KTH
AF2903 Road Construction and Maintenance
19 March 2013

Assessment of pavement damage

or

Quantitative measurement techniques

vti
FINDING A BETTER WAY

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Why is it important to assess the condition of pavements ?

vti
FINDING A BETTER WAY

- Pavement Management Systems (PMS) is a set of tools or methods to assist decision makers in finding a optimum strategies for providing, evaluating and maintaining pavement in a serviceable conditions over a period of time.
- PMS provides a rational and cost-effective approach to pavement maintenance operations.

Methods

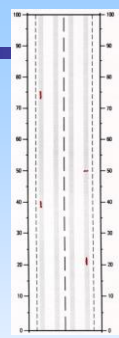
- Visual survey
- Profile measurements
- Wear due to studded tyres
- Coring and sampling
  - Material testing
- Skid resistance
- Falling Weight Deflectometer (FWD)
- Lateral wander
- Roughness (smoothness)
- Continuous scanning – Road Surface tester (RST)
  - Roughness, Rut, Video profiling, Digital images, etc.
- Pavement Instrumentation
  - Temperature and moisture
  - Frost penetration
  - Response sensors

Visual survey (inspection)

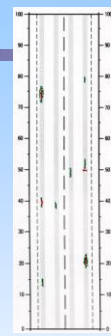
Visual inspection includes:

- Cracking
  - Longitudinal
    - Fatigue cracking
      - Single crack in the wheel path
      - Alligator cracking
    - Seasonal (frost heave) cracks
    - Joint cracking
  - Transversal (thermal) cracking
  - Pattern cracks
    - Block Cracking
    - Joint Reflection Cracking
- Potholes
- Bleeding
- Ravelling
- Corrugation and shoving
- Segregation
- Patching
- Depressions

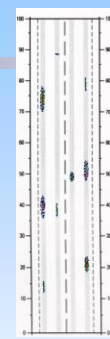
Visual survey cont.



Inspection 1
Crack index, Si = **7**



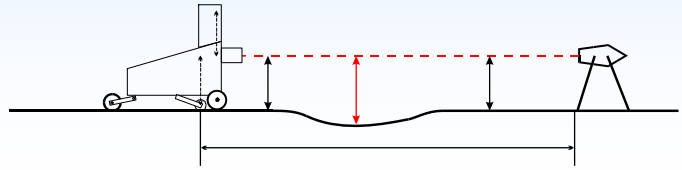
Inspection 2
Crack index, Si = **46**



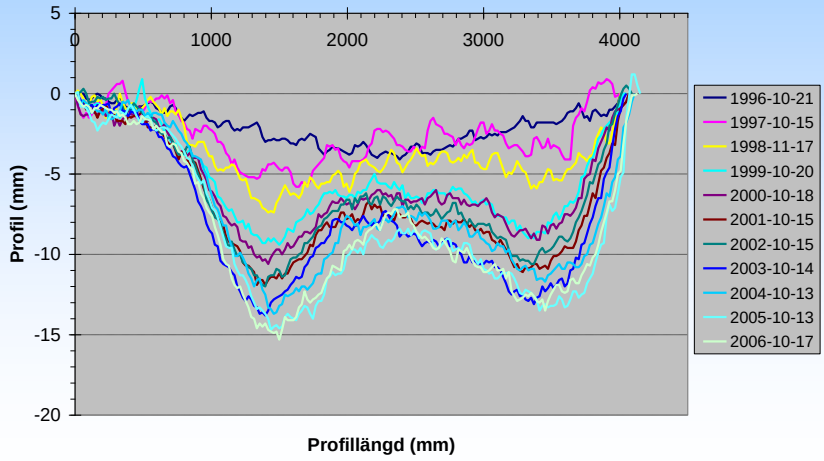
Inspection 3
Crack index, Si = **103**

1.	$LSpr_{låg}$, längd 2 m	$Kr_{låg}$, 6 m		Kr_{medel}, 8 m
2.	$LSpr_{låg}$, 1 m	$LSpr_{svår}$, 3 m		$Kr_{låg}$, 7 m
3.		$LSpr_{medel}$, 2 m		$LSpr_{svår}$, 3 m
4.				$TSpr_{låg}$, 1 st
5.		$LSpr_{låg}$, 2 m		$LSpr_{medel}$, 4 m
6.		$LSpr_{låg}$, 3 m		$Kr_{låg}$, 3 m
7.		$LSpr_{låg}$, 2 m		$LSpr_{svår}$, 4 m
8.		$LSpr_{medel}$, 3 m		Kr_{medel}, 6 m
9.	$TSpr_{låg}$, antal 1 st	$TSpr_{medel}$, 1 st		
10.	$LSpr_{medel}$, 2 m	Kr_{medel}, 4 m		$Kr_{svår}$, 5 m

