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The Use of Deflection Measurements in Pavement Management of the Primary Road Network of Wallonia, Belgium.

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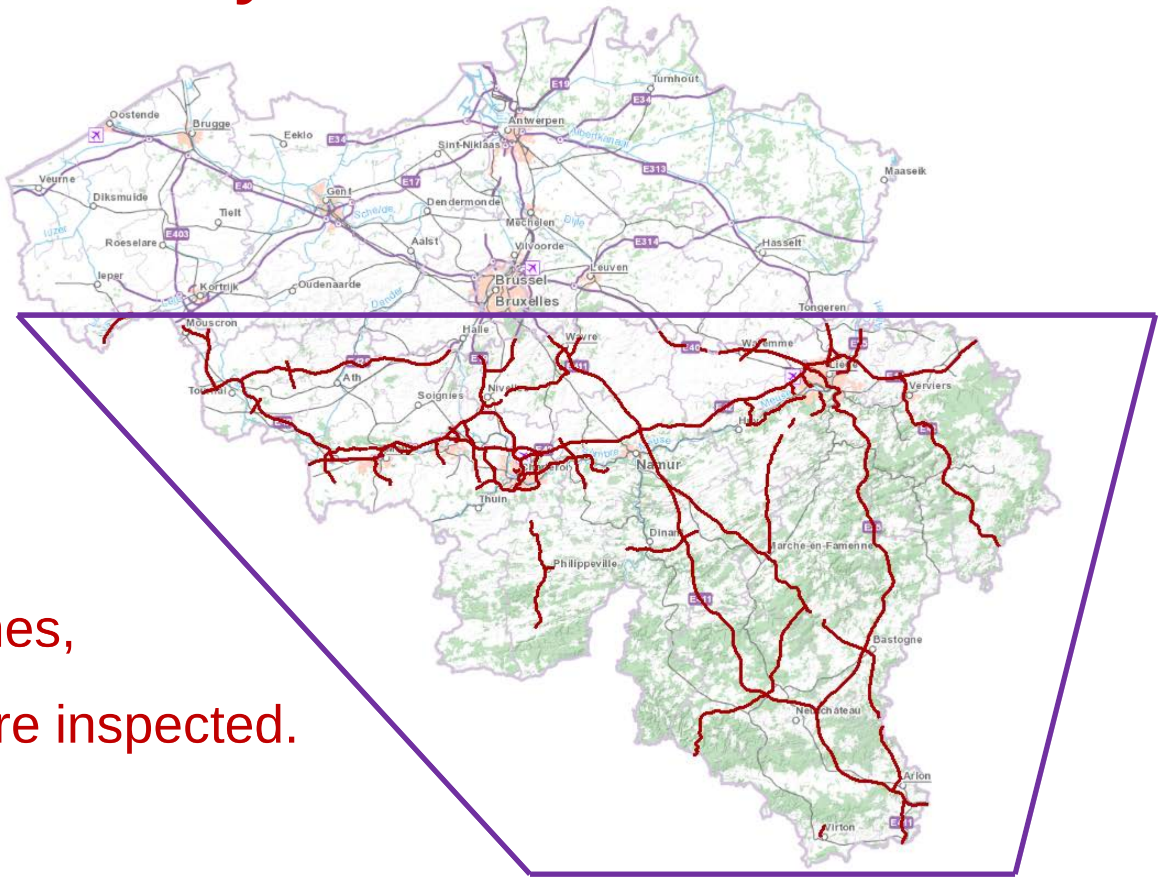
Map of the network

1200 km motorways + 600 km main roads

mostly 2X2 lanes,

hence ±7200 km of lanes,

of which ±1500 km were inspected.



Wallonia = southern part of Belgium

Context of presented work

- **Primary roads (managed by “SOFICO”):**
  - **Motorways and main roads.**
- **Available: surface characteristics**
  - **roughness, skid resistance, rutting.**
- **Missing: bearing capacity, residual life**
  - **Priorities of maintenance based on surface characteristics only,**
  - **Need for structural analysis of those roads.**

Why do we use indicators?

- Road structure details unknown:
  - Back-calculation for the network is unreliable.
- Easy to compute:
  - Direct from “raw measurement data”.
- Only needs: classification and prioritization.
- Note:
  - Measurement data are available for detailed analysis (when preparing a call for tender).

What the indicators express?

