-surfacing to a newly-constructed single coat surface dressing treatment. The slurry or microsurfacing application helps to fill the voids between the chips. Cape seals provide highly durable surface treatment. The slurry or microsurfacing bonds the chips to prevent loss of the chips due to traffic abrasion. For a successful cape seal, it is important to have single coat surface treatment with lower residual bitumen content than a traditional chip seal. The most critical element to avoid in a cape seal is an excess of slurry that eliminates the desired knobby surface texture. Curing time of four to ten days should be allowed between placement of the broomed surface after surface dressing and before application of slurry seal or microsurfacing to remove loose cover material or other foreign material that would prevent adherence. Table 9.7 gives quantities of bitumen emulsion and aggregates required to execute a cape seal. For surface dressing, RS-2 emulsion shall be used. For slurry seal, SS-2 grade emulsion shall be used. Polymer modified emulsion shall be used if microsurfacing is used as top layer.

**Table 9.7: Quantities of Bitumen Emulsion and Aggregate for Cape Seal**

| Thickness of Cape Seal | Nominal Size of Aggregate | Quantity of Aggregate (kg/m2) | Quantity of Emulsion (I/m2) | Slurry Mixture (Type 1), kg/m2 |
|---|---|---|---|---|
| 12.5 mm Thick | 9.5 to 2.36 mm | 14 - 16 | 1.4 - 2.0 | 2.7 - 4.5 |
| 19.0 mm Thick | 19.0 to 9.5 mm | 22 - 27 | 1.8 - 2.3 | 3.5 - 5.5 |

9.3.6 **Sand Bituminous Premix Patching.** Sand bitumen premix patching consists of laying a mixture of fine aggregate and bituminous binder to rectify cracks, slippage, corrugations, shoving, shallow depressions and raveling. 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 paving viscosity based bitumen or rapid curing cut - back such as RC-3, or a medium curing cut-back such as MC-3. The area is thoroughly cleaned and a tack coat with bitumen emulsion or VG-10 bitumen or cutback (RC-3 or MC-3) is applied

at the rate of 2.5 kg per 10.sq m 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 cum 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.

9.3.7 **Open – Graded Premix Patching.** Open – graded premix 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. The binder can be bitumen of suitable viscosity grade, rapid curing cut-back such as RC-3 or medium / slow setting or tailor-made bitumen emulsion. The details of materials and construction procedure are given in IRC:14-2004 and IRC:SP:100-2014.

9.3.8 **Maintenance Mixes**

9.3.8.1 Maintenance mixes are classified into four types:

(a) Mixes for Immediate Use.
(b) Storable Mixes.
(c) Maintenance Mixes using RAP.
(d) Ready Made Mixes.

9.3.8.2 **Maintenance Mixes for Immediate Use.** Such emulsion-aggregate mixes can be mixed in a pug mill or in a concrete mixer and transported to the site where these are to be used. The heating of the aggregate is normally not necessary. In cold weather conditions, warm aggregates and emulsions heated upto 75 $^0$C to 85 $^0$C can be used for better workability. Procedure for preparation of mix for immediate use and storable mixes is given in IRC:SP:100-2014. The bitumen emulsion recommended few patching mixes are MS, SS-2 grades or tailor-made. The recommended aggregate gradation is given in Table 9.8. Bitumen emulsion containing slightly higher amounts of solvent-generally produces the acceptable patching mixes for immediate use. The quantity of emulsion shall be 7 to 8% (4.5 to 5.5 % residual bitumen) by weight of aggregate.

**Table 9.8: Grading for Maintenance Mixes**

| Sieve Size (mm) | Percent Passing |
|---|---|
| 9.5 | 100 |
| 4.75 | 40-100 |
| 2.36 | 10-40 |
| 1.18 | 0-10 |
| 0.075 | 0-2 |

9.3.8.3 **Storable Maintenance Mixes.** During the cold weather and rainy moths, most of the maintenance mixes used are those which may be stored/ stockpiled, which can be produced in late summer or early months of winter, transported and stored in remote located for later use . Such mixes are usable for periods up to six months and are workable without the use of heat. These must be covered by polythene or tarpoline. The production of stockpile maintenance mix is simple and includes a pug mill type mixer. Slow setting (SS-2) grade or tailor made emulsion is to be used for this purpose. The aggregate gradation for stockpile mixes is same as given in Table 9.4. The duly mixed material shall be stored in a clean, covered area to prevent contamination and not stored in a low area or depression where water could get into the mix. For prolonged stockpiling and to be usable at lower temperatures, a high float medium setting emulsion is recommended. These mixes may contain residual bitumen in the range of 4.5 to 5.5% depending on gradation and surface characteristics of aggregates.

