CODE OF PRACTICE FOR MAINTENANCE OF BITUMINOUS ROAD SURFACES

(First Revision)

Published by:

INDIAN ROADS CONGRESS

Kama Koti Marg,
Sector-6, R.K. Puram,
New Delhi-110 022

June, 2015

Price : ₹ 666/-
(Plus Packing & Postage)

CONTENTS

CODE OF PRACTICE FOR MAINTENANCE OF BITUMINOUS ROAD SURFACES

1 INTRODUCTION

"Code of Practice for Maintenance of Bituminous Road Surface" was first published in 1982. To cater for the technological developments which were taking place in course of time the Road Maintenance & Asset Management Committee (H-6) formed a sub-group consisting of Dr. P.K. Jain, Dr. S.S. Jain, Shri K. Sitaramanjaneyulu and Shri M.N. Nagabhushana for the revision of the document. The H-6 Committee deliberated on revised draft document prepared by the sub-group, in a series of meetings. Finally the H-6 Committee approved the draft "Code of Practice for Maintenance of Bituminous Road Surfaces" in its meeting held on 24th November, 2014.The Highways Specifications & Standards Committee (HSS) approved the draft document in its meeting held on 12th January, 2015. The Council in its 204th meeting held at Bhubaneshwar (Odisha) approved IRC:82-2015 "Code of Practice for Maintenance of Bituminous Road Surface" after taking on board the comments offered by the members.

The Composition of H-6 Committee is as given below:

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SECTION 2

SCOPE

2.1 By early detection of distress and appropriate repair of bituminous surface at initial stages, further deterioration of the pavement surface can be prevented or delayed. This Code of Practice deals with the "Routine", "Preventive" and "Periodic" maintenance of bituminous surfaces.

2.2 Several phases are involved in undertaking maintenance operations for bituminous surfaces as discussed in subsequent sections. Section 3 and 4 deals with importance and types of maintenance. Maintenance planning and system approach to pavement maintenance are described in Sections 5 and 6, respectively. Types of pavement distresses, identification, severity, their causes, and methods of treatment are given in Section 7.

2.3 Preventive maintenance is the need of the day and is described in Section 8. Periodic renewals are covered in Section 9. Sections, 10, 11, 12, and 13 deal with the materials and methods for rectification, tools and equipment, arrangements for traffic, and organization and management, respectively.

2.4 Operations falling in the category of pavement rehabilitation and strengthening are beyond the scope of this Code of Practice. For design of rehabilitation and strengthening measures for existing pavements, reference may be made to the following publications:

i) IRC:81 “Guidelines for Strengthening of Flexible Road Pavement using Benkelman Beam Deflection Technique”

ii) IRC:37 “Tentative Guidelines for the Design of Flexible Pavements”

iii) IRC:115 “Guidelines for Structural Evaluation and Strengthening of Flexible Pavement using Falling Weight Deflectometer”

SECTION 3

IMPORTANCE OF MAINTENANCE

3.1 The timely upkeep and maintenance of bituminous surfacing offers numerous benefits for preservation of road asset. The importance of overall maintenance is described below:

i) Reduction in rate of deterioration and improvement in life of road

ii) Reduction in Vehicle Operation Costs (VOC)

iii) Reduction in rate of accidents

iv) Keeping roads traffic worthy in all weathers

v) Reduction in pollution due to reduced fuel consumption on well maintained pavement surface

vi) Savings in budgetary expenditure of restoration/ reconstruction

3.2 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.

SECTION 4

TYPES OF MAINTENANCE

4.1 Maintenance operations covered in this Code of Practice are classified into three broad categories

a) ***Routine Maintenance:*** This covers items such as filling of potholes, repairing of cracks and patch work, which are undertaken by the maintenance staff almost round the year. Routine maintenance is also required for pavement markings on the bituminous surfaces to guide the road users and improve road safety.

b) ***Preventive Maintenance:*** The preventive maintenance is performed to improve or extend the functional life of pavement surface while in good condition. This may defer the need of periodic maintenance and rehabilitation.

c) ***Periodic Maintenance:*** This includes regular maintenance operations compared to preventive maintenance such as applying a renewal coat, which are required to be carried out periodically at the specified frequency or based upon condition and performance of road surface depending upon category of road, traffic and climatic conditions.

SECTION 5

PLANNING OF MAINTENANCE ACTIVITIES

5.1 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.

The first step towards planning of maintenance operations is the evaluation of the existing pavement surface in terms of its physical condition as well as structural capacity. For this purpose, pavement condition surveys may be undertaken by the visual assessment of the surface by identifying type, location and magnitude of the distress as described in Appendix -1 and recorded in a standard format as in ***Proforma 1,*** in order to decide time as well as type of maintenance treatment to be given. In case more precise condition data is required in project level based maintenance strategies, then surface distress may be recorded by actual measurements as described in Appendix – 2 and recorded in a standard format as given in ***Proforma 2.*** The rating of pavement may be assigned as per criteria given in Tables 5.1 to 5.3 for different categories of roads.

Table 5.1 Pavement Distress Based Rating for Highways

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

Notes: 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 ***Proforma 1.***

Table 5.2 Pavement Distress Based Rating for MDR(s) and Rural Roads (ODR and VR)

Defects	Range of Distress		
Cracking (%)	>20	10-20	< 10
Ravelling (%)	>20	10-20	<10
Pothole (%)	>1	0.5 to 1	<0.5
Patching (%)	>20	5-20	<5
Settlement and depression (%)	>5	2 to 5	<2
Rating	1	1.1 - 2	2.1 - 3
Condition	Poor	Fair	Good

Table 5.3 Pavement Distress Based Rating for Urban Roads

Defect	Range of Distress		
Cracking %	>15	5-15	<5
Ravelling %	>10	5 to 10	<5
Potholes %	>0.5	>0 and ≤0.5	NIL (0)
Settlement %	>5	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

In some situations, there is a likelihood of a particular distress falling in one rating category, say good, while some other distress falls in a different rating category, say fair or poor. In order to obtaining/assigning the overall rating in such circumstances, based on an appropriate weightage with regard to the significance of a particular distress, a methodology has been proposed and given in Appendix-4.

5.2 Apart from visual surveys, functional evaluation of pavement based on riding quality (i.e. road roughness), deflection and skid resistance should also form the basis for taking maintenance decisions in case of highways and urban roads. Skid resistance is an important parameter from the angle of ensuring enhanced safe movement of vehicles, especially during wet weather conditions. Lower skid number invites safety hazards and would require immediate attention. The serviceability indicators for consideration of maintenance and taking appropriate decisions are given in Tables 5.4 and 5.5. The serviceability indicators for level 1, 2 and 3 are to be read in conjunction with the distresses as given in Table 5.1 for highways and Table 5.3 for urban roads.

Table 5.4 Serviceability indicators for Highways

Sl. No.	Serviceability Indicators	Level 1 (Good)	Level 2 (Fair)	Level 3 (Poor)
1	Roughness (Max. permissible)	1800 mm/km	2400 mm/km	3200 mm/km
2	Skid Resistance (Skid Number, SN by ASTM-274) Minimum Desirable	60 SN	50 SN	40 SN

Table 5.5 Serviceability Indicators for Urban Roads

Sl. No.	Serviceability Indicators	Level 1 (Good)	Level 2 (Fair)	Level 3 (Poor)
1	Roughness (Max. permissible)	1800 mm/km	2600 mm/km	3400 mm/km
2	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.

5.3 Necessary information about the routine maintenance requirement shall be readily available with the maintenance staff who are expected to be continuously in the knowledge of the physical condition of the road surface. However, for preventive and periodic renewal requirement or short term/long term maintenance strategies, condition surveys are carried out at a fixed frequency. Keeping this in view, it is desirable that at least two condition surveys are conducted every year on each stretch , first before and the second after the monsoon in case of highways and urban roads. Minimum one condition survey is required for other roads, preferably after monsoon. Generally, the condition surveys are carried out from a vehicle travelling at a speed of 5 km/hour supplemented by inspection of the critical locations by walking. The data collected should be recorded methodically, kilometer wise. It is desirable that these visual surveys are carried out by a team of experienced engineers at a responsible level. Condition survey may be conducted by automated survey vehicles also.

