5.4 Highway Maintenance

Preserving and keeping each type of roadway, roadside, structures as nearly as possible in its original condition as constructed or as subsequently improved and the operation of highway facilities and services to provide satisfactory and safe transportation, is called maintenance of Highways.

The various maintenance functions includes:-

- Surface maintenance
- Roadside and drainage maintenance
- Shoulder and approaches maintenance
- Snow and ice control
- Bridges maintenance
- Traffic service
- Highway maintenance is closely related to the quality of construction of original road.
- Insufficient pavement or base thickness or improper construction of these elements soon results in expensive patching or surface repair.
- Shoulder care becomes a serious problem where narrow lanes force heavy vehicle to travel with one set of wheels off the pavement.
- Improperly designed drainage facilities, mean erosion or deposition of material and costly cleaning operation or other corrective measures.
- Sharp ditches and steep slopes require manual maintenance as compare to cheap maintenance of flatter ditch and soil by machine.
- In snowy country, improper location extremely low fills and narrow cuts leave no room for snow storage, creating extremely difficult snow removal problems.

Maintenance Work

Surface maintenance of Roads:-

Pavement maintenance and rehabilitation programs, restore riding quality and maintain the structural integrity of the pavement over its full design life. Asphalt concrete pavements are subjected to various types of pavement distress or **Failure** these include.

i. ***Alligator Cracking:***

A series of interconnecting or interlaced cracks caused by fatigue of the asphalt concrete surface under repeated traffic leading. [Cracking is due to foundation movement at subgrade]

ii. ***Block Cracking:***

Cracks forming large interconnected polygon usually with sharp corners or angles. These cracks are generated by hardening or shrinking e.g. asphalt or reflection cracking for underlying layers such as cement treated base.

iii. ***Transverse Cracking:***

Cracks approximately at right angle to the pavement center line. These may be caused by hardness and shrinkage of asphalt or differential thermal stresses of asphalt concrete or may be reflection cracking.

iv. ***Longitudinal Cracking:***

Cracks approximately parallel to the pavement centerline. These are caused by poorly constructed construction joints and shrinkage of the asphalt concrete surface. Longitudinal cracks may also be reflection cracks.

Crack Sealing

v. ***Raveling:***

Wearing away the pavement surface caused by dislodging of aggregate particles and binders. This is usually a result of insufficient asphalt binder in the mix or stripping of asphalt from particles of aggregate.

vi. ***Drip Track Raveling:***

Progressive disintegration of the surface between wheel paths caused by dripping of gasoline oil from vehicle.

vii. ***Bleeding or Flushing (Fatting Up):***

The exuding of bitumen on to the pavement surface causing reduction in skid resistance. Bleeding is generally caused by excessive amount of asphalt in the mix or low air void content. It occurs in the mix in hot weather.

viii. ***Corrugations:***

Due to instability of base or poor original riding surface (plastic movement of pavement)

ix. ***Pot Holes:***

When cracks become deep.

x. ***Ruts:***

Depressions formed under the wheel due to heavy load, this causes consolidation, deformation or plastic flow.

General surface maintenance:

- For maintenance of gravel roads blading and occasional resurfacing is required.
- For surface treatments of low type bituminous surface in maintenance of roads; Patching, seal coating or possible loosening oiling, re mixing and relaying are involved.
- For high type bituminous concrete and Portland cement concrete, the Removal and replacement of failure areas and resurfacing are approximate treatment methods for highway maintenance.
- Use same material and methods for road surface maintenance as far as possible.
- Highway Maintenance must be planned for rapid performance and to cause least possible disruption or hazard to traffic.

Shoulders:-

Depend on the surface character of these areas:

- SOD shoulders must be moved and occasionally bladed down to the level of the roadway so that water is not trapped in the traveled way. Gross must be kept in good condition.
- Shoulders protected by bituminous blankets or surface treatments same as for

roadway surface.

Gravel and earth shoulders that leaves a drop off at the pavement edges creates a serious accident hazard, hence, should be corrected by reconstruction, resurfacing or other appropriate means.

- Due to continuous wetting and drying of shoulder, edge joints result between lane and shoulder which may cause settlement of pavement due to entrance of water in sub grade soil. It can Repaired by filling the joint with sand and asphalt concrete.