9.3.8.4 **Maintenance Mixes using RAP (MMRAP).** Many bituminous pavement overlay projects include cold milling of bituminous surface and produce large quantities of Reclaimed Asphalt Pavement (RAP). There are a number of uses for RAP in pavements application, and an increasing one is to use it as maintenance mix. It is recommended that, when possible, cold milling be used which produces RAP material in small pieces so that it would not require further crushing. Bitumen emulsion or foamed bitumen is usually incorporated to the RAP by plant mixing. Special emulsion formulations have been developed for preparing RAP containing maintenance mixes, since softening of the aged RAP asphalt binder is desired. Emulsion contents or foamed bitumen in the range of 1.5 to 2.5 percent by dry weight of RAP are typical for these mixes. RAP maintenance mixes are stored in stockpiles and their handling is similar to traditional

emulsion maintenance mixes. Normally SS-2 emulsion with more solvent is useful. These mixes may be used successfully for both thin and deep patching, the latter including potholes repair. In areas where coarse, crushed aggregates are not available, the use of RAP usually results in superior maintenance mixes to those produced from local aggregates.

9.3.8.5 **Readymade Mixes.**

9.3.8.5.1 Ready to use cold mix patching materials are also effective for instant repair of potholes on roads under inclement weather and operating conditions. These mixes are expected to contain 4.5 to 5.5Sâ of residual bitumen and continuously graded aggregates. Such mixes can be stored upto six months from date of manufacture. More details are given in "Specification for Readymade Bituminous Pothole Patching Mix Using Cutback Bitumen (IRC:116-2014) and IRC:SP:100-2014.

9.3.8.5.2 The following tests shall be carried out for assessment of the quality of maintenance mixes.

(a) Binder content.

(b) Wet coating test.

(c) Static Immersion test.

(d) Water resistance test.

(e) Workability test.

(f) Bond test.

9.3.8.5.3 Details of tests are given in IRC:SP:100-2014. And IRC:116-2014.

9.3.8.5.4 Pothole shall be cleaned of loose material and dust with a stiff wire brush and to be made of regular shape. Pothole needs not be dry. However, excess water, if any in the pothole, shall be removed from the pothole. A prime coat shall be applied to WMM/granular surface before placing the mix to ensure good bond at the bottom. The mix is intended for filling potholes up to 75 mm deep. For deeper potholes (more than 75 mm), patching mix shall be placed and compacted in two or more layers of 25 to 75 mm. Initially the pothole may be filled using Crusher Run Macadam (CRM). First, the outside edge or periphery of the patch shall be compacted with a hand rammer and then compaction shall proceed inwards. To prevent initial pick up of the loose mix by the hand rammer, either continue to

wet the hand rammer with water or place empty plastic lined bags on the loose mix. For deep potholes, place the patching mix and compact in 75 mm thick layers. After compaction, the compacted patch shall be about 10 mm higher than the existing road surface to allow for further compaction by traffic. If there are numerous closely spaced patches, it is preferable to use a small roller rather than a hand rammer. If a roller is used, the compacted patch shall be about 3 mm higher than the existing road surface. Before opening the compacted patch to traffic, sufficient amount of clean sand shall be sprinkled on the patch to prevent pick up by traffic.

9.3.9 **Stress Absorbing Membrane for Crack Sealing**

9.3.9.1 This method deals with sealing of the cracks using a Stress Absorbing Membrane (SAM), which is an elastomeric bitumen rubber membrane, which is laid over a cracked bituminous surface, together with a covering of aggregate chips, in order to extend the life of the pavement before major treatment is carried out. SAM can be laid as a single coat or a double coat depending upon severity of cracking. The quantities of materials required for SAM are given in Table 9.9.

