

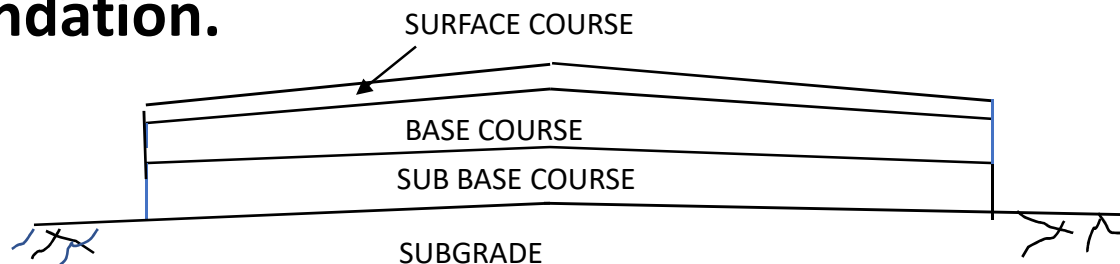
# PROJECT SAMPARK



Improving the Pavement Conditions :  
Pavement Condition Assessment methods,  
Methods for optimizing the reparation  
and maintenance cost for roads

# WHAT IS A PAVEMENT ?

The structure consisting of superimposed layers of selected and processed materials placed on a subgrade to support the applied loads and distribute the to soil foundation.



It provides adequate , smooth , durable and serviceable support for the loads imposed by traffic **at all times in all weather conditions.**

A good pavement contributes to a large extent to the quality of a **highway or airport.**

# WHY DO WE REQUIRE A GOOD PAVEMENT ?



Pavement in good condition ensures

- (i) Increase in riding quality and saving in **Vehicle Operation Cost**.
- (ii) Saving in travel time.
- (iii) Reduction in accident rate.**
- (iv) Less fatigue and discomfort during travel.
- (v) Increased mobility of **Essential services and Defence forces**.
- (vi) Reduced suffering and pain of those involved in highway accidents.
- (vii) Savings in maintenance cost.

## CAUSES OF PAVEMENT FAILURES

- Defects in the quality of materials used.
- **Defects in construction method and quality control during construction**
- Inadequate surface and subsurface drainage.
- Increase in traffic volume and magnitude of wheel loads.
- Inadequate pavement crust thickness.
- Settlement of foundation of embankment of the fill material.
- **Natural and Environmental factors - heavy rainfall, land slides, soil erosion, high water table, snow fall, frost action.**

# PAVEMENT PERFORMANCE AND ITS EVALUATION

**Pavement Performance** - the ability to serve traffic safely and comfortably over a period of time.

## **Objectives of Evaluation**

- a) To assess as to whether and to what extent the pavement fulfils the requirement.
- b) To plan maintenance and strengthening jobs in time.

# PAVEMENT CONDITION ASSESSMENT METHODS

**Visual Evaluation** – Distresses (Alligator cracking, Longitudinal and transverse cracking, Bleeding, Pothole, Patching, Ravelling, Rutting) are visually noted and recorded.

**Functional Evaluation** – based on Riding quality (road roughness), Pavement distress and Skid resistance.

Surface distresses are actually measured in smaller representative stretches.

1. **Pavement Condition Rating (PCR)** – rating 0 to 3 by IRC.  
(direct rating system)

- It provides a measure the present condition of pavement.
- Provides an objective and rational basis for determining maintenance and rehabilitation needs.
- Used to establish the rate of pavement deterioration for early identification and rehabilitation needs.

Pavement Distress Rating

Defect(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& Depression (%)	>5	1 to 5	<1
Rut depth in mm	>10	5 to 10	<5
Overall Rating	1	1.1 -2.0	2.1 – 3.0
Condition	Poor	Fair	Good

Pavement Distress Weightage

S.No	Defect(Type)	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	Settlements (%)	0.75
7	Rut depth (%)	1.00

## 2. Pavement Condition Index (PCI) - rating 0 to 100 by ASTM

(Deduct Value or Deduct Point Method)

- It is the numerical indicator of overall pavement condition.
- It takes into account the roughness and distress of pavement.