Snow and ice control:-

Ice forming on the roadway reduces coefficient of friction between tires and surface, which makes vehicle control almost impossible. In highway maintenance we can apply abrasive to heavily traveled roadway and street. Suitable materials that can be used are clean and sharp sand, cinders and washed stone screening.

Bridge maintenance:-

Bridges maintenance is a major part of highway maintenance. Bridges can be maintained in good condition by following the below guidelines:-

- Exposed steel work must be cleaned by sand blasting flame or other means followed by *repainting*.
- Deck joint may extrude or become filled with dirt so that cleaning and resealing is necessary
- .Out of control vehicle, causing damage to guard rail, must be Repaired and strengthened.
- If bridge deck become rough resurfacing is required
- Remedial measures to correct serious scour around and under piers and abutments.

Traffic services:-

Include stripping, sign repair and maintenance (particularly needed for repair after stormy weather.

Surface treatment of highways:-

Although the best type of surface course is pre-mix carpet for highway maintenance;

- Intensity of traffic is not very high.
- the pro-mix mixers are not easily available due to long transportation or technical reasons.

- when the cost is high.

The surface treatment methods are employed. The surface treatment may be single or multiple.

Single Surface Treatment:

Is wearing course in which the bituminous material is sprayed and the aggregate is placed uniformly over the applied bitumen mineral. The thickness of such layer approximate the nominal size of aggregate used.

Multiple Surface Treatment:

(Double or Triple) is a wearing surface in which a course aggregate is placed on bitumen coat (prime coat) already applied, followed by spraying of bitumen and then by subsequent application of finer aggregate over a second bitumen coat. Generally the minimum size of the smallest aggregate is one of the aggregate used in the preceding application usually thickness of single layer approximately maximum size of aggregate.

Function of surface treatment:

- To provide long lasting economical surface for granular base road having light and medium traffic volume.
- To prevent entry of surface water into old pavement that has been weathered or cracked.
- It improves the skid resistance of bitumen surface where the surface has polished under traffic.
- To provide temporary cover in case of delayed incomplete pavement.

In **Highway Maintenance,** for good surface treatment it is necessary that:

- Base course is well prepared to its profile and is made more free from pot holes and ruts.
- Excellence of surface dressing depends upon the correct proportion of binder aggregate.
- Before laying that first surface dressing coat, the base should be made free from all dust loose soil etc.
- In all bituminous construction it is necessary that the newly surface posses a bond with the existing base at the interface. It is also necessary that the base is nearly impervious.

MOWING:-

Vegetation along the right-of-way will be mowed for the following reasons:

- Eliminate obstructions to sight distance on curves.
- Control weed and brush growth.
- Reduce snow drifting on the roadway.
- Provide for unobstructed drainage.
- Reduce the fire hazard in some areas.
- Improve road aesthetics.
- Eliminate obstruction to signs.
- Increase the visibility of large animals on the right-of-way.

All high traffic volume highways will receive one shoulder cut in the late spring and an additional full right-of-way cut. All other provincial highways in Alberta will receive up to 2 shoulder cuts per year (as required) and a full right-of-way cut once every 3 years or as warranted for brush control purposes. The first shoulder cut will be 4.5 metres in width and should be completed during the early summer months. The second shoulder cut or full cut may be warranted in the late fall, depending on re-growth. Where required, trimming around all appurtenances located adjacent to the highway will be carried out during the second cut. In urban areas the mowing of boulevards and raised medians will be the responsibility of the municipality. The department will discuss their area's mowing plans and arrangements with local municipal officials. Where possible, the department will try to coordinate their operations with that of the municipalities.

5.5 Highway Project Formulation

1. Technical appraisal report

The project preparation starts with the preparation of technical appraisal report (TAR). It consist of ,

1. Background
2. Technical parameters and technical designs
3. Preliminary cost estimate
4. Economic feasibility

2. Preliminary project report:

Preliminary project report is prepared covering the following,

1. Background
2. Technical provisions, their basis and technical designs
3. Economic evaluation
4. Environmental impact assessment
5. Source of funding

3. Detailed project report:

After the PPR is approved, detailed project report is prepared complying with the observations received with approval.

