

B.Sc - Road & Railway Design I.

Lecture 12.



ROAD MAINTENANCE & PAVEMENT MANAGEMENT

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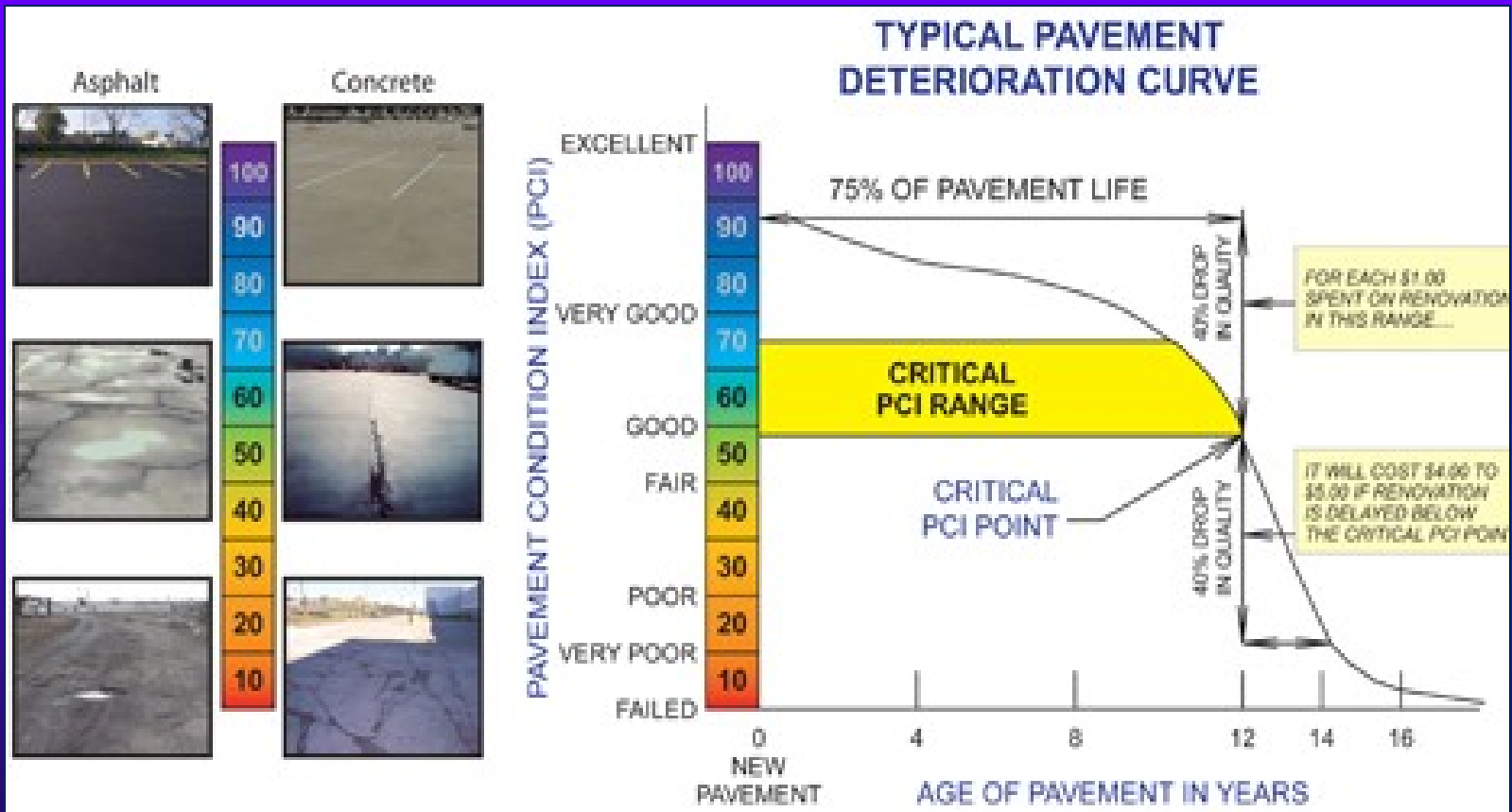
Pécs, 2019



DETERIORATION OF PAVEMENTS

- ❖ After completion and opening to the traffic, road pavements' *deterioration* begins immediately
- ❖ Deterioration of asphalt pavement is *natural*, because over time its components begin to change and are affected by elements such as rain, snow, freeze, sunlight and chemicals that come into contact with the pavement surface (e. g. de-icing during winter)
- ❖ The bitumen i. e. the “glue” of the flexible pavement begins to lose it's natural stiffness (ageing) and resistance to water, allowing it to penetrate into and underneath the pavement
- ❖ Once this happens, the surface can quickly fall prey to a number of different types of deterioration

DETERIORATION OF PAVEMENT CONDITION





CAUSES OF DETERIORATION

- ❖ Deterioration of asphalt pavements can also be due to factors that go beyond just normal wear and tear, causing *premature deterioration*
- ❖ The premature deterioration of pavement is usually due to *failures* in construction – or *human error*
- ❖ This can be due to a number of *factors* including:
 - ❖ insufficient or improperly compacted base below the asphalt
 - ❖ over or under compaction of asphalt
 - ❖ improper temperature of asphalt when applied
 - ❖ poor drainage
- ❖ When asphalt pavement is constructed and maintained properly it wears out slowly and *can last* up to 15-20 years (PCC pavements can last up to 30-35 years)
- ❖ *Proper maintenance* is key to protecting the pavement from the *external factors* that wear it out

TYPES OF DETERIORATION

- ❖ **Main types of deterioration caused by the preceding external factors and excess traffic load:**
 - ❖ ***Cracking*** - There are many different types of cracking that can occur: alligator crack, edge cracks, slippage (caused by improper compaction), reflection (older cracks occurring in a new overlay), edge joint, shrinkage and widening
 - ❖ ***Distortion*** - Caused by improper pavement construction, deterioration of the underlying base or existing asphalt layer and high load factors; asphalt distortions include: unevenness (roughness), channels or ruts, corrugations and shoving, grade depressions, upheaval and utility cut depressions
 - ❖ ***Disintegration*** - Types of asphalt disintegration includes potholes, raveling, gas and oil spillage



ROAD MAINTENANCE

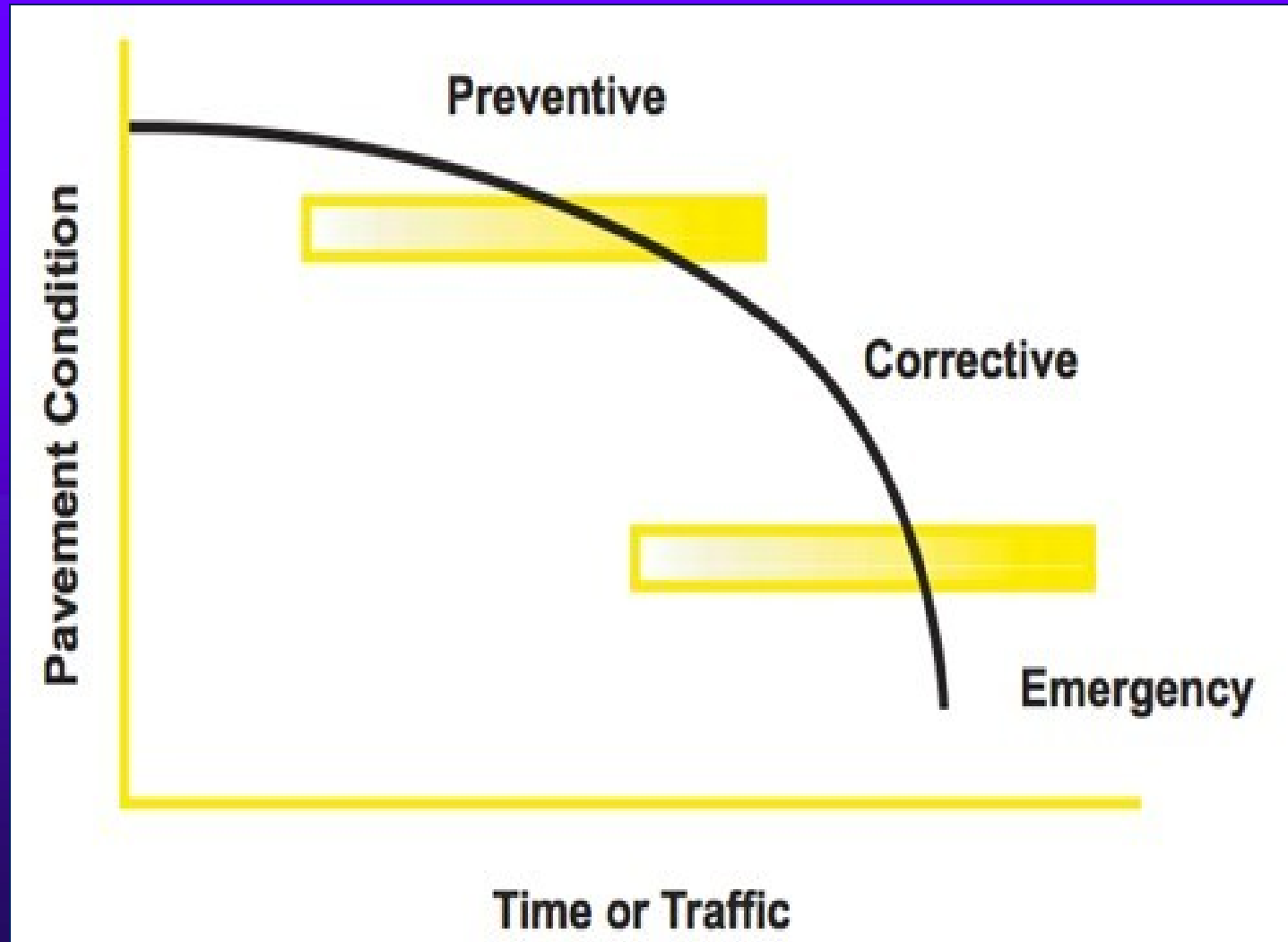
- ❖ The goal of maintenance is to preserve the road network - an asset representing a very considerable value of national property
- ❖ Road maintenance comprises activities to keep pavement, shoulders, slopes, drainage facilities and all other structures and property within the road margins as near as possible to their as-constructed or renewed condition
- ❖ It includes minor repairs and improvements to eliminate the cause of defects and to avoid excessive repetition of maintenance efforts
- ❖ For management and operational convenience, road maintenance is categorized as routine, periodic, and urgent



