Highway Maintenance and Rehabilitation

2.2. Pavement Condition Survey

Movement of Material: Ravelling, Fretting, Bleeding, etc

- Movements of materials include ravelling and bleeding: some ravelling is caused by excessive wear of the wearing course and may lead to the formation of potholes. It is normally counted as cracking or crazing.
- Ravelling of severity 1 on crazing of severity 2, counted as Type A damage
- Ravelling: more or less large losses of gravel from surface dressing (deficiency of bonding hence of the quantity and/or quantity of bitumen)
- Scabbing: loss of all or part of a thin (<3 cm) wearing course of coated materials and separation from its substrate; this is often preceded by major cracking of the wearing course;
- Fretting: deficient implementation due to bad equipment operation: poor distribution of bitumen by the sprayer, hence surface unequally covered by the bitumen or bad gravel distribution on the pavement

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2.2. Pavement Condition



Severity 1

Isolated stripping on cracking

Severity 1



Isolated stripping of scabbing type

Severity 1

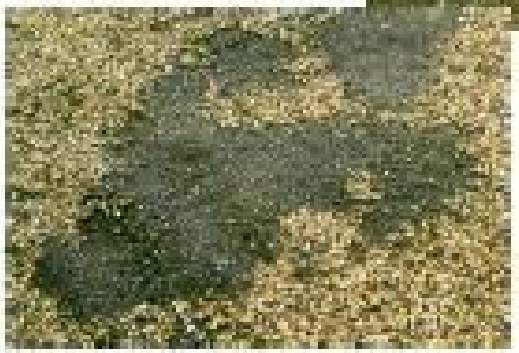


Discontinuous stripping of plucking type



Severity 2

Very marked generalized fretting



Severity 2

Continuous stripping bleeding appearance of roadbase

Severity 2

Very marked continuous without in wheel tracks



Highway Maintenance and Rehabilitation

2.2. Pavement Condition Survey

Shoulder and Ditch Erosion

- There are other forms of damage that are specific to a climate, a country, or a given traffic pattern and that may require rebuilding of the shoulders as part of maintenance

- Lacy Edge: the damage occurs in pavements in which the roadbase and shoulders are of the same type, and is caused by the frequent stopping of vehicles on the shoulders. The extent of the damage is more important than its severity.

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2.2 Pavement Condition



Severity 1

Photo 31
Lacy edge forming; damage not clearly marked

Severity 2



Photo 32
Continuous marked lacy edge



Severity 3

Photo 33
Disappearance of pavement

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2.2. Pavement Condition Survey

Low Shoulders : this damage is caused by maintenance of the shoulder, which gradually become lower than the pavement surface

Shoulder substantially lower than pavement (up to 10 cm)



Highway Maintenance and Rehabilitation

2.2. Pavement Condition S



Severity 1

Erosion of ditch

Ditch erosion:

the erosion may take a number of forms, rainwash of ditch; rainwash and destructions of ditch; destruction gravely endangering a part of the pavement.

Severity 3



Destruction by undermining of shoulder

Highway Maintenance and Rehabilitation

2.3. Pavement Maintenance

INTRODUCTION

- The performance of a pavement is affected by the type, time of application, and quality of maintenance it receives.
- The proper identification of pavement defects and the determination of their causes is crucial to the selection of proper maintenance treatments and repair strategies.
- Delays in maintenance increases the quantity of defects and its severity so that it increases the cost of repair.
- In addition, a recognition that different pavements deteriorate at different rates is important in selecting the proper time for maintenance.
- Preventive timely maintenance slows down the rate of pavement

Highway Maintenance and Rehabilitation

2.3. Pavement Maintenance

- Factors which affect pavement deterioration rates are:
  - Traffic loads,
  - Weather Condition,
  - Pavement Materials,
  - Pavement Thickness,
  - Construction Quality and
  - Effectiveness of Previous Maintenance
- The primary reason for maintenance are:
  - To correct deficiencies produced by distress ,
  - To protect the investment and

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2.3. Pavement Maintenance

- "Pavement maintenance is work performed from time to time to keep a pavement, under normal conditions of traffic and forces of nature, as nearly as possible in its as-constructed condition."
  - distinction are usually made between forms of maintenance, based on their required frequency.
  - The International Road Maintenance Handbook uses the grouping of "routine" and "periodic" maintenance.