**Table 9.9: Quantity of Materials Required for 10 sqm of Road Surface for Stress Absorbing Members**

| Sr No. | Type and Width of Crack | Specification of SAM to be applied | Quantity of binder kg/10 $m^2$ | Quantity of chipping |
|---|---|---|---|---|
| (a) | Hair cracks and map cracks upto 3 mm width | Single coat SAM | 08-10 | 0.10 $m^3$ of 5.6 mm chips |
| (b) | Map cracks or alligator cracks 3 mm to 6 mm width | Single coat SAM | 10-12 | 0.11 $m^3$ of 5.6 mm chips |
| (c) | Map cracks or alligator cracks 6 mm to 9 mm width | Two coat SAM<br>1st coat<br>2nd coat | 12-14<br>08-12 | 0.12 $m^3$ of 11.2 mm chips<br>0.10 $m^3$ of 5.6 mm chips |
| (d) | Cracks above 9 mm width | Two coat SAM<br>1st coat<br>2 nd coat | 14-16<br>08-12 | 0.12 m* of 11.2 mm chips<br>0.10 $m^3$ of 5.6 mm chips |

9.3.9.2 Binder shall be a modified binder with elastic recovery value more than 75. The minimum softening point of the minder shall be 60°C.

9.3.9.3 The base on which the SAM is to be laid shall be well prepared. The surface shall be thoroughly cleaned either by using a mechanical brush or any other suitable equipment preferably a jet of air. The equipment and general procedures shall be in accordance with Manual for Construction and Supervision of Bituminous Works. The application temperature for modified binder shall be 160-180°C. Immediately after application of the modified binder, clean & dry aggregate shall be spread uniformly on the surface using a mechanical grit spreader. Small areas may be treated with manual spreading. Where a two coat SAM is required the 2nd coat shall be applied within 90 days of first coat and a gap of 15 days between two coats is necessary. Traffic may be permitted over a SAM, 3 hours after rolling, but the speed shall be limited to 20 km/hr until the following day. Speed control measures are to be approved by the Engineer, prior to laying.

## 10. DRAINAGE

### 10.1 **Drainage Facilities**

10.1.1 Proper drainage is the most important factor for stability and performance of a road. Water flow or stagnation can cause erosion of soil & weakening of pavement, destroy the shoulders and slopes and wash out culverts. Therefore, it must be ensured that drains and culverts/causeways function properly so that water is drained out freely and quickly away from the road surface.

10.1.2 Managing water on the right of way requires a drainage system that effectively responds to the immediate environment. A typical highway drainage system includes conveyances of all types, gutters, drains, ditches, culverts, storm sewers, and other miscellaneous drainage structures.

10.1.3 Drainage facilities should be maintained as nearly as possible to the condition and at the capacity for which they were originally designed and constructed. The entire drainage system should be generally inspected at least twice a year, pre-monsoon and post-monsoon with past experience and professional judgment.

10.1.4 Deficiencies should be corrected after they are discovered. Additional inspections may be required during heavy storms and periods of high runoff in order to determine the effectiveness of the system.

10.1.5 High water marks should be observed and recorded as well as conditions that threaten damage to the drainage facility or the highway. This is also to be marked for Bridge also to cross check the high flood levels.

10.1.6 Maintenance personnel must be continually alert to assure that all-natural water course channels crossing the right of way remain open.

10.2 **Drains.** The following points should be checked while inspecting various types of drainage works:-

10.2.1 **Side Drains**

(a) Blockages of drain.

(b) Damages to cross section of the drain.

(c) Ponding and silting in drain and

(d) Erosion of the bed.

10.2.1.1 Open drains should be routinely checked and maintained as close as possible to the line, grade, depth, and cross section to which they were constructed.

10.2.1.2 Vegetation in ditches often helps prevent erosion and treats storm water. Remove vegetation only when flow is blocked or excess sediments have accumulated. Remove vegetation using “best management practices” that minimize erosion and sediment escape to water bodies.