Based on the condition survey data, the causes for the development of various distresses/ defects shall be examined in detail as described in Section 7 and a decision shall be taken whether to initiate or defer the maintenance activity, or to go in for more detailed structural investigations to determine the rehabilitation needs, if necessary. Type of maintenance activity to be undertaken shall depend upon condition rating, as per Tables 5.1 to 5.3.

Where severity of distress on the pavement has reached the level which adversely influences the riding quality significantly and affects smooth flow of traffic, these should be rectified straightway by providing appropriate maintenance treatment. For other defects like minor

cracking, and ravelling, optimal preventive strategy should be adopted having regard to the various factors such as finances available, and a decision taken whether to go in for preventive maintenance measures like sealing, application of periodic renewal or strengthening. In other words, the planning of the various maintenance operations should be correlated and looked upon as a total system rather than each activity being considered in isolation.

A plan has to be drawn for preventive maintenance or periodic renewals depending upon pavement condition rating as given in Tables 5.1 to 5.3. Once the overall maintenance plan has been drawn up, attention should be given to the proper organization and management aspects of the programme including deployment of various resources, i.e. men, materials and equipment, in an efficient manner. For each maintenance activity, the work at site should be carefully controlled so that the optimum output and quality are achieved.

In case of rural roads, periodic renewal treatments may be decided when condition rating reaches to a value of 2 to 1. However, in case of highways and urban roads, periodic renewal may be undertaken at a serviceability level of 2. Preventive maintenance shall be undertaken before pavement rating drops to 2.

Condition surveys may be undertaken/carried out visually *(Appendix 1)* and supplemented with actual measurements where needed *(Appendix 2)* or using instrumented vehicles *(Appendix 3).*

Modern trend is to use instrumented system for assessment of pavement condition since these are more accurate and faster. It is recommended that condition assessment of highways be carriedout using instrumented system. The description of the equipments used for measuring pavement condition in terms of distress, roughness, skid resistance etc. are given in *Appendix 3.*

SECTION 6

SYSTEM APPROACH TO PAVEMENT MAINTENANCE

6.1 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, whereas, Pavement Management System (PMS) consists of a comprehensive, coordinated set of activities associated with the planning, design, construction, maintenance, evaluation and research of pavements. A major objective of PMS is to assist the highway engineer in making consistent and cost effective decisions related to the construction, maintenance and rehabilitation of pavements.

6.2 The Pavement Maintenance Management System performs the following functions:

i) To identify projects in need of Maintenance & Repairs (M&R) and to establish priorities

ii) Identification of the type of maintenance and/or rehabilitation required

iii) Requirement of type and timing of future M&R

iv) To minimise life-cycle costs or maximise benefits

v) To predict performance of pavement in future

6.3 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.

SECTION 7

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

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

i) **Surface Defects:** These include fatty surface, smooth surface, streaking, and hungry surface

ii) **Cracks :** These include all types of cracks, viz, hair-line cracks, alligator cracks, longitudinal cracks, edge cracks, shrinkage cracks, and reflection cracks

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

iv) **Disintegration:** These include stripping, loss of aggregates, ravelling, potholes, and edge breaking

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

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

7.2.1 *Bleeding or Fatty Surface*

7.2.1.1 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.

7.2.1.2 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.

7.2.1.3 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:

i) Excessive binder in hot mix due to faulty mix design or lapses in quality control

ii) Lower voids in hot mix

iii) Use of softer grade binder

iv) Too heavy tack coat or prime coat

v) Loss of cover aggregates in surface dressing

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

7.2.1.4 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 7.2.1, (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 7.2.1 Bleeding

7.2.1.5 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.

7.2.2 *Smooth Surface*

7.2.2.1 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 7.2.2** indicates a smooth surface.

Photo 7.2.2 A View of Smooth Surface

7.2.2.2 Location

Smooth surface may be restricted to a lane/carriageway.

7.2.2.3 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.

7.2.2.4 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.

7.2.2.5 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.

7.2.3 *Streaking*

7.2.3.1 Symptoms

Streaking is characterized by the appearance of alternate lean and heavy lines of bitumen either in longitudinal direction or a transverse direction. Photo 7.2.3.shows streaking.

Photo 7.2.3 Streaking of Bituminous Pavement

7.2.3.2 Location

Streaking may occur in a lane or a carriageway.

7.2.3.3 Causes

Longitudinal streaking results when alternate longitudinal strips of surface contain different quantities of bitumen due to non-uniform application of bitumen across the surface. Some of the more common causes of streaking are mechanical faults, improper or poor adjustment and operation of bitumen distributors. These streaks can also be formed as a result of applying the bituminous binder at too low temperature; a temperature at which bitumen is 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 also be caused by spurts in the bitumen spray from the distribution spray bar. These could be as a result of mechanical faults in the bitumen distributor. Transverse streaking may result in corrugation in the pavement surface.

7.2.3.4 Severity Levels

Not applicable

7.2.3.5 Treatment

The satisfactory repair for longitudinal and transverse streaking is to remove the streaked 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.

7.2.4 *Hungry Surface*

7.2.4.1 Symptoms

Hungry surface is characterized by the loss of fine aggregates from the surface or the appearance of dry surface with fine cracks; Photos 7.2.4 indicate a dry and hungry surface

Photo 7.2.4 View of Dry and Hungry Surface

7.2.4.2 Location

Hungry surface may be in full lane or carriageway.

7.2.4.3 Causes

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

7.2.4.4 Severity Levels

Not applicable

7.2.4.5 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.

7.3 Cracks

7.3.1 *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.

7.3.2 Hairline Cracks

7.3.2.1 Symptoms

Hairline cracks are present in narrow area and their width is less than one mm (Photo 7.3.1). 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 disappear in hot summer.

Photo 7.3.2 Hairline Cracks

7.3.2.2 Location

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

7.3.2.3 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 excessive compaction.

7.3.2.4 Severity Levels

Not applicable

7.3.2.5 Treatment

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

7.3.3 *Alligator and Map Cracking*

7.3.3.1 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.

7.3.3.2 Location

Alligator or map cracks normally appear along the wheel path.

7.3.3.3 Causes

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

i) Excessive deflection of pavement surface normally in wheel paths.

ii) Inadequate pavement thickness.

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

iv) Overloading of heavy commercial vehicles.

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

vi) Stripping of underlying bituminous courses

7.3.3.4 Severity Level

Alligator cracking may be classified as low severity, medium severity and high severity. (Photos 7.3.3-a,b,c.)

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.

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.

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

Photo 7.3.3 Alligator Cracks

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.

7.3.3.5 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 the 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 bitumen

c) Milling and surface recycling

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

7.3.4 *Longitudinal Cracking*

7.3.4.1 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 7.3.4 Longitudinal Cracking

7.3.4.2 Location

These cracks may appear at joints between two paving lanes or between pavement and paved shoulders.

7.3.4.3 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.

7.3.4.4 Severity Level

Severity of longitudinal cracks may be defined as low, medium and high. (Photos 7.3.4: 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).

7.3.4.5 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.

7.3.5 *Transverse Cracks*

7.3.5.1 Symptoms

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

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

Photo 7.3.5 Transverse Cracks

7.3.5.2 Location

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

7.3.5.3 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.

7.3.5.4 Severity Level

Severity of transverse cracks may be defined as low, medium and high (Photos 7.3.5: 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 6 mm wide and are frequent (numerous).

7.3.5.5 Treatment

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

7.3.6 Edge Cracking

7.3.6.1 Symptoms

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

7.3.6.2 Location

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

(a) Low severity

(b) Medium severity

(c) High severity

Photo 7.3.6 Edge Cracking

7.3.6.3 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.

7.3.6.4 Severity Level

The severity levels of edge cracks are low, medium and high (Photos 7.3.6: 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).

7.3.6.5 Treatment

The following procedure/techniques are used for prevention or treatment of edge cracking:

i) 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.

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

iii) 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.

7.3.7 *Reflection Cracking*

7.3.7.1 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 7.3.7 Reflection Cracking

7.3.7.2 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.

7.3.7.3 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.

7.3.7.4 Severity Levels

Not applicable

7.3.7.5 Treatment

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.

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.

7.4 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.

7.4.1 *Slippage*

7.4.1.1 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.

(a) Low (b) High

Photo 7.4.1 Slippage of the Bituminous Wearing Coat

7.4.1.2 Location

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

7.4.1.3 Causes

Slippage is caused by unusual thrust of wheels in a specific direction due to omission or inadequacy of tack 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.