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2.3. Pavement Maintenance

Routine Maintenance

- Routine maintenance is carried out on routine wise basis & regularly in order to preserve and keep the original pavement shape by crack sealing, small patching, repair of some rutting, & depression.
- A well equipped, an efficient and committed maintenance crew is essential.
- The crew should be able to carry out small maintenance works with a little, or even without interrupting the vehicular movement.
- Extensive practice has proved that if the maintenance work is carried out on routine basis, the expenses of maintenance work of a road could be minimize.
- The maintenance crew will always make a frequent site

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2.3. Pavement Maintenance

Periodic Maintenance

- This is a major maintenance work, which includes all the maintenance works as mentioned earlier and in addition to that the overlay of the existing bituminous surfacing up to a thickness of 50 mm.
- Some agencies consider this overlay layer as a part of rehabilitation but this over lay is needed when the riding quality of the surface becomes uneven due to continuous routine maintenance works.
- This could happen even before completion of the design period of the existing pavement.

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2.3. Pavement Maintenance

While other sources (e.g. TRRL) use “routine”, “recurrent”, “periodic”
and “urgent”. “… There are four categories:

- **routine** maintenance, required continually on every road, whatever its engineering characteristics or traffic volume
- **recurrent** maintenance, required at intervals during the year with a frequency that depends on the volume of traffic using the road
- **periodic** maintenance, required only at intervals of several years
- **urgent** maintenance, needed to deal with emergencies and problems calling for immediate

Highway Maintenance and Rehabilitation

2.3. Pavement Maintenance

- Generally, maintenance activities are divided into two categories:
  - Preventive Maintenance
  - Corrective Maintenance
- **Preventive Maintenance** – is that group activities performed to protect the pavement and decrease the rate of deterioration of the pavement quality.
- **Corrective Maintenance** – is that group activities performed to correct a specific pavement failure/ area of distress.

Highway Maintenance and Rehabilitation

2.3. Pavement Maintenance

1. Preventive Maintenance

There are two types of preventive pavement maintenance:

- Surface Seal
- Crack Sealing

i. **Surface Seals:** are those maintenance activities consisting of applications of asphalt alone (asphalt and aggregates) which are applied continuously to the whole surface of a traffic lane.

ii. These surface seals are most often applied to:

- Rejuvenate/Retard the oxidation of asphalt at the surface.
- Restore skid resistance of the surface.
- Seal fine cracks which have appeared at the surface.
- Prevent the intrusion of water into the pavement structure through cracks which penetrate through the HMA layer.

Highway Maintenance and Rehabilitation

2.3. Pavement Maintenance

- The most common types of seals applied to HMA surface are:
  - Fog seals
  - Rejuvenators
  - Chip seals/ surface treatments
  - Slurry seals

1. Fog seals:

- It involves a light application of a slow setting emulsion to an oxidized pavement surface.
- The primary objective is to restore/rejuvenate the cement at the surface of the asphalt roadway.
- A fog seal consists of a single application of a slow setting emulsion which has been diluted by an equal amount of water.
- This diluted liquid is sprayed on the surface at a rate of 0.1 to

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2.3. Pavement Maintenance

Fog seals (continue…)

- Higher quantity being used for coarse textured, dry surfaces.
- The primary advantage of fog seal is its low cost and ability to postpone the need for surface treatment.
- Care must be taken when applying fog seals to ensure that excess asphalt is not applied which results in loss of skid resistance.
- Some sand should be kept to avoid such situation (applications of excess asphalt).
- This treatment is suitable for low volume roads which can be closed to traffic during applications of the treatment (4 to 6 hours needed for the emulsion to break and set up sufficiently to provide

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2.3. Pavement Maintenance

2. Rejuvenators:

- Many products are available in the market which rejuvenate the oxidized asphalt at the surface.
- They are made from tar products to make the surface resistant to fuel spillage.
- Rejuvenators are usually applied with asphalt distributors.
- Rejuvenators must be able to penetrate the HMA surface to the desired depth (at least ¼ inch) (6.4mm) within a reasonable time.

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2.3. Pavement Maintenance

- If the HMA Surface is not sufficiently porous or the viscosity of the rejuvenator is high or too much rejuvenator is applied, the rejuvenator tends to form a thin layer at the surface resulting in slippery and hazardous condition.
- Therefore, rejuvenators are mostly used on low volume, low speed roads or parking lots.
- The durability of rejuvenating applications has not been well established.
- Rejuvenation may also postpones the need for surface treatment.

