Prediction of Deterioration of Asphalt Pavements by Mechanistic-Empirical Methods

Eugene OBrien

University College Dublin

Professor of Civil Engineering

Eugene.OBrien@ucd.ie

Portorož, Slovenia
Trucks bounce & rock; axles hop....
Spatial Repeatability – same truck on same stretch of road

![Graph showing impact factors at different speeds](image)

- **43.3km/hr**
- **44.6km/hr**
- **44.8km/hr**
- **46.1km/hr**
- **47.6km/hr**

Distance (m) vs. Impact Factor
Spatial Repeatability can be detected with multiple-sensor WIM
Lack of Spatial Repeatability for ‘similar’ trucks

Impact Factor

Distance (m)

Portorož, Slovenia
Portorož, Slovenia

‘Statistical’ Spatial Repeatability (France)

Impact Factor

Distance (m)
‘Statistical’ Spatial Repeatability (Netherlands)

Portorož, Slovenia
Implications for Road Damage

- Traditionally assumed that impact force was applied at random locations along pavement
- In fact, certain locations will repeatedly attract high impact loading
- This damages & changes the road profile
- New road profile changes pattern of Spatial Repeatability
- Feeds on itself: Road profile influences truck dynamics ⇒ spatial repeatability pattern ⇒ change in profile ⇒ change in spatial repeatability pattern ⇒ ......
Computer model to represent truck dynamics

Quarter Car Model used to represent entire truck fleet

[Diagram of Quarter Car Model]

- Longitudinal Distance (m)
- Transverse Distance (m)
- Elevation (m)
- Profile height (m)

16-Sensor WIM Array

[Graph showing elevation and distances]
Probabilistic Quarter-Car Model
Optimisation to find Quarter-Car Properties

Find $\mu_i$ & $\sigma_i$ which minimise

$$\Sigma (SSR_{meas} - SSR_{theory})^2$$
Knowing $\mu_i$ & $\sigma_i$, we can predict patterns of SSR for any profile.
Road Damage Model – Collop & Cebon

- Road model
- Tyre forces
- Vehicle simulation
- Force vs. Time
- Strain vs. Distance
- Influence function
- Road response calculation
- Fatigue damage fed back into primary response
- Surface rutting fed back into vehicle simulation

Road strain at each point
Surface profile evolution – 1\textsuperscript{st} 3 million axles

Profile elevation in m

- Initial profile
- 1 million axle load
- 2 million axle load

Portorož, Slovenia
Mean dynamic force – 1st 3 million axles

Mean Dynamic Force (kN)

Distance (m)

Initial profile  1 million axle load  2 million axle load

Portorož, Slovenia
Surface profile change – 1st 3 million axles

Distance in m

Portorož, Slovenia
Main profile changes – 1st 3 million axles
Profile after 6th, 7th & 8th million axles

Profile elevation in m

- 6 million axle load
- 7 million axle load
- 8 million axle load

Portorož, Slovenia
Change in profile after 6th, 7th & 8th million axles
Mean force after 6th, 7th & 8th million axles

Mean Dynamic Load (kN)

Distance (m)

- 6 million axle load
- 7 million axle load
- 8 million axle load

Portorož, Slovenia
Evolution of dynamic forces in pavement life

Mean Dynamic Force (kN) vs. Distance (m)
Evolution of profile during pavement life

Profile Elevation (m) vs Distance (m)
Conclusions

• Pattern of Statistical Spatial Repeatability changes during the pavement life
• Pavements with the same properties (stiffnesses, etc.) but different initial profiles have substantially different lives
• Failure eventually occurs at a frequency that relates to applied force patterns