Tyre / road interaction: the problem with the road

Peter G Roe

Senior Academy Fellow, TRL Ltd, UK

Overview

1. Introduction – the challenge for road engineers
2. What is safety?
3. Types of road surfacing – what makes them “safe”?
4. Monitoring and maintaining skid resistance
5. Towards optimisation

Introduction

- Tyre manufacturers are in a competitive market place
- Making and selling a safety-critical product.
  - Facing increasing demands on performance
  - Need to maintain or improve “wet grip” and durability
  - Responding to legislation for less noise, “cleaner” compounds, reduced rolling resistance, disposal
- Tyres are often assessed on standardised surfaces on proving grounds
  - These cannot represent the range of surfacings on real roads.
- Manufacturers ask:
  - *How can we produce a consistent product with so many different road surfaces out there?*

Introduction

- Road engineers operate in a different world
- My objective today is put the perspective of the road engineer before the tyre manufacturing community…
- To look at
  - The challenge facing those engineers
  - The principles with which they have to work and the compromises that they must make
    - To provide and maintain safe, environmentally friendly and durable road surfaces.
- Ultimately, I want to pose the question:
  - *How can tyre manufacturers and road engineers work together to optimise characteristics to deal with "the problem of the road?"*

The challenge for road engineers

Varied networks and traffic

- Networks range from country lanes to multi-lane highways.

- Traffic varies from a few cars and tractors to many thousands of trucks and cars each day..

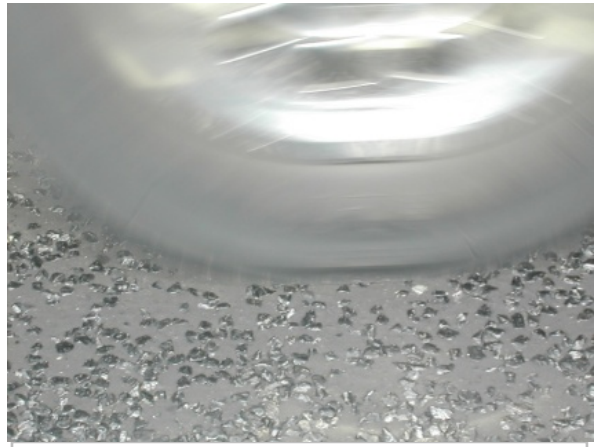
- The roads can be in the countryside, in cities and towns, near the coast, up mountains.

The challenge for road engineers

A wide range of conditions

- Surfaces are blasted by the weather:
- hot sun, wind and rain
- snow and cycles of freezing and thawing.

- Subjected to chemical attack
- Deposits of oils from vehicles and salt to prevent ice in winter.



- Impacted by millions of heavy axles and tyres
- Sometimes with studs in them!

The challenge for road engineers

A wide range of situations

- Fast traffic; slow traffic; straight roads and bends

- Different road users

- Crossings, junctions and other hazards!

The challenge for road engineers

Build and maintain the road in all these situations

With limited budgets

- Make the road safe
- Reduce tyre/road noise
- Reduce spray
- Reduce contribution to rolling resistance
- Make the surface durable
- Minimise road works…

What is “safe”?

- What is the problem?
  - Typically regarded as being able to accelerate, brake and corner without collision or loss of control.
- In other words, build road surfaces that reduce the likelihood of wet skidding.
- But there is a wide range of practical issues on real road networks to consider
  - Road layouts vary
  - Traffic speeds vary
  - Different vehicles vary in performance
  - Different drivers make different demands

What is “safe”?

- Therefore a risk management approach is often taken to dealing with road surfaces
- But risks of skidding can never be zero
  - There will always be someone who goes too fast or circumstances in which a collision is unavoidable.
- Advanced maintenance policies aim for adequate for average circumstances at different locations
  - Lower risks where braking or cornering less likely therefore lower skid resistance needed
  - In setting target levels, engineers need to take accident risk into account
    - Affected by traffic levels and speeds, road layouts and other factors

What is “safe”?