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2.3. Pavement Maintenance

3. Chip seals/ Surface Treatments

- This type of surface treatment consists of single or multiple applications of asphalt and aggregate over a weathered surface.
- The thickness of surface treatment is limited to 1 inch.
- A thin HMA overlay is considered as a surface treatment.
- **Chip seal** – is a single surface treatment which involves spraying asphalt material followed immediately by a thin aggregate cover which is rolled as soon as possible.
- **Sand seal** – is a type of single surface treatments which use sand as a cover aggregate.
- Sand seals are low cost treatments and are appropriate for use on low volume rural roads or

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2.3. Pavement Maintenance

Multiple Surface Treatment

Is a surface obtained by repeating the process of a single surface treatment a second or even a third times.

- The maximum size of cover aggregate for each successive applications is usually reduced by 50 percent.
- Cover aggregate should be clean; otherwise, it doesn't adhere to the asphalt material.
- Surface treatments add little load-carrying strength to the pavement structure.
- When properly designed and constructed, surface treatments are economical, easy to place and reasonably durable.
- Not only they provide a water proofing cover over the existing pavement structure, they resist abrasion by traffic.
- The asphalt binder can be asphalt cement, cutback asphalt or emulsified asphalt.

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2.3. Pavement Maintenance

- The Construction sequence for single surface treatment:
  1. Set up traffic control. A detour is preferred.
  2. Clean the surface to remove dirt and other loose materials.
  3. Apply the asphalt binder to the surface at the specified rate and temperature using a calibrated asphalt distributor.
  4. Spread the aggregate at the specified rate evenly over the surface immediately after the asphalt binder is applied.
  5. Immediately roll the aggregate to push it through the asphalt binder and to seat it firmly against the underlying layer.

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2.3. Pavement Maintenance

4. Slurry Seals:

- A slurry seal is a homogeneous mixture of emulsified asphalt, water, well graded fine aggregate and mineral filler which has a creamy, fluid like appearance when mixed in proper proportions.
- The layer thickness is approximately equal to the maximum aggregate size.
- Based on the function served by the slurry seal, there are generally three gradations used for the slurry seals.

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2.3. Pavement Maintenance

- **Type I Slurry Seal**: has the finest gradation with most of the aggregates smaller than 2.36mm (sieve no 8).
- It is sometimes used as a preparation for HMA overlay/ Chip Seal.
- It has been used on low traffic areas such as parking lots and paved shoulders.
- The primary functions of the seal:
  - Sealing the asphalt surface from moisture,
  - Prevention of additional oxidation of the asphalt surface,
  - Prevention of loss of surface materials.

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2.3. Pavement Maintenance

Type II Slurry Seal: is slightly coarser than the Type I Slurry Seal having a maximum aggregate size of 6.4mm.

- It is the most extensively used of the mix types.
- It is used when moderate to severe ravelling has occurred due to

oxidation of the asphalt and to restore or improve skid resistance.

- When improved skid resistance is a criterion, the aggregate should be angular and polish resistant, the use of natural sands is prohibited.

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2.3. Pavement Maintenance

Type III Slurry Seal: is typically reserved for pavements which have developed severe surface irregularities requiring a thicker sealer with larger aggregate.

- It is recommended for use as the first course in a multi course application and to restore skid resistance.
- Because of its thickness, it fills slight depressions on the paved surface to prevent water ponding on the surface of the road.
- Slow setting emulsified asphalt (SS) of all types are used in slurry seal applications.
- Quick setting emulsified asphalt (QS) is used when the road must

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2.3. Pavement Maintenance

2. Crack Sealing:

- is a routine maintenance activity which involves cleaning out the cracks and filling the clean cracks with a sealant in order to prevent water and non-compressibles from entering the pavement structure.
- The most common type of cracks which needs sealing are:
  - Longitudinal cracks
  - Traverse cracks
  - Edge cracks and
  - Block cracks
- **Fatigue/ Alligator cracks** are seldom routed and sealed individually because the intensity of the crack pattern usually warrants an area treatment rather than individual crack treatment.
- The treatment involves removal and replacement, overlay or seal coat for low severity fatigue cracking.