4. Check list of items for a highway project report

1. Project report
   a. Preliminary
   b. Road features
   c. Road design and specification
   d. Drainage facilities including cross-drainage structures
   e. Material, labour and equipment
   f. Rates
   g. Construction programming
   h. Miscellaneous
2. Estimate
   a. General abstract of cost
   b. Detailed estimates for each major head
      ✓ Abstract of cost

- ✓ Estimates of quantities
- ✓ Analysis ofrates
- ✓ Quarry/material source charts

3. Project drawings

a. Locality map-cum-site plan

b. Strip plan showing the location of utilities, right-of-way, trees and junction

c. Land acquisition plans.

5.1 Pavement Distress in Flexible and Rigid Pavements

Causes of Failures in Flexible Pavements

This may be due to settlement of any one of the components of the pavement.

Causes of Failure in subgrade soil:

- Excessive settlement of the subgrade of soil in the form of excessive undulations or waves or corrugations on the pavement surface.
- Inadequate stability is due to excessive moisture, improper compaction and inherent weakness of the soil
- Excessive stress application causes the deformation of the subgrade to be plastic and unrecoverable resulting in subsidence of the subgrade

Causes of Failure of sub-base or base course:

- Settlement of layers due to internal readjustment of aggregates and movement of wheel loads which results in loosening of compacted layer.
- Lack of stability due to inadequate thickness or poor mix of base or sub-base course.
- Loss of base course materials

Causes of Failure of wearing course:

- Inferior or improper mix design
- Inadequate binder cement and Inferior quality of binder

TYPES OF FLEXIBLE PAVEMENT FAILURES

Alligator cracking or Map cracking (Fatigue)

This is a common type of failure of flexible pavements. This is also known as fatigue failure. Followings are the primary causes of this type of failure.

- Relative movement of pavement layer material
- Repeated application of heavy wheel loads
- Swelling or shrinkage of subgrade or other layers due to moisture variation

Alligators on Road surface

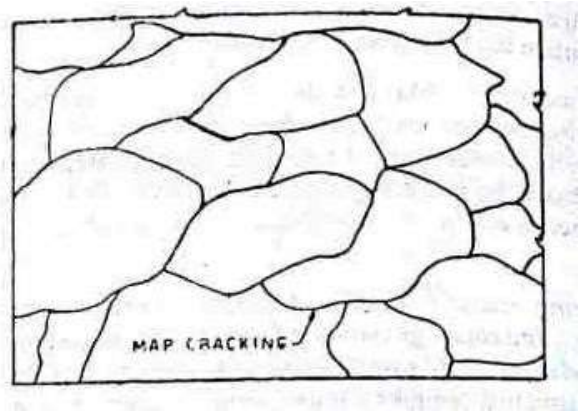


Figure 5.1.1 Map cracking

[Source: "Highway Engineering" by S.K.Khanna,C.E.G.Justo, Page: 494]

Consolidation of Pavement layers (Rutting)

Formation of ruts falls in this type of failure. A rut is a depression or groove worn into a road by the travel of wheels.

This type of failure is caused due to following reasons.

- Repeated application of load along the same wheel path resulting longitudinal ruts.
- Wearing of the surface course along the wheel path resulting shallow ruts.

Rutting on Road Surface

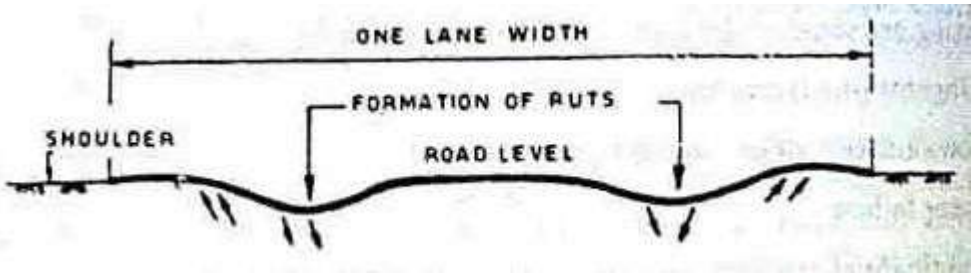


Figure 5.1.2 Formation of Ruts

[Source: "Highway Engineering" by S.K.Khanna,C.E.G.Justo, Page: 494]

Shear Failure Cracking

Shear failure causes upheaval of pavement material by forming a fracture or cracking. Followings are the primary causes of shear failure cracking.