CATEGORIES OF ROAD MAINTENANCE

- ❖ ***Routine or preventive maintenance*** comprises small-scale works conducted regularly, aiming to ensure the daily passability and safety of existing roads in the short-run and to prevent their premature deterioration; frequency of activities varies but is generally once or more a week or month - typical activities include roadside *verge clearing and grass cutting*, *cleaning* of silted ditches and culverts, *patching*, and *pothole repair*, *de-icing* and *snow removal* in winter
- ❖ ***Periodic or corrective maintenance*** covers activities on a road section at regular and relatively long intervals, aiming to preserve the structural integrity of the road; these operations tend to be large scale, requiring specialized equipment and skilled personnel and can be classified as *preventive maintenance*, *resurfacing*, *overlay*, and *pavement reconstruction*
- ❖ ***Urgent or emergency maintenance*** is undertaken for repairs or reconstruction, that can't be foreseen but require immediate attention, such as collapsed culverts or landslides that block a road

TIMING OF MAINTENANCE CATEGORIES





MAINTENANCE & REHABILITATION

- ❖ Although it is difficult to distinguish maintenance and operation activities from those of *upgrading and reconstruction*, it is generally accepted that maintenance does not include rehabilitation, correction of alignment, building shoulders or pavement/road widening
- ❖ If the sections to be rebuilt constitute more than 25-33% of the road's length, or current value, the work may be classified as *rehabilitation*, not maintenance
- ❖ Assuring that road maintenance is not neglected, it needs to be incorporated into project and sector strategies, which requires a clear and realistic strategy for *road network (asset) management* based on an appropriate *pavement management system (PMS)*



ROAD NETWORK (ASSET) MANAGEMENT

- ❖ *Road Network (Asset) Management* is a systematic process of maintaining, upgrading, and operating physical assets – a given road network -, cost-effectively
- ❖ It combines the use of sound road engineering principles, accepted business practices and economic theory to improve the decision-making process related to a given road network
- ❖ As a base of asset management, *Pavement Management System (PMS)* is a framework of the process of planning the maintenance and repair of a network of roadways in order to optimize pavement conditions over the entire network



PAVEMENT MANAGEMENT SYSTEM

- ❖ 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 OUTCOME

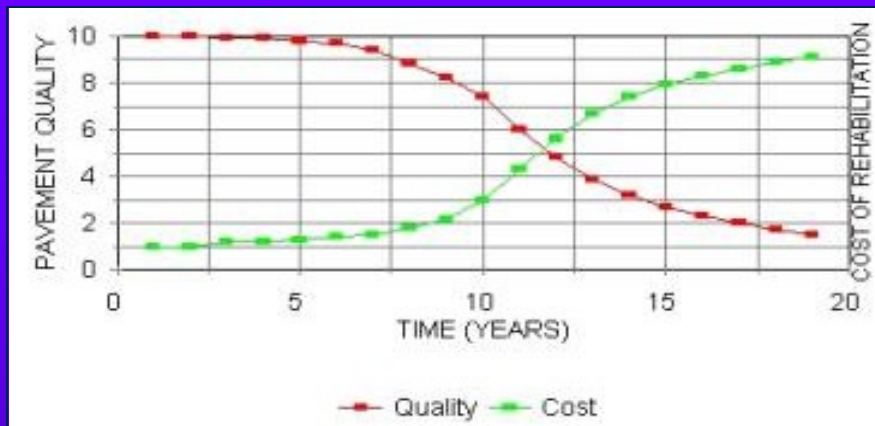
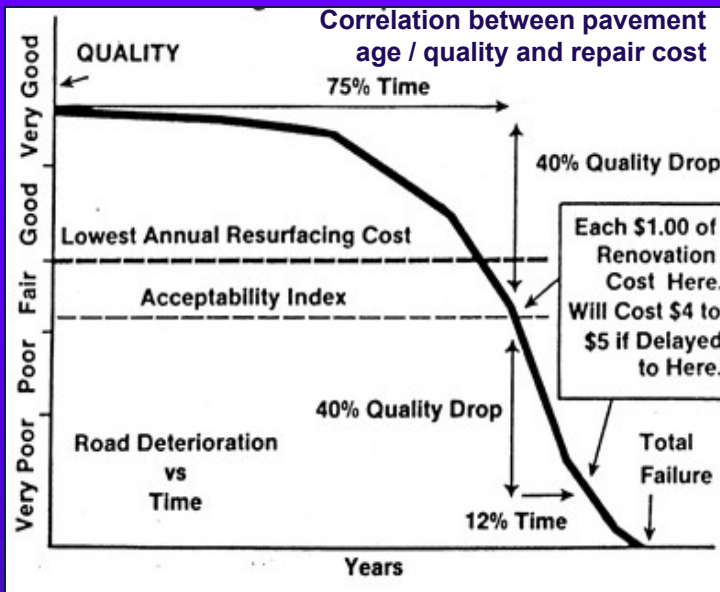
- ❖ PMS software helps the user create composite pavement quality rankings quantified as *Pavement Condition Index (PCI)* or *Present Serviceability Index (PSI)*, based on pavement quality measures
- ❖ Recommendations are usually biased towards predictive maintenance, rather than allowing a road to deteriorate until it needs more extensive and more expensive intervention
- ❖ Typical tasks performed by PMS 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



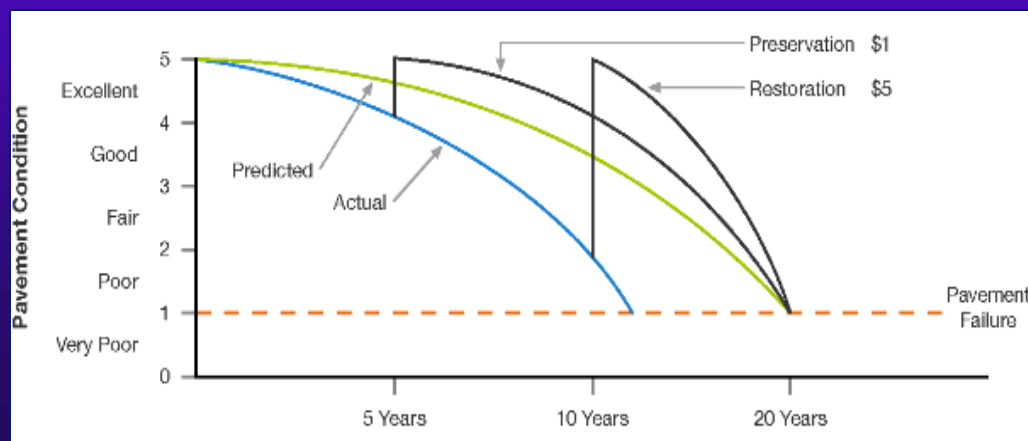
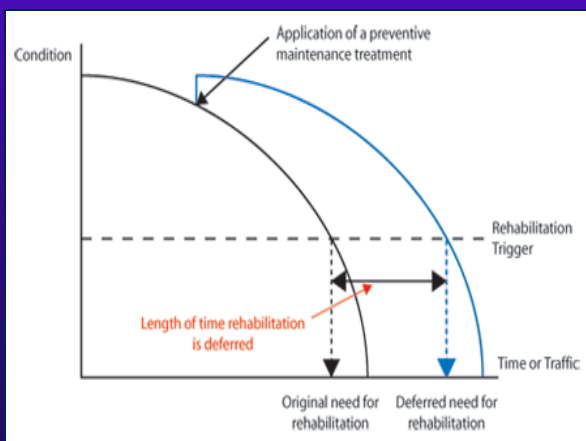
REPAIR COSTS & PERFORMANCE

- ❖ Research has shown that it is far less expensive to keep a road in good condition than it is to repair it once it has deteriorated
- ❖ This is why *pavement management systems* place the priority on preventive maintenance of roads in good condition, rather than reconstructing roads in poor condition
- ❖ In terms of lifetime cost (or *Life Cycle Cost – LCC*), and long term pavement conditions, this will result in better system performance
- ❖ Road administrations or agencies that concentrate on restoring their bad roads often find that by the time they have repaired them all, the roads that were in good condition have deteriorated