Highway Maintenance and Rehabilitation

2.3. Pavement Maintenance

Repairs of cracks

- Cracks are sealed for two major reasons:
  - To prevent the intrusion of clayey materials, and
  - To prevent the intrusion of water into the underlying pavement layers.
- Many types of satisfactory crack sealing materials are available. However, there are certain general properties that should apply to any material used for this purpose.
- These properties include:
  - Good bonding/ adhesion
  - Flexibility and Extendibility
  - Ease of application
  - Resistance to softening
  - Resistance to cracking
  - Resistance to weathering.
  - Compatibility to asphalt

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2.3. Pavement Maintenance

- Typical sealing procedures involve the following steps:

1.Place proper traffic control devices in the work zone.

- Route the cracks to remove debris and any deteriorated crack sealing material.
- Clean the cracks with compressed air or stiff bristle broom.
- Pour hot crack filling material into the crack with 6mm depth below the surface.
- After allowing the sealant to cool, broom off the excess sand, remove traffic control devices, and open to traffic.

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2.3. Pavement Maintenance

2. Corrective Maintenance

Corrective maintenance consists of:

1. Patches
2. Chip Seals

1. Patches:

Patching is one of the most common methods for repair of localized areas of intensive cracking, whether the cracking is (load associated or environmental related) or construction related.

- If the cracking has deteriorated to the point that disintegration of the pavement materials around the cracks is occurring, the defective material must be removed and replaced.
- Patching can either be:
  - Partial depth repairs

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2.3. Pavement Maintenance

- Partial depth repairs involves removing the surface layer and replacing it with HMA.
- Full depth repairs involves removal of the complete pavement down to the sub grade or to an intermediate sub base layer.
- Typical repairs in flexible pavements for cracked areas involves full depth repairs.
- Partial depth repairs are reserved for cracks that results due to poor bond to the underlying layer or for shoving and corrugations.
- A patch consisting of HMA is considered to be a permanent repair and should last for years.
- Emergency repairs of potholes frequently involve the use of cold mix materials under severe environmental conditions.
- This is a temporary repair and serves as an expedient measure in order to keep traffic movement until permanent

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2.3. Pavement Maintenance

- The proper procedure for making a permanent patch in a HMA surface involves the following steps:

•Set up traffic control consistent with the class of highway.

•Mark of the area to be removed using paint, or chalk.

•Cut through the pavement around the perimeter of the polygon using a saw.

•Remove the loose material down to a solid base.

•Apply tack coats to the sides and bottom of the hole when patching with HMA.

•Place 4 inch (100mm) layer of HMA and compact each layer.

•Using a straightedge, check around the perimeter of the patched area to ensure that the patch is approximately level with the surrounding

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2.3. Pavement Maintenance

8)Seal the edges of the patch using a sand or chip seal which involves a light application of liquid asphalt blotted with sand or aggregate chips.

•Sweep all loose materials from the road surface and remove to a suitable site and remove traffic control devices and open to traffic.

- The following patching procedure is followed for temporary repairs:

1. Set off traffic control devices.
2. Remove all large, loose materials from the hole as much as is practical by brooming.
3. Fill the patch with cold mix patching material and compact by hand

tamping or preferably with truck wheels.

4. Sweep all loose materials from the roadway surface, remove traffic control devices, and open to traffic.

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2.4. Pavement Rehabilitation

Rehabilitation

"Work undertaken to significantly extend the service life of an existing pavement. This may include overlays and pre overlay repairs, and may include complete removal and reconstruction of the existing pavement, or recycling of part of the existing materials."