7.4.1.4 Severity Level

Slippage may be classified as low severity and high severity slippage (Photos 7.4.1 : 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.

7.4.1.5 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.

7.4.2 *Rutting*

7.4.2.1 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.

(a) Low severity (b) High severity

Photo 7.4.2 Rutting in Bituminous Surface

7.4.2.2 Location

Rutting generally appears along the wheel path.

7.4.2.3 Causes

The causes of rutting are the following:

i) Heavy channelized traffic and overloading of vehicles

ii) Inadequate compaction of the mix at the surface or in the underlying bituminous courses during construction

iii) Improper mix design, lacking in stability to support the traffic

iv) Weak pavement due to poor sub grade and inadequate design

v) Use of soft bitumen or waxy bitumen

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

7.4.2.4 Severity

Rutting may be classified as low severity when 4-10 mm deep and high severity when more than 10 mm (Photos 7.4.2 a and b).

7.4.2.5 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.

7.4.3 *Corrugation*

7.4.3.1 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 7.4.3

Photo 7.4.3 Corrugation of Bituminous Surface

7.4.3.2 Location

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

7.4.3.3 Causes

Corrugations occur due to the following reasons:

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

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

iii) Faulty laying of surface course

iv) Insufficient rolling or rolling a tender mix

v) Braking action of vehicles on grade especially near intersections

7.4.3.4 Severity

Not applicable

7.4.3.5 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.

7.4.4 *Shoving*

7.4.4.1 Symptoms

Shoving is a form of plastic movement within the bituminous layers resulting in bulging of the pavement surface. Photo 7.4.4 shown shoving of bituminous layers.

Photo 7.4.4 Shoving of Bituminous Surface

7.4.4.2 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 7.4.4 shows shoving of bituminous layers. Shoving occurs near the wheel path.

7.4.4.3 Causes

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

ii) Lack of bond between bituminous surface and underlying layer

iii) Heavy traffic movement involving negotiation of curves and gradients

7.4.4.4 Severity Level

Not applicable

7.4.4.5 Treatment

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

7.4.5 *Shallow Depression*

7.4.5.1 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 7.4.5

Photo 7.4.5 Shallow Depression in Bituminous Surface

7.4.5.2 Location

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

7.4.5.3 Causes

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

7.4.5.4 Severity Level

Not applicable

7.4.5.5 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.

7.4.6 *Settlements and Upheaval*

7.4.6.1 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 7.4.6 and 7.4.7, respectively

Photo 7.4.6 Settlement in Bituminous Surfacing

Photo 7.4.7 Upheaval in Bituminous Surfacing

7.4.6.2 Location

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

7.4.6.3 Causes

The following are the causes for settlements and upheavals in bituminous pavements:

i) Inadequate compaction of the fill at locations behind bridge abatements, over utility cuts, etc.

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

iii) Inadequate pavement thickness.

7.4.6.4 Severity

Not Applicable

7.4.6.5 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.

7.5 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.

7.5.1 *Stripping*

7.5.1.1 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 7.5.1

Photo 7.5.1 Stripping of Bituminous Surface

7.5.1.2 Location: Stripping is either localized or extended to lane or the entire carriageway.

7.5.1.3 Causes

Stripping may be caused by the following reasons:

i) Use of hydrophilic aggregates.

ii) Inadequate mix composition.

iii) Continuous contact of water with the coated aggregate.

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

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

vi) Occurrence of rain or dust storm immediately after construction

vii) Higher concentration of salt in soil and rain water

viii) Use of improper grade of bitumen

ix) Ageing of the bitumen leading to the embrittlement of the binder film.

7.5.1.4 Severity

Not applicable

7.5.1.5 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.

7.5.2 *Ravelling*

7.5.2.1 Symptoms

Ravelling 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 ravelling process generally starts from the surface downward or from the edge inward. Pavement surface lead to rough and jagged appearance after occurrence of ravelling. Ravelling differs from fretting that it involves plucking out of surface aggregate by traffic without loss of cohesion.

7.5.2.2 Location

Ravelling may occur on any part of a lane or carriageway.

7.5.2.3 Causes

Ravelling is likely to occur on a surface due to one or more of the following reasons:

i) Inadequate bitumen content in a mix

ii) Overheating of bitumen during mixing process

iii) Inadequate compaction during construction

iv) Stripping of bitumen from aggregates due to water at interface

v) Construction during cold and wet weather

vi) Use of inferior quality aggregates prone to fracture, crushing and opening of new faces

vii) Use of absorptive aggregates

viii) Excessive ageing of binder

ix) Lack of performance related contract specifications

x) Improper filler/bitumen ratio

xi) High intensity hydrostatic pressure due to combined effects of traffic and water

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

xiii) Traffic stresses exceed breaking strength of mix

7.5.2.4 Severity Level

Ravelling may be classified into three severity levels, viz., low severity, medium severity and high severity (Photos 7.5.2.: 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.

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

Photo 7.5.2 View of Ravelling

7.5.2.5 Treatment

The treatment of Ravellled surface shall depend upon severity of Ravelling.

a) **Low severity ravelling:** The low severity ravelling may be corrected by application of fog seal, sand seal, seal coat, slurry seal or microsurfacing

b) **Medium severity ravelling:** This may be corrected by application of seal coat, slurry seal or microsurfacing treatment in affected area

c) **High severity ravelling:** Depending upon the condition of ravelled surface and specification of existing surface, the high severity ravelling 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.

7.5.3 *Potholes*

7.5.3.1 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.

(a) Small (b) Medium (c) Large

Photo 7.5.3 Potholes of Different Severity

7.5.3.2 Location

Potholes may occur in any part of road surface.

7.5.3.3 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.

7.5.3.4 Severity

Potholes may be classified as small, medium and large (Photos 7.5.3 : 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.

7.5.3.5 Treatment

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

1. Mixes (cold mixed/hot mixed) for immediate use
2. Storable cold mixes (cutback IRC:116/emulsion IRC:100)
3. Readymade mixes
4. Cold mixes by Patching machines

7.5.4 *Edge -Breaking*

7.5.4.1 Symptoms

A common defect in bituminous surface is edge breaking wherein the edge of the bituminous surface gets broken in an irregular way. Photo 7.5.4 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 7.5.4 Edge Break-up

7.5.4.2 Location

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

7.5.4.3 Causes

The following are the causes for edge breaking:

- Infiltration of water which make the foundation layers weak causing the pavement edges to break
- Worn out shoulders resulting in insufficient side support to the pavement.
- Inadequate strength at the edge of the pavement due to inadequate compaction.
- Lower layer of pavement being wider than upper layers.
- Too narrow width

7.5.4.4 Severity

Not applicable

7.5.4.5 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 at least for some width to protect the edges. Surface and subsurface drainage, wherever deficient, should be improved

SECTION 8

PREVENTIVE MAINTENANCE

8.1 Introduction

8.1.1 Delays in maintenance increase the severity of distress in pavement leading to higher maintenance expenditure. Preventive maintenance is a planned maintenance activity, which decreases rate of surface deterioration and extend service life of bituminous pavement. It is a maintenance activity as a planned strategy of cost effective treatment of existing roads and its appurtenances that preserves the system, prevents future deterioration and improves the functional condition of the system without contribution to load carrying capacity of pavement. Such treatments are cost effective, if provided on a pavement in fair to good condition. The placement of right preventive maintenance treatment at the right time saves pavement from leading to poor condition (Tables 5.1 to 5.3), where rehabilitation and reconstruction would be inevitable.