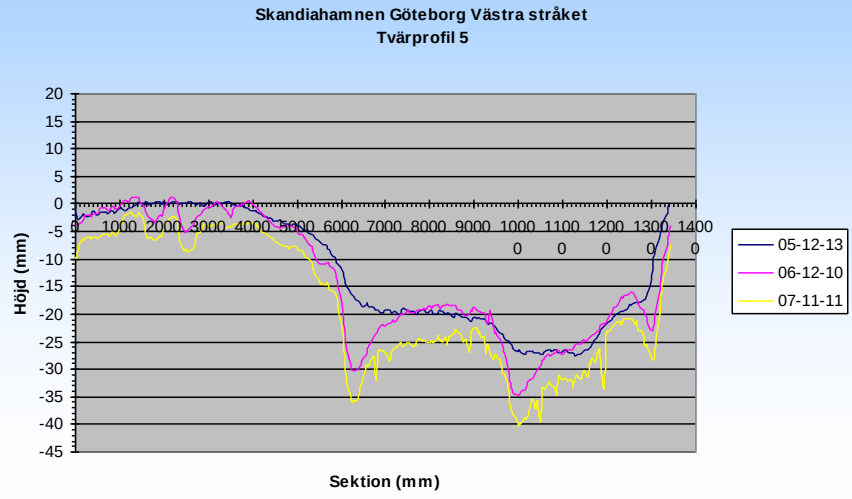
Profile measurements - Rut



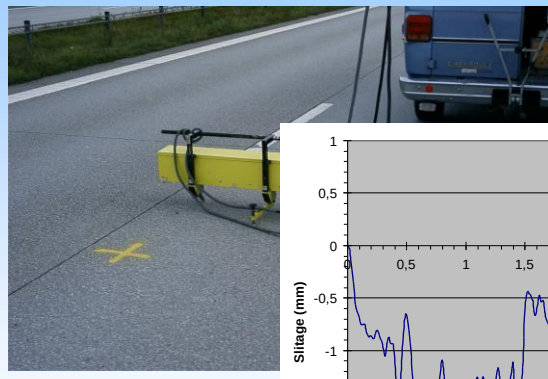
Profile measurements cont.

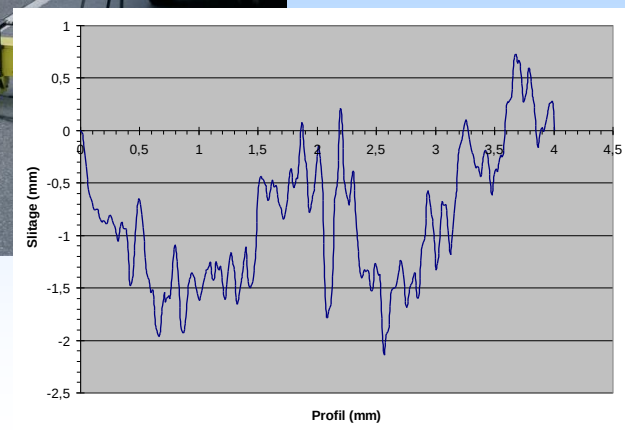


Profile measurements cont.