- Excessive wheel loading
- Low shearing resistance of pavement mixture

Shear Fail on Road Surface

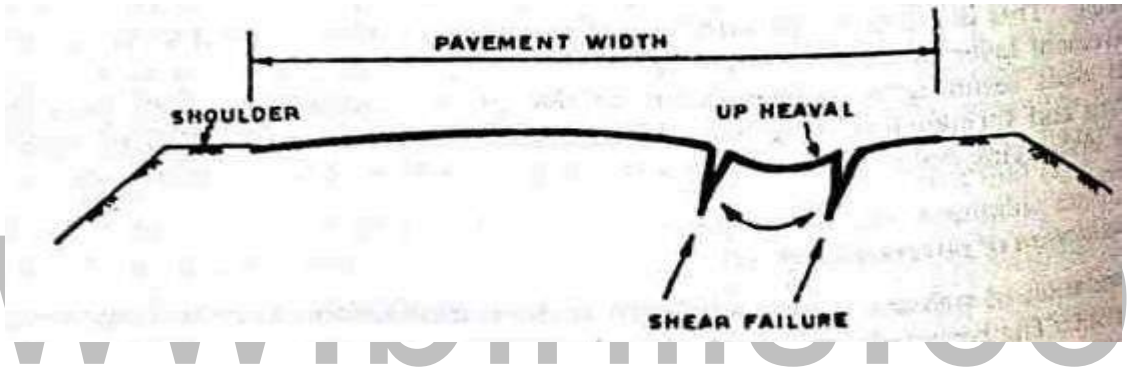


Figure 5.1.3 Shear Failure Cracking

[Source: "Highway Engineering" by S.K.Khanna,C.E.G.Justo, Page: 494]

Longitudinal cracking

This types of cracks extents to the full thickness of pavement. The following are the primary causes of longitudinal cracking.

- Differential volume changes in subgrade soil
- Settlement of fill materials
- Sliding of side slopes

Longitudinal Crack on Road Surface

Frost heaving

Frost heaving causes upheaval of localized portion of a pavement. The extent of frost heaving depends upon the ground water table and climatic condition.

Frost Crack on Road Surface

Figure 5.1.2 Failure due to Frost heaving

[Source: "Highway Engineering" by S.K.Khanna,C.E.G.Justo, Page: 495]

Lack of binding to the lower course

When there is lack of binding between surface course and underlying layer, some portion of surface course looses up materials creating patches and potholes. Slippage cracking is one form of this type of failure. Lack of prime coat or tack coat in between two layers is the primary reason behind this type of failure.

Road Failure due to Lack of Binding

Reflection cracking

This type of failure occurs, when bituminous surface course is laid over the existing cement concrete pavement with some cracks. This crack is reflected in the same pattern on bituminous surface.

Reflection Crack on Road Surface

Formation of waves and corrugation

Transverse undulations appear at regular intervals due to the unstable surface course caused by stop- and-go traffic.

Wave Failure on Road Surface

Bleeding

Excess bituminous binder occurring on the pavement surface causes bleeding. Bleeding causes a shiny, glass-like, reflective surface that may be tacky to the touch. Usually found in the wheel paths.

Bleeding Failure on Road Surface

Pumping

Seeping or ejection of water and fines from beneath the pavement through cracks is called pumping.

Mud Pumping on Road Surface

CAUSES OF FAILURES OF RIGID PAVEMENTS

- Deficiencies in Pavement materials
- Structural Inadequacy
- Improper Construction and Maintenance

Deficiencies in Pavement materials

Causes are;

- Soft aggregates
- Dirty aggregates with silt and clay
- Low quality joint filler
- Poor sealer material
- Poor quality steel
- Improper use of cement for the specific region

Structural Inadequacy

Causes are;

- Poor subgrade soil and improper assessment of its strength
- Improper mix design approach
- Inadequate pavement thickness
- Incorrect spacing of joints
- Incorrect design of load transfer devices
- Absence of longitudinal hinge joints
- Long length of slab
- Non-existence of temperature steel

- Deep foundation movements

Improper Construction and Maintenance

Causes:

- Poor workmanship in pavement and joint construction
- Poor surface finish
- Improper and insufficient curing
- Use of concrete mixes which are wet