10.2.1.3 Excessive erosion of drains must be controlled or repaired. Drain linings of loose or grouted rock and concrete or other energy dissipation methods can control erosion. However, these linings need be checked frequently and repaired as necessary.

10.2.1.4 Keep drains free of litter and debris. Repair cracks and breaks as necessary.

10.2.1.4 Be alert for diversion ditches on top of cut slopes that prevent slope erosion by intercepting surface drainage. Diversion ditches must be maintained to retain their diversion shape and capability.

10.2.1.5 Surplus material that results from drain cleaning can often be used for widening. Material placed into the adjacent portions of the highway or disposal areas must not obstruct or impair other roadside drainage

areas. Do not use material that may cause sedimentation problems to water bodies. Take care to avoid causing erosion problems or loose unstable fills. Do not use non-porous materials such as clay. They can become unstable when wet and trap water in the existing fill.

10.2.2 **Culverts**

(a) Silting/blockage of waterway due to accumulation of debris.

(b) Erosion of the bed at inlet and outlet.

(c) Settlement/formation of cracks in the abutments.

(d) Exposure of reinforcement in the deck slab.

10.2.2.1 Changes in the upstream watershed due to logging, land development activities, farming practices, forest fires, etc., may increase water runoff, sedimentation, and debris. With these conditions more frequent inspections, particularly after periods of high runoff, are necessary to enable maintenance personnel to take corrective measures if damage has occurred. During storms and floods, critical areas need to be inspected and the culvert inlets kept clear.

10.2.2.2 Badly worn or broken culverts should be repaired, replaced, or rehabilitated to minimize the possibility of damage to the roadbed by water saturating the fill material.

10.2.2.3 Culverts with 50 percent or more constriction should be flushed or otherwise cleaned to restore the culvert's original capacity

10.2.2.4 Culverts should be checked for scour around the inlet and outlet. Scoured areas should be repaired with rip-rap or some other protection if necessary. In some cases, standing water is desirable at the inlet end of the culvert to settle out sediment. Vegetation at culvert ends shall be controlled.

10.2.3 **Causeways**

(a) Crack/potholes in the surface.

(b) Damages/loss of guide posts and flood gauges.

(c) All points at (b) above in the case of vented causeways.

**Table – 10.1: Defects and Remedial Measures-Drainage Works**

| Sr No. | Type of defects | Probable causes | Remedial action |
|---|---|---|---|
| **A** | **Side drains** | | |
| (i) | Ponding | Inadequate cross section | Deepen/widen the drain |
| (ii) | Silting | Too flat slope causing low velocity | Deepen drains or provide lateral drains if feasible |
| (iii) | Blockage of drain | Accumulation of debris, growth of vegetation | Cleaning, clearing of vegetation |
| (iv) | Erosion of bed/sides | Too steep slope | Provision of drain checks; Regarding/Realigning drains |
| **B** | **Culverts** | | |
| (i) | Silting sanding blockage by debris | Invert slope too flat. Culvert Constructed at too low level. Vegetation and debris carried by flood get lodged in the culvert. | Cleaning and clearing Provision of debris rack should be considered |
| (ii) | Erosion of bed at culvert outlet | Too steep grade of culvert | Repair erosion and flatter grade if feasible. |
| (iii) | Settlement | Settlement of soil below the culvert | Repair of cracks in case of minor settlement. In case of major settlement culvert to be reconstructed. |
| (iv) | Exposure of Reinforcement in deck slab | Due to inadequate cover/ displacement of form works while concreting | Remove rusting if any and do grouting with concrete mix |
| **C** | **Causeways** | | |
| (i) | Cracks in paved surface | Settlement of slab, shrinkage etc. | Repair (sealing) of cracks |
| (ii) | Damages/loss of guide posts and flood gauges. | Due to accident, floods, or removal by locals | Replacement |

## 10.3 **Shoulders**

10.3.1 Shoulders/Berms provide lateral support to the pavement. Well maintained shoulders also enable quick drainage of surface water to the side drains. Therefore maintenance of shoulders is equally important as it is to the paved surface.

10.3.2 Shoulders should be hard enough to take occasional traffic movements. The surface should slope uniformly from the edge of the pavement so as to enable quick drainage of water.