Wear due to studded tyres

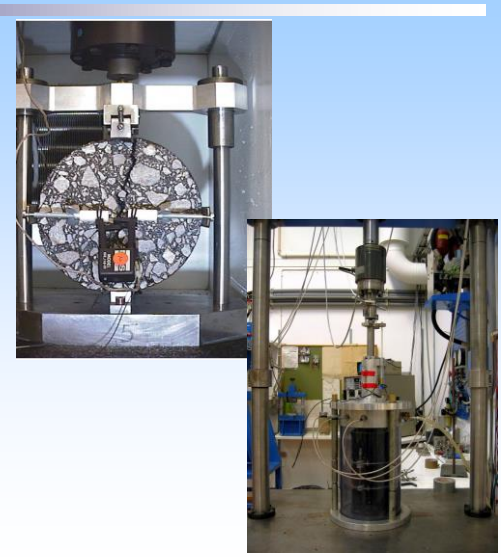




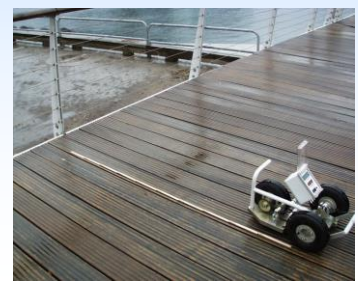
Coring and sampling

Coring and sampling – Material testing

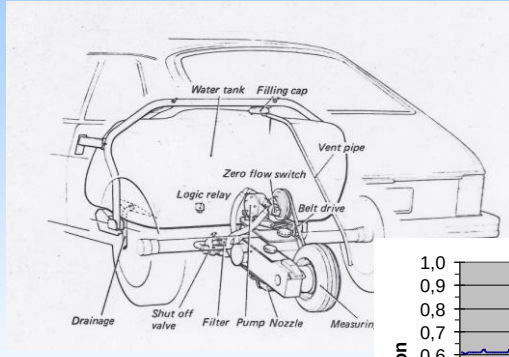
Laboratory testing:
- **IDT Test**
- **RLT test**
- **etc.**



Skid resistance

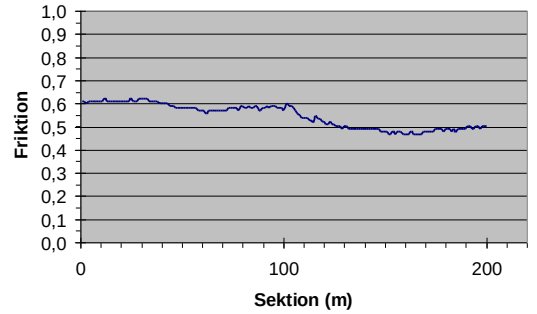


Skid resistance cont.

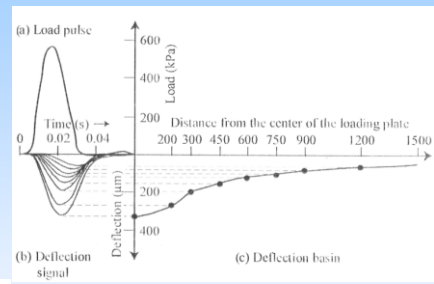


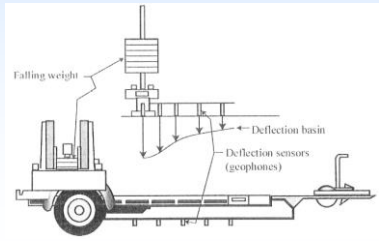
Skid resistance is the force developed when a tyre, that is prevented from rotating, slides along the pavement surface.

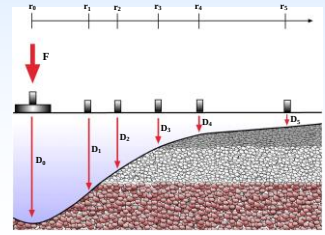
Friction factor: f = F/L
Skid number: SN = 100(f)
where: F = frictional resistance to motion in plane of interface.
L = load perpendicular to interface.



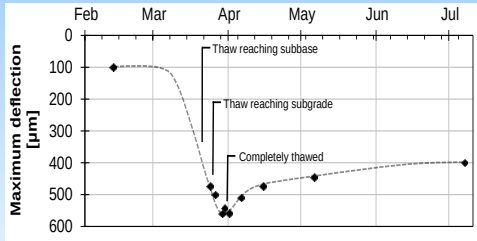
Falling Weight Deflectometer (FWD)

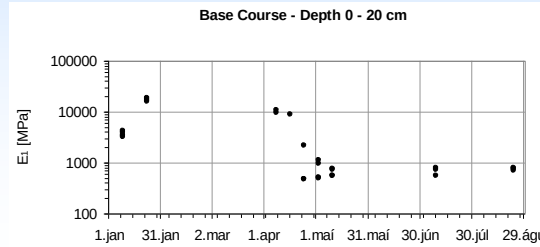




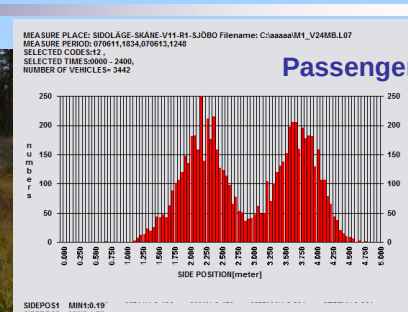


FWD - results

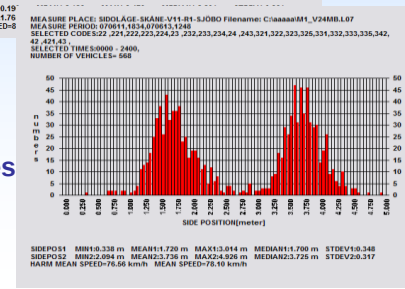




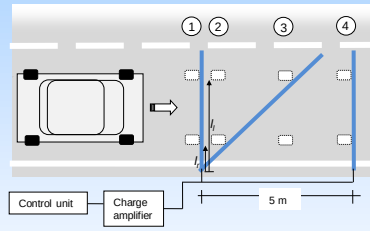
Lateral wandering (side position)