**Standard PCI Rating Scale**

100	Good
85	Satisfactory
70	Fair
55	Poor
40	Very poor
25	Serious
0 -10	Failed

**Clubbed Condition Ratings**

Pavement Condition	Pavement Rating	
	IRC	ASTM
Good	2.1 - 3.0	70-100
Fair	1.1-2.0	41-69
Poor	0 -1.0	0-40

### 3. Present Serviceability Index (PSI) – rating 1 to 5 by AASHTO

(widely used throughout the world)

rating 1 – very poor pavement

rating 5 – excellent pavement

#### **Flexible Pavements**

$$PSI = 5.03 - 1.91 \log(1 + SV) - 1.38(RD)^2 - 0.01v(C + P)$$

#### **Rigid Pavements**

$$PSI = 5.41 - 1.80 \log(1 + SV) - 0.09v(C + P)$$

SV = Slope variance giving an index of the longitudinal profile.

RD = Rut depth under a 4 ft. strait edge.

C = Amount of cracking(lineal feet of cracks/1000 sq ft. area).

P = Patched area(sq ft/1000 sq ft area).

**Structural Evaluation** – based on deflection of the pavement

- i) Static Plate Bearing Test.
- ii) Benkelman Beam method.
- iii) Falling Weight Deflectometer.
- iv) Lacroix Deflectograph.
- v) Dynaflect.

# PAVEMENT CONDITION SURVEY

- Carried out after every monsoon on each road.
- Surface condition is assessed in terms of **roughness, pavement surface distresses, skid resistance and texture depth**.
- Based on condition survey and condition rating – type of maintenance activity to be decided.
- A plan has to be drawn for preventive maintenance or periodic renewals based on pavement condition rating.

## **A. Measurement of Unevenness or Roughness**

assessed in terms of Roughness Index in mm/km.

1. Fifth wheel Bump Integrator.
2. Car axle Mounted Integrator.
3. Laser Profilometer.

## **Measurement of Pavement Surface Distress**

Distress is developed in the pavement in the form of cracking, ravelling, potholes, edge break, rut depth, patch work, texture with passage of time due to traffic volume, loads and climatic conditions.

- 1) Manual method.
- 2) Pavement surface imaging technique.

## **Measurement of Skid resistance**

- i) Stopping of test vehicles.
- ii) Braking of vehicles with a test wheel.
- iii) Portable Skid resistance Tester.
- iv) Mu-Meter.

## **Measurement of Texture Depth**

- i) Sand patch method.
- ii) Laser based system.

# SERVICEABILITY INDICATORS FOR HIGHWAYS

S.No	Serviceability Indicator	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) Min desirable	60 SN	50 SN	40 SN

Level 1- match with new pavement condition.

Level 2- in service min desirable level.

Level 3- warrant for intervention to restore the pavement to level 1

# MAINTENANCE OF ROADS

**Road Maintenance** - Preserving and keeping each type of roadway, roadside structures as nearly as possible in its original condition as constructed or as subsequently improved to provide satisfactory and safe transportation.

## **Includes**

Maintenance of pavement, structures, drains and cross-drainage works, shoulders and slopes, bridges, road furniture.

## **Importance**

- i) Improvement of Riding quality.
- ii) Reduction in rate of **deterioration and improvement in life of road.**
- iii) Reduction in Vehicle Operation Costs (VOC).
- iv) Reduction in rate of accidents.
- v) Keeping roads **traffic worthy in all weathers** .
- vi) Reduction in pollution due to reduced fuel consumption.
- vii) Savings in budgetary expenditure of restoration/ reconstruction.

# TYPES OF MAINTENANCE

## 1. ROUTINE MAINTENANCE

undertaken by the maintenance staff almost round the year.

- filling of potholes.
- repairing of cracks and patch work.
- maintenance of shoulders and cross slope.
- up-keep of road side drains.
- pavement markings.