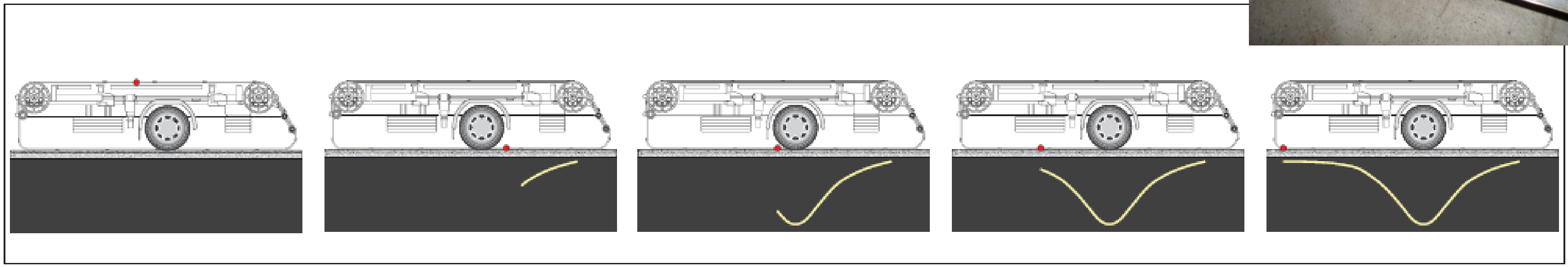
+ A global indicator
  - expressing residual service life, and
  - allowing a classification of road sections.
+ Based upon indicators for:
  1. Bearing capacity.
  2. Bonding between (upper) layers.
  3. Cohesion of (whole) road structure.
  4. Traffic volume (number of vehicles).
  5. Aggressiveness of heavy traffic.

Deflection measurements

- On concrete roads (rigid roads)
  - Falling Weight Deflectometer (FWD)
  - Force: 100kN
  - 1 measurement point every 100m
  - 9 geophones (0, 300mm,...,2400mm)

Deflection measurements

- On bituminous surfaces (semi-rigid roads)
  - Curviameter
  - 13T axle
    (65kN wheel load)
  - 1 point every 5m