10.3.3 The maintenance work of shoulder mainly consists of removal of ruts and depressions and restoration of slope as mentioned above.

10.3.4 Shoulder may be higher than carriageway/ misshaped due to carriageway material has stored on the shoulder due to action of traffic/ water, soil from cutting has slapped on shoulder vegetation has been misshaped due to traffic.

10.3.5 Remedial measure for this defect is to regrade shoulder surface is correct level and control vegetation.

10.3.6 Shoulder lower than carriage way forming ruts/ depression is mainly due to water erosion, settlement of shoulder, carriageway overlaid to and shoulder is not corrected to the level of pavement and due to diversion of traffic over the shoulder and material has been worn or away.

10.3.7 Ruts depression to the shoulder to be corrected by adding material and ensure correction of shoulder after overlay/ periodic renewal.

10.3.8 The slope needs to be protected against the potential erosion forces of water and to retain their shapes and stability. The action needed for maintenance is given in following paras.

10.3.8.1 Vegetation overgrowth on slopes caused due to insufficient grass cutting bush cleaning and tree trimming. These overgrown trees can full and block the carriageway visibility to road users in reduced with increased risk accidents. Further vegetation can block the drainage system or present it being inspected or cleaned in time.

10.3.8.2 Surface water erosion caused due to rain water concentration into channel at the top of slopes or lack of vegetation cover. It neglected it will result for deep erosion of slope, slips and obstruction of road side

ditch/ shoulder. To overcome this, cut off ditch in cutting, curbs/ channel drains and chute for embankments turfing, seeding and slope pitching to be provided.

10.3.8.3 Earth slips are caused when slope is too steep for its height and the soil, water seepage from above and due to ground water pressure or flow. This earth slips it not correction then soil in the slope may continue to move down words and make slope unstable blocking/ damage to the roadway.

10.3.8.4 Earth slip repair means are undertaken by reducing slope angle cleaning over burden slop material, providing gabion structure for support concrete retaining wall provision of locally available vegetation growth / roots on slope also reduces the changes of earth slops. Cribwork components in slopes wooden status also reduce chances of earth slip.

## 11. DESERT ROADS

11.1 **Special Problems.** Maintenance of desert roads involve two peculiar problems which are not common in other roads. These are:-

(a) Drifting sand dunes.

(b) Raincuts/Erosion of embankment.

11.2 **Drifting Sand Dunes.** It occurs mainly during summer months in desert areas. Due to wind and sand storm, the fine sand gets deposited on the road surface. This creates a serious traffic hazard.

11.2.1 **Remedial measures.** The problem can be reduced to a large extent if the alignment of the road is fixed so as to run parallel to the sand dunes. Wherever the alignment is to cross sand dunes, it should not disturb the natural profile of the sand dunes. These precautions are to be taken at the construction stage. During maintenance, the problem can be controlled by adopting the following measures.

11.2.3 **Plantation of Shelter Belts.** Trees and Bushes should be planted in rows on the windward side about 15 mtrs away from the edge of the road. The space between the rows of trees should be covered by plating low bushes and brass. The trees should be planted minimum 3 mtrs apart. These trees, bushes and grass should be nurtured till they can survive on their own.

11.2.4 While providing vegetative cover on the windward side, care should be taken to remove any obstructions on the leeward side. Any obstruction on the leeward side will further increase the accumulation of sand.

11.2.5 The following types of trees and grasses are suitable for plantation for controlling drifting of sand.

(a) **Trees**

(i) Babool
(ii) Kumat
(iii) Khejdi
(iv) Farash
(v) Jal

(b) **Grasses**

(i) Sawan
(ii) Dhuman
(iii) Moonj
(iv) Murat

11.2.6 **Brush Wood Barriers.** Barriers may be erected with locally available Brush wood on the surface of the sand dune, sufficiently away from the road to check the movement of sand. These barriers should be maintained regularly.

11.2.5 **Clearance of Extra Width.** In sand dune areas, 3 to 5 mtrs extra width on either side of the road should be cleared so that even if some quantity of sand accumulates, it will not cause obstruction to traffic. It is also desirable to provide a hard base with moorum or kankar on the shoulders in such areas to enable traffic to pass on the shoulders.