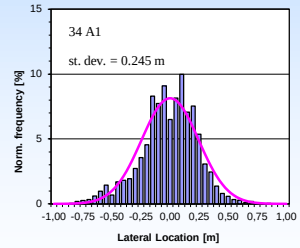


Heavy vehicles



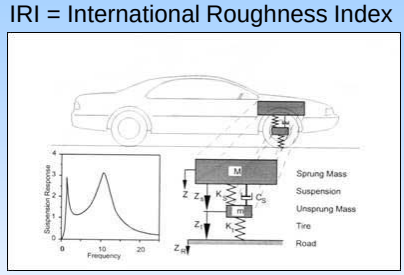
Lateral wandering (side position)





Roughness (Smoothness)

IRI = International Roughness Index



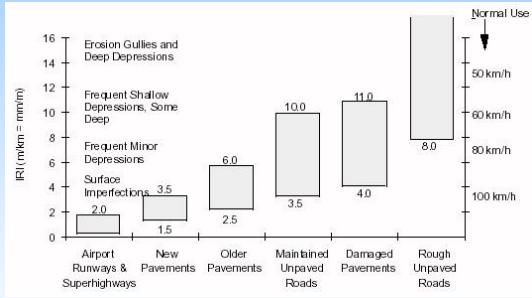
$$IRI = \frac{1}{L}\int_0^{L/S} \left| \dot{z}_s - \dot{z}_u \right| dt$$

- **Roughness** is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small the surface is smooth. Roughness is typically considered to be the high frequency, short wavelength component of a measured surface.
- **Profilometer** is used to measure a surface's profile, in order to quantify its roughness. Vertical resolution is usually in the nanometre level, though lateral resolution is usually poorer.
- worldwide standard for measuring pavement smoothness called the International Roughness Index, or IRI. The index measures pavement roughness in terms of the number of mm per m (inches per mile) that a laser, mounted in a specialized van, jumps as it is driven across the road system. The lower the IRI number, the smoother the ride.
- A measure of a pavement's longitudinal surface profile as measured in the wheel path by a vehicle travelling at typical operating speeds. It is calculated as the ratio of the accumulated suspension motion to the distance travelled obtained from a mathematical model of a standard quarter car traversing a measured profile at a speed of 80 km/h (50 mph). The IRI is expressed in units of meters per kilometer (inches per mile) and is a representation of pavement roughness.

Response Type Road Roughness Meters (RTRRMs)

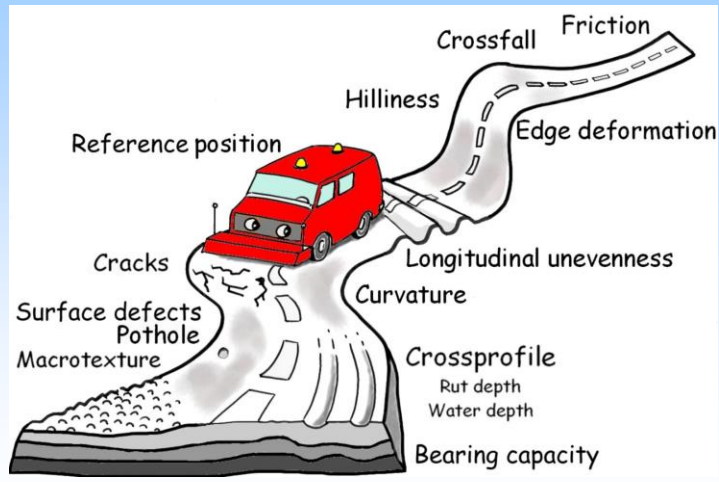
RTRRMs measure the vertical movements of an automobile or the axle of a trailer relative to the vehicle frame. The meters are installed in vehicles with a displacement transducer on the body located between the middle of the axle and the body of a passenger car or trailer. The transducer detects small increments of axle movement relative to the vehicle body. The output data consists of a strip chart plot of the actual axle body movement versus the time of travel.

