Ride vibration & road condition

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Hydroplaning at banked outer-curve

Oncoming Heavy Goods Vehicle brakes at curve entrance. The waterfilm is very thick just there, due to improperly designed Drainage Gradient (DG).

Video source:
Prof B Psarianos, NTUA

Outline

The effects of road standards on ride vibration:

- White winter roads:
  - -Corrugated icecap => extreme vibration & noise.
  - -Corrugation not restricted in winter maintenance.
- Frost-related roughness in Winter; + 39 % vibration.

Root causes to high ride vibration: Often man-made!

Relating ride to IRI.

Further validation of RBCSV.

TPCS as a tool to reduce ride vibration.

Improperly banked curve; Kilpisjärvi case.

Dec 2011, corrugated icecap on Hw 90:

Ambulance passengers needed earmuffs

Photos: S Engblom, Wiman Ambulance, J Granlund

Noise in Ambulance:

- Average 100 dB(A).
- Peak 120 dB(A).

Corrugation in the icecap

Photos taken in March 2011, after worst corrugation was graded away.

Noise in Ford Galaxy @ 90 km/h

Normal icecap: 65 dB(A)

Corrugation (graded): >75 dB(A)

3-4 dm wavelengths

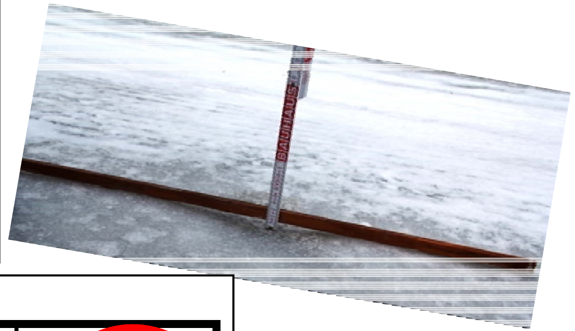
Less than 1.5 cm amplitude

STA winter maintenance specification

Ojämnhet

Ojämnheter i tjock is eller packad snö ska mätas med en 60 cm lång rätskiva. Detta gäller såväl längs som tvärs vägen, samt vid anslutande statlig väg.

Rätskivan ska vila mellan två ojämnheter eller mellan en ojämnhet och vägytan varefter mätning sker vinkelrätt mot rätskivan.



Krav vid uppehållsväder och när åtgärdstid efter nederbörd löpt ut.

Sektions-element	Vägytetemperatur			Ojämnhet cm
	varmare än -6°C friktionstal	-6°C till -12°C friktionstal	kallare än-12°C friktionstal	
Körfält	snö/isfritt	0,35	0,25	1,5
Vägren	0,25	0,25	0,25	1,5
Sidoanläggning	0,25	0,25	0,25	1,5

Current spec. works with iceruts and local roughness.

Corrugation with 3-4 dm cause wheel resonance

=> Over +10 dB noise at allowed 1.5 cm amplitude.

Additional spec. is needed for corrugation!

The impact of frost related roughness

Seat vibration at the Ramsele–Rundvik route in Sweden:

Early spring, severe frost $A(8) = 0.91\ m/s^2$ (68 km/h)

Autumn, no frost $A(8) = 0.66\ m/s^2$ (75 km/h)

Conclusions:

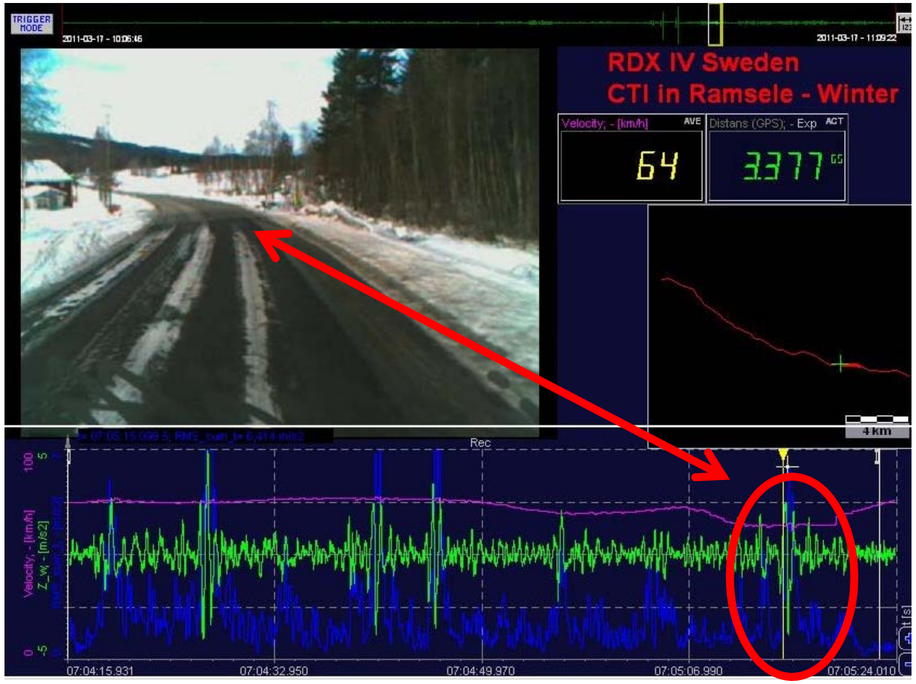
- The daily vibration was +39 % during the spring than in autumn, despite -7 km/h slower speed.
- Winter roughness should be reflected in strategys for road condition surveys. Measure roads also when frozen.

Poor Quality in Road Repair - Sweden

Road 1035 was locally reconstructed in autumn 2010.

- March 2011: Bumpier than urban speed bumps!

At a 3 dm bump, our laser system odometer bounced off!!!



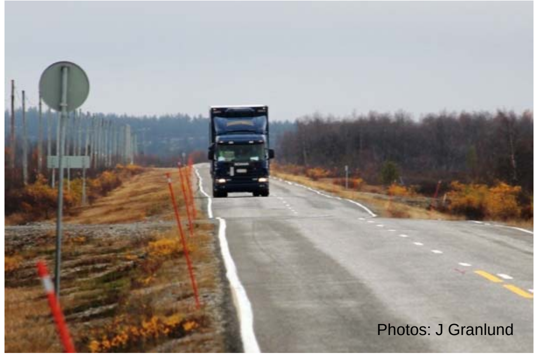
Photos: J Granlund

Poor Quality in Road Repair – Sweden (2)

Road 1035, 6 km resurfaced in summer 2011.

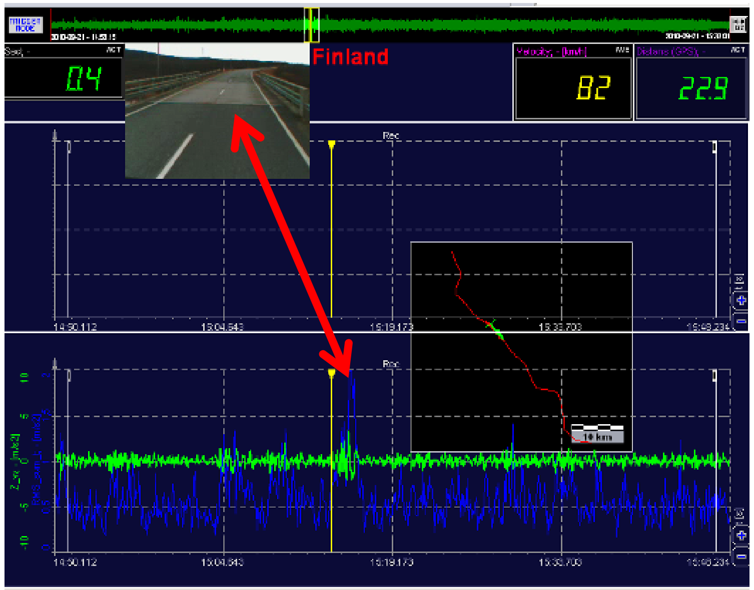
Sept 2011: Average ride 0.6 m/s^2 > EU Action Value!