11.3 **Raincuts/Erosion of Embankment.** As the embankment is made up of sand which is cohesionless, erosion of shoulders and side slopes take place even due to light rain, resulting in the formation of gullies.

11.3.1 **Repair Measures.** The rain cuts/gullies should be filled with stones if available or with any other available hard materials like moorum, kankar, gravel, etc. In high embankments, the side slopes should be protected by any one or a combination of the following measures:-

(a) Boulder pitching.

(b) Turfing by grass, bushes/shrubs.

(c) Brush wood barricading across the embankment slopes.

(d) Provision of lined chutes.

(e) Provision of edge walls/check walls.

11.4 **Identification of Sand Dunes and Positioning Resources.** It is essential that the locations of sand dunes are identified and necessary resources are placed nearby before the onset of sand storms so that the road blocks are cleared without any delay.

11.4.1 **Clearance of Sand from Road.** The clearance of sand can be done either manually or by mechanical means. Mechanical methods include the use of pay loader fitted with a blade or farm tractor equipped with rear blade.

11.5 **Administrative and Logistic Support.** Due to extreme hot conditions in deserts, adequate precautions should be taken to prevent heat stroke and other related problems to the personnel working, by way of providing drinking water, provision of canopy over the operator's seat in plants/machinery etc. The high temperature and saline water also affect the performance of the machines. Adequate maintenance should be taken for the vehs/plants/eqpts deployed in the deserts.

## 12. HILL ROADS IN HEAVY RAINFALL AREAS

12.1 In Hill roads in heavy rainfall areas, the major problems in maintaining the roads are:-

(a) Land slides/ Slip failure.

(b) Drainage.

(c) Soil erosion and scouring due to river.

(d) Pavement damages.

12.2 The maintenance/repair measures to be adopted are given below:-

12.2.1 **Land Slides**

12.2.1.1 By adopting the following measures, landslides can be controlled:-

(a) The hill slope should be maintained to proper angle so that it is stable.

(b) Ensure proper surface drainage of the soil mess above the road surface by providing catch water drains, lined chutes etc.

(c) Where there is a problem of subsoil water, provide subsoil drains in the form of perforated pipes.

(d) No deforestation should be done on the hill face above the road as this will disrupt the stability of the hill slope.

(e) Provisions of Bally Barricading, afforestation, turfing and plantation of buses and shrubs.

(f) Construction of protective structures such as Breast walls, check walls, toe walls.

(g) Cultivation of paddy and other crops requiring standing water should be discouraged on the hill above the road.

(h) Heavy blasting in hill slope should be avoided.

(j) Provision of vegetative cover on the hill slope.

(k) Construction of canals for the purpose of irrigation by locals should be discouraged.

12.2.1.2 **Record of Land Slides.** Record of land slides in the format given in HQ DGBR letter No. 80560/P/DGBR/2/DS dated 21 Nov 90 and amended vide Dte letter No. 80560/P/DGBR/04/DS dated 04 Jan 91 will be maintained at all platoons/RCCs for their respective road sectors.

12.2.2 **Drainage.** Most of the maintenance problem in hill roads receiving heavy rain fall are caused by improper drainage. Proper drainage is, therefore of utmost importance to hill roads. The following measures will be taken to ensure proper drainage:-

(a) All drainage works like side drains, catch water drains, culverts and causeways should be inspected by the platoon commander/OC RCC before the onset of monsoons. Prompt action should be taken to remove any blockage/hindrance to free flow of water. Any repairs required for catch pits or vent way of cross drainage works should be done on priority. All vegetation, debris on upstream and downstream

side of culverts and catch water drains to be checked prior to monsoon to enable free flow of water. Scouring of abutments, catch pits, vent ways of culverts to be inspected frequently in the case of perennial nallahs to avoid untoward incidents.

(b) Where the side drains are likely to be blocked with side, it should be covered with ballies closely packed or with bamboo mats.

(c) When the side drains are blocked in part length, false drains with guide bunds should be cleared and any vegetative growth removed.

(d) Weepholes of Retaining/Breast Walls/Abutments/Wing walls of culverts should be cleared and any vegetative growth removed.