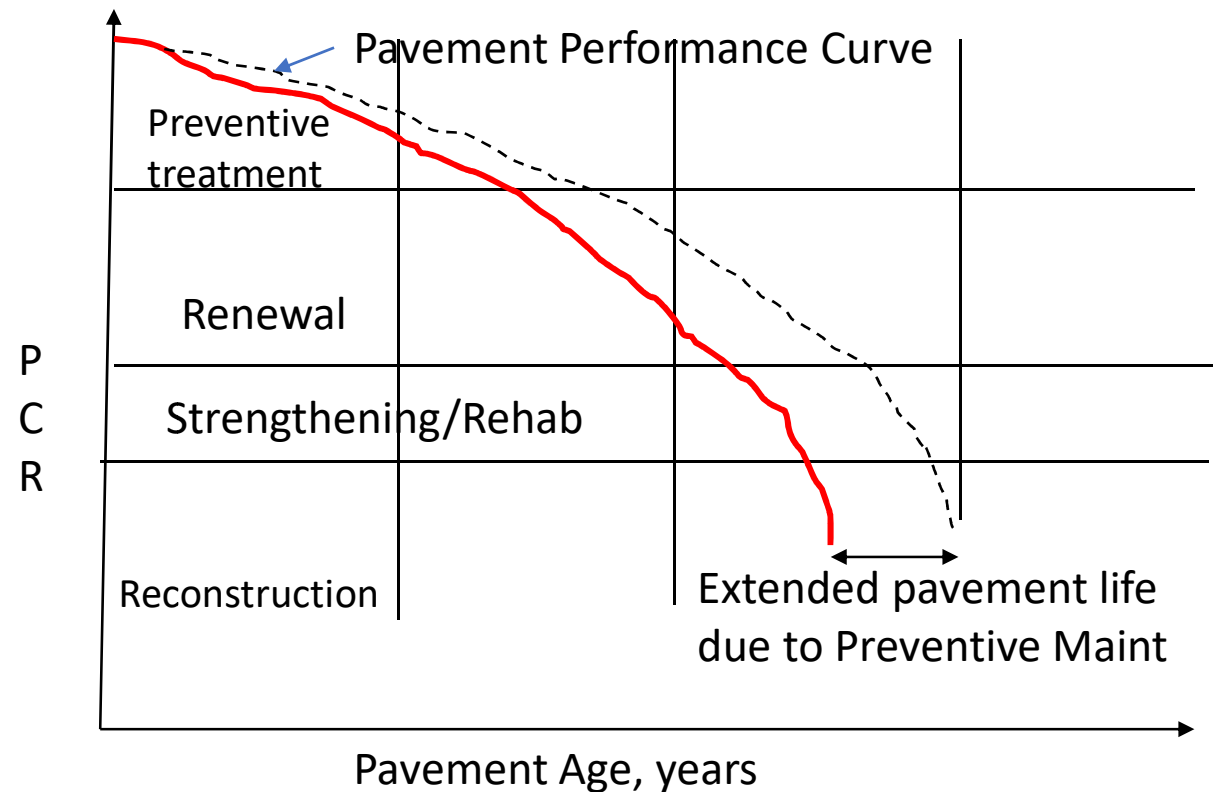
## 2. PREVENTIVE MAINTENANCE

A planned maintenance activity, which decreases the rate of surface deterioration and **extend service life** of bituminous pavement. 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.

### PREVENTIVE MAINTENANCE TREATMENTS

- Crack sealing/crack filling.
- Fog seal.
- Slurry seal.
- Micro surfacing.
- Surface dressing.
- Thin surfacings.
- Ultra thin friction courses.



**PERIODIC MAINTENANCE** Provision of a surfacing layer at regular intervals of time or at a specified condition.

### Structural enhancements

To extend the service life of an existing pavement.

To improve the load carrying capacity.

To preserve the required serviceability level of the pavement.

To offset the wear and tear caused by traffic and weathering.

### PERIODIC RENEWALS

Surface dressing ( one or two coats).

Thin premix carpet.

Mixed seal.

Stone matrix asphalt.

Dense bituminous concrete.

Micro surfacing (one or two layers).

### Suggested Renewal Treatment on Flexible Pavement by MORTH

Road Category	Condition Rating	Roughness, mm/km	Suggested treatment(th –mm)
NH	2	2400	30-40 BC grad-2
MDR/CI-9	2	2800	30 BC grad-2

## 4. SPECIAL REPAIRS

Strengthening of pavement structure.