8.2 Selection of Preventive Maintenance Treatment

8.2.1 Preventive maintenance treatments shall be selected based upon the condition of existing pavement. The cracking, rutting, riding quality, climate and traffic are given due consideration in selection of preventive maintenance treatments. The concept of preventive maintenance stipulates that deterioration modes can be anticipated and at least partially mitigated before their occurrence. This provides following long term solutions:

- Improved level of service resulting from improved pavement performance
- Delayed need for rehabilitation and reconstruction
- Life cycle cost saving

8.2.2 For preventive maintenance applications, the following guidelines must be considered:

- Existing distress to be treated
- Anticipated distress to be delayed or prevented
- Appropriate treatment for existing condition
- Timing of treatment for best results
- Maximizing performance while minimizing cost

8.2.3 A thin overlay may not be considered as a preventive maintenance, when it is applied to a distressed pavement in poor condition. Slurry seal/microsurfacing may not be considered as preventive maintenance, when placed on an extensively cracked surface. A preventive maintenance strategy comprises following:

- Identification of causes of distress
- Measurement of distress
- Selection of appropriate treatment
- Timing of treatment

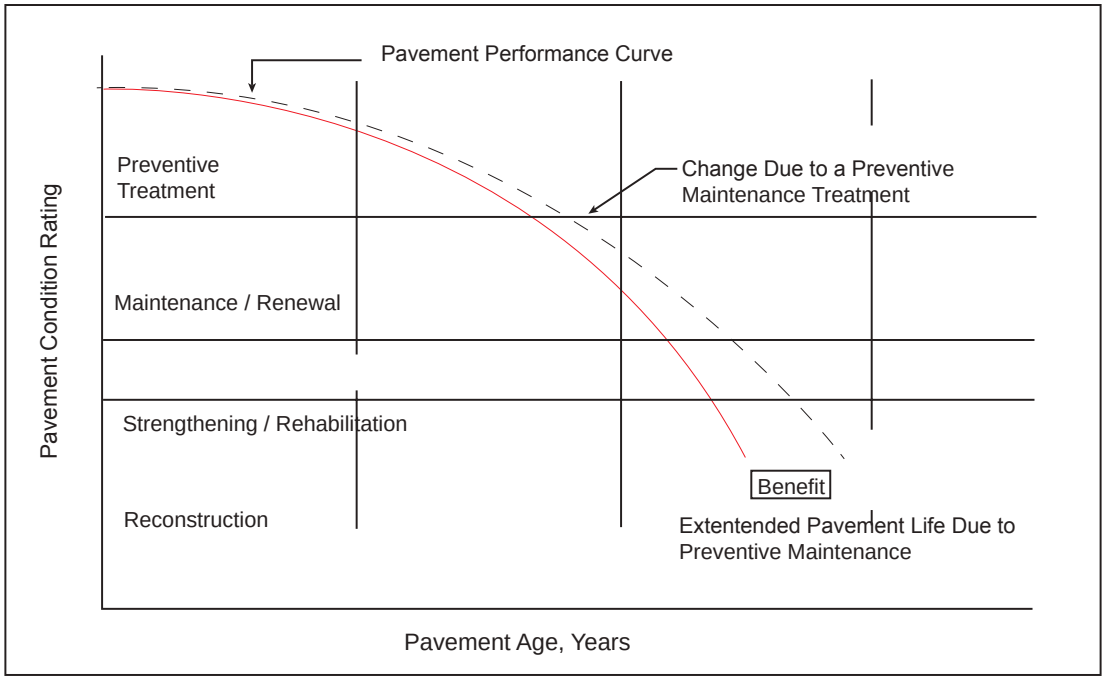

Fig. 8.1 Conceptual Illustration of Interventions

8.2.4 Figure 8.1 illustrate timing of preventive maintenance treatment, while selection of treatment depends upon type of distress, causes, severity, climate and traffic. Refer to Tables 5.1 to 5.5 in Section 5 and conceptual illustration given in Figure 8.1, preventive maintenance shall be undertaken when drop in quality of pavement surface is less than 30% as quantified in Tables 5.1 to 5.3 by pavement condition rating criteria. Preventive maintenance treatments shall be effective before the pavement condition rating drops below 2. The type of treatment shall depend upon pavement condition rating as well as type and area of distress. The detailed warrants for choice of the treatment are given in Tables 8.1 to 8.7.

8.2.5 Suitable preventive maintenance treatment may be identified by following attributes:

- Purpose of treatment
- Applicability
  - Traffic
  - Environment
  - Surface condition
- Limitations
- Construction considerations

- Expected performance
- Cost effectiveness

8.2.6 The typical preventive maintenance treatments are given below:

- Crack sealing/crack filling
- Fog seal
- Slurry seal
- Microsurfacing
- Chip seal
- Thin surfacings
- Ultra thin friction courses

8.3 Warrants for Preventive Maintenance

The description and warrants for preventive maintenance treatments are given in Tables 8.1 to 8.7

Table 8.1 Crack Filling or Crack Sealing

Crack Filling or Crack Sealing	Warrant			
	Climate	Traffic	Addressed	Limitations
These treatments are intended primarily to prevent the intrusion of moisture through existing cracks. Crack sealing refers to a sealing operation that addresses "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 cracks that undergo little movement. Sealants used are typically elastomers modified bituminous materials that soften upon heating and harden upon cooling.	Treatment can perform well in all climatic conditions.	Performance is not significantly affected by varying traffic.	▪ Longitudinal cracking ▪ Minor block cracking ▪ Transverse cracking ▪ No structural benefits, ▪ Acceptable if the extent of cracking is minimal (little to no structural cracking).	▪ Structural failure (i.e., extensive fatigue cracking or high severity rutting) ▪ Extensive pavement deterioration, little remaining life
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 8.2 Fog Seal

Description	Warrants			
	Climate	Traffic	Conditions Addressed	Limitation
Fog seals are placed primarily to seal the pavement, inhibit ravelling rejuvenate hardened/oxidized bitumen surface, and provide some pavement edge-shoulder delineation. Fog seals are very light applications of a diluted bitumen emulsion placed directly on the pavement surface with no aggregate. Typical application rates range from 0.23 to 0.45 kg. per m^2	Treatment performs well in all climatic conditions.	Increased traffic can increase surface wear	▪ Longitudinal, ▪ transverse, and block cracking ▪ Ravelling/ weathering (loose material must be removed) ▪ Bitumen aging, oxidation and hardening ▪ No structural improvement, but can help reduce moisture infiltration through fatigue cracks (if their severity is low)	▪ Structural failure (such as significant fatigue cracking) ▪ Friction loss ▪ Thermal cracking
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.			

Table 8.3 Slurry Seal

Characteristics	Warrants			
	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 improving skid resistance at speeds below 60 km/hr. Thickness is generally less than 10 mm	Treatment performs effectively in all climatic conditions.	Performance in terms of surface wear is affected by increasing traffic. Accommodate the higher traffic volumes.	▪ Transverse, longitudinal and block cracking ▪ Ravelling/ weathering (loose material must be removed) ▪ Asphalt aging, oxidation and hardening ▪ Friction loss ▪ Moisture infiltration Adds no structural capacity; however, can temporarily seal cracks (if severity is low) or serve as a rut-filler (if the ruts are not severe and are stable)	▪ Structural failure (such as significant fatigue cracking and deep rutting) ▪ Thermal cracking
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 8.4 Microsurfacing

Characteristics	Warrants			
	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 Ravelling and oxidation of the pavement surface. Also effective at improving surface friction and filling minor irregularities and wheel ruts (up to 40 mm	Effective in all climate conditions.	Successful on both low- and high- traffic volume	▪ Longitudinal and transverse cracking ▪ Ravelling/ weathering (loose material must be removed) ▪ Bleeding ▪ Roughness ▪ Friction loss ▪ Moisture infiltration ▪ Adds limited structural capacity. Temporarily seals fatigue cracks (if severity is low) and can serve as a rut-filler (if the existing ruts are stable)	▪ Structural failure (i.e., extensive fatigue cracking) ▪ Extensive pavement deterioration, little remaining life ▪ Thermal cracks ▪ Can accelerate 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 ravelling, not to be placed when freezing temperatures are expected.			