TYPICAL RIGID PAVEMENT FAILURES

- Scaling of Cement Concrete
- Shrinkage Cracks
- Warping Cracks
- Spalling of Joints

Scaling of cement concrete

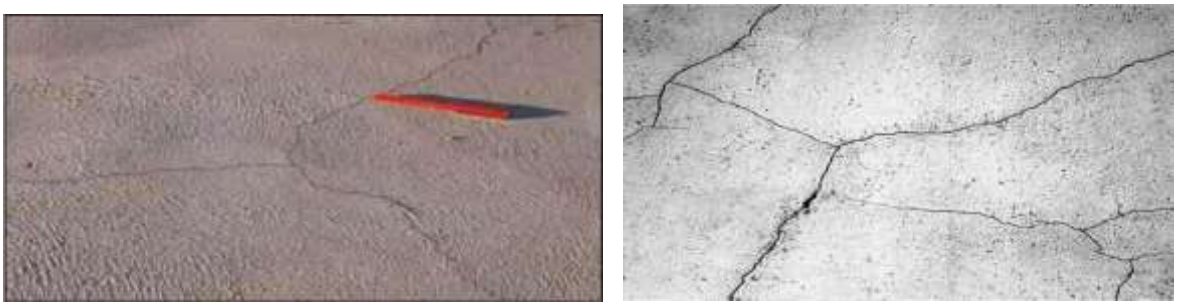
Scaling of rigid pavement simply means, peeling off or flaking off of the top layer or skin of the concrete surface. This may be due to the following reasons

- Improper mix design
- Excessive vibration during compaction of concrete
- Performing finishing operation while bleed water is on surface

Shrinkage cracks

Shrinkage Crack on Road Surface (a)

Formation of hairline shallow cracks on concrete slab is the indication of shrinkage cracks. Shrinkage cracks develop on concrete surface during the setting & curing operation. These cracks may form in longitudinal as well as in transverse direction.



Shrinkage Crack on Road Surface (b)

Joint spalling

Joint spalling is the breakdown of the slab near edge of the joint. Normally it occurs within 0.5 m of the joints. The common reasons for this defect are

- Faulty alignment of incompressible material below concrete slab
- Insufficient strength of concrete slab near joints
- Freeze-thaw cycle
- Excessive stress at joint due to wheel load

Joint Spalling Crack on Road Surface

Warping cracks

In hot weather, concrete slab tends to expand. Therefore the joints should be so designed to accommodate this expansion. When joints are not designed properly, it prevents expansion of concrete slab and therefore results in development of excessive stress. This stress cause formation of warping cracks of the concrete slab near the joint edge. This type of crack can be prevented by providing proper reinforcement at the longitudinal and transverse joints. Hinge joints are generally used to relieve the stress due to warping.


Warping Crack on Road Surface

Pumping

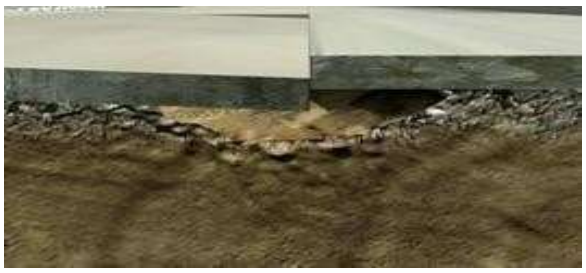
When material present below the road slab ejects out through the joints or cracks, it is called pumping. When soil slurry comes out it is called mud pumping.

The common reasons for this defect are

- Infiltration of water through the joints, cracks or edge of the pavement forms soil slurry. Movement of heavy vehicles on pavement forces this soil slurry to come out causing mud pumping.
- When there is void space between slab and the underlying base of sub-grade layer
- Poor joint sealer allowing infiltration of water
- Repeated wheel loading causing erosion of underlying material

Pumping can also lead to formation of cracks. This is because; ejection of sub-grade material below the slab causes loss of sub-grade support. When traffic movement occurs at these locations, it fails to resist the wheel load due to reduction of sub-grade support and develops cracks.

This type of defect can be identified when there is presence of base or sub-grade material on the pavement surface close to joints or cracks.




Joint Soil Spillage on Road Surface

5.3 Pavement Evaluation

It is the study of various factors pertaining to pavement, such as subgrade support, pavement composition and its thickness, traffic loading and environmental condition.