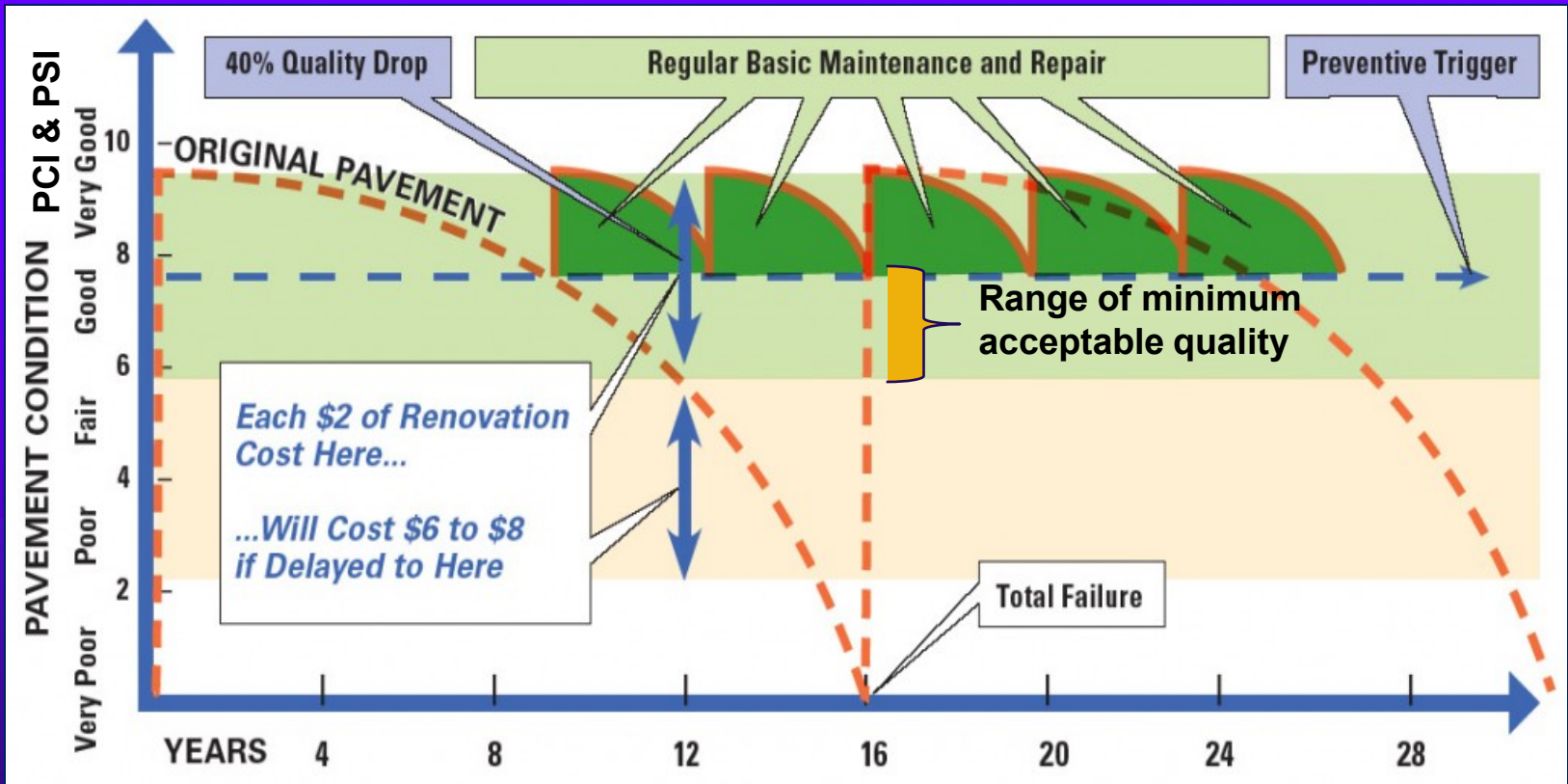
PAVEMENT DETERIORATION CURVE



Deterioration of pavement condition /quality and cost of re-establishment of „as new” condition / quality in function of time / traffic load

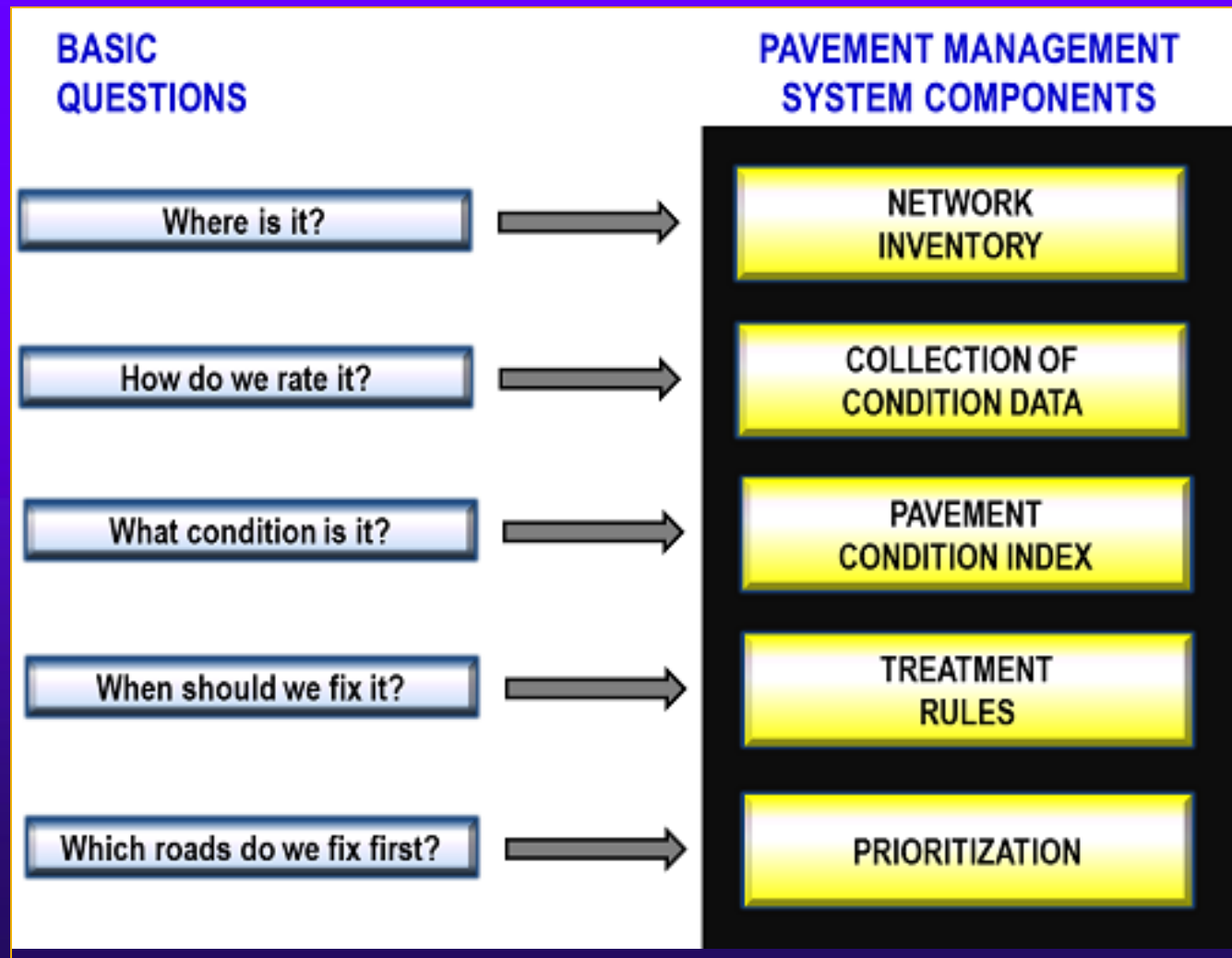


COST OF „TIMELY” MAINTENANCE



The *Present Serviceability Index (PSI)* is just a measure of the current overall quality rating of a section of a road based upon visual observation; the scale goes from 5 (very good) to 0 (very poor). It is similar to the 100 point scale used in *Present Condition Index (PCI)* based condition rating