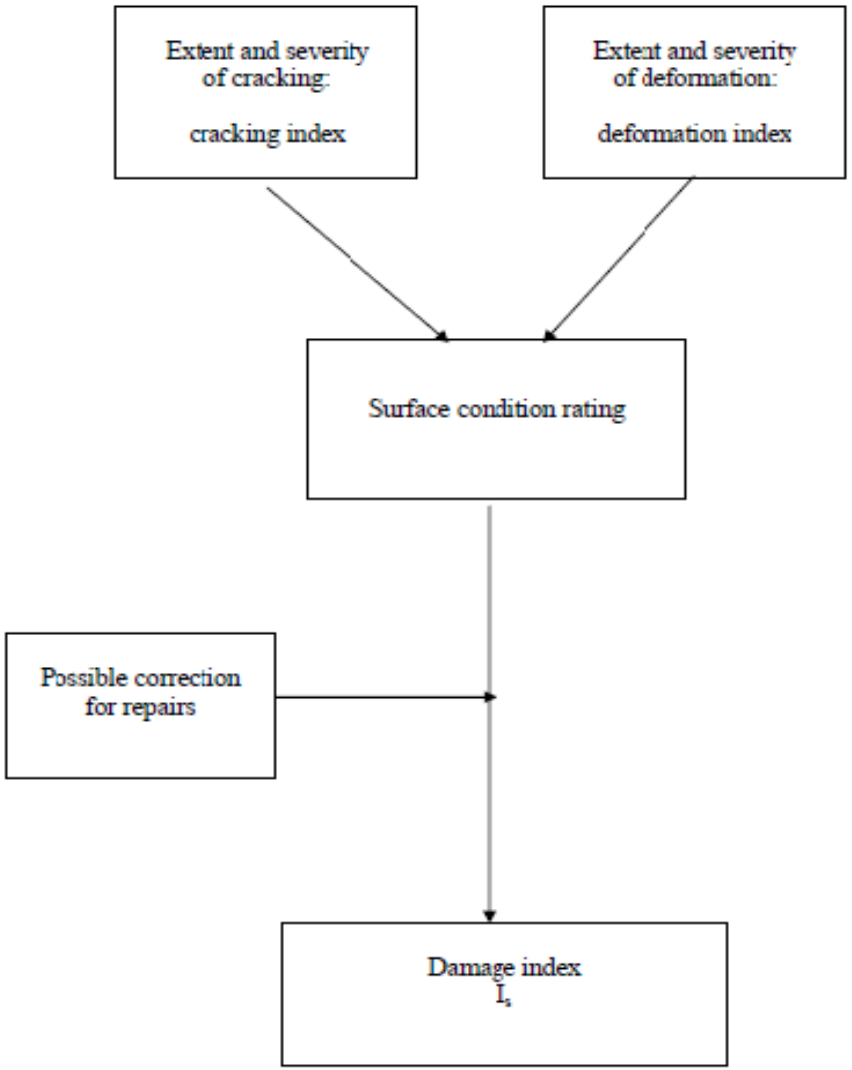
For simplicity, rehabilitation is subdivided into two major categories:

1. **Rehabilitation methods with overlays**
2. **Rehabilitation methods other than overlays**

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2.4. Pavement Rehabilitation