Roughness - IRI



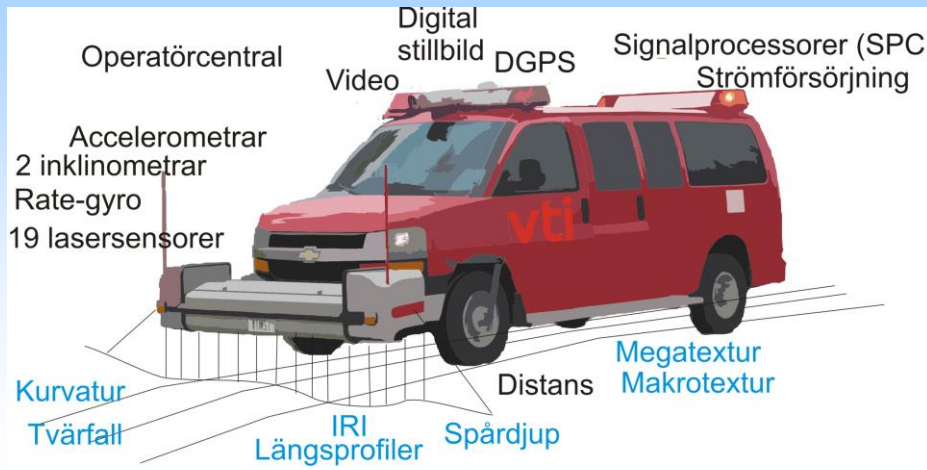
- The international roughness index (IRI) was developed by the World Bank in the 1980s. IRI is used to define a characteristic of the longitudinal profile of a travelled wheel-track and constitutes a standardized roughness measurement.
- The commonly recommended units are meters per kilometer (m/km) or millimeters per meter (mm/m).

Continuous scanning



Road Surface Tester (RST)

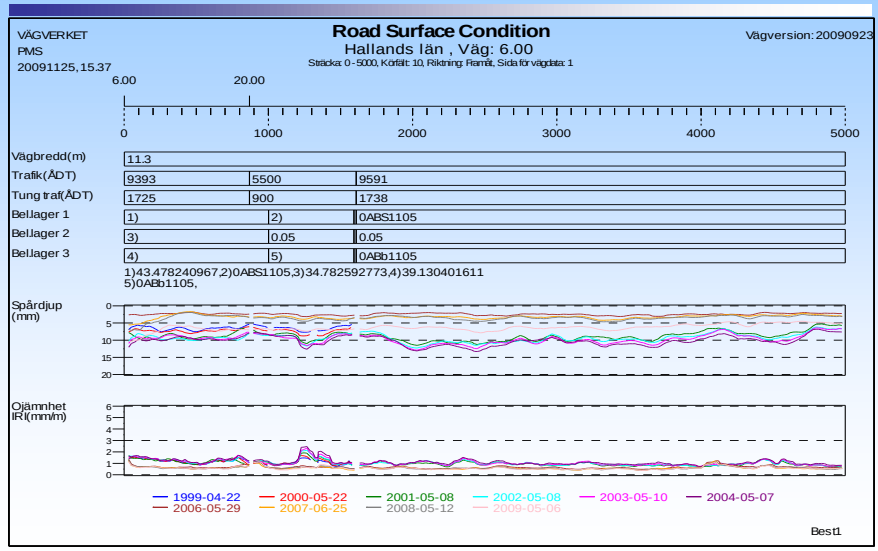
Road Surface Tester (RST)