The main aim:

- To assess as to whether and to what extent the pavement fulfills the design requirements.
- To investigate the structural inadequacy of pavements and also the requirements for providing safe and comfortable traffic operations.

Methods of Evaluation of Pavements:

- Structural Evaluation
- Evaluation of Pavement Surface Condition

Structural Evaluation

- Plate bearing test can be conducted for both flexible and rigid pavements to assess the structural capacity.
- The assessment may be made by
  - ✓ The load carried at a specified deflection at a place or
  - ✓ The amount of deflection at a specified load on the plate
- The performance of a flexible pavement is closely related to the elastic deformation under loads or its rebound deformation.

Evaluation of Pavement Surface Condition

- Surface conditions of flexible pavements may be determined by their unevenness, patches, ruts and cracks. These surface conditions affect the riding quality of the pavements.
- Unevenness of the pavements may be measured using unevenness indicator, profilograph, profilometer or roughometer.

  Unevenness Index:

  It is the index by adding the unevenness of the surface on a cumulative scale represented as cm/km length of road.

Table 1 Unevenness with Ride Quality

Unevenness Index, Cm/Km	**Riding Quality**
Below 95 95 to 119 120 to 144 145 to 240	Excellent Good Fair Poor
Above 240	Very poor (Resurfacing is required)
In new pavements Below 120 120 to 145 Above 145	 Good Fair Poor

Strengthening of Existing Pavements

- A highway is expected to have adequate stability to withstand the design traffic under prevailing climate and subgrade conditions.
- Only solution to manage the increased traffic is either to direct the traffic on some adjacent roads or to strengthen the existing pavements.
- Strengthening may be done by providing additional thickness of pavement provided the subgrade is strong enough.

Overlay

Construction of one or more layers over the existing pavement

Types of overlay:

- Flexible overlays are bituminous surfaces constructed over existing flexible pavements or existing concrete pavements.
- Rigid overlays consists of plain, simply reinforced or continuously reinforced concrete pavements.

Combination of Overlays:

Table 2 Types of Overlay

Existing pavement	Overlay
Cement concrete	Cement concrete
Cement concrete	bituminous
Bituminous or flexible	Cement concrete
Bituminous or flexible	Bituminous or flexible

The choice of overlay depends on various factors

- Total thickness of overlay required
- Wheel load
- Sub grade strength, etc.

Benkelmann Beam Deflection Method for Structural Evaluation of Pavement

Benkalmann Beam is a device used to measure the rebound deflection of a pavement.

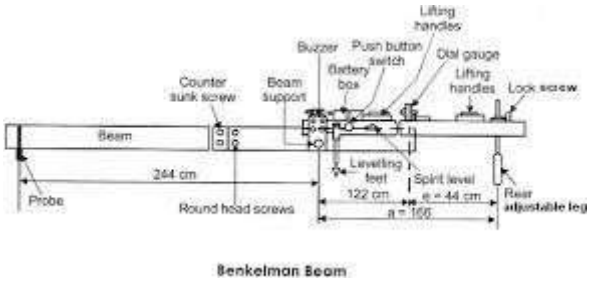
Principle:

A well designed and constructed flexible pavement which has been well conditioned also deforms elastically under the design wheel load i.e. there is an elastic recovery or rebound of the deformed pavement surface. This is the basic principle of deflection method of pavement which is used to design the overlay thickness.

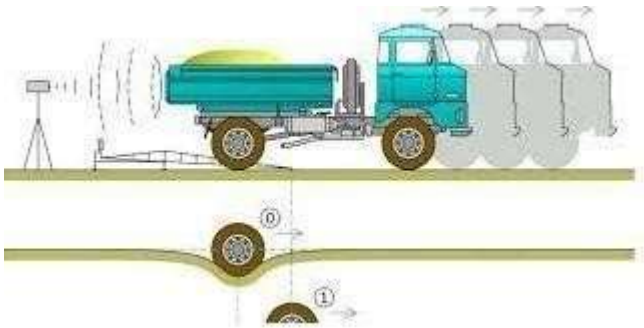
Equipment:

Benkelmann beam consists of a slender beam 3.66 m long pivoted at a distance of 2.44 m from the tip. The tip is a probe end. The datum frame rests on a pair of front leveling legs and a rear leg with adjustable height.