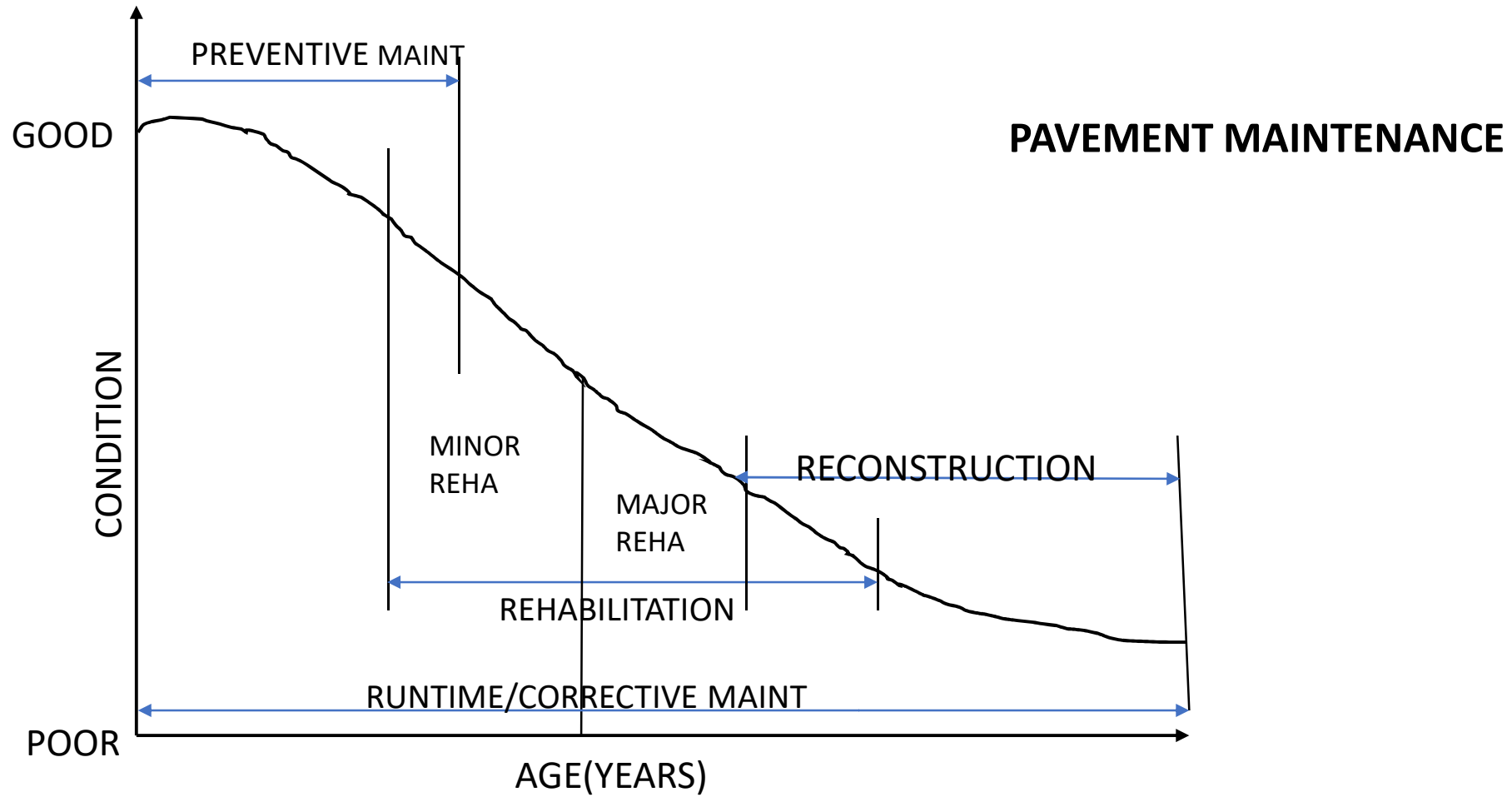
Reconstruction of pavement.

Widening of roads.

**Improvement of geometrics.**

**Repair of damages caused by monsoon/floods.**

Repair of subsurface drainage and cross drainage structures.



# DEFECTS IN BITUMINOUS SURFACING

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## 1. SURFACE DEFECTS

- Bleeding or Fatty surface

Smooth surface

Streaking

Hungry Surface



## 2. CRACKS

- Hair-line cracks

Alligator cracks

Longitudinal cracks

Edge cracks

Shrinkage cracks

Reflection cracks



## 3. DEFORMATION

- Slippage

Rutting

Corrugations

Shoving

Shallow depression

Settlements and upheaval

## 4. DISINTEGRATION

- Stripping


Ravelling

Pot holes

Edge breaking



# YPES OF PAVEMENT DISTRESS, CAUSES AND TREATMENT

	Type of Distress	Symptoms	Probable causes	Type of treatment
	<b>Surface Defects</b>			
	Fatty surface	Collection of binder on the surface	Excessive binder in hot mix, lower voids in hot mix, heavy tack coat and prime coat, soft grade binder	Applying heated coarse sand, open graded premix, milling out the affected portion.
	Smooth surface	Slippery	Polishing of aggregates under traffic, excessive binder.	Resurfacing with premix carpet, surface dressing, micro surfacing.
	Streaking	Presence of alternate less and heavy lines of bitumen	Non-uniform application of bitumen across the surface or at a low temperature	Application of a new surface
	Hungry surface	Loss of fine aggregates from the surface or presence of fine cracks	Use of less bitumen or absorptive aggregates.	Slurry seal or fog seal. 