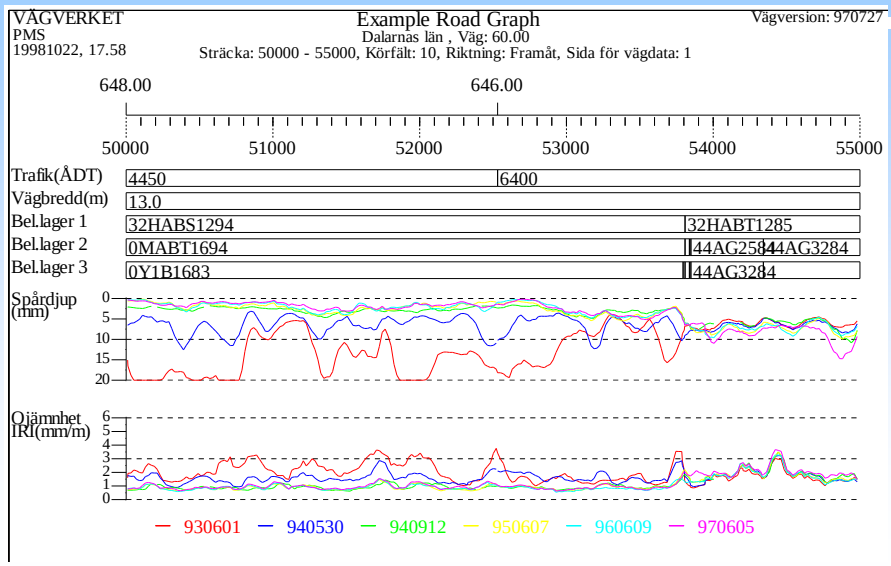
RST - what is measured

- Three longitudinal profiles (0.1 meter)
- Transverse profile (1 meter)
- Rut depth, max, left and right (20 meter)
- IRI, left and right (20 meter)
- Macrotexture, MPD in three tracks (1 meter)
- Megatexture, two tracks (1 meter)
- Curvature, Hilliness (20 meter),
- Crossfall (1 meter)
- Digital images (20 meter)