Table 8.5 Surface Dressing

Description	Warrants			
	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 gradation and maximum size. Treatment seals pavement surface and improves friction.	Treatment performs well in all climatic conditions.	With proper design and placement, chip seals can perform well on high-volume roads. However, use is primarily limited to lower-speed, lower volume roads because of the propensity for loose chips to crack windshields.	▪ Longitudinal, transverse and block cracking ▪ Ravelling/ weathering (loose surface material must be removed) ▪ Friction loss ▪ Roughness ▪ Bleeding ▪ Moisture infiltration ▪ Adds almost no structural capacity. However, effective at sealing fatigue cracks in comparison with other treatments.	▪ Structural failure (i.e., extensive fatigue cracking and/or deep rutting) ▪ Thermal cracking ▪ Extensive pavement deterioration, little or no remaining life ▪ 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.			
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 8.6 Thin hot-mix/cold mix Bituminous Overlays

Description	Warrants			
	Climate	Traffic	Conditions Addressed	Limitations
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 performs well 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 subjected to strain from loadings. Such layers may be subject to topdown cracking under certain combinations of loadings, environmental conditions, and pavement structures.	Functional/Other ▪ Longitudinal and transverse cracking ▪ Ravelling/ weathering (loose surface material must be removed) ▪ Friction loss ▪ Roughness ▪ Bleeding ▪ Block cracking may perform better with additional milling) **Structural** Rutting (assumes rutting has stopped; requires use of separate rut-fill application)	▪ Structural failure (i.e., fatigue cracking) ▪ Extensive pavement deterioration, little remaining life ▪ Thermal cracking
Site Restrictions	Edge-shoulder drop-off should be considered. Surface should be uniform to ensure uniform compaction.			
Construction Considerations	Surface must be clean. A tack coat prior to overlay placement will help improve the bond to the existing surface. Thin HMA overlays dissipate heat rapidly and, therefore, depend upon minimum specified mix placement temperatures and timely compaction..			

Table 8.7 Ultrathin Friction Courses

Description	Warrants			
	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 should perform well in all climatic conditions	Capable of withstanding high ADT volumes and truck traffic better than other thin treatments	▪ Longitudinal, transverse and block cracking. Higher severities can be addressed with cold milling. ▪ Ravelling/ weathering (loose surface material must be removed) ▪ Friction loss ▪ Roughness ▪ Bleeding ▪ Provides some increased capacity and retards fatigue cracking. Not suited for rutted pavements.	▪ Structural failure (i.e., significant fatigue cracking and/or deep rutting) ▪ Extensive pavement deterioration, little remaining life ▪ 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.			

SECTION 9

PERIODIC RENEWALS

9.1 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.

9.2 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.

9.3 Identification of Stretches to be Renewed

The stretches of the road showing signs of distress such as hungry surface/hair-line cracking, Ravelling etc., should invariably be included in the renewal programme. This would ensure that the surface of the road and the pavement structure do not deteriorate further. The 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 the same.

9.4 Types of Renewal Treatments

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 have different life spans depending upon traffic and environmental conditions.

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

i) IRC:14 'Recommended Practice for Open Graded Premix Carpet'

ii) IRC:110 'Standard Specifications and Code of Practice for Design and Construction of Surface Dressing'

iii) IRC:111 'Specifications for Dense Graded Bituminous Mixes'

iv) IRC:SP:78 'Specifications for Mix Seal Surfacing (MSS), Close Graded Premix Surfacings (CGPS)'

v) IRC:SP:79 'Tentative Specifications for Stone Matrix Asphalt'

vi) IRC:SP: 81 'Tentative Specifications for Slurry Seal and Microsurfacing'

vii) IRC:107 'Specifications for Bitumen Mastic Wearing Courses'

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.

9.5 Periodicity of Renewal

Based on the experience and condition indices given in Tables 5.1 to 5.5, broad guidelines for the type of renewals are given in Table 9.1. This may be utilized as a guide for working out annual renewal programme on different sections of roads.

Table 9.1 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/2 Coat Micro Surfacing

* 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

The priority of renewal treatment may be decided based on rating assigned as explained in section 5.1, earlier. If there are 10 roads (say), with ratings from 1.4 to 1.8, the roads may be

arranged based on the ascending order of condition rating and the periodic renewal shall be prioritised in the same order subject to budgetary allocations.

9.6 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.

SECTION 10

MATERIALS AND METHODS FOR RECTIFICATION OF DISTRESS ON BITUMINOUS SURFACE

10.1 General

The Section 7 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:

i) Rejuvenation

ii) Seal and

iii) Patching

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.

10.2 Bituminous Materials

10.2.1 *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.

10.2.2 *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.

10.2.3 *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 1.0 to 25 μm 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.

10.2.4 *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.

10.2.5 *Modified Bitumen*

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

10.2.6 *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.

10.2.7 *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.

10.2.8 *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.

10.2.9 *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.

10.3 Maintenance Techniques

10.3.3 *Rejuvenating Seal*

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 bituminous material with or without cover aggregate of fine grading. The application of cover aggregate may be required or may not be required.

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

- The area to be treated needs to be in fair to good condition and not approaching the end of its life.
- When the road surface is in a condition which does not show significant cracking, ravelling or rutting.
- Where the road is structurally adequate i.e. major patching or reconstruction is not required.

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 for 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:

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

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.

10.3.4 *Fog Seal*

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 ravelling 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.

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 50°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 l/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

10.3.5 *Slurry Seal*

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 ravelling 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:

- Rapid application and early open to traffic
- Excellent surface texture and friction resistance
- Ability to correct minor surface irregularities
- Minimum loss of kerb height
- No need for manhole and other structure adjustments
- Excellent low cost treatment for urban streets

Slurry seal is applied in a very thin layer of 3 to 6 mm. The grade of emulsion to be used is 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 10.1. The details of this treatment are given in IRC:SP:100.

Table 10.1 Specifications for Different Types of Slurry Seal Treatments

Items	Type I	Type II	Type III
Applications	For filling hair cracks on surface cracks less than 1 mm	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 of 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 to 13.5	6.5 to 12

*By weight of dry aggregate only, **Indicative only, CVPD- Commercial Vehicles Per Day

10.3.4 *Microsurfacing*

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:

- ➢ Quick application (One lane- km in 35 minutes)
- ➢ Minimum traffic hold up (Work is done in lane wise manner) Quick opening to traffic
- ➢ Life span exceeds the life span of ordinary Bituminous Concrete
- ➢ Non-polluting for environment since no heating or hot paving is required
- ➢ Does not require sensor paver or compaction equipments
- ➢ Longer life since oxidation is reduced

- Waterproof Surface – Protection from rains
- Ideal for surface sealing treatment since it improves skid resistance and provides surface durability
- Does not increase pavement elevation significantly (This saves from water logging, drainage and other associated problems)
- Cost effective as compared to Hot-Mix
- Reduces noise caused by movement of traffic
- Environment friendly (reduced emissions) and savings in natural resources

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 10.2.

Table 10.2 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/m²)	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

Details of microsurfacing application are given in IRC:SP:81 and IRC:SP:100

10.3.5 *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 10.3 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 10.3 Quantities of Bitumen Emulsion and Aggregate for Cape Seal

Thickness of Cape Seal	Nominal Size of Aggregate	Quantity of Aggregate (kg/m^2)	Quantity of Emulsion (l/m^2)	Slurry Mixture (Type 1), kg/m^2
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

10.3.6 *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 ravelling. The fine aggregate shall be a medium coarse sand (fineness modulus of more than 2.5) or fine grit passing 1.70 mm IS Sieve and retained on 180-micron IS Sieve. The binder can be 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 cu m and 6.8 kg (quantity of binder in terms of penetration grade bitumen) per 10 sq m area respectively. The mix is spread and laid wherever required. When smoothening a corrugated surface ,it may be expedient to use a drag spreader with its blade adjusted to clear the high spots. The mixture is then rolled thoroughly till it is compacted.

10.3.7 *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 and IRC: SP:100

10.3.8 *Maintenance Mixes*

Maintenance mixes are classified into four types:

a) Mixes for Immediate Use

b) Storable Mixes

c) Maintenance Mixes using RAP

d) Ready Made Mixes

a) 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. The bitumen emulsion recommended for patching mixes are MS, SS-2 grades or tailor-made. The recommended aggregate gradation is given in Table 10.4. Bitumen emulsion containing slightly higher amounts of solvents generally produces the acceptable patching mixes for immediate use.

Table 10.4 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

The quantity of emulsion shall be 7 to 8 % (4.5 to 5.5 % residual bitumen) by weight of aggregate.

b) Storable Maintenance Mixes

During the cold weather and rainy months, 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 locations 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 10.4. 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.

c) 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.

d) Readymade Mixes

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 5.5% 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) and IRC:SP:100.

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

- Binder content
- Wet coating test
- Static Immersion test
- Water resistance test
- Workability test
- Bond test

Details of tests are given in IRC: SP: 100 and IRC: 116

Pothole shall be cleaned of loose material and dust with a stiff wire brush. Pothole need 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.