# TYPES OF PAVEMENT DISTRESS CAUSES AND TREATMENT

	Type of Distress	Symptoms	Probable causes	Type of treatment
	<b>CRACKS</b>			
	Hairline cracks	Short and fine cracks at close intervals on the surface	Insufficient bitumen content, excessive filler , improper compaction, oxidation of bitumen in surface.	Fog seal, slurry sealing, application of liquid rejuvenating agents, mill and surfacing.
	Alligator or map cracking	Inter-connected cracks forming a series of small blocks	Inadequate pavement thickness, weakening of subgrade or lower layers due to saturation, excessive overloads, brittleness of binder.	Crack sealing by bitumen emulsions, rubberised modified bitumen, mill and resurfacing.
	Longitudinal cracking	Cracks in a straight line along the road	Alternate wetting and drying beneath the shoulder, weak/improper joint bet adjoining layers.	Crack sealing, remove and replace the cracked pavement with fresh overlay.
	Edge crack	Cracks near and parallel to pavement edge	Lack of support from shoulder, poor drainage, frost heave, inadequate pavement width	Good drainage along edge of the road, permeable material on shoulders

# TYPES OF PAVEMENT DISTRESS CAUSES AND TREATMENT


	Type of Distress	Symptoms	Probable causes	Type of treatment
	Reflection cracks	Sympathetic cracks over joints and cracks in the pavement underneath	Differential movement across the underlying crack or joint	Fog seal, slurry sealing, application of liquid rejuvenating agents, use of SAM or SAMI
	<b>DEFORMATION</b>			
	Slippage	Formation of crescent shaped cracks pointing in the direction of thrust of the wheels	Unusual thrust of wheels in a direction, lack of failure of bond between surface and lower pavement courses	Removal of the surface in the affected area and replacement with fresh material
	Rutting	Longitudinal depression in the wheel tracks	Heavy channelised traffic, inadequate compaction of pavement layers, poor stability of pavement materials	Filling the depressions with premix material
	Corrugations	Formation of regular undulations	Lack of stability in the mix, faulty laying surface course, insufficient rolling or rolling a tender mix.	Scarification and relaying, surfacing, cutting of high spots and filling low spots

# TYPES OF PAVEMENT DISTRESS CAUSES AND TREATMENT

	Type of Distress	Symptoms	Probable causes	Type of treatment
	Shoving	Localised bulging of pavement surface along with crescent shaped cracks	Unstable mix, lack of bond between layers, heavy traffic movement involving negotiation of curves and gradients.	Removing the material from firm base and relaying with stable mix.
	Shallow depression	Localised shallow depressions	Presence of inadequately compacted pockets.	Filling with premix material.
	Settlement & upheaval	Large deformation of pavement	Poor compaction of fills, poor drainage, inadequate pavement or frost heave.	Excavate defective fill and redone, strengthening.



# TYPES OF PAVEMENT DISTRESS CAUSES AND TREATMENT

	Type of Distress	Symptoms	Probable causes	Type of treatment
	<b>DISINTEGRATION</b>			
	Stripping	Separation of bitumen from aggregate in the presence of moisture	Use of hydrophilic aggregate, inadequate mix composition, continuous contact with water, poor bond between agg and binder at the time of construction, poor compaction.	Replacement with fresh bituminous mix added anti-stripping agent, slurry seal , micro surfacing.
	Ravelling	Failure of binder to hold the aggregates shown up by pock marks or eroded areas on the surface	Poor compaction, poor bond between binder and aggregates, insufficient binder, brittleness of binder.	Slurry seal, micro surfacing, resurfacing.
	Pot holes	Bowl shaped cavities of varying sizes	Ingress of water into the pavement, lack of bond between surfacing and WMM base, insufficient bitumen content.	Filling with cold/hot mix ready mixes, penetration patching.
	Edge-breaking	Irregular breakage of pavement edges	Water infiltration, poor lateral support from shoulders, inadequate strength of pavement edges.	Cutting the affected area and rebuilding. 