By suitably placing the probe between the dual wheels of a loaded trucks, it is possible to measure the rebound and the residual deflection of the pavement structure. Rebound deflection is used for overlay design and the residual deflection may be used attributed to non-recoverable deflection of the pavement.



Benkelman Beam



Deflection Test on Road surface

Procedure

- The road to be evaluated is first surveyed to assess the general conditions of the pavement.
- The pavement stretches of length not less than 500 m are classified and grouped on to different classes of length, viz., good, fair and poor for the purpose of studies.
- Loading points for deflection measurements are located along the wheel paths.
- A minimum of 10 deflection observation points may be selected and its may be staggered if necessary.
- The truck is stopped in such a way that the left side rear dual wheel is centrally placed over the first point for deflection measurement.
- The probe end of the benkelmann beam is inserted between the gap and positioned exactly over the deflection observation point.
- The initial dial gauge reading, D_o is noted.
- The truck is moved forward through a distance of 207 m from the point and stopped. The intermediate dial gauge reading D_i is noted.
- The truck is then moved further forward 9m. The final dial reading, Df is

recorded.

- These three deflection dial readings, D_o, D_i and D_f form one set of readings at one deflection point.
- Temperature at intervals of one hour are taken on the pavement surface.

Rebound deflection value D at any point is given by one of the following two conditions:

a. If $(D_i - D_f) < 0.025$ mm, then $D = 2 (D_o – D_f) = 0.02 (D_o - D_f)$mm

b. If $(D_i - D_f) > 2.5$ division of dial gauge. A correction has to be applied for the vertical movement of the front legs.

$D = 2 (D_o – D_f) + 2 K (D_i - D_f)$ division The value of

$$K = \frac{3d - 2e}{f}$$

Where d = distance between the bearing of the beam and the rear adjusting leg

e = distance between the dial gauge and the rear adjusting leg

f = distance between the front and rear legs

The value of K depends on the type of equipment. The value of K for the equipment available in India is 2.91.3

$D = 0.02 (D_o – D_f) + 0.0582 (D_i - D_f)$ mm

The mean value of deflection at n points is given by

$D = D/n$

The standard deviation of the deflection value is given by,

Characteristics deflection D_C is given by

$D_C = D + t \sigma$

Where t is to be chosen upon the percentage of the deflection values to be covered in the design.

When t = 10,

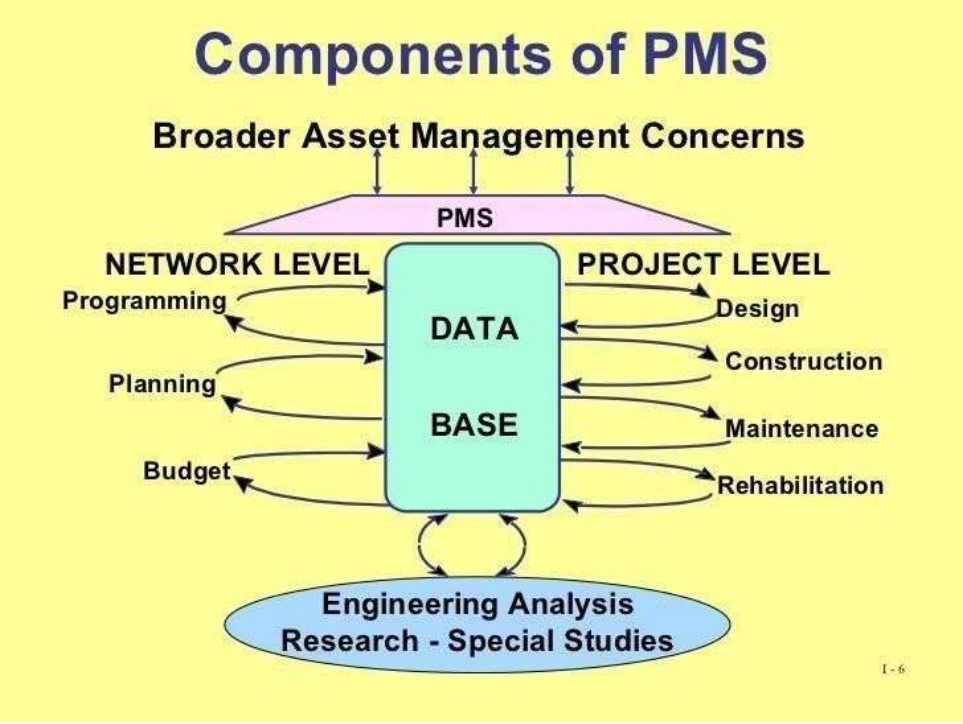
$D_C = D + \sigma$ covers about 84 % of the cases of deflection values on the pavement