PMS COMPONENTS

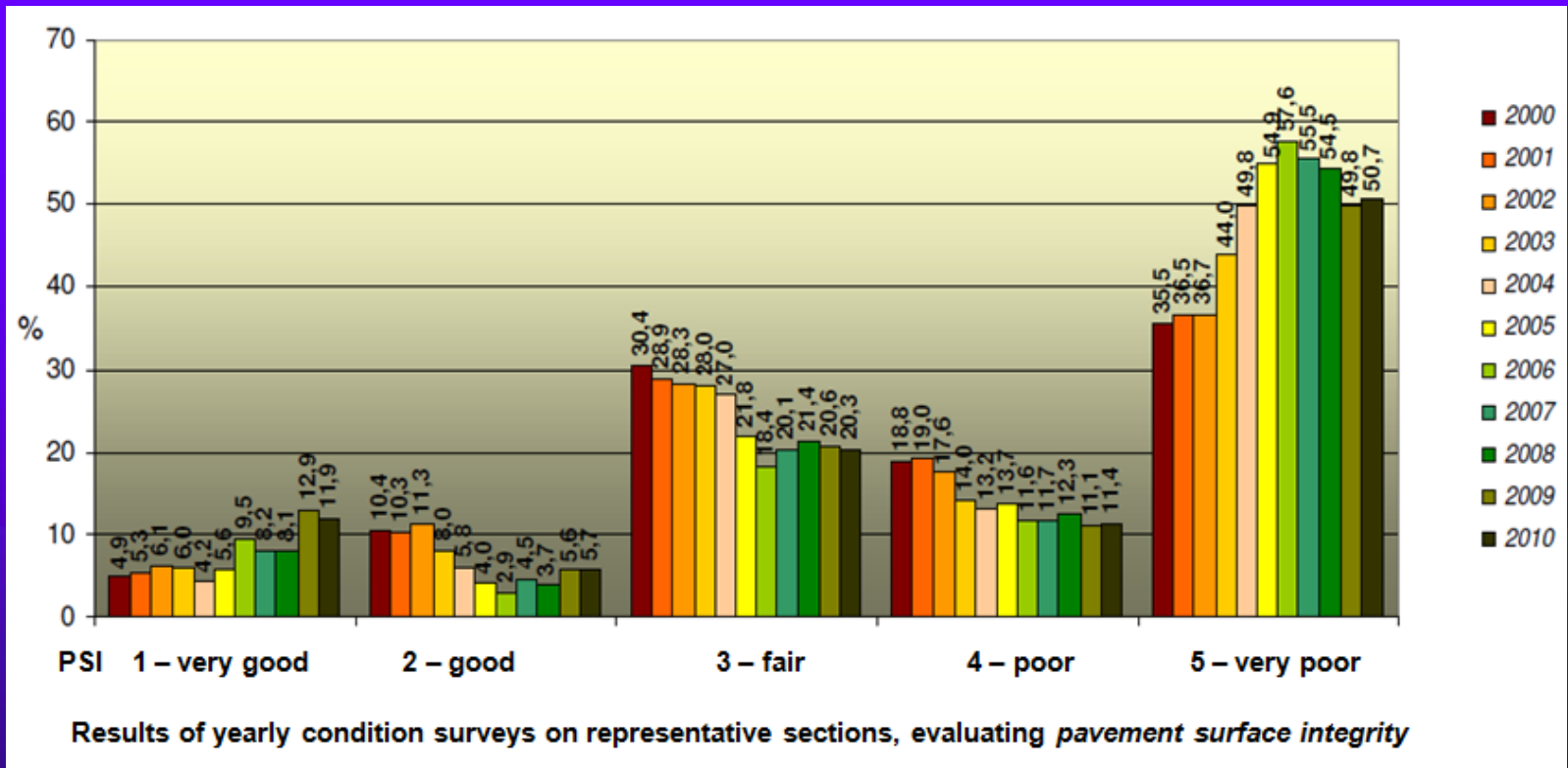




PAVEMENT CONDITION INDEX

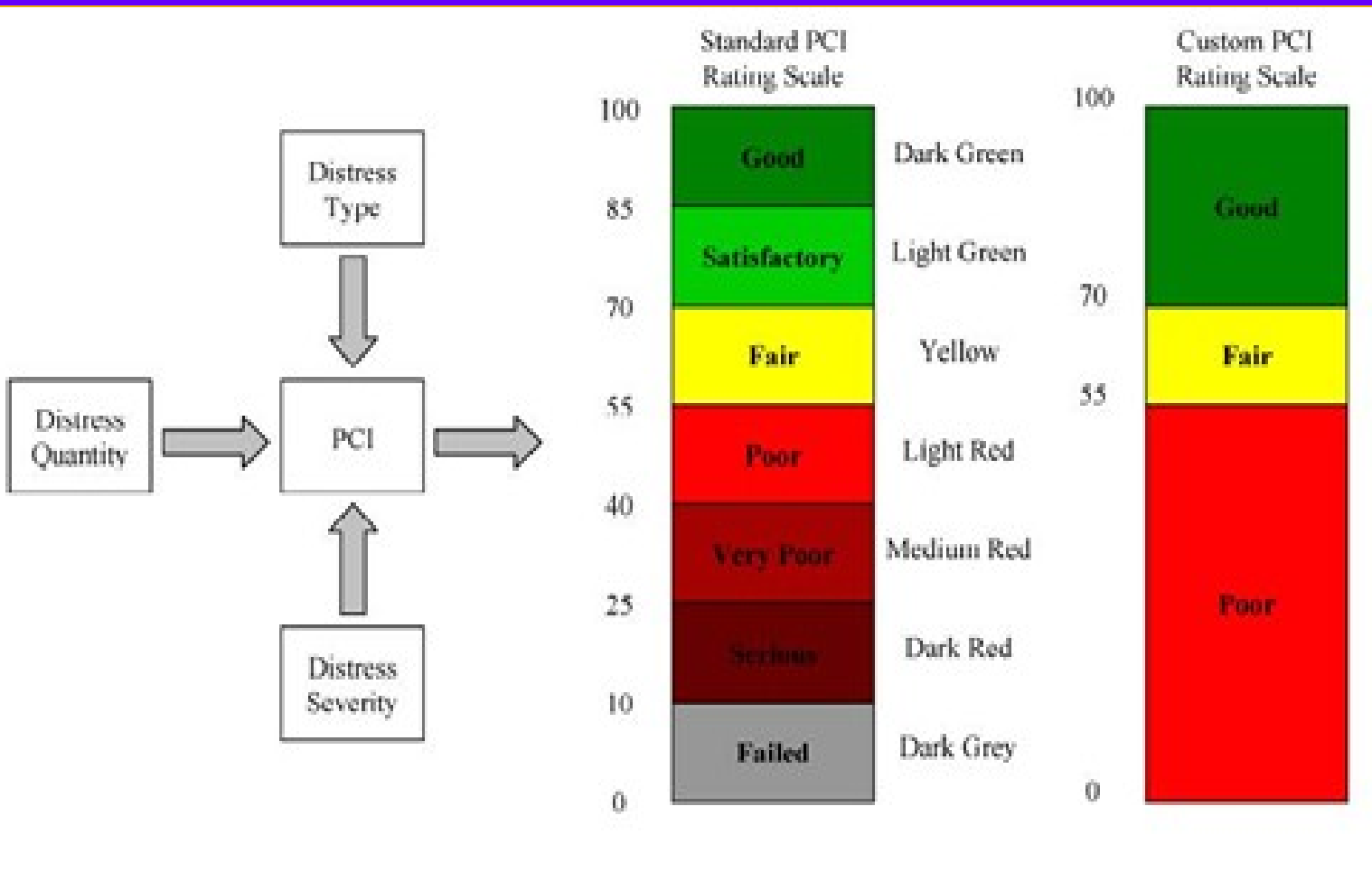
- ❖ Creating a PMS, the first step is to obtain a network level assessment of the condition of all the roads in the network
- ❖ Trained staff drives each road; carefully identifies the type, severity and extent of the cracks or distresses on the road and then documents the conditions
- ❖ All data are collected into a *database*, than converted into a *Pavement Condition Index (PCI)* on a scale from 0 to 100 (this latter being the best)
- ❖ PCI indicates the general condition of a pavement; it is a statistical measure (average) of scores determined by comparison of real condition to the ideal one, using 3-7 different condition criteria (surveying processes and calculation methods have been standardized)

CONDITION SURVEY RESULTS

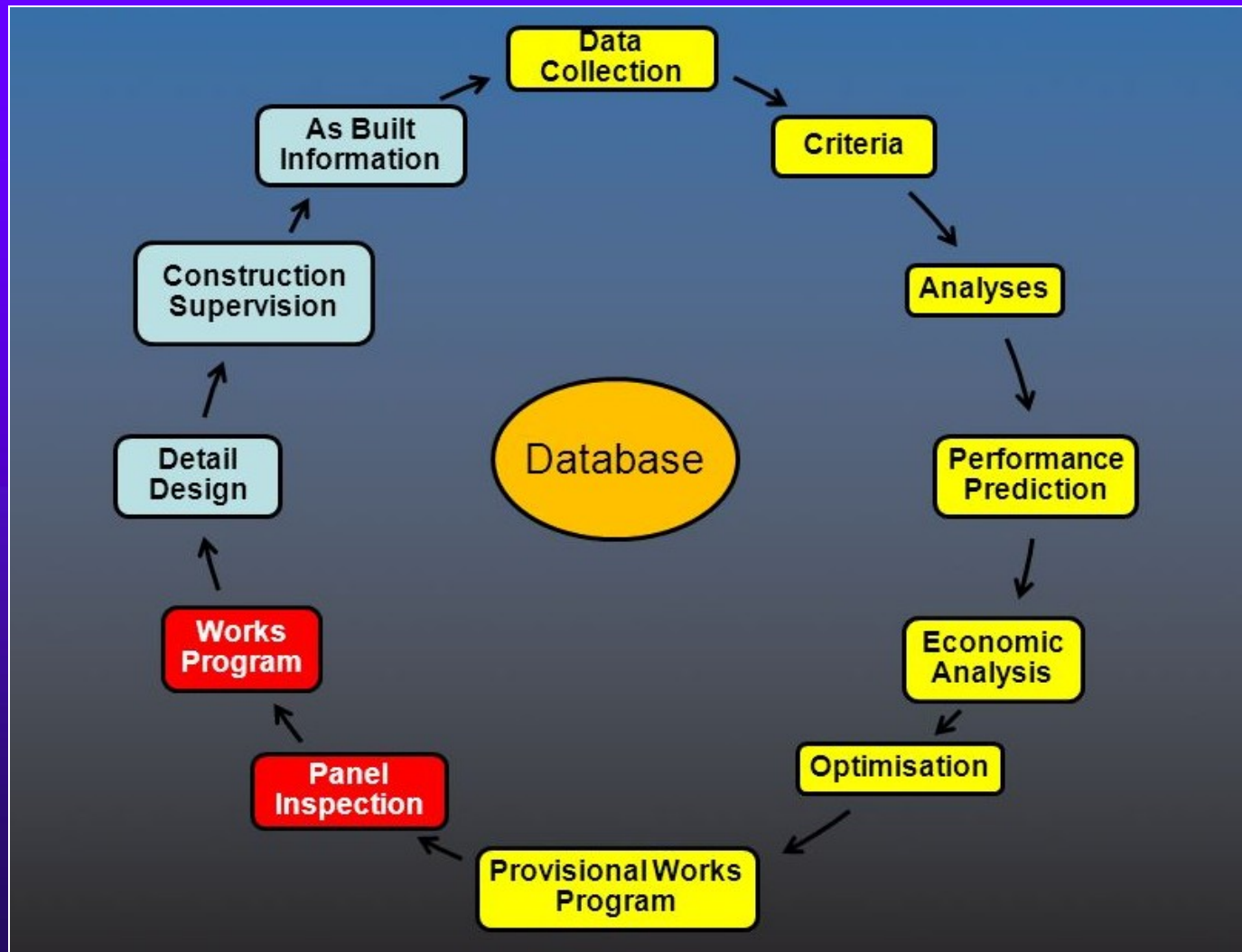


Condition distributions of the Hungarian National Road Network (cca. 30 000 km), evaluated on the base of *pavement surface integrity* from 2000 to 2010, expressed in percentage of total length

CALCULATING PCI (%)



TYPICAL PMS PROCESS



TOOLS OF PAVEMENT CONDITION SURVEY

KUAB FWD 150, 50
bearing capacity measurement



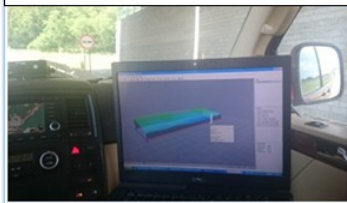
VIDEOCAR
Quick visual inspections
of pavement
surface