# MAINTENANCE COST OF ROADS

## **depends on**

- Volume and intensity of traffic.
- Cost of materials.
- Labour and machinery.
- Type of terrain.
- Type of wearing surface.
- Minimum level of serviceability considered for that category of road.
- Climatic conditions.

# OPTIMIZATION OF MAINTENANCE COSTS

Important aspect for cost-effective maintenance - **Selection and Timing of maintenance activities.**

**Preventive Maintenance** relatively inexpensive - Preserves the system, Retards future deterioration and Improves functional condition. Most effective when pavement is structurally sound and exhibits little or no distress.

Preventive maintenance shall be undertaken before **PCR** drops to 2.

**Pavement distress** already present- corrective maintenance (pothole repair, patching, joint replacement or slab replacement) is more appropriate.

**Routine maintenance** like crack filling may be considered for small distress.

**Periodic renewals** may be undertaken at a **PCR** of 2.

**Strengthening** requirement be assessed if **PCR** is 1.

**PAVEMENT MANAGEMENT SYSTEM (PMS)** - A tool or method that assists in optimizing strategies for providing and maintaining pavements in a serviceable condition over a given period of time.

**PMS constitutes the following aspects**

- Pavement Condition Data.
- Maintenance Standards.
- Economic Analysis.
- Programming.
- Control of Works and Feedback.
- Budgetary Analysis.

helps users select cost-effective alternatives for pavement maintenance and rehabilitation.

**Highway Development and Management Tool (HDM-4)**- developed by WB.

A powerful management software tool for the analysis, planning, management and appraisal of road maintenance, improvements and investment decisions. to make comparative cost estimates and economic evaluations of different construction and maintenance options.

perform a comprehensive life-cycle analysis of agency costs, user costs, and benefits using condition deterioration models for roughness, cracking, ravelling, rutting and edge breaking.

# COST SAVING IN MAINTENANCE

Area	-	Jammu & Kashmir (UT)
of Road	-	BG – POONCH (NHDL), Pavement in <b>Good</b> condition
	-	40 km
Renewal coat	-	30 mm AC
Recycle Period	-	3 years
Re Surf rates	-	2017-18
Preventive maint to be adopted	-	Micro surfacing 10 mm th.

## **CALCULATIONS**

Routine Maint as per Scale =  $40 \times 4.63 = 185.2$  lakhs.

Resurf 30 mm BC with correction work 50 mm BM - 1604 lakhs.

Micro surf 10 mm th with 2% cement =  $40 \times 7 \times 1000 \times 1.05 \times 200 = 588$  lakhs (rate of micro surf Rs 200/sqm).

By extending the recycle period is differed by 2 years by adopting preventive maintenance of micro surfacing.

Cost of Maint = Routine Maint Cost for 5 y + Preventive Maint cost (Micro surf) =  $185.2 \times 5 + 588 \times 1 = 1514$  lakhs.

Cost of Maint without Preventive Maint = Routine Maint Cost for 5 Y + Cost of Renewal coat =  $185.2 \times 5 + 1604 = 2530$  lakhs.

**Cost saving in cost of maint in 5 year period =  $2530 - 1514 = 1016$  lakhs (40.16% of total maint cost)**

## **CONCLUSION**

There is a need to introduce the system of assessing the condition of each road before planning the maintenance works to be carried out in BRO.

In BRO, maintenance of roads is being carried out as **Routine Maintenance** (drain clearance, berm filling, patch repair etc), **Periodic renewals**(resurfacing) and **Special/Emergent repairs**(IRMD, SRMD, Impvt/Rehab of roads).

There is no concept of cost effective **Preventive Maintenance** (fog seal, slurry seal, micro surfacing, thin asphalt layers with NMAS of 9.5 mm) in BRO which **extend the life of pavement and reduces the costs of renewal coats and rehabilitation.**

A certain percentage (about **20%**) of **Periodic renewal** funds may be utilized for **Preventive maintenance** with better materials.

**Condition survey** of important roads in each Project should be carried out through Consultancy Agencies for working out the time and type of preventive treatment to be applied on each road and to conclude a consolidated **Performance Based Maintenance Contract.**

Resurfacing works carried out by Self in 2017



Resurf works carried out by self in 2017



**THANKS**