Some root causes to vibration



Severe bumps typically at:

- Settlements in thawing permafrost, Hw 21.
- Poorly installed culverts.
- Transversal joints at improper patches.
- Wrong pavement height at bridge joints.
- Settlement in backfill at bridges.



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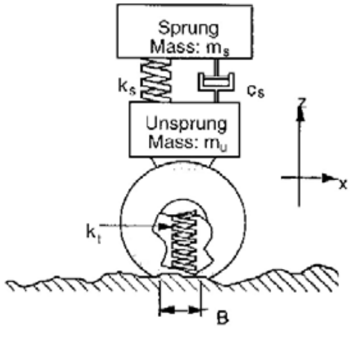
Comparing driver vibration to IRI-values

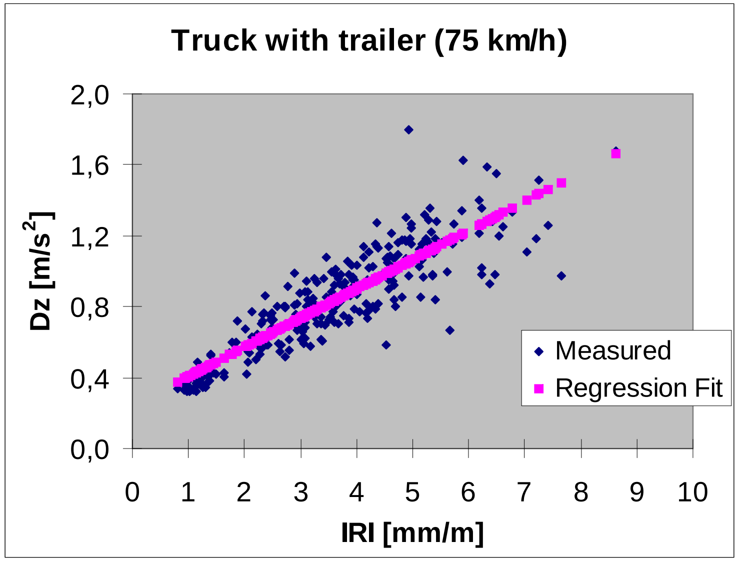


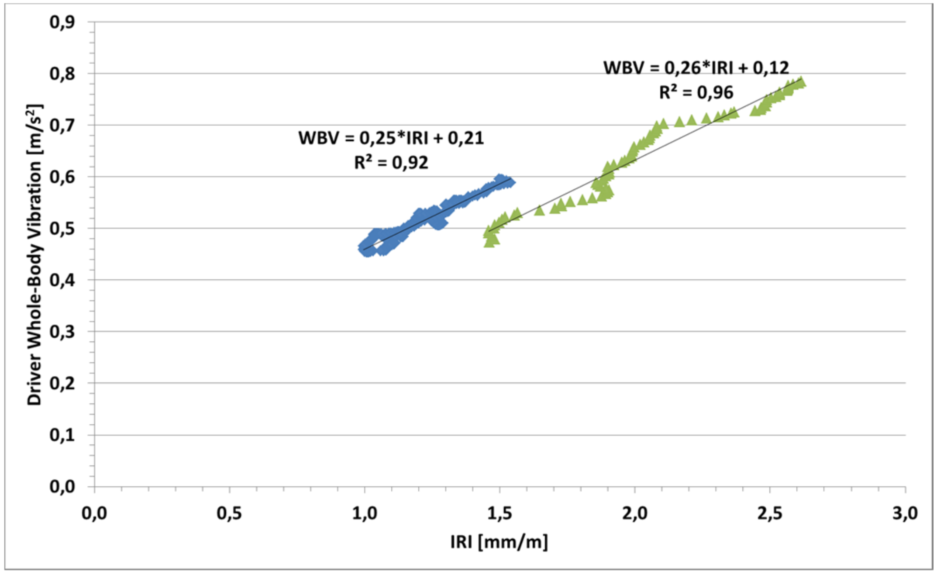
Quarter car model

International Roughness Index (IRI) may be computed from any road profile data.

Sampling at max 3 dm long steps.