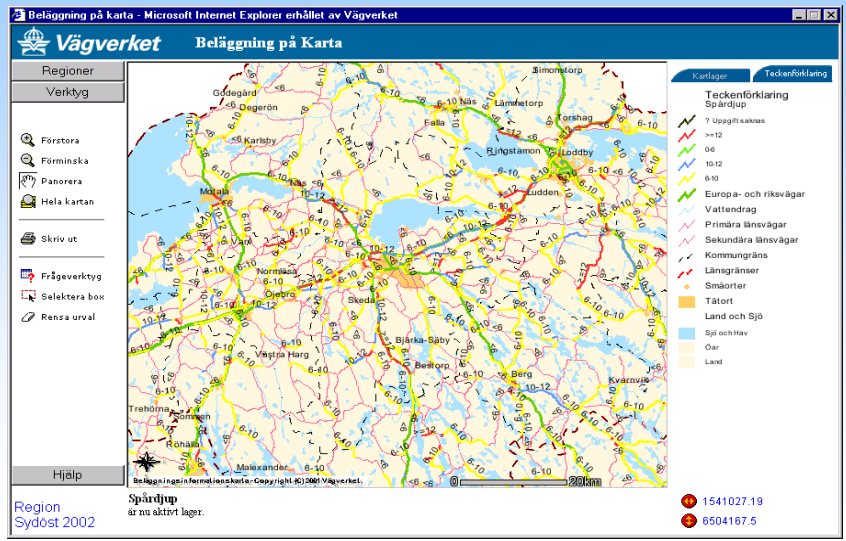
SNRA´s PMS data



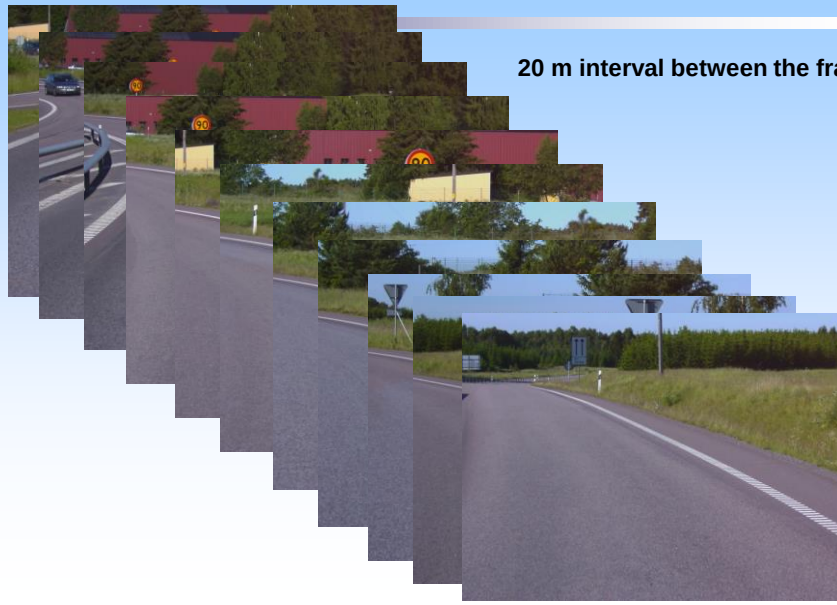
SNRA´s PMS data



Network level: Rut depth

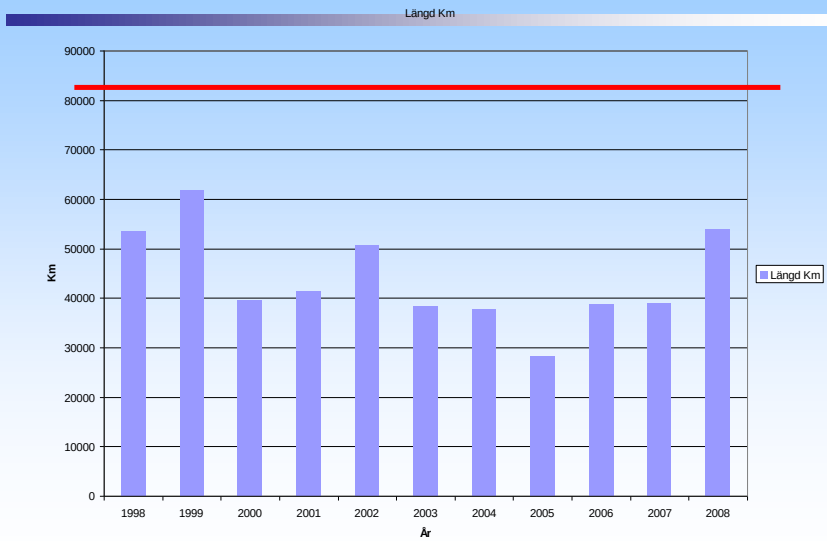


Digital Images



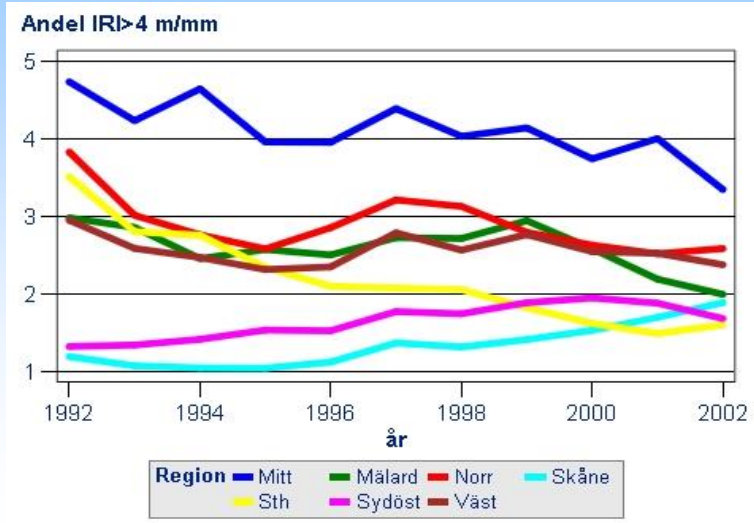
20 m interval between the frames

Total measured length (lane km) with RST



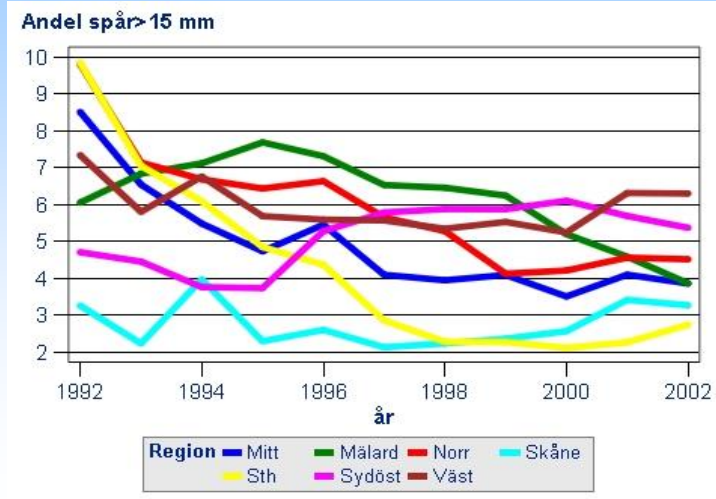
Change in longitudinal unevenness

Percentage IRI>4 mm/m AADT>2000 vehicles/day

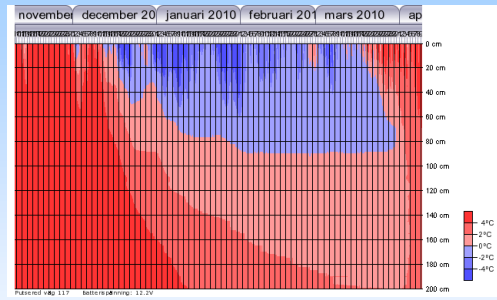


Change in transverse unevenness

Percentage Rut depth>15 mm AADT>2000 vehicles/day



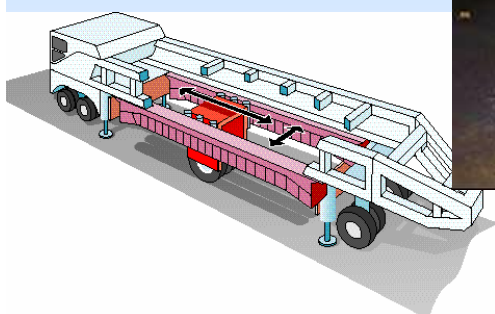
Frost depth penetration



www3.vv.se/tjaldjup/

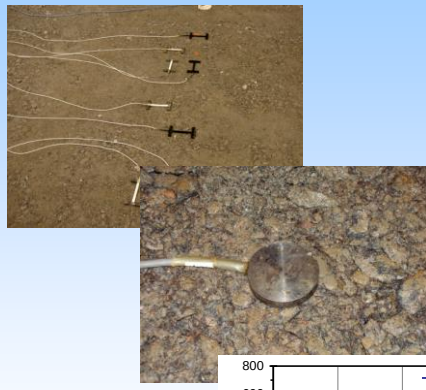