SKIDDOMETER BV 11
longitudinal skidding
resistance
measurement



PROFILOGRAPH
Pavement unevenness measurement



LINESCAN
recording of pavement surface defects

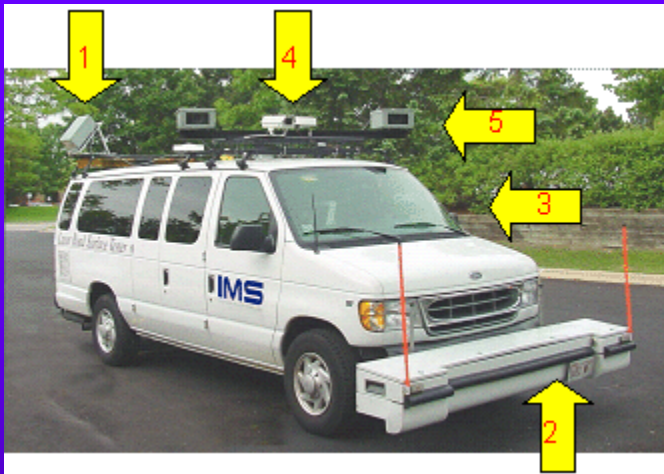




ROAD SURFACE TEXTURES

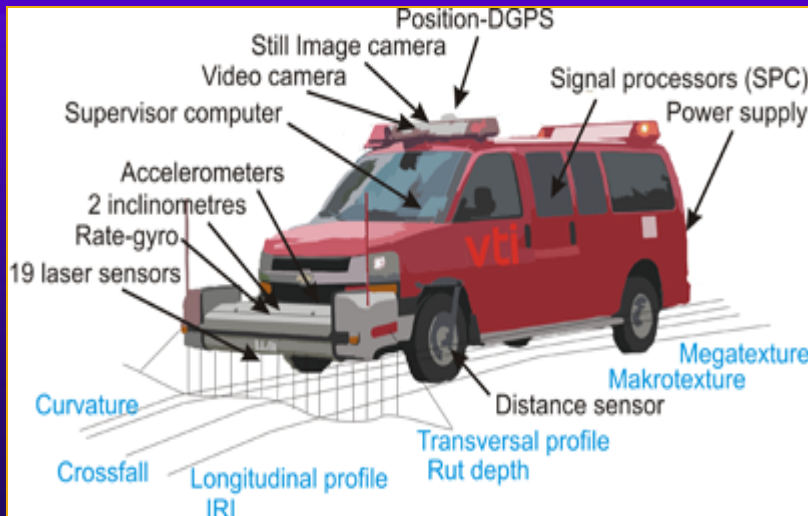
- ❖ Road surface textures are deviations from a planar and smooth surface, affecting the vehicle/tyre interaction. Pavement texture is divided into:
 - ❖ *microtexture* (MiTx) with wavelengths from 0 mm to 0.5 millimetres,
 - ❖ *macrotexture* (MaTx) with wavelengths from 0.5 millimetres to 50 millimetres, and
 - ❖ *megatexture* (MeTx) with wavelengths from 50 millimetres to 500 millimetres
- ❖ *MaTx* and *MeTx* are measured with *profilographs*; since *MiTx* has so short waves, it is preferably measured by longitudinal skidding resistance measurements (*skiddometer*) rather than by profiling
- ❖ *Profilographs* that record texture in both left and right wheel paths can be used to identify road sections with hazardous split friction

AUTOMATIC CONDITION SURVEY



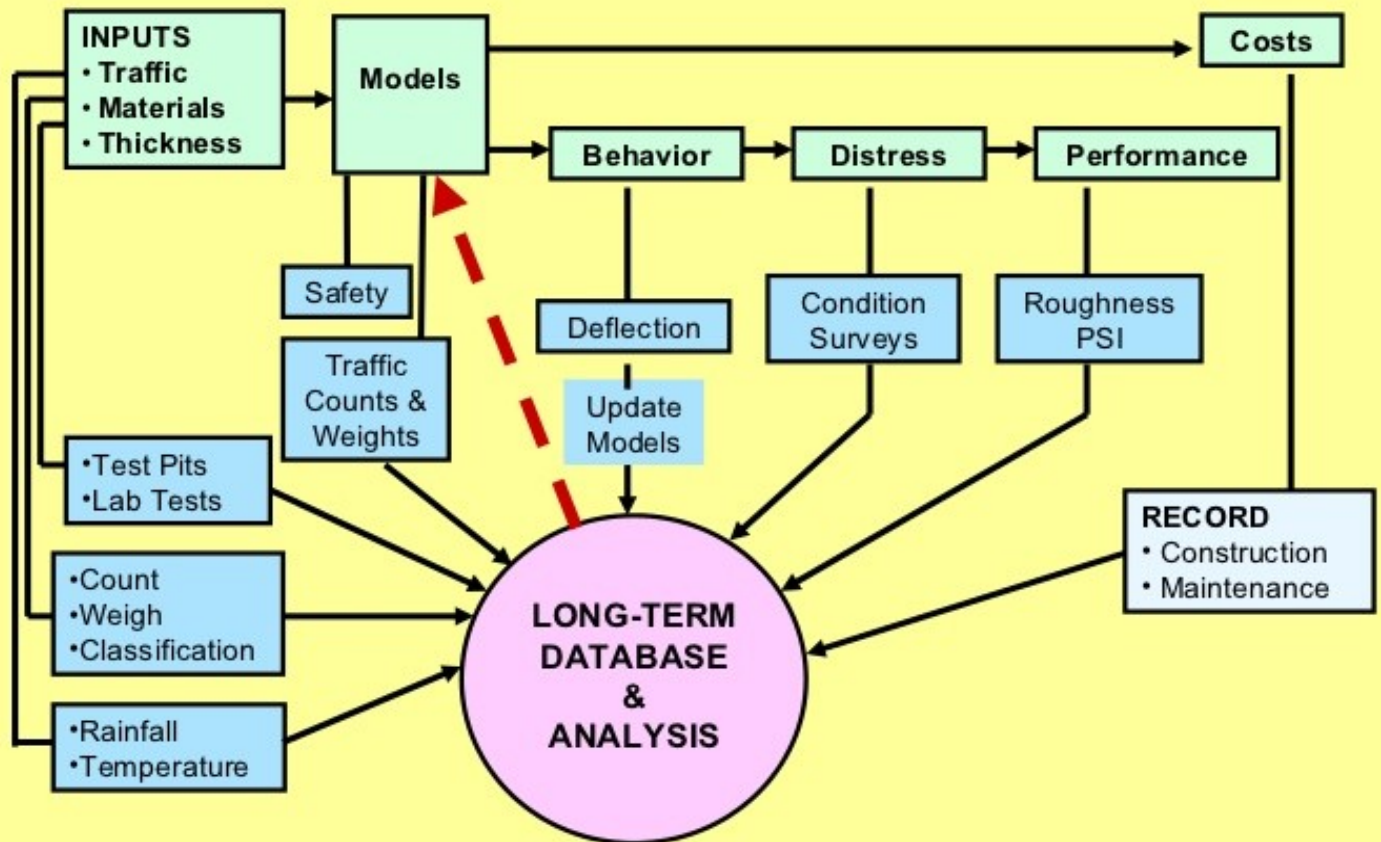
The Laser Road Surface Tester (RST) at a Glance:

1	2	3	4	5
Distress data for:	Objective Pavement Distress data for:	Data for:	Data for:	Data for:
<ul style="list-style-type: none"> Rear or pavement view images Data QA Right-of-way asset inventory & Condition rating Surface distress data extraction using specialized processing software 	<ul style="list-style-type: none"> Roughness Rutting Transverse cracking Texture Alligator cracking Block cracking Geometrics, crossfall, excessive crown, grade, and radius of curvature 	<ul style="list-style-type: none"> RST control Timecode Roadway inventory Pave type Lane count Full suite of surface distresses Environmental inputs Roadway attributes 	<ul style="list-style-type: none"> GPS coordinates Data location verification Production review 	<ul style="list-style-type: none"> Forward view images Data QA Right-of-way asset inventory & condition rating

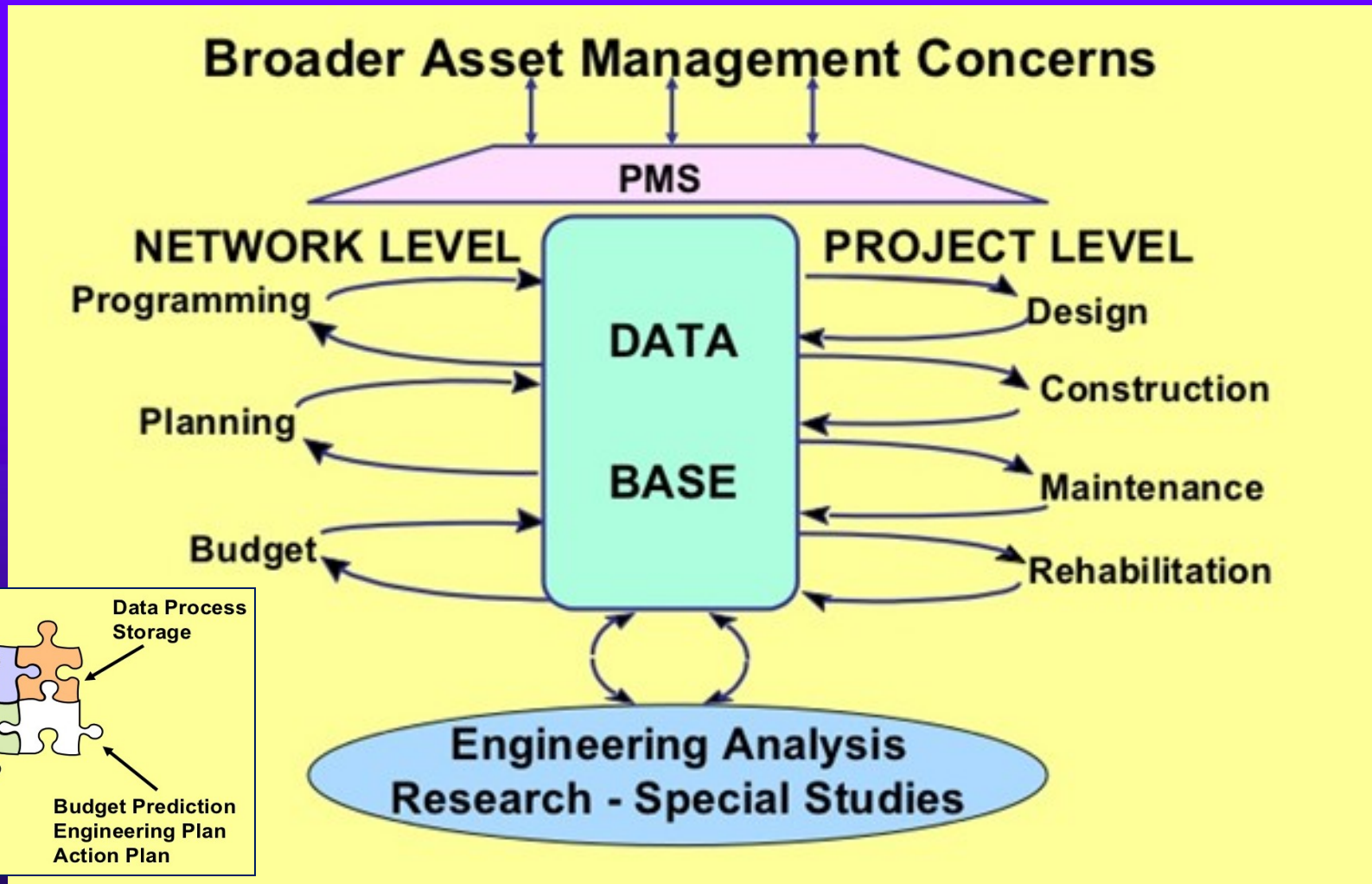


- ❖ The *profilograph* is a device used to measure pavement surface roughness (longitudinal evenness)
- ❖ Data collected by a profilograph is used to calculate the *International Roughness Index (IRI)*, which is expressed in units of mm/m
- ❖ IRI values range from 0 (equivalent to driving on a plate of glass) upwards to several hundred mm/km (a very rough road)
- ❖ The IRI value is used for road management to monitor road safety and quality issues

