RAIL IRREGULARITIES
characteristics, significance
and effects of reprofiling

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scope of presentation

- rail irregularities (primarily corrugation)
  - examples
- significance: dynamic loads, wheel/rail noise
  - rail (and wheel) irregularities
  - influence on air-borne and ground-borne noise
- measurements and measuring equipment
  - corrugation and acoustic roughness
  - long wave irregularities (>1m)
- typical irregularities
  - different “types” of railway system
  - difference between pre- and post-grind irregularities
- conclusions

rail irregularities: corrugation
(quasi-periodic irregularity on the rail)

- there is a great variety of rail corrugation
- corrugation can occur on all types of track
- all types of corrugation appear to be constant frequency phenomena: wavelength = speed / frequency
wheel & rail roughness:

- rails are much rougher than wheels
  - except for very short wavelengths (\(\lambda<10\text{mm}\))
  - wheels with cast iron brake blocks would be much rougher than those shown
  - also noisier

effect of irregularities on air-borne and ground-borne noise

- “corrugation” increases air-borne noise (100-5000Hz)
- long-wave irregularities (100-1000mm) increase ground-borne noise (25-250Hz)
  - no influence of short-wave irregularities (30-100mm)
rail corrugation and wheel / rail noise: the influence of reprofiling

• rail corrugation is the main cause of excitation of wheel and rail, and therefore of noise
• removal (or prevention) of irregularities is therefore a critically important way of reducing wheel / rail noise
• How can these be measured, especially long wave irregularities?
• How large are irregularities?
• What are the effects of reprofiling?

measurement of roughness & corrugation: manual equipment

• trolley (CAT)
  – useable by one person
  – measure at walking speed (1m/s)
  – can also measure long wavelengths (>1m) and welds
• straight-edge based equipment
  – accurate
  – slow, bulky, very limited measuring length (1m increments), can’t measure long waves

results from CEN test of EN15610 protocol: CAT is “H”
measurement of irregularities: vehicle-based equipment

- equipment for reprofiling train
- hi-rail based equipment
- available for speed range 0.5-50km/h

presentation of data (CAT)

- left hand graph is typical graph of roughness c.f. ISO3095
  - “natural” feature of surfaces is that roughness decreases with wavelength
- RH graph shows difference from ISO3095
  - similar presentation proposed by Spannar et al (Sweden)
Irregularities on different types of railway system

- Significant differences between different “types” of system
  - tram / light rail
  - metro (high and low rails in curve v. different)
  - mixed traffic
  - dedicated high speed line
  - heavy haul

- 20-30dB reduction in best case
- 20dB increase in worst case
  - 10-30mm, but significant for noise
- typical reductions are 5-20dB (30-1000mm)
long wave irregularities (hi-rail vehicle)

• Effect of speed (40km/h and 50km/h) on measurements over 700m
  – 1000-3000mm (left), full scale +/-0.500mm
  – 10-30mm (right), full scale +/-0.020mm

one-third octave spectra (6-5000mm)

• excellent reproducibility of RCA
• good correlation with CAT for $\lambda>20\text{mm}$
  – short waves underestimated by RCA contact
Conclusions (general)

• Rail and wheel roughness / corrugation contribute to railway noise.
  – shorter wavelengths contribute more to rolling noise (100-5000Hz)
  – longer wavelengths (25-250Hz, 100-1000mm at metro speeds) contribute to ground-borne noise
• Rail roughness is typically greater than wheel roughness for most of the wavelength range of interest.

Conclusions (measurements)

• Straight-edge based equipment
  – measurements are barely adequate for rolling noise
  – inadequate for ground-borne noise (wavelengths too short)
• Trolley (CAT) can give measurements that are adequate for both rolling noise and ground-borne noise.
• Vehicle-based equipment (RCA) gives good measurements of irregularities with 20mm<λ<5000mm (and maybe greater) at 50km/h.
Conclusions (irregularities)

- significant differences between character of irregularities on different “types” of system
  - tram/light rail: high short wave roughness
  - metro: peaky corrugation
  - mixed traffic: low short wave roughness, broad corrugation peak
  - heavy haul: low roughness, little corrugation
  - dedicated high speed: low roughness / corrugation (but maybe not always!)

Conclusions (reprofiling)

- Typical grinding gives 5-20dB decrease in roughness for 1000mm>λ>30mm.
- Good grinding can give reduction of 20-30dB.
- Typically get increase of 20dB in roughness for 10-30mm (stone signature); grinding occasionally gives increase at longer wavelengths!
  - increased roughness 10-30mm is short-lived i.e irregularities are rapidly worn / plastically deformed
- Milling gives similar roughness to typical grinding.
  - milled finish is very consistent and well controlled.
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• Many RailMeasurement clients contributed CAT measurements of roughness from different railway systems.