Instrumented test roads - APT testing

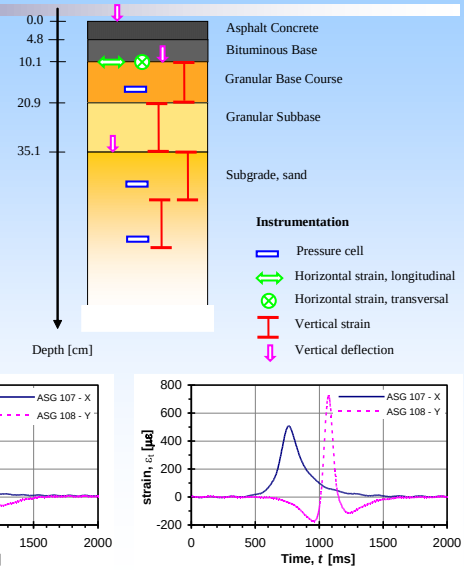
The HVS Nordic is a mobile APT test facility.

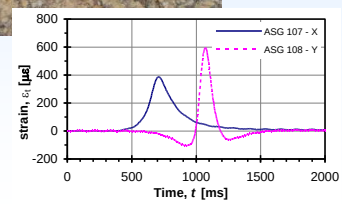


APT = Accelerated Pavement Testing
HVS = Heavy Vehicle Simulator

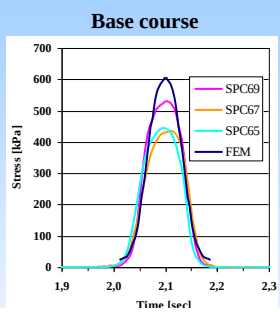
Instrumentation - Response measurements

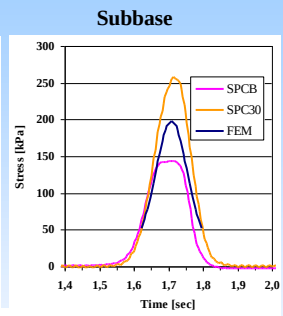


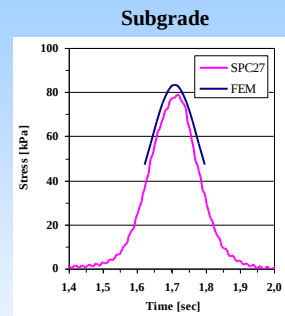


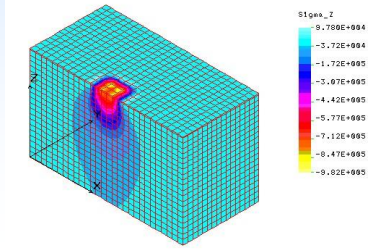


Instrumentation - stress measurements

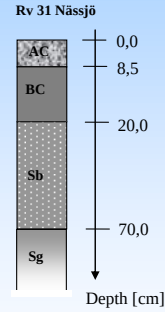


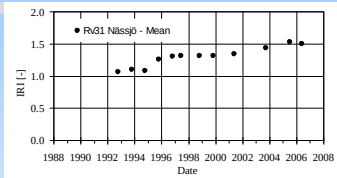


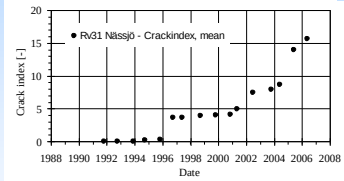


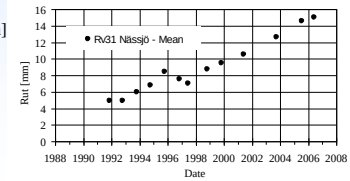


The Swedish LTPP database









LTPP = Long Term Pavement Performance