DATA COLLECTED FOR A DATABASE



COMPONENTS OF PMS

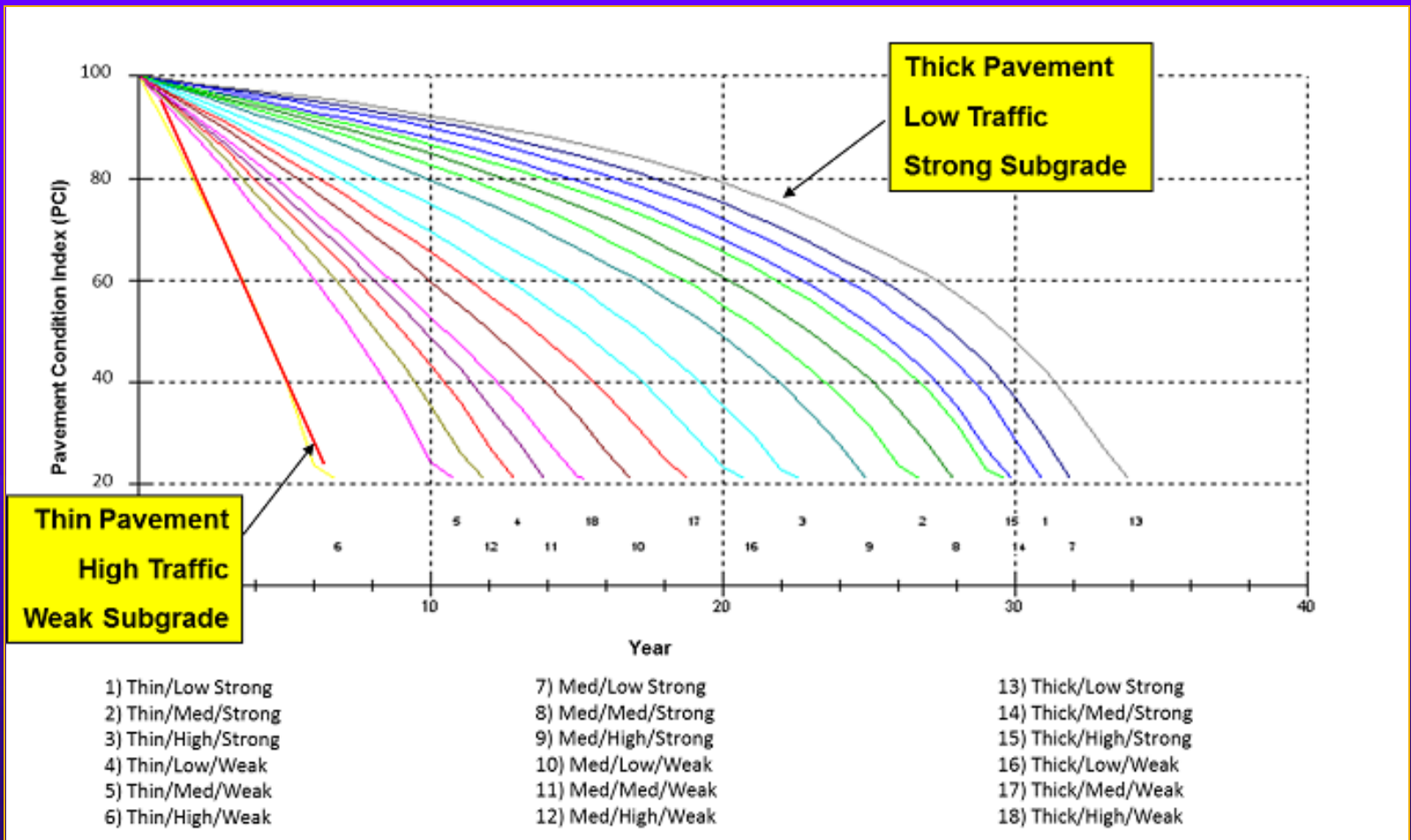




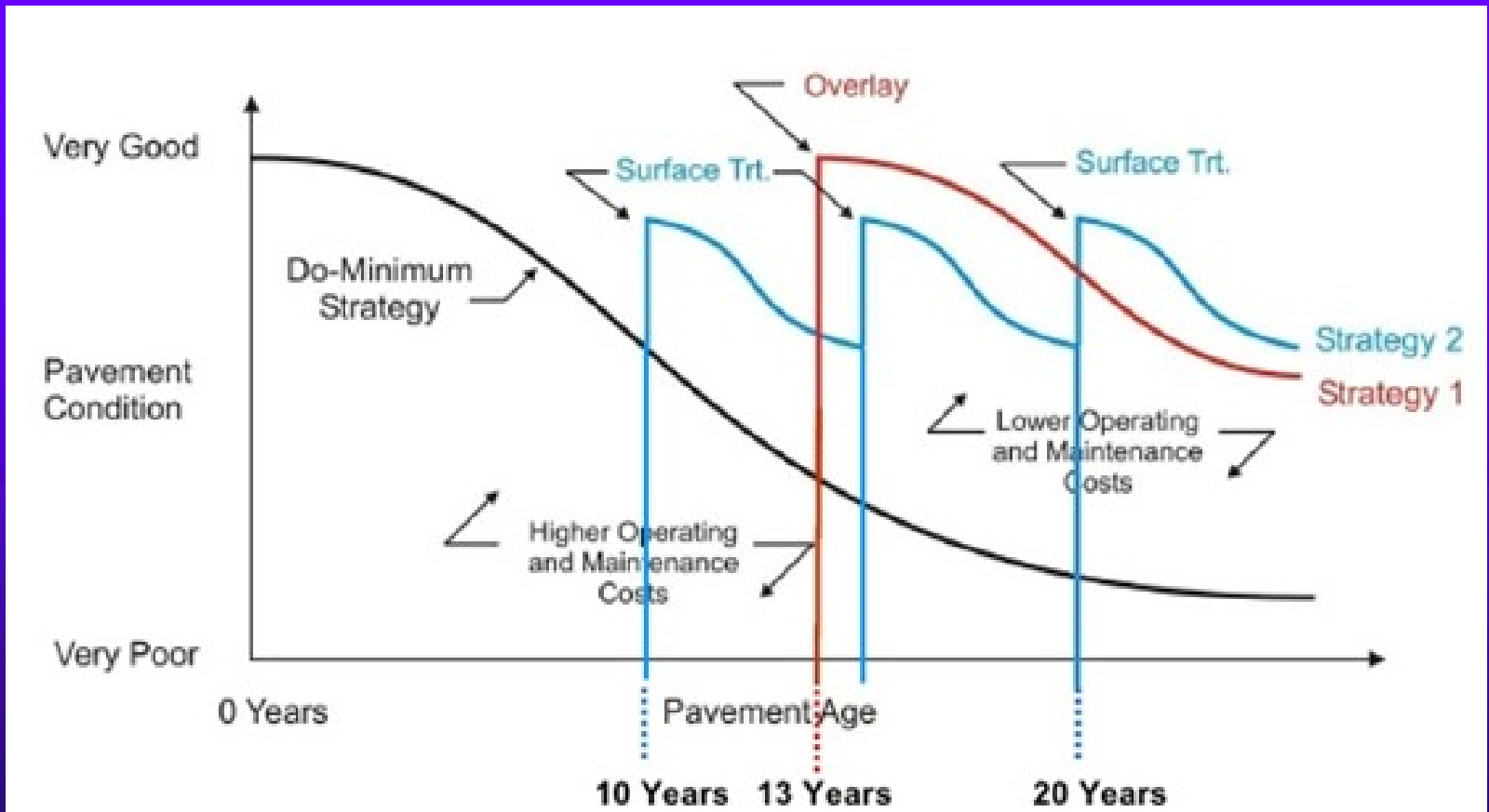
WHAT DOES A PMS DO?