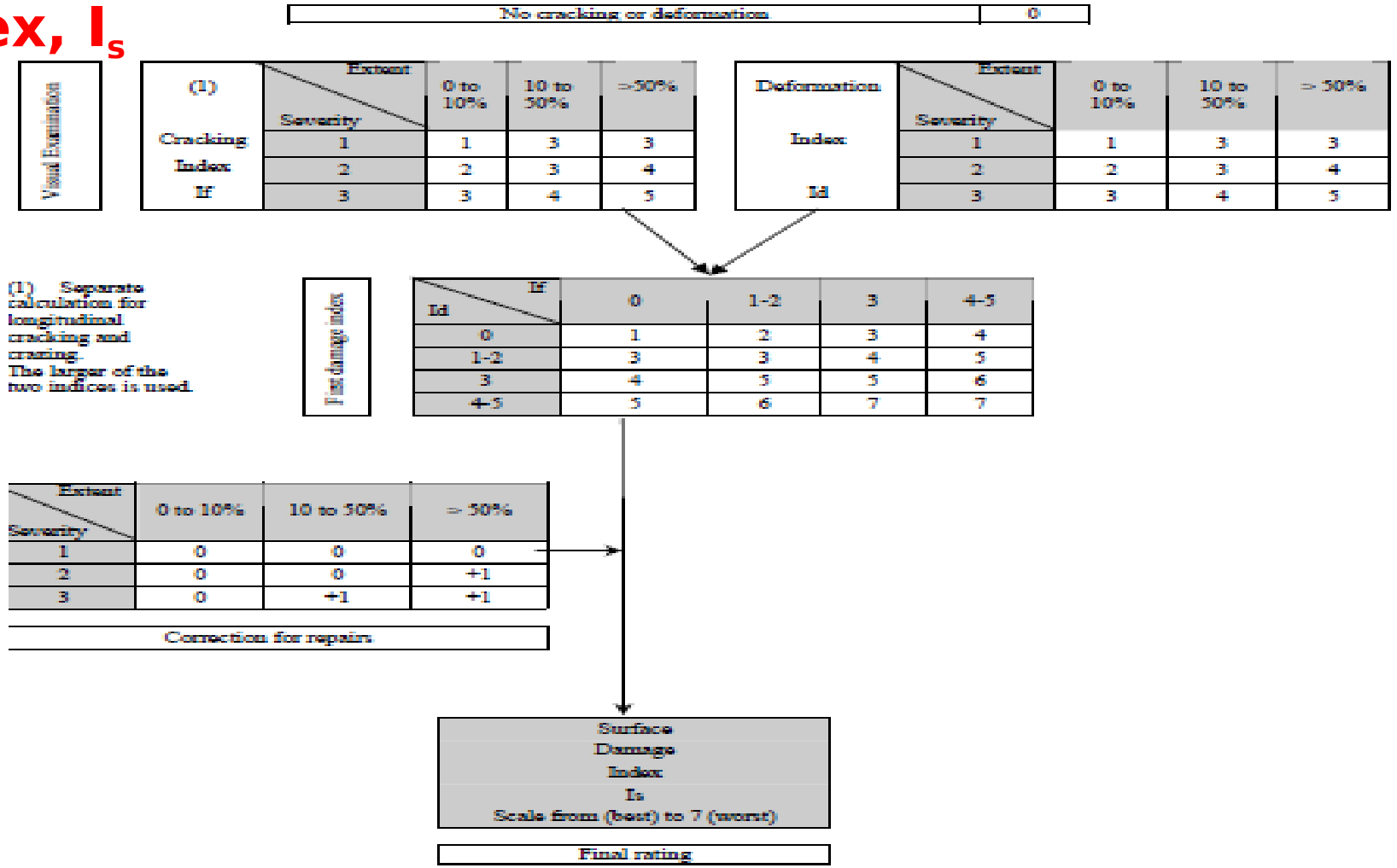
Damage Index



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2.4. Pavement Rehabilitation

Determination of Damage Index, I_s



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2.4. Pavement Rehabilitation

Damage Index, Is : Divided in to 3 ranges:

- **Rating 1 or 2:** Little or no cracking or deformation; good surface condition requiring no (or only just requiring) immediate maintenance.
- **Rating 3 or 4:** Cracks with little or no deformation, or deformation without cracking; intermediate surface condition, bad enough to trigger maintenance work in the absence of any other consideration.
- **Rating 5, 6 or 7**: Extensive cracking and deformation; poor surface
condition requiring major maintenance or overlay work.

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2.4. Pavement Rehabilitation

Deflection

- Deflection is also divided into three ranges, by thresholds d1 and d2:
  - D1- value below which pavement performance is generally good
  - D2 - value above which pavement performance is poor
  - D1 – D2 -range of indecision.

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2.4. Pavement Rehabilitation

Pavement Quality Rating Qi as a function of the **Index Is** and the **Deflection value**.

Three main ranges have to be considered:

- Q1, Q2 and Q3 : these ratings mean that there is nothing that needs to be done, or at most maintenance work depending on the traffic carried by the road. When sealing is required, the cracking index is used to determine the data and type of work.
- Q7, Q8 and Q9 : these ratings mean that the pavement requires an overlay, the thickness of which is determined by the traffic.
- Q4, Q5 and Q6 : this is a zone of indetermination for which the index Is and the deflection value seem

2.4. Pavement Rehabilitation

Q4 : pavement with marked damage in spite of a good bearing capacity. The validity of the deflection measurement should be checked together with the nature of the damages (in particular rutting layers of coated materials, unrelated to the deflection measurement). Depending upon the answer, Q will be reclassified as Q2 (priority to deflection) or Q7 (priority to damage).

Q5 : same analysis as above; allowance will be made for the position of the deflection with respect to the limits and to the traffic; depending upon the answer, may be reclassified as Q3, Q7, or Q8.