(e) Special attention should be paid in the case of catch-water drains. A blocked catch water drain will cause enormous harm to the road in the long run as it will result in formation of slides. Therefore it should be ensured that there is no blockage in catch water drains or any damage to the side walls which can cause seepage of water. It is better not to have a catch water drain at all rather than having one which is blocked/damaged.

12.2.3 **Soil Erosion and scouring.** Soil erosion from slopes is another problem on hill roads. If control measures are not taken timely, it can create major slides. The following measures should be taken to control the soil erosion in slopes both above the road formation.

(a) It should be ensured that cross drainage structures while discharging water to the valley side do not cause soil erosion. For this purpose, necessary channel training works like guide walls/ drop walls should be provided at the inlet/outlet of culverts. Paving/ pitching should done at the apron and should be properly maintained.

(b) Vegetative cover should be provided at slopes where soil erosion is observed. This should be done either by turfing or by planting bushes and shrubs depending on site conditions.

12.3 **Vegetative Growth on Protective Works and Berms.**

12.3.1 The growth of vegetation on Protection works such as retaining walls/breast walls, wing walls etc. is another problem on hill roads which

should be attended to timely. The roots of the vegetation if allowed to penetrate into the interstices in the Dry masonry structures and weep holes can cause failure of the structure. The vegetation growth when noticed, should be immediately removed.

12.3.2 Similarly vegetative growth on road side berms should be trimmed regularly so that the height of vegetative growth is not more than 15 cms. On hill side slope, the growth should be so regulated that it does not affected the visibility and vertical clearance required for the road.

12.3.3 Before onset of monsoon, essential construction material to be stacked nearby potential hazard location or nearby detachments for quick response machinery in case of road blockage I damages or formation wash away.

## 13. ROAD IN HIGH ALTITUDE AND SNOW FALL AREA

13.1 Heavy snow fall resulting in severe cold climate and low level of oxygen in the atmosphere cause numerous problems for the maintenance of roads in High Altitude/Snow fall area. Detailed instructions have already been issued separately about the precautions to be taken by men and for machines in these areas and therefore not repeated in this T.I.

13.2 **Snow Clearance**

Snow clearance operations are of two types:-

(a) Continuous snow clearance which involves clearance of snow as and when it occurs.

(b) Summer snow clearance which commence when the snow precipitation is over and the total accumulated snow of the season is cleared in the operation.

13.3 **Continuous Snow Clearance.** In this operation, snow should be cleared as quickly as possible from the road formation. Depending on the intensity of snowfall, it should be cleared either manually or mechanically or by a combination of both.

13.3.1 **Application of Chemicals to Prevent Icing.** In case there is delay in clearing the snow, ice formation will take place on the pavement which is a traffic hazard. To prevent ice formation, either calcium chloride or sodium chloride should be sprinkled at the rate of about 0.5 kg/sqm on

the pavement, if delay is anticipated in clearing the snow sand. Spreading on icy surface should be resorted to wherever essential to prevent skidding of vehicles. Use of non skid chains should however be preferred.

13.3.2 **Drainage during Snow Clearance.** It is normal practice to clear the snow initially from the carriage way only to facilitate traffic. This result in the snow melts water flowing over the pavement causing extensive damage. To prevent this, temporary cross drains should be provided to divert the water to the valley.

13.4 **Summer Snow Clearance.** Where the road is closed during winter months due to heavy snow fall, the snow clearance operation is under taken during summer to clear the entire snow accumulation of the season open the road for traffic. This operation is termed as summer snow clearance.

13.4.1 **Snow Markers.** Snow markers should be erected on the valley side of the road at suitable intervals where snow accumulation medium intensity occurs, before the snow fall starts. The purpose of the snow marker is to indicate location of the road as well as the depth of snow to the clearance team. GI pipes of 80 mm dia, 3 to 5 m long, graduated at 0.25 m intervals are to be erected as snow markers.

13.4.2 **Tracing the Road Alignment.** The following precautions should be taken for the safety of men and machinery during snow clearance:-

(a) Quarried stones.

(b) Gravel material.

(c) Hump pipe.

(d) Gabion / inter link chains.