1. Detailed input data collection (traffic, foundation, materials performance, climatic data)
2. Input data recording and analysis
3. Pavement performance parameters definition (surface, structural, materials)
4. Mechanistic Pavement Design
5. Condition survey programme outline
6. Survey data analysis
7. Pavement condition assessment
8. Pavement performance forecast
9. Maintenance programme and annual budget definition
10. Pavement rehabilitation design

PERFORMANCE PREDICTION CURVES

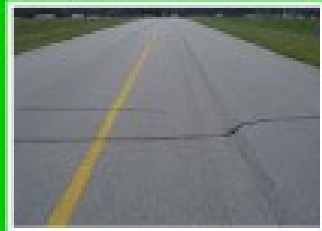




PAVEMENT MAINTENANCE STRATEGIES

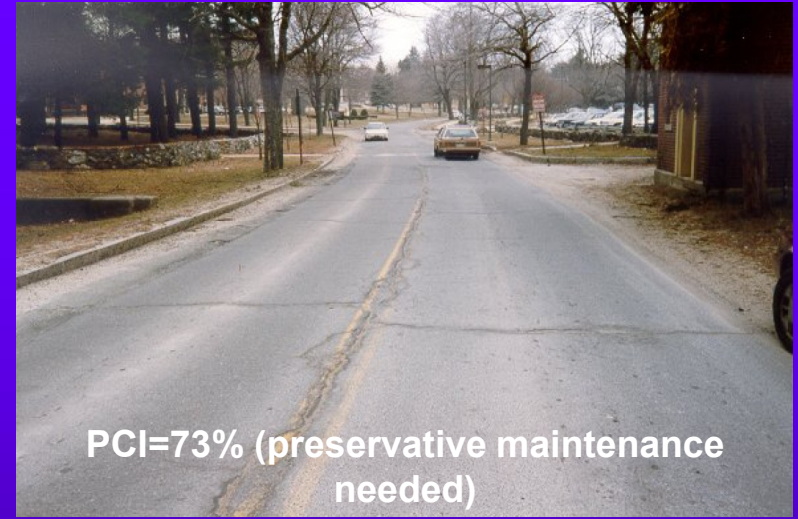


Example: eventual combination of treatments

SELECTING TREATMENTS 1

	PCI	PCI	REPRESENTATIVE PAVEMENT SURFACE	REPAIR ALTERNATIVE
ROUTINE MAINTENANCE	86 - 100	90		Pavements with PCIs above 85 will benefit from routine maintenance actions, such as periodic crack sealing, periodic joint resealing, or patching.
PAVEMENT PRESERVATION	56-85	65		Pavements with a PCI of 56 (65 for PCC pavements) to 85 may require pavement preservation, such as a surface treatment, thin overlay, or PCC joint resealing.
MAJOR REHABILITATION	0 - 55	25		Pavement allowed to deteriorate below a PCI of 55 (65 for PCC) will require costly reconstruction to restore it to operational condition.

PAVEMENT CONDITION & MAINTENANCE



SELECTING TREATMENTS 2

Overall rating	Primary rating indicators	Secondary ratings indicators	Treatment measures	Surface	Structure
10	No visible defects	Road surface in perfect condition, like new	Routine maintenance	Excellent	
9	Less than 10% of surface with surface defects	Road surface in very good condition		Very good	
8	10% to 30% of surface with surface defects	Little or no other defects	Resealing & Restoration of skid resistance	Fair	Good
7	Greater than 30% of surface with surface defects	Little or no other defects Old surface with aged appearance		Poor	
6	Less than 20% of other cracking may be present Patching generally in <i>good</i> condition May be out of shape requiring <i>some</i> reduction in driver speed	Surface defects may be present No structural distresses	Surface restoration ---	Fair	Fair
5	Greater than 20% of cracking present Patching generally in <i>fair</i> condition Out of shape requiring reduction in driver speed Very localised structural distress (<m ² of surface) may be present	Surface defects may be present	Carry out localised repairs and treat with surface treatment or thin overlay	Poor	
4	Structural distress present Rutting or alligator cracking for 5% to 25% of surface Short lengths of edge breakup/cracking Small number of potholes	Other defects may be present	Structural overlay ---	Poor overall	
3	Significant areas of structural distress Rutting or alligator cracking for 25% to 50% of surface Significant continuous lengths with edge breakup/cracking Frequent potholes	Other defects may be present	Required to strengthen road Localised patching and repairs required prior to overlay		
2	Large areas of structural distress Rutting or alligator cracking for over 50% of surface Severe rutting (over 75 mm deep) Extensive patching in very poor condition Many potholes	Very difficult to drive on	Road reconstruction ---	Very poor overall	
1	Severe structural distress with extensive loss of pavement surface Road disintegration of surface Many large and deep potholes Patching in failed condition	Severe deterioration Virtually undriveable	Needs full depth reconstruction with extensive base repair	Failed overall	

ROUTINE MAINTENANCE

❖ *Preventative or stop-gap*

- ❖ keep pavements in operational / safe condition
- ❖ applied on pavements above the condition limit
- ❖ slowing the rate of deterioration
- ❖ does not add structural capacity

❖ *Patching*

- ❖ Replace a partial depth or the full depth of the HMA layer and may include replacement of base and subbase layers
- ❖ Repair structural and material related distresses such as alligator cracking, rutting, corrugation, slippage cracking



❖ *Crack Sealing*

- ❖ Cleaning and sealing or resealing cracks on the HMA layer
- ❖ Fill longitudinal cracks, transverse cracks, or joint reflection cracks
- ❖ Primary purpose: prevent water infiltration (pavement overall in good condition; worthless otherwise)



MINOR REHABILITATION 1

- ❖ Generally applied to the entire pavement section with the primary goal of slowing the rate of deterioration
- ❖ Applied on pavements above a condition limit - include the following types of treatment:

- ❖ Fog seal
- ❖ Rejuvenators
- ❖ Slurry seal
- ❖ Surface treatment

❖ *Fog seal*

- ❖ Spraying a light coat of binder, usually a bitumen emulsion heated up to 66 °C (0.13 l/m²-0.23 l/m²) on the surface of an existing pavement
- ❖ Prolong the life of an AC pavement, reduce raveling and improve waterproofing
- ❖ Good for pavements with little or no traffic (includes paved shoulders)



MINOR REHABILITATION

2

❖ *Rejuvenators*

- ❖ Bituminous materials sprayed on the surface of an existing pavement using a distributor (0.09 l/m²-0.36 l/m² rate based on the condition of the HMA surface)
- ❖ Seal and waterproof pavement surface
- ❖ Penetrate the HMA surface and soften the asphalt binder.
- ❖ Reduce the rate of asphalt hardening → reduce the severity of temperature cracking

❖ *Slurry seal (emulsion + water + well-graded fine aggregate + mineral filler)*

- ❖ Provide a surface seal or skid-resistant surface to structurally sound pavements
- ❖ Fill small cracks (< 0.32 cm width); larger cracks need to be repaired prior the treatment
- ❖ Pavement with low to moderate level of traffic



MINOR REHABILITATION

3

❖ *Surface treatment*

- ❖ Apply an asphalt binder followed by a layer of aggregate, rolled into the binder → *Chip seal* →
- ❖ If sand → *Sand seal*
- ❖ Provide a surface seal or skid-resistant surface to structurally sound pavements
- ❖ Single or double treatments applied
- ❖ Suitable for pavements with low to moderate traffic



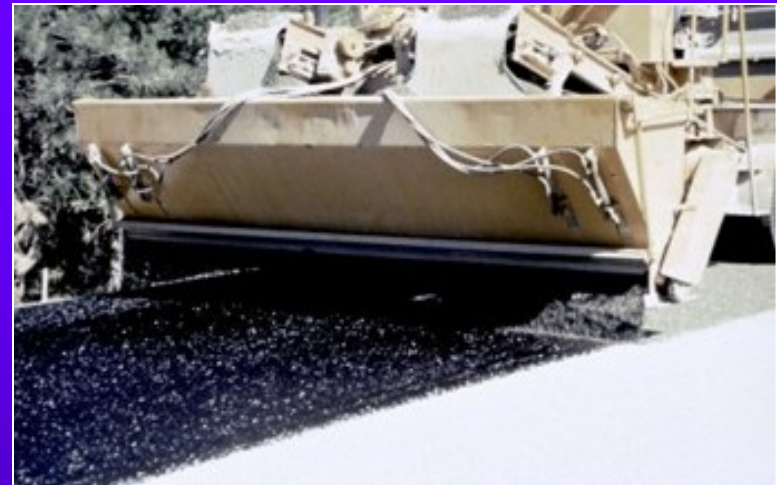
❖ *Other treatments (Cap Seal = Chip seal + Slurry seal)*

- ❖ *Micro-surfacing*: Slurry seal with high quality materials, dense graded aggregate, asphalt additives.
- ❖ Used to fill the wheel ruts up to 3.8 cm
- ❖ Provide stable, durable surface

MINOR REHABILITATION WORKS



Spreading bitumen emulsion



Crushed chip application



Sealcoat rolling



Distributor truck and scrub broom



MAJOR REHABILITATION 1

❖ *Major Rehabilitation*

- ❖ Applied to improve structural and / or functional requirements
- ❖ Applied to deteriorated pavements, pavements deteriorating at a rapid rate and pavements subjected to a sudden increase in traffic load

❖ *Types of major rehabilitation:*

- ❖ Overlays
- ❖ Pre-Overlay
- ❖ Repair Reflective Cracking
- ❖ In-place Recycling

❖ *Overlays*

- ❖ Usually applied when pavement is in good condition
- ❖ May require minor repairs to the pavement prior to the HMA overlay
HMA overlay over PCC pavements