10.3.9 *Stress Absorbing Membrane for Crack Sealing*

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 10.5.

Table 10.5 Quantity of Materials Required for 10 sqm of Road Surface for Stress Absorbing Membranes

Sl. No.	Type and Width of Crack	Specification of SAM to be applied	Quantity of binder kg/10 m^2	Quantity of chipping
1.	Hair cracks and map cracks upto 3 mm width	Single coat SAM	08-10	0.10 m^3 of 5.6 mm chips
2.	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
3.	Map cracks or alligator cracks 6 mm to 9 mm width	Two coat SAM 1st coat 2nd coat	 12-14 08-12	 0.12 m^3 of 11.2 mm chips 0.10 m^3 of 5.6 mm chips
4.	Cracks above 9mm width	Two coat SAM 1st coat 2nd coat	 14-16 08-12	 0.12 m^3 of 11.2 mm chips 0.10 m^3 of 5.6 mm chips

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

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.

Following standards/specifications may be referred for maintenance treatments.

i) IRC:101 'Interim Guidelines for Warm Mix Asphalt'

ii) IRC:116 'Specifications for Readymade Bituminous Pothole Patching Mix Using Cut-back Bitumen'

iii) IRC:SP:81 'Tentative Specifications for Slurry Seal and Microsurfacing'

iv) IRC:100 'Use of Cold Mix Technology in Construction and Maintenance of Roads Using Bitumen Emulsions'

SECTION 11

TOOLS AND EQUIPMENT

11.1 General

Use of mechanized methods and techniques for carrying out various maintenance activities are recommended for achieving efficiency and quality in maintenance operations. Suitable tools, plants and equipment of appropriate capacity need to be deployed keeping in view the type and magnitude of the work and desired output. Proper maintenance and upkeep of all maintenance tools, plants and equipment is very important to ensure quality work. It is always advisable to follow equipment maintenance instructions and schedule as per manufacturer's specifications. Some of the tools and equipment especially tend to develop inaccuracies and defects with usage and hence, their regular monitoring/checking and rectification is essential.

Crack filling, pothole filling and patching works form the major part of the bituminous surface maintenance. While the crack sealing is generally carried out by manual methods, pothole filling and patching can be efficiently carried out by mechanized methods.

11.2 Pothole Filling/Patching

There are two main elements of durable pothole filling/patching; the material and the repairs process. For every combination of these two factors, the cost effectiveness of the overall pothole filling/patching work will depend on material, labour and equipment costs and the quantity of the work. The most economical combination of materials and process to the extent possible should be adopted to produce long lasting and cost effective patch repairs.

11.3 Tools and Equipment for Pothole/Patch Repairs

For carrying out durable, long lasting and cost effective repairs of potholes and patches, the following tools and equipment are generally required:

i) Material truck (with hand tools)

ii) Equipment truck

iii) Mechanical tool/equipment for pavement cutting and dressing

iv) Compaction device (vibratory walk behind roller or plate compactor)

v) Air compressor with pavement cutter

vi) Spot mix (preparing hot/cold asphalt mix in situ)

vii) Asphalt mix carrying and laying equipment

viii) Traffic control devices and equipment

ix) Mechanical brooms for highways and urban roads

11.4 Modern Mobile Mechanised Pothole Filling/Road Patching Technologies

For durable and cost effective pothole filling/road patching, innovative indigenous and imported mechanized road patching technologies are available. Most machines and techniques incorporate use of cold mixes, while some use infrared radiation technique for heating the road surface for use as patching material. The following are some of the widely used technologies for the purpose:

- Machine Mixed Spot Cold Mix and Patching Equipment
- Mobile Mechanized Maintenance Units
- Jet patching Velocity Spray Injection Technology

The deteriorated portion of the existing pavement adjoining the pothole should be cut and loose particles removed before patching of pothole.

A view of various machines is given in Photos 11.1 to 11.4

11.1 Production of Emulsified Cold Mix for Patching Mixes

11.2 Velocity Injection Jetpatching Machine

11.3 Infrared road patching technology

11.4 Mobile Mechanised Maintenance Unit

These equipment and technologies are for general applications for pothole filling/patch repairs. Mobile mechanized maintenance units may be equipped for other applications also. For more specific applications or other maintenance treatments, various equipment and methods that are generally used are detailed in documents indicated in Section 9.4.

SECTION 12

ARRANGEMENTS FOR TRAFFIC AND SAFETY MEASURES DURING ROAD MAINTENANCE

12.1 Safety during Maintenance Work in Progress

12.1.1 The road construction and maintenance activities are an integral part of road network development and its preservation. Maintenance of roads is a normal recurring and periodic activity. During execution of maintenance activities, proper arrangements for safe operation and movement of normal traffic, maintenance workers and equipment in the work zones are most important. The road work zones are areas of conflict between normal operating traffic, workers, maintenance equipment and machines and work zone traffic. Care has to be taken to avoid/ remove conflicts between workers, maintenance equipment and traffic. As a good practice, it should be essential to prepare a Work Zone Traffic Management Plan (WTMP) to provide for reasonably safe and efficient movement of road users through or around the work zones, while reasonably protecting the workers and equipment. WTMP should provide for continuity of the movement for motorised vehicle, bicycle, and pedestrian traffic, transit operations, and access to properties and utilities.

It is equally important to ensure the safety of workers in Work Zones. Work zones present constantly changing conditions that are not expected by the road users, which create an even higher degree of vulnerability for the workers present near the roadway. A concurrent objective of the WTMP is the efficient construction and maintenance of the highway, as well as efficient resolution of traffic incidents, if any, likely to occur in the work zone. The WTMP, therefore, should facilitate the smooth and efficient flow of traffic as well as safe working environment.

12.1.2 Since maintenance operations involve considerable hardship, inconvenience and hazard to traffic and also hazard to maintenance workers, all possible precautions should be taken to make safe arrangements for traffic. These include erection of barriers, signs, red flags and lights. In order to promote road safety and efficiency by providing for the orderly

movement of traffic on all roads during maintenance phases, road signs and other traffic management tools help in regulations of traffic and provide warning and guidance needed for safe, uniform and efficient operation.

12.1.3 A road sign should meet the following five basic requirements for their effectiveness:

a) Meet the requirement;

b) Command attention;

c) Convey a clear and simple meaning;

d) Command respect from road users; and

e) Give adequate time for response.

Design, placement, operation, maintenance, and uniformity are aspects that should be carefully considered in order to maximize the ability of a road sign to meet these basic requirements.

12.1.4 The maintenance related activities shall confine to half of the pavement width at a time leaving the other half for use by the traffic, to the extent possible. Otherwise, diversion roads may have to be constructed or the traffic diverted to some other alternative route with a proper information arrangement about the alternative. The maintenance operation itself can be conveniently confined to a small length at a time. The appropriate warning sign to be used such as “Men at Work” sign during working, or the “Narrow Road Ahead” sign if half of the road width is available for traffic, should also be displayed. During night, there should be adequate lighting with red reflectors/flashers/blinkers. All signs shall be in accordance with IRC 67 ‘Code of Practice for Road Signs.’ For further guidance and details on safety measures and traffic management during maintenance, IRC:SP 55 “Guidelines on Traffic Management in Work Zones” may be referred to.

12.2 Road Signs, Pavement Markings and other Traffic Control Devices

12.2.1 After completion of the maintenance work, the existing road markings, road signs etc. shall be restored to ensure safe and smooth movement of traffic. The maintenance staff shall keep the road authority informed of deficiencies, if any, observed in road signages, markings and other traffic control devices. Safety measures for necessary action to remove the deficiencies, is warranted to be identified for implementation therefore, as per relevant IRC Standards and Codes of practice.