(e) Sand bags with soil/ river bed material.

(f) Sufficient number of T&P for labours.

(g) All men machines should be deployed in a dispersed manner to guard against avalanches. At the end of the day's work, the machines should be parked at safe locations ie. Free from slides and avalanches.

(h) A sentry with a whistle should be detailed at a vantage point to give early warning of avalanches.

(j) A Nursing Asstt. with first aid and preferable with an ambulance or light vehicle should be available at site.

(k) Instructions issued by medical authorities for protection against snow bite and other snow related illnesses to men should be strictly adhered to.

(l) Similarly, maintenance instructions for veh/eqpt/plant issued by Workshop for proper functioning in extreme cold weather conditions should be strictly followed.

(m) The snow clearance partly should have communication links with the camp by way of Walkie-Talkie/radio communication sets.

13.5 **Avalanches.** The most important and immediate problem after snow clearance is the control and drainage of snow melt water on the road surface. A maintenance team should be detailed to control this water by permitting it to flow across the road at suitable intervals and also to clear the existing drains and culverts. The maintenance team should also give priority to:-

(a) Restore the road formation if breached/damaged due to avalanches.

(b) Removal of Icing from the Pavement. Where a thin layer of snow has remained on the pavement, it becomes hard and slippery which is dangerous for traffic due to the skidding effect on vehicles. This thin layer of ice should be removed the ensure safety of traffic.

(c) Removal of Snow from behind Retaining Walls. Freezing of water behind the retaining walls will result in cracking of the structure due to increase in volume of back fill. Therefore, the snow behind retaining walls should be cleared on priority.

(d) Restoring damages to drains, culverts, R/B walls and other protective works.

(e) Repairs to pavement such as pot hole repairs.

## 14. MAINTENANCE OF ROAD FURNITURE

14.1 Traffic signs are intended to convey information about the road to drivers. It is therefore essential that these are maintained in good condition so that the information/message is clearly seen and understood by the drivers. This will also enable the drivers to be confident that the information

is reliable and correct. Therefore, damaged or missing sign boards should be replaced promptly. Similarly, temporary sign boards erected during maintenance works should be removed as soon as the work is over.

14.2 The serviceability of the sign/caution boards should be part of the regular inspection of the road as mentioned in para 3 above. Boards which cannot be repaired at site should be taken to HQ RCC/Workshop for repairs.

14.3 A record to traffic signs with their locations, date of repair/ replacements should be maintained at each Road Maintenance platoon.

14.4 Kilometer Stones are the basic reference for the position f any point on the road. These should be pained at regular intervals so that the readings are legible. Any vegetation around the KM stones should be promptly removed so that these are clearly visible to the road users.

14.5 **Guard Rails/Parapet Rails/Parapet Walls.** These are very important for the safety of traffic especially on hill roads. Any damages to these devices should be promptly repaired. These should be painted/white washed at regular intervals to maintain their visibility and serviceability.

## 15. CONCLUSION

15.1 This Technical instruction has been compiled based on the "Manual for Maintenance of Roads" of the Ministry of Surface Transport (Road Wing) published by the Indian Roads Congress and the experience gained over the years by the BRO on Maintenance of Hill Roads. It is meant for the purpose of reference and guidance of the department staff. There can be no pre-determined solutions for the complex problems faced on maintenance of Hill Roads. This Technical instruction, intends to add to the practical wisdom and ingenuity of the Maintenance Engineer.

## REFERENCES

### IRC PUBLICATIONS PERTIAINING TO MAINTENANCE OF ROADS


1. Ministry of shipping & Transport (Roads Wing) Manual for maintenance of roads.

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3. IRC:101-1988 “Guidelines for Design of Continuously Reinforced Concrete Pavement with Elastic Joints”.

4. IRC:116-2016 “Specifications for Readymade Bituminous Pothol Patching Mix Using Cut- Back Bitumen”.

5. IRC:SP:81-2008 “Tentative Specifications for Slurry Seal and Microsurfacing”.

6. IRC:SP:100-2014 “Use of Cold Mix Technology in Construction and Maintenance of Roads Using Bitumen Emulsions”.

7. International Road maintenance Hand book.