Q6: pavement having a large deflection value without apparent damage; to validate or unvalidate the surface condition, check the age of the pavement or the

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2.4. Pavement Rehabilitation

Pavement Quality Rating Vs Required Road Works

Deflection / Surface damage index Is	d1 d2		
	Class 1	Class 2	Class 3
1 - 2 Little or no cracking or no deformation	Q1 (maintenance)	Q3 (maintenance)	Q6 (to be reclassified)
3 - 4 Cracks with little or no deformation, deformation without cracks	Q2 (maintenance)	Q5 (to be reclassified)	Q8 (overlay)*
5 - 6 - 7 Cracks and deformation	Q4 (to be reclassified)	Q7 (overlay)*	Q9 (overlay)*

* or other rehabilitation method

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2.4. Pavement Rehabilitation

Pavement rehabilitation

- Pavement rehabilitation is defined as taking constructive measures to restore the structural and functional condition of roads where distress has caused unacceptable pavement serviceability.
- Structural strength of the existing pavement is utilized to some extent in the design of the rehabilitated pavement.
- Other factors such as agency policy, practical construction aspects, availability of skills, materials, environmental mitigation and maintenance aspects shall be considered in selection of the rehabilitation option.
- Rehabilitation options are classified into:
  - overlays
  - partial reconstruction

Highway Maintenance and Rehabilitation

2.4. Pavement Rehabilitation

- *Overlays are one or more courses of asphalt construction on existing pavement.*
- *The overlay often includes a leveling course, to correct the contour of the old pavement, followed by a uniform course or courses to provide needed thickness.*
- Rehabilitation methods other than overlays include:

Recycling: the rehabilitation, it is advantageous if is expected from the existing pavement material and the material needed for rehabilitation will mostly new material.

Reconstruction: In this category, little or no contribution

- the existing pavement materials which are re-used in part or as a whole in the construction of the rehabilitated pavement.

Highway Maintenance and Rehabilitation

2.4. Pavement Rehabilitation

- Examples of major rehabilitation methods employed as non-overlay techniques include:
  - Full-Depth Repair
  - Partial Depth Patching
  - Joint-Crack Sealing
  - Sub sealing-Under sealing
  - Grinding and Milling
  - Subdrainage
  - Pressure Relief Joints
  - Load Transfer Restoration
  - Surface Treatments

that may be

- Finally, non-overlay rehabilitation methods also include, as required when these elements have become deficient, geometric improvements and/or drainage improvements or restoration.

Highway Maintenance and Rehabilitation

2.4. Pavement Rehabilitation

- The extent of the pavement investigation depends on prevailing conditions on site and shall be carried out in the following sequence:
  - desk study (shall always be carried out)
  - initial assessment (shall always be carried out)
  - detailed condition surveys (if required)
  - structural surveys (if required)

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2.4. Pavement Rehabilitation

- A desk study shall always be carried out to gather available information about the road section, which may include:
  - as-built data including construction records and information about geometry and drainage
  - maintenance records
  - data from previous traffic counts and axle load surveys
  - data from previous investigations such as, deflection, DCP, rutting, roughness, defects, surface sampling, rutting, roughness, cracks, measurements of and others

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2.4. Pavement Rehabilitation

- Initial assessment includes visual inspection and examination of data obtained in the desk study. The initial assessment shall establish the length of sections with
  - no significant problems
  - Localised distress clearly related to specific problems such as poor drainage, expansive subgrade soils, or others
  - distress obviously related to the surfacing only
  - possibilities of inadequate structural strength
- Initial assessment shall give recommendations on:
  - remedial action for the localised distress
  - remedial action for the surface distress
  - a further field test programme for sections with possibilities of inadequate structural strength or with distress where the existing pavement may be salvaged

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2.4. Pavement Rehabilitation

- Detailed condition surveys shall be carried out where the existing pavement may be salvaged and distress is not obviously related to either surfacing only or localized problems.
- Detailed condition surveys include measurements of the following parameters
  - rutting
  - surface defects
  - potholes
  - cracks, all cracks and wide cracks> 3 mm
  - loss of stones (ravelling)
  - patches
  - roughness
  - shoulder conditions
  - drainage conditions

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2.4. Pavement Rehabilitation

- Structural surveys shall include collection of one or more of the following data:
  - Dynamic Cone Penetrometer (DCP)
  - Maximum surface deflection with Benkelman beam (8160 kg axle)
  - Pit logs and laboratory tests of samples such as moisture content, grading, Atterberg limits, CBR, or others as required

Highway Maintenance and Rehabilitation

2.4. Pavement Rehabilitation

- Which method is the appropriate for a road section depends on the following:
  - condition of the existing pavement
  - strength requirements for the new pavement
  - types of material in the existing pavement
  - available materials for construction of the new pavement
  - required surface levels of the new road
  - construction practicalities