SECTION 13

ORGANISATION AND MANAGEMENT

13.1 Maintenance of a road requires proper planning, programming and adequate tools, equipment, machinery and skilled workers/operators to carry out the required maintenance activities. There should be well equipped dedicated maintenance units or divisions within the organization in order to achieve the intended purpose in an effective and efficient manner. For primary roads, the nodal agency to identify the priorities and initiate action related to maintenance implementation is either MORTH or NHAI. In case of secondary and tertiary roads, the maintenance is the responsibility of the State governments whereas urban roads are looked after by the local bodies. The traditional method of maintenance of roads by departmental work force or road gangs is being phased out and the road authorities are exploring alternative methods of implementing maintenance. Maintenance by contract is perceived as an efficient method. While it has been in practice since long and used successfully for implementing renewal programmes, the experience of road agencies with contracting out of routine maintenance has not been so successful and most road agencies have not yet switched over to routine maintenance contracts. This may be due to lack of standardization of contract forms and non-availability of maintenance contractors. Considering the size of the country's road network and road hierarchy, several forms and methods of implementing routine maintenance may be required to choose the one most suited to a road agency. Efforts are underway in this direction to standardize various types of maintenance contracts. In addition to this, availability and development of maintenance contractors requires to be addressed in a big way. In the transition period, the road agencies have to modernize the existing system to bring in efficiency, productivity and improved performance by introducing mechanization, mobile maintenance units, new and energy saving materials and institutionalizing dedicated maintenance set up. The effort should continue be to move towards contracting out of maintenance by proper packaging the scope of the maintenance contracts to improve their viability, and also to test alternative forms of contracts to develop a proper maintenance contract framework specific to the requirements of a road agency. Contracting out maintenance requires assured funding and effective supervision. Some model bidding documents for road maintenance have been developed for use of road agencies and these documents incorporate provisions for performance security, maintenance standards, performance criteria, simplified payment procedure, damages for non-performance, etc so as to ensure that the contractor is held accountable for the performance of maintenance.

13.2 Performance Based Maintenance Contracting (PBMC) is widely used for maintenance of roads. The contract specifies objective performance standards which define the road

condition to which the roads are to be maintained and not allowed to fall below the specified level any time over the maintenance contract period. Monthly lump sum payments are made for maintenance on the basis of the accepted contract price. Monthly lump sum payments are subject to deductions if the required performance standard is not achieved. The deductions are effected as specified in the contract. Effective supervision is required to ensure that there is no deficiency in the performance of maintenance and condition of the roads and road assets included in the contract is maintained to the specified level.

13.3 For routine maintenance of low volume roads like village roads and ODRs, use of labor based and semi- mechanized methods are generally preferred. As the traffic increases, the level of mechanization should also increase for carrying out maintenance efficiently. For maintenance of roads carrying high volumes of traffic, machine based methods and technologies capable of carrying out maintenance with speed and safety and causing minimum interruptions in movement of traffic are recommended.

13.4 Planning and scheduling of the maintenance operations should be given due importance. The annual renewal programme should be drawn up well in advance keeping in view the condition of the surface and any improvement work carried out recently or scheduled to be taken up in the near future. In case sufficient funds are not available for renewal works, the priority may be decided following the suggested criteria given in Section 9.5. This would enable the field engineer to plan and implement maintenance programmes in a rational manner and according to available budget.

APPENDIX 1

PAVEMENT CONDITION ASSESSMENT/VISUAL SURFACE CONDITION ASSESSMENT

Surface distress is a measure or indicator of the structural and resulting functional state of a pavement structure and is generally given the prime importance by concerned agencies. Physical distress is identified and a quantitative visual assessment of distress is made by a well experienced/trained team of 3-4 persons while moving in a vehicle at a speed of 8-10 km/hr.

While recording the distresses, the details for the following are visually noted and recorded in individual percentage for each km length in **Proforma 1.**

1. Alligator or fatigue cracking
2. Longitudinal and transverse cracking
3. Bleeding
4. Depressions/Settlements
5. Potholes
6. Patching
7. Ravelling
8. Rutting

PROFORMA-1

VISUAL SURFACE DISTRESS MEASUREMENT

Name of the Road :

Carriageway Width (m) :

Chainage of Test Section : Km……..to Km……

Date of Observation:

Type of Surface : Km …….to Km……..

Weather Condition :

Chainage		Cracks (%)	Patch Work (%)	Potholes (%)	Bleeding (%)	Depression (%)	Edge Breaking (%)	Ravelling (%)	Shoving (%)	Rut Depth (mm)	Drainage and Shoulder condition	Total
From	To											

Recorded by

Checked by

APPENDIX 2

PAVEMENT DISTRESS MEASUREMENTS

In project level based maintenance strategies,more precise condition data may be required and hence actual measurements of all the following distresses need to be measured in smaller representative sections:

1. Alligator or fatigue cracking
2. Longitudinal and transverse cracking
3. Bleeding
4. Depressions/Settlements
5. Potholes
6. Patching
7. Ravelling
8. Rutting

In such cases, the required information with measurements may be collected from field and recorded in Proforma 2.

PROFORMA-2

MEASUREMENT OF SURFACE DISTRESS

(FLEXIBLE PAVEMENT SECTION)

Name and Number of the Road

Carriageway Width (m) :

Chainage of Test Section : Km……..to Km……

Date of Observation:

Chainage of Sub-Section : Km …….to Km……..

Weather Condition :

Type of Surface :

Cracks with Type			Patch Work		Potholes			Bleeding		Depression/ Settlement		Edge Breaking		Ravelling		Shoving		Rut Depth* (mm)	Remarks (Drainage and Shoulder Condition)
Type	Size (m) (LxB)	Area (m^2)	Size (m) (LxB)	Area (m^2)	Size (mm) (LxB)	Area (mm^2)	Depth (mm)	Size (m) (LxB)	Area (m^2)	Size (m) (LxB)	Area (m^2)	Size (m) (LxB)	Area (m^2)	Size (m) (LxB)	Area (m^2)	Size (m) (LxB)	Area (m^2)		

* To be measured using 3 m straight edge

Checked By_____

Recorded By_____

APPENDIX-3

METHODOLOGY FOR PAVEMENT CONDITION SURVEY

The surface condition of the pavement is assessed mainly in terms of roughness, pavement surface distress in the form of cracking, ravelling, potholes, edge break, patch work, rutting, skid resistance and texture depth.

A. Pavement Surface Roughness Measurements

The roughness of existing pavement is assessed in terms of Roughness Index in mm/km as per the procedure given in IRC:SP:16 using Fifth Wheel Bump Integrator/Automatic Road Unevenness Recorder and Car Axle Mounted Bump Integrator. Also, as per the international practice, the Roughness in terms of International Roughness Index (IRI) is measured using various state-of art equipments such as Dipstick, Walking Profiler and Laser Profilometer.

1. Fifth Wheel Bump Integrator/Automatic Road Unevenness Recorder

Fifth Wheel Bump Integrator (FWBI) is attached to the vehicle (Photo 1) and runs at a specified speed of 32±1 km per hour. Depending upon the undulations on road surface, the fifth wheel makes vertical movements relative to the road surface. To record the vertical movements of fifth wheel, integrating unit is connected to the axle of fifth wheel with the help of a cord which is firmly fixed onto the frame. The tension in the cord is mounted by a spring inside the drum. The cable is wound around the pulley for about 2½ turns after initial tensioning. The vertical movements of wheel are recorded in an electromagnetic counter which is connected through a circuit, with power supply provided from the jeep battery.

Photo 1 Fifth Wheel Bump Integrator

With the recording of roughness, the distance travelled is recorded so that the roughness can be expressed in terms of specified length of road section, say per km. Usually, the unevenness

is expressed in mm/km. In order to facilitate recording of distance travelled, an arrangement for measurement of wheel revolutions is provided on the axle of fifth wheel itself.

2. Car Axle Mounted Bump Integrator

Car Axle Mounted Bump Integrator consists of an integrating unit, which is mounted on the rear axle of a car/jeep (Photo 2). There are two sets of counters, one each for the bump and distance measurements together with a switch, located on the panel board. Any one set of counters can be used at a time by the recorder. The advantage of having two counters is that while one is in use, the other will display the data for the previous run. Apart from this, the switching of counters with the help of toggle switch provided in the panel board gives km wise data exactly. The power source is car battery itself.

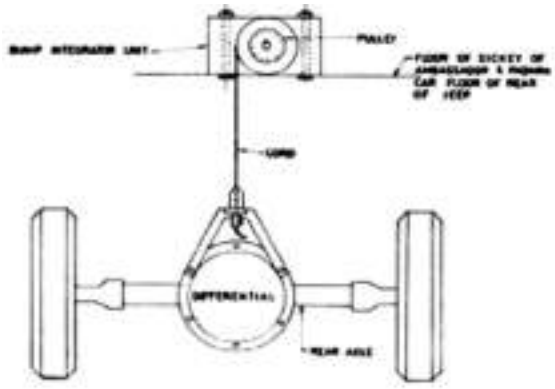

Photo 2 Schematic of Car Axle Mounted Bump Integrator

A cable is taken from a fixed point on the rear axle of vehicle and is wound around a pulley forming part of the integrating unit. The integrating unit is located in the floor of vehicle's dicky. The cable is wound around the pulley for about 2½ turns after initial tensioning. The working of integrating unit and the recording process are same, as in the case of FWBI.