Examples: Relating driver Whole-Body Vibration to IRI:





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Truck driver WBV = a + b * IRI

Factors a & b vary between road sections and trucks.

Typical ranges:

$0.1 < a < 0.35$; $0.2 < b < 0.3$ Bad roads/trucks => High factors

-Why vibration despite zero roughness, why isn´t a = 0?

- Variance in pavement deflection at soft spots in the road.
- IRI doesn´t reflect megatexture waves < 0.5 m at all. Early tendencies of washboarding, ravelling and pothole formations may be present despite low IRI.
- Wheel geometric and stiffness eccentricity.
- Truck frame beaming at long wave unevenness.
- How efficiently isolated are the truck engine´s combustion pulses from the frame, cab and driver seat?

Estimating driver WBV from IRI

Finnish PMS: Hw 21 Northbound had IRI = 1.81 mm/m.

Grocery truck, premium type (comfy). But old & worn.

Using ”low mid-range” a & b values: WBV ≈ 0.18 + 0.23 * IRI.

=> WBV ≈ 0.18 + 0.23 x 1.81 = 0.60 m/s^2.

Measured truck driver WBV in RDX IV = 0.58 m/s^2.

With fair choice of a & b, IRI gives WBV within some 15 %.

Use the UK HSE A(8)-calculator to consider daily driving hours.

Average IRI < 1.5 mm/m

Scope: Keeping A(8) under the EU Action Value 0.5 m/s^2 at 7-8 hour daily driving.

A(8) = 0.50 corresponds to 0.53 m/s^2 at 7 hrs/day.

With a = 0.18 & b = 0.23, then WBV ≈ 0.18 + 0.23 * IRI = 0.53,

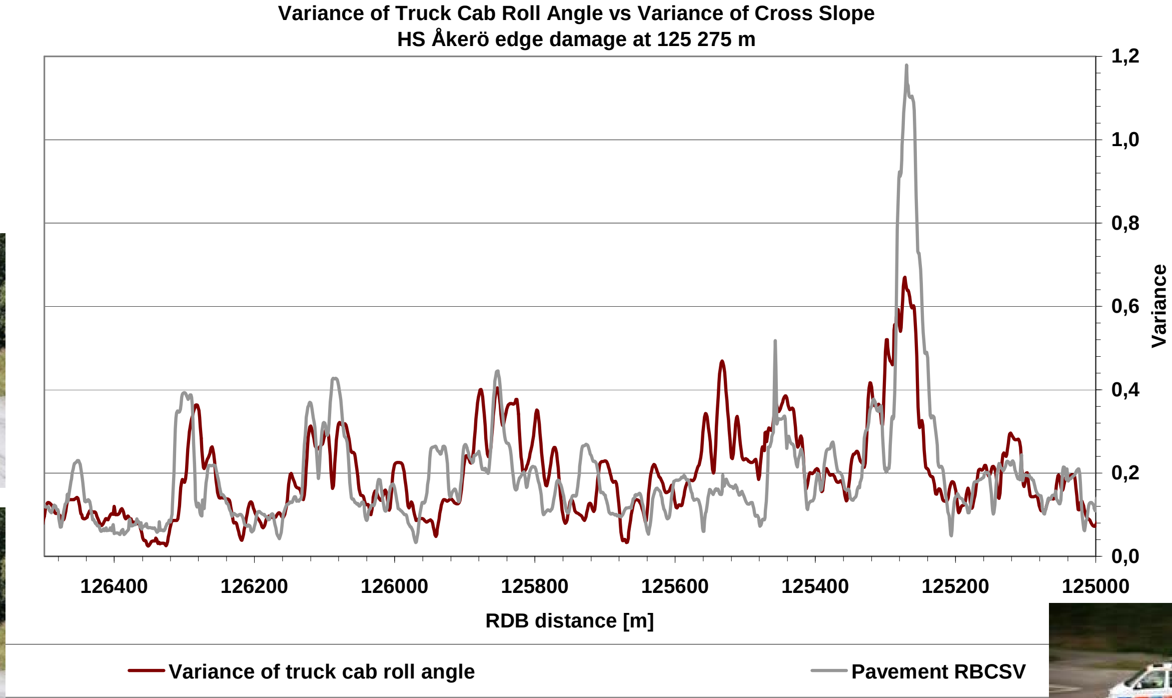
…**<u>IRI should be less than some 1.5 mm/m</u>**.