MAJOR REHABILITATION

2

❖ *HMA on HMA Pavement*

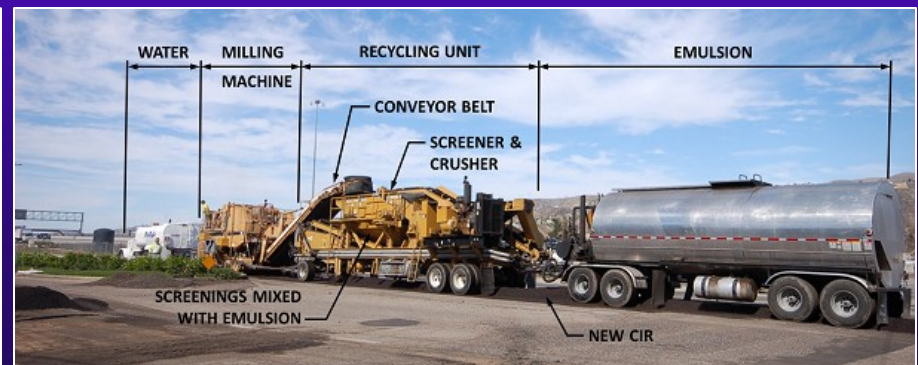
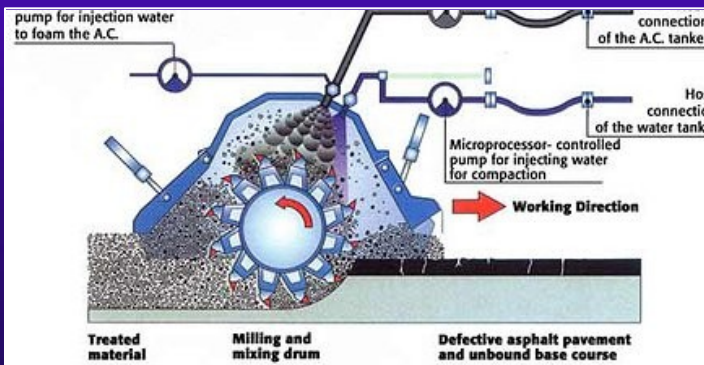
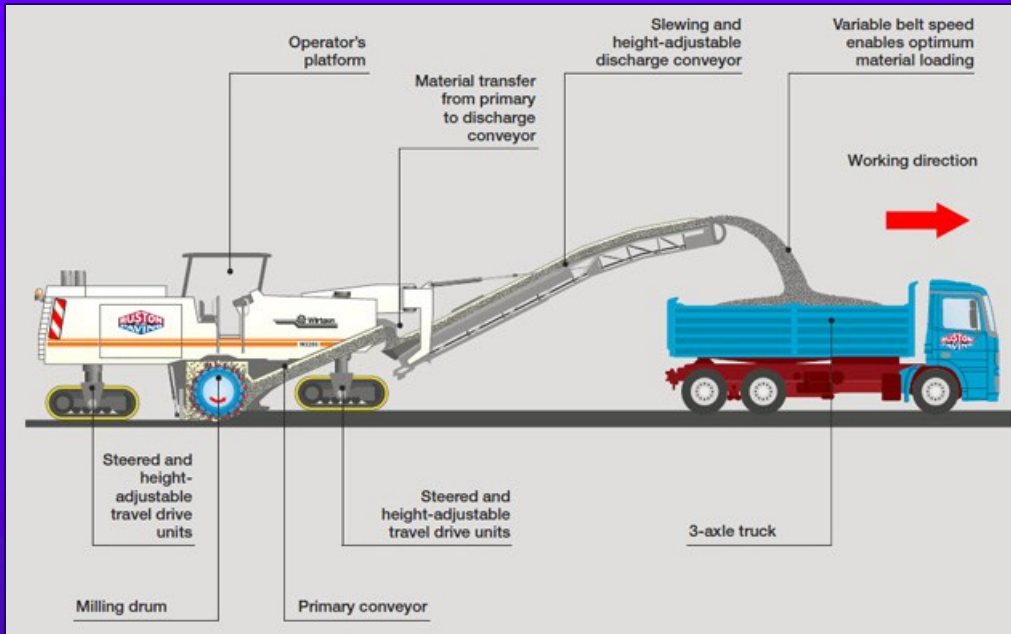
- ❖ HMA thickness design
- ❖ Combined with other activities such as *cold milling, hot recycling, and heater scarification*
- ❖ Should perform minor repairs on the existing pavement *prior to overlay*

❖ *HMA on Concrete Pavements*

- ❖ HMA thickness design
- ❖ Structural condition of the PCC pavement
- ❖ Main issue: propagation of reflective cracks and further deterioration
- ❖ Discomfort generated by the reflective cracks
- ❖ Water infiltration

MILLING & RECYCLING

1



MILLING & RECYCLING

2

- ❖ Depending upon the quality of the original components, asphalt is recyclable up to a considerable percent (<100%)
- ❖ *Reclaimed Asphalt Pavement (RAP)* is the asphalt pavement material that has been removed from paved surfaces and/or reprocessed (recycled)
- ❖ At the asphalt plant the RAP asphalt millings and/or broken chunk asphalt is crushed and screened to the appropriate size; then, with the use of a special RAP collar fitted to the asphalt plant, RAP is introduced and mixed with 'virgin' materials
- ❖ The hot mix asphalt plant is able to recycle 30% (sometimes more) RAP into the final 'virgin' mix



MAJOR REHABILITATION

3

❖ *Pre-overlay repair* (for PCC slabs)

- ❖ Slab stabilization
- ❖ Fractured slabs
- ❖ Slab repair / replacement
- ❖ Load transfer restoration

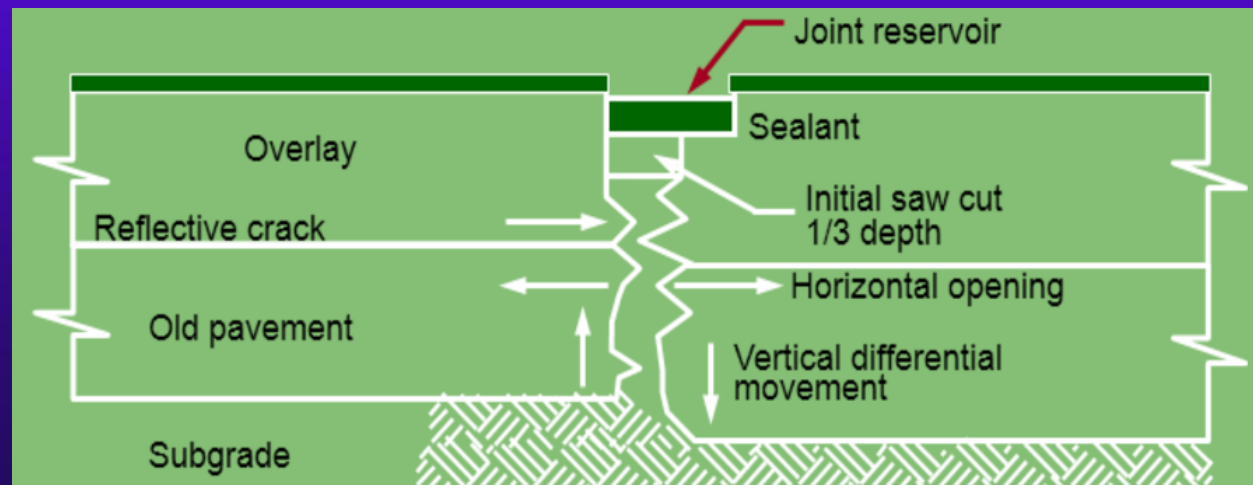
❖ *Pre-overlay Treatments* of PCC Pavements

- ❖ Crack and seat
- ❖ Crack size max 60 cm
- ❖ Must have existing good subgrades
- ❖ Concrete slab rubbilization
- ❖ Pavement is broken into pieces ranging from aggregate size to a max of 6-12in
- ❖ Compaction with a 10 ton steel wheel or vibratory roller

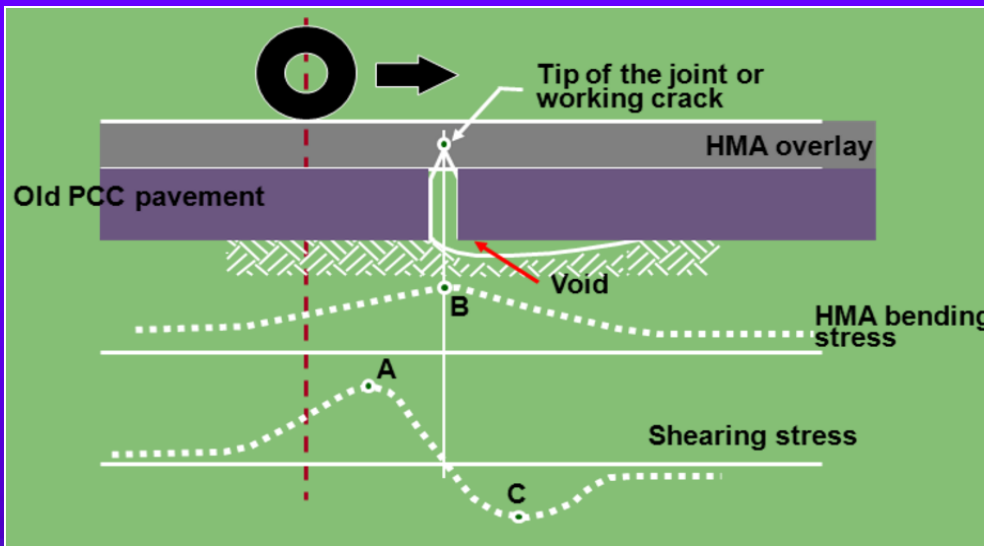
MAJOR REHABILITATION

4

- ❖ **Post-overlay Treatments on HMA layer**
 - ❖ **Sawing and Sealing Joints**
 - ❖ **Concede appearance of reflection cracking**
 - ❖ **Objective: control rate of deterioration**
 - ❖ **Reduces spalling of reflection cracks**
 - ❖ **Slabs should have well-defined joints**
 - ❖ **Saw cut must be directly above the underlying joint**

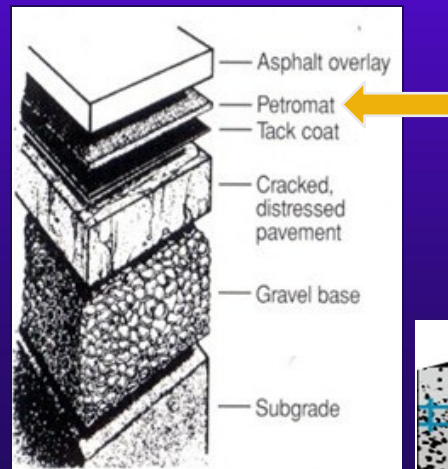


REFLECTIVE CRACK CONTROLLING MEASURES



❖ Interlayers

- ❖ Prevent reflective cracking: geo-textiles contribution related to climate
- ❖ Geotextiles or fabrics
- ❖ Stress relieving or stress absorbing membrane interlayers
- ❖ “Band aid” type crack sealants



❖ Interlayer systems

- ❖ Stress-relieving interlayer
- ❖ Crack-arresting interlayer



**THANK YOU VERY MUCH
FOR YOUR KIND ATTENTION!**