Some of the commonly used system, which are now finding applications in India too, for measurement of Pavement Surface Roughness in terms of International Roughness Index in m/km are described below:

3. Laser Profilometer

Laser based road profiling is a high speed road roughness measuring system. The Laser Profilometer beam is installed in front of the survey vehicle. The field measurements using Laser Profilometers can be done at speeds ranging from 30 to 100 kmph. This system is based on the measurement of vertical displacements using Laser Rays. Laser Profilometer Bar, as shown in Photo 3, comprises of two Laser sensors used for measurement of longitudinal profile of the pavement surface. These sensors are placed along the wheel path of survey

vehicle. The system directly gives International Roughness Index(IRI) for both wheel paths of survey vehicle viz. Left IRI and Right IRI in terms of m/km.

Photo-3 Laser Profilometer Installed in Front of the Survey Vehicle

4. Merlin

MERLIN (Machine for Evaluating Roughness using Low-cost Instrumentation) can be used either for direct measurement or for calibrating response-type instruments such as the vehicle-mounted bump integrator. It consists of a metal frame 1.8 m long with a wheel at the front, a foot at the rear, and a probe midway between them that rests on the road surface. The probe is attached to a moving arm at the other end of which is a pointer that moves over a chart. The machine is placed at successive locations along the road and the positions of the pointer are recorded on the chart to build up a histogram. The width of this histogram can be used to give a good estimate of roughness in terms of the International Roughness Index. A typical view of the equipment is shown in photo 4.

Photo-4: A Typical View of MERLIN

5. Dipstick-Auto Read Road Profiler

It is a precise electronic digital level and profiler. It stands on two support legs. Just by a simple twist of the wrist, it can take readings along a survey line. It measures, displays and records the elevation difference between front and the rear leg. The readings that are taken are accurate upto 100th decimal place. It directly gives International Roughness Index in m/km. A typical view of the equipment is shown in photo 5.

Photo 5 A Typical View of Dipstick

6. Walking Profiler

Walking Profiler is a precision instrument designed to collect surface profile data. These data can be used to accurately assess the characteristics and quality of any continuous paved surface. Typically, the surface profile is used to generate a number of internationally recognized roughness index, ride quality and pavement maintenance indices etc.

It is a precision surveying tool which is designed to operate at a moderate and steady walking pace in a straight line. The equipment has an integral Control Unit which provides all the functions of instrument calibration, survey setup and operator feedback. Like Dipstick, it also directly gives International Roughness Index in m/km. A typical view of the equipment is shown in photo 6.

Photo 6 A Typical View of Walking Profiler

B. Measurement of Pavement Surface Distress

Distress is developed in the pavement surface in the form of cracking, ravelling, potholes, edge break, rut depth, patch work, texture etc. with passage of time due to a variety of influencing factors such as traffic volume and loads and climatic conditions etc.

1. Manual Method:

The measurements of pavement surface distress on flexible pavements are measured manually in terms of area in square meter, meter as given in **Appendix-2**

2. Pavement Surface Imaging Technique:

Image Processing Techniques are being used for quantification of pavement surface distress. These techniques involve the use of pavement cameras for pavement surface imaging. These pavement cameras, as shown in photo 7, generate the calibrated images (with known length and width) of the pavement surface. The measurement of various surface defects viz. cracking, ravelling, patching and pot holes is done by using the Image Processing software.

Photo 7 Pavement Surface Imaging Using Pavement Cameras

C. Measurement of Skid Resistance

A variety of devices are available for the measurement of skid resistance. These include:

- Stopping distance based techniques for initial assessment of surface friction of pavements.
- The Portable Skid Resistance Tester can be conveniently used for measuring skid resistance of pavements. For obtaining reliable results with this method, tests should be carried out at carefully selected representative locations.
- Side Force Coefficient or cornering friction on paved surfaces using Mu-Meter, a high speed device for measuring skid resistance.
- Skid Trailor used for measuring braking force coefficient of friction. This is also a high speed device for measuring skid resistance.

1. Portable Skid Resistance Tester (British Pendulum Tester): This is a dynamic pendulum impact type tester used to measure the energy loss when a rubber slider edge is propelled over a test surface. The tester is suited for laboratory as well as field tests on flat surfaces and for polish value measurements on curved laboratory specimens from the accelerated wheel tests. (ASTM – E 303 – 1978). A typical view of the equipment is shown in photo 8

Photo 8 A Typical View of Portable Skid Resistance Tester

2. Mu-Meter: Mu-Meter is a continuous friction measuring equipment comprising of a light weight trailor unit (254 kg) capable of being towed by a standard vehicle. The trailor unit comprises a triangular frame on which two friction measuring wheels are mounted. The rear wheel which drives the recorder also measures the distance. The Mu-Meter measures the sideway coefficient of friction generated between the test surface and the smooth tread tyres operating at 7½ degree angle to the direction of travel under wet condition. The speed of measurements is 40 mph (64 kmph).

The tyre pressure of the measuring wheel is 0.70 kg/sqcm and for the rear wheel is 2.10 kg/sqcm. The unit is provided with an Average Friction Automatic Printout Unit (APO) carried in the cab of the vehicle and is operated electrically by a 12v battery. (ASTM E – 670 -79).A typical view of the equipment is shown in photo 9.

Photo 9 A Typical View of Mu-Meter

D. Measurement of Texture Depth

The macro texture depth is determined by sand patch method as per clause 602.12 of "Specifications for Road and Bridge Works" of the MORTH (Fifth Revision)

The macro texture in terms of Mean Profile Depth in mm can also be collected automatically using modern laser based systems usually installed in Automated Road Survey Systems.

APPENDIX 4

UTILITY FOR RATING OF PAVEMENT BASED ON QUANTITY OF DISTRESS:

A simple application in Ms-excel has been prepared for calculating the overall/final rating of the road based on the quantity (%) of various distresses as per the ranges described in Table 5.1 to 5.3 in Section 5, for different categories of roads. The application developed for all categories of roads, is available to the users in the CD enclosed with this document.

This utility assigns the rating value to each individual parameter from 1, 1.1 to 2.0 and 2.1 to 3.0 which corresponds to Poor, Fair and Good condition of the road respectively. After assigning the rating number to each parameter, an appropriate weightage (fixed) is given (multiplier) to the rating value of each individual parameter, for calculation of the **Weighted Rating Value** of each individual parameter.

For the calculation of the **Weighted Rating Value** of each individual parameter, the following fixed weightages have been assigned.

S.No.	Parameter	Weightage (Fixed) (Multiplier Factor)
1	Cracking	1.00
2	Ravelling	0.75
3	Potholes	0.50
4	Shoving	1.00
5	Patching	0.75
6	Settlement	0.75
7	Rut Depth	1.00

The **Final Rating Value** is calculated by taking the average of the **Weighted Rating Values** of all parameters viz. cracking, ravelling, potholes, shoving, patching, settlement and rut depth. For demonstration of the calculations, one typical example for highways (as per Table 5.1) is given below. Similarly, final rating for other category of roads may also be worked out, using the same approach.

Calculation of Final Rating Values based on quantity (%) of distress

Distress Type	Input (%)	Rating as per Table 5.1	Weightage	Weighted Rating Value
Cracking (%)	9.00	1.2	1.00	1.2
Ravelling (%)	8.00	1.2	0.75	0.9
Potholes (%)	0.00	3.0	0.50	1.5
Shoving (%)	0.09	2.1	1.00	2.1
Patching (%)	5.00	1.5	0.75	1.1
Settlements (%)	4.00	1.2	0.75	0.9
Rut Depth (%)	9.00	1.3	1.00	1.3
Final Rating Value				1.3
Condition				Fair

(The amendments to this document will be published in its periodical, 'Indian Highways' which shall be considered as effective and as part of the code/guidelines/manual, etc. from the date specified therein)