Allow more road surface roughness by low a & b factors.

Low a is achieved with a stiff pavement, well-balanced wheels et c.

<u>Pitfall:</u> IRI overestimate ride vibration at long waves, if truck speed is much less than 80 km/h. F x at undulating secondary/tertiary roads.

Lateral buffeting – a severe risk



Road “warpiness” is detected by the new RBCSV parameter. Limit value 0.30 %. Further validated with data from Finland.

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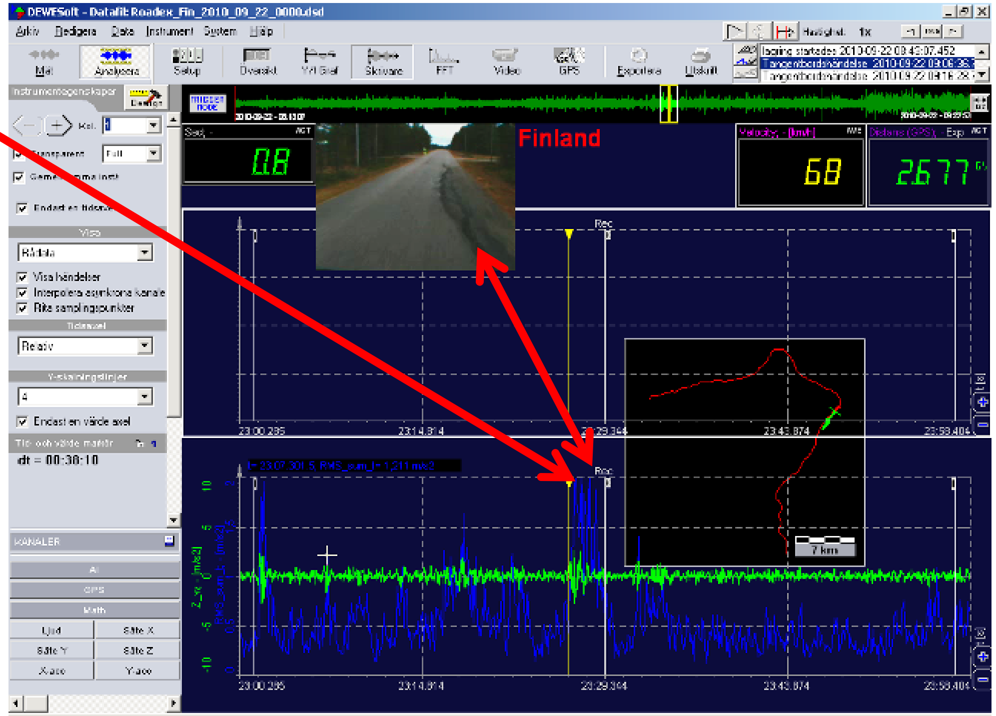
Lateral buffeting at Raattama Rd

Route Palojoensuu – Enontekis – Raattama – Muonio. Including parts of Hw 93, Rd 956 & 957 and Hw 79.

Rd 957 very rough => severe Rock ´n Roll, lateral buffeting.

All Roadex demo-routes occasionally gave high lateral buffeting.



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TPCS reduces wheel hop vibration

Photos: J Granlund & P Granlund

With TPCS off at Loch Arkaig dirtroad, the cab was shaking so hard that the measurement computer fell into the floor.

South Laggan roundtrip, A82 + dirtroad: A(8) = 0.86 m/s^2,
with TPCS active A(8) = 0.70 m/s^2

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Many improperly banked outer-curves at all demo routes

Photo: M Risberg & R Evans

Outer-curves have 5 times more fatal single-crashes than inner-curves.

At low volume roads: 6 times.