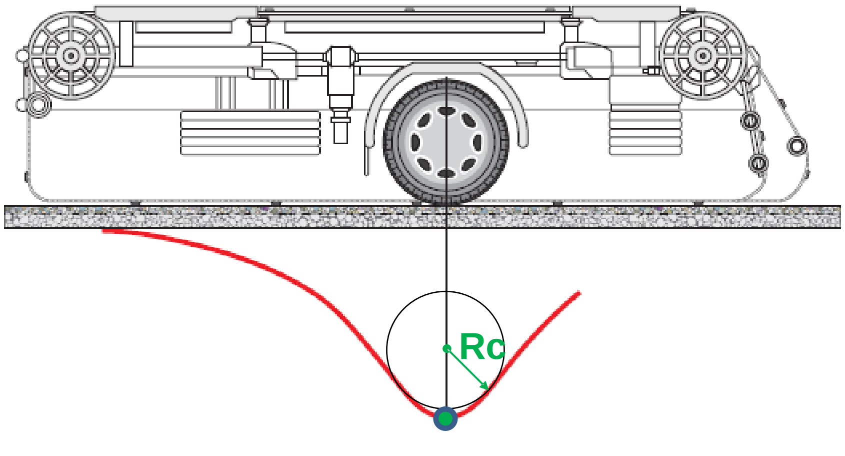
Deflection and Curvature Radius

Curviameter

- maximum deflection

measured radius

100 points on curve

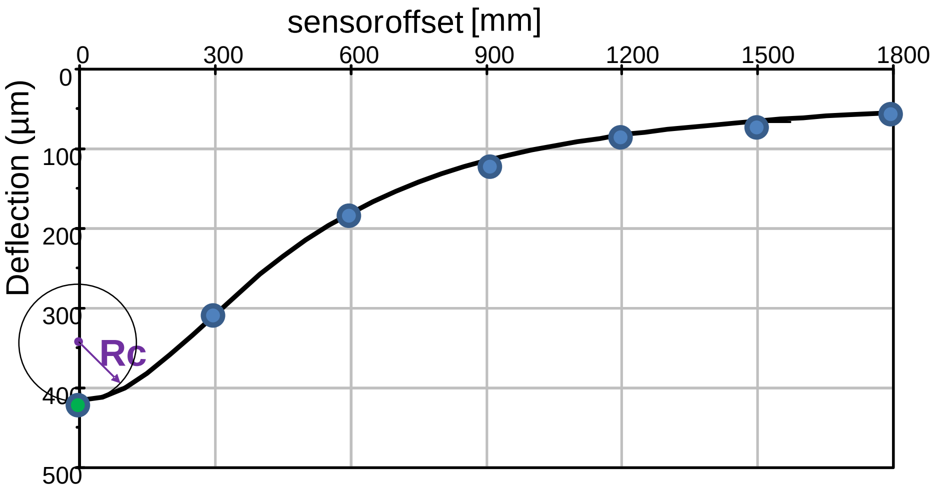


FWD

- maximum deflection

computed radius

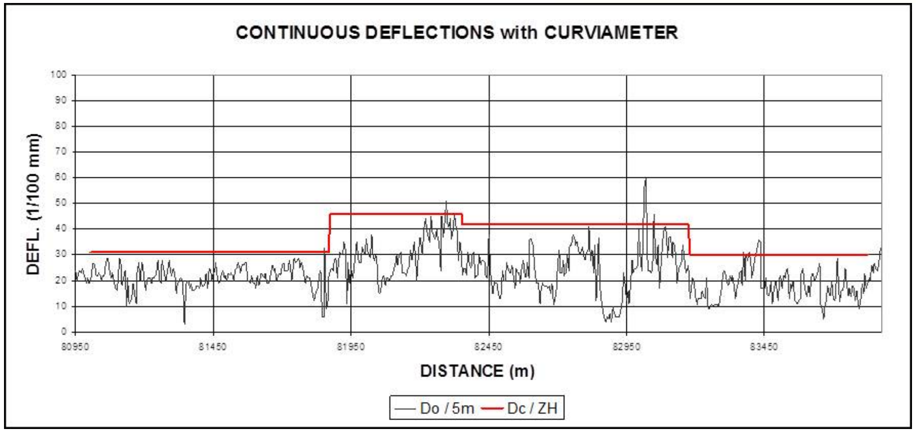
“hysteresis” data



Step 1: "homogeneous sections"

- Curviameter

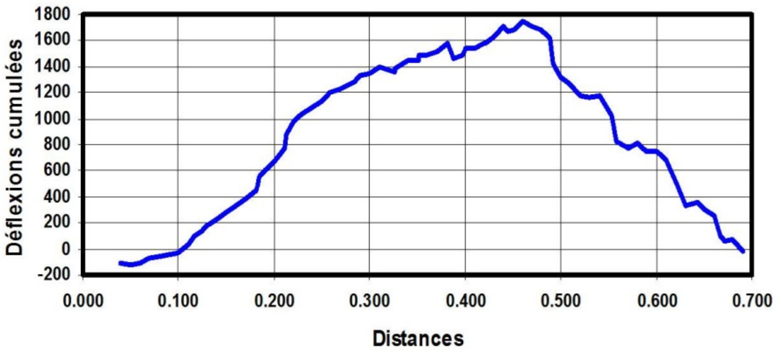
statistical analysis of
the maximal deflections *(Dmax)*
(as in a French standard)



Also delivers characteristic deflection *(Dc)* in the homogeneous section: $Dc = Dmax,average + 2.\sigma$

- FWD

dynamic segmentation by
the cumulative sum method
(cf. COST 336 of FWD)