When t = 2.0, $D_C = D + 2\sigma$ covers about 97.7 % of the cases of deflection values on the pavement IRC recommends $D_C = D + \sigma$

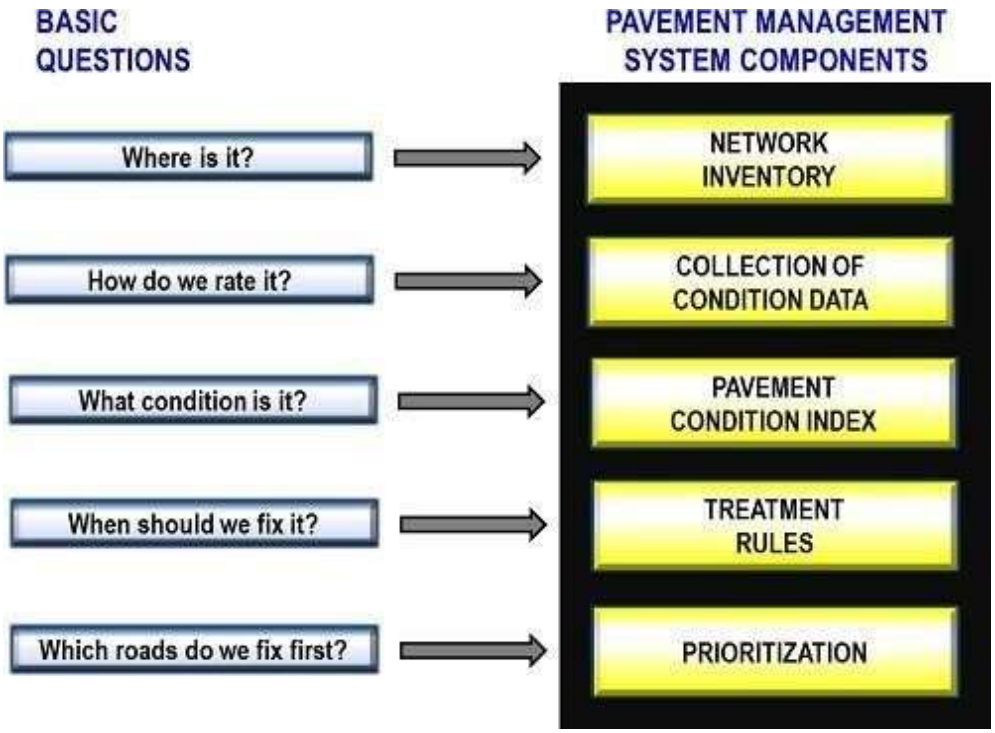
5.2 Pavement Management System

Pavement Management is the process of planning the maintenance and repair of a network of roadways or other paved facilities in order to optimize pavement conditions over the entire network.

A pavement management system (PMS) is a planning tool used to aid pavement management decisions. PMS software programs model future pavement deterioration due to traffic and weather, and recommend maintenance and repairs to the road's pavement based on the type and age of the pavement and various measures of existing pavement quality. Measurements can be made by persons on the ground, visually from a moving vehicle, or using automated sensors mounted to a vehicle. PMS software often helps the user create composite pavement quality rankings based on pavement quality measures on roads or road sections. Recommendations are usually biased towards predictive maintenance, rather than allowing a road to deteriorate until it needs more extensive reconstruction.



COMPONENTS OF PMS (a)



COMPONENTS OF PMS (b)

Typical tasks performed by pavement management systems include:

- Inventory pavement conditions, identifying good, fair and poor pavements.
- Assign importance ratings for road segments, based on traffic volumes, road functional class, and community demand.
- Schedule maintenance of good roads to keep them in good condition.
- Schedule repairs of poor and fair pavements as remaining available funding allows.