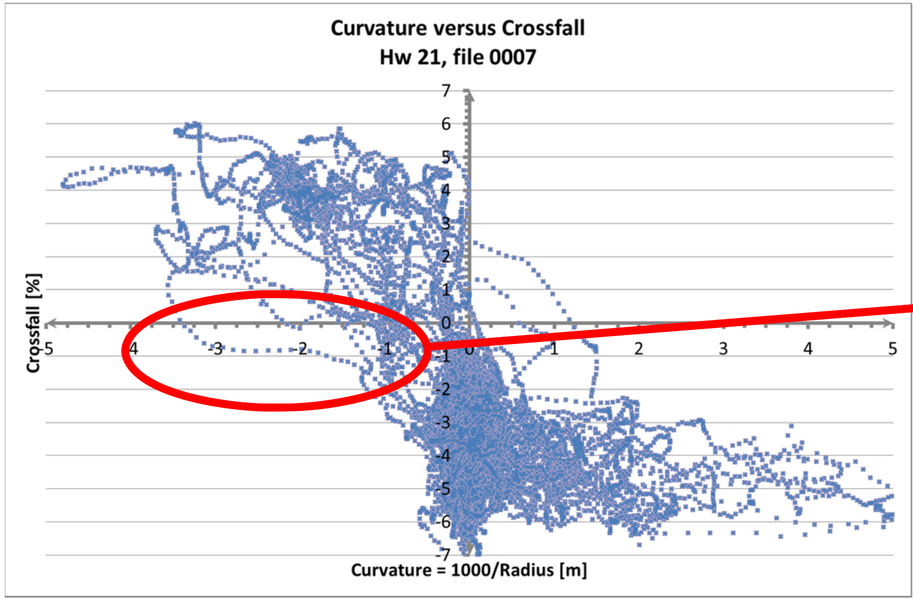
Improperly banked outer-curves

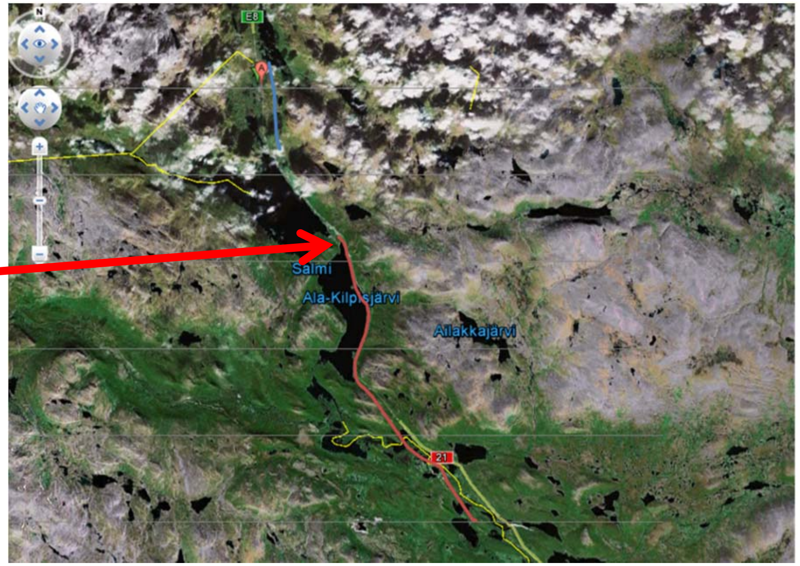
Photo: J Granlund

Sharp outer-curve with adverse camber

=> High need for side friction,
high risk for loss-of-control crashes.

Road data taken by Destia´s Profilograph.





Summary

Corrugation should be better restricted in winter maintenance (and on dirtroads too).

Consider frost-related roughness in Winter (+ 39 %).

=> Measure road roughness in winter also.

Root causes to high vibration: Often man-made!

At highways, IRI gives fair estimate of ride vibration.

Lateral buffeting: RBCSV further validated in Finland.

TPCS as a tool to reduce ride vibration.

Improperly banked curves – a common NP problem

Demonstrated easy detection of flat outer-curves on Hw 21 at Kilpisjärvi, Finland.

Road safety starts with safe roads…

Photo: Johan Granlund, Vectura

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