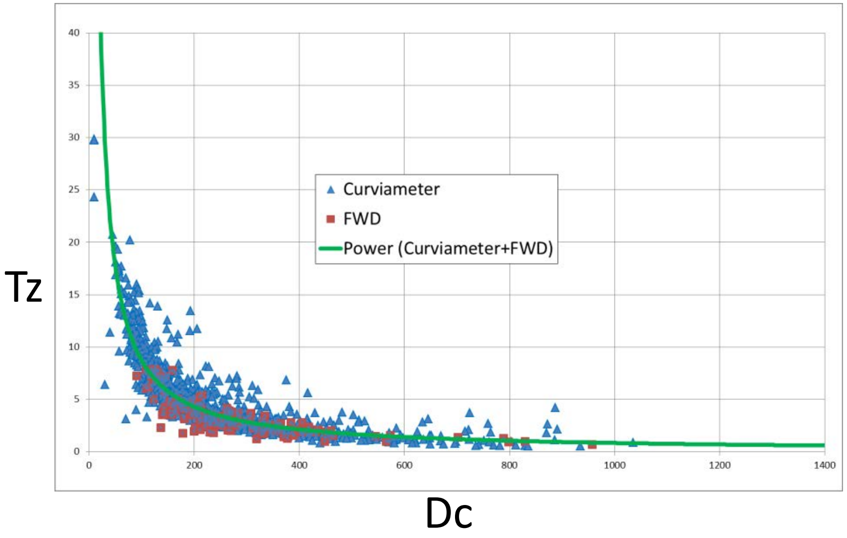


Step 2: compute indicators

- Details/definitions: see paper.
- Philosophy:
  - Exploit available knowledge on data interpretation,
  - Extend carefully where necessary: “same” indicator for FWD (rigid) and Curviameter (semi-rigid),
  - Combine “structural indicators” into “reasonable global indicator”, weighing by “traffic indicators”,
  - Check that categorization by global indicator is as good as categorization by back-calculation.

KPI1: bearing capacity

- FWD: $Tz = (Rc / Dmax)^{0.5}$
  - Rc to be computed for FWD data
  - Tz low ~ bad bearing capacity
- Curviameter: Dc
  - Dc ~ life-time
- Tz α Dc



- Hence: Tz should express bearing capacity of road in reasonable shape.

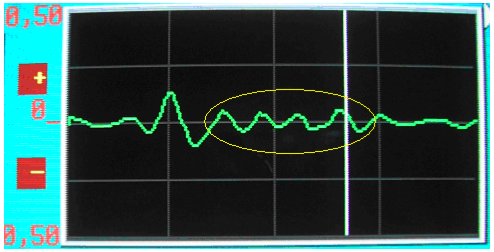
KPI1: bearing capacity

- Product “Dmax . Rc”
  - Large variation in homogeneous section means very bad structural shape of the section.
  - Very high value means critical structural shape.

- KPI1:
  - first a selection on (Dmax . Rc)
  - otherwise: KPI1 = f(average Tz)

KPI2: layer bonding

- Bad bonding in upper layers may give:
  - Small Rc (Curviameter), big D(0)-D(300) (FWD)
  - Noise on raw Curviameter signal:

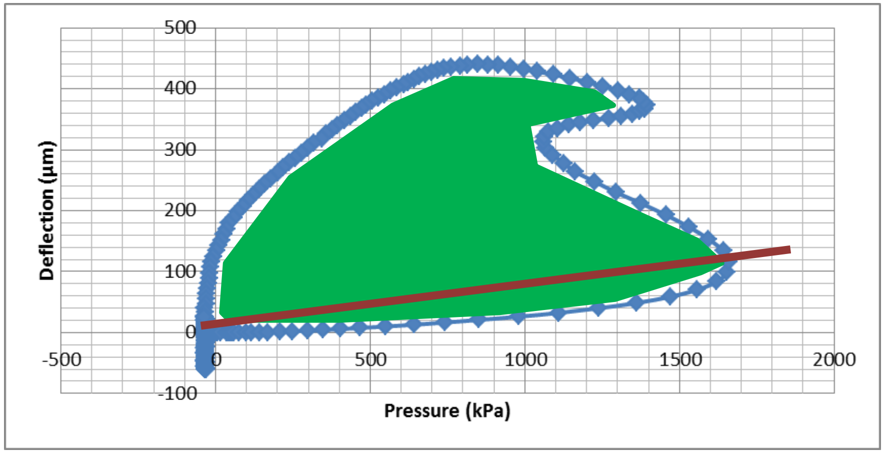


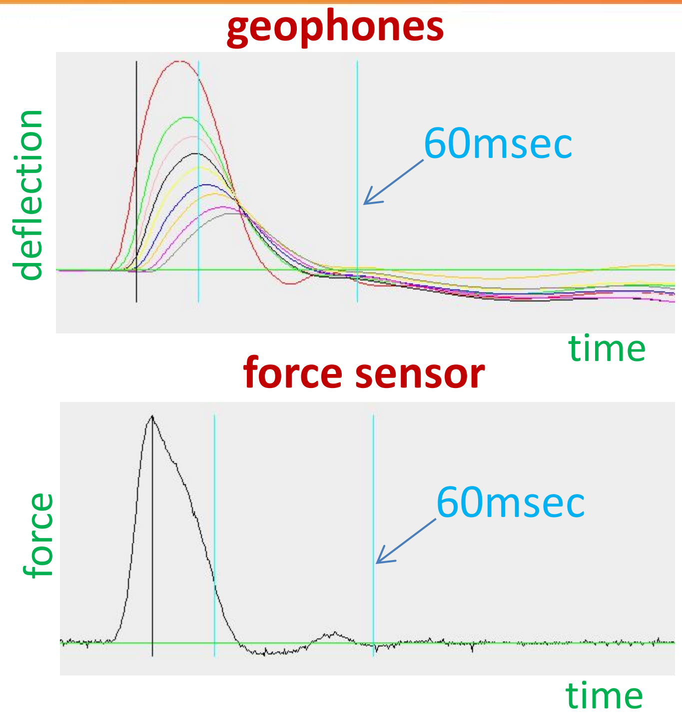
- KPI2:
  - If large variation in Rc then high KPI2 (bad bonding, Rc both with FWD and Curviameter)
  - Otherwise compute KPI2 from:
    - difference between D(0) and D(300) (in case of FWD)
    - indicator for noise on raw signal (in case of Curviameter)

KPI3: cohesion (FWD)

- Load-displacement plot:

  surface and slope



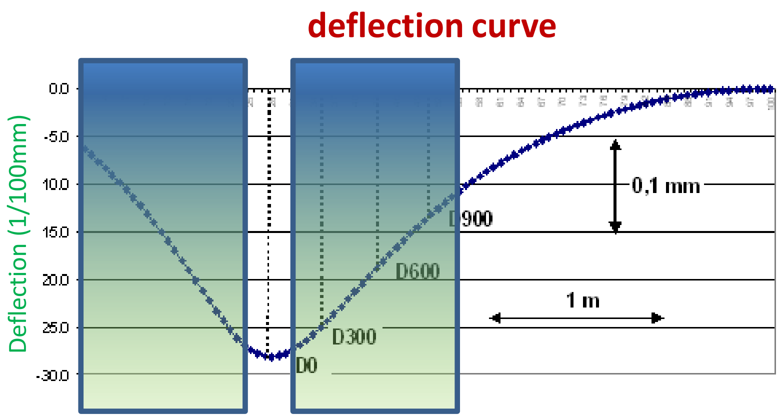


- KPI3:
  - Use D(0), D(900) for "upper part" and D(900), D(2100) for "lower part"
  - Surfaces: **all small** (KPI3 is good) or **all large** (KPI3 is bad)
  - Otherwise: **count "jumps" for surfaces & slopes, upper & lower part**

KPI3: cohesion (Curviameter)

- E(0) = difference of these areas under the curve:

(inspired by “energy” surface of FWD)



- KPI3:
  - Compute in homogeneous section:
    - Average Em of E(0), standard deviation σM
    - 1st criterion: **Em very small** (good) or **very large** (bad)
    - Else, 2nd criterion: **σM small** (rather good)

      or **σM large** (rather bad)

KPI4 and KPI5: traffic

- KPI4: any type of vehicles
  - daily average **number of vehicles**, as counted
  - rescaled on interval [0;5]

- KPI5: heavy vehicles only
  - different for rigid and semi-rigid road
  - **aggressiveness** factor w.r.t. standard axle load
  - transfer from % of heavy vehicles to average spectrum of the province (since we don't have traffic spectrum on each location)
  - rescaled on interval [0;5]

Global indicator
residual service life

- KPI1 (bearing capacity) is transformed using KPI4 and KPI5 (traffic): KPI1m

- Combined indicator

CSI = (KPI1m + KPI2 + KPI3) / 3

- **Global indicator:**
  - CSI > 3: road is **“end of life”, GI > 4**
  - **Otherwise**: GI gets **“cubic effect”** of characteristic deflection **on expected life time**.

GI versus back-calculation

- Back-calculation (as on “project level”):
  - linear-elastic model,
  - on 53 homogeneous sections, 8 road structures.
- Observations:
  - similar categorization of structural health,
  - this back-calculation also has its limits,
  - useful to compare life-time expectance not only with GI but also with Tz, KPI1, KPI2, KPI3.

Conclusions

- these indicators:
  - down to earth, pragmatic approach.
- imperfections but:
  - GI gives a good categorization,
  - checked by back-calculation.
- network level indicators:
  - easy to compute from raw measurement data only,
  - global indicator is used for priority setting.
- detailed data are still available:
  - KPI1 (Tz), KPI2, KPI3: first indication of cause of distress,
  - deflection data for tender preparations for road works.

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