- Roads are subjected to traffic, which affects the surface skid resistance characteristics.
- Surfacing specifications:
  - Emphasise underlying safety rather than instantaneous conditions.
  - Consider longer-term conditions and take account of cyclic behaviours such seasonal effects.
  - Tend to be biased towards passenger cars rather than trucks since braking characteristics are so different.

An aside…

- Talking of safety
- If public advertising is to be believed, tyre selling points often seem to focus on performance at the extremes
- This may be an advantage (for tyre sales) but…
- …does this undermine the work road engineers by encouraging risk-taking?

Types of road surfacing

Three basic categories:

Asphalt

- A mixture of graded aggregate, fines with bitumen binder..
- Different proportions of different materials are used for different purposes.
- Usually mixed hot at a remote plant and transported (hot) to the site
- Laid by machine and compacted using rollers.

Cement Concrete

- A mixture of graded aggregate, fines with Portland cement binder.
- Usually mixed on-site and laid by a paving train.
- May be reinforced with steel bars or grids
- Can be laid in small bays by hand.
- Different finishes may be used to aid skid resistance.

Surface Dressings

- Aggregate chippings spread on to a binder film on an existing surface
- Seal the surface and restore skid resistance
- Some are specialised treatments for localised use with special aggregates and binders, such as High Friction Surfacings

Types of road surfacing

Different types of asphalt have been developed over the years

For different situations

- Make use of local resources and traditions in different countries
- For example:
- Chipped hot-rolled asphalt
- Gussasphalt
- Dense bitumen macadam
- Dense asphalt concrete

Types of road surfacing

New types of asphalt have been developed over recent years

Environmental influences

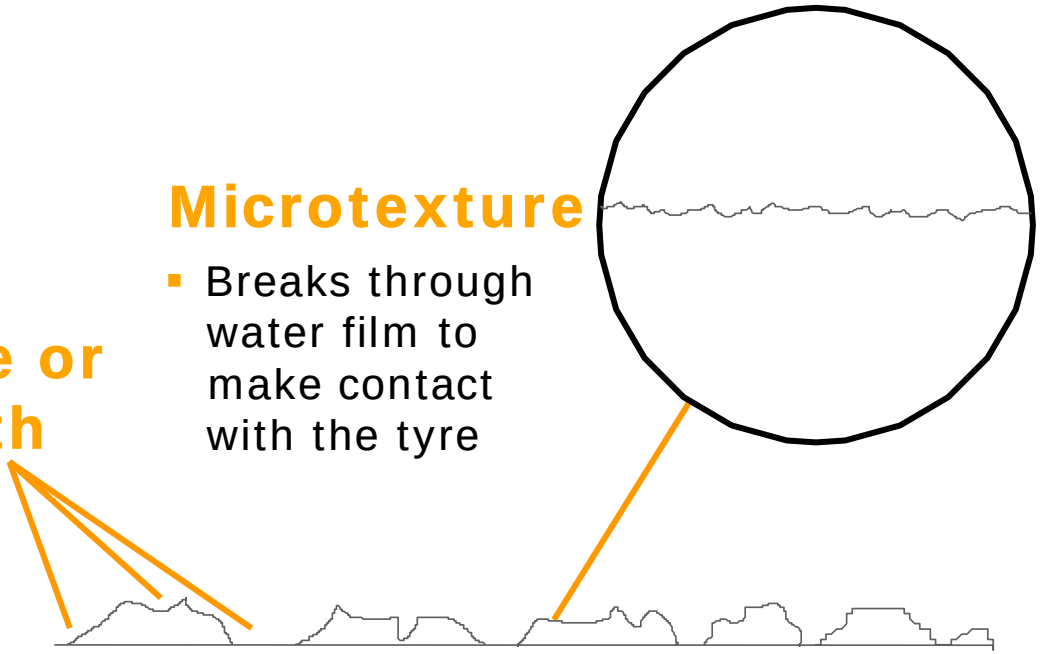
- Reduced spray and noise
- Porous Asphalt
- Stone Mastic Asphalt (SMA)
- Proprietary “thin” surfacings

What makes a road surface safe? – Surface texture: macro- and microtexture

- The road surface provides two important components:

Microtexture

- Breaks through water film to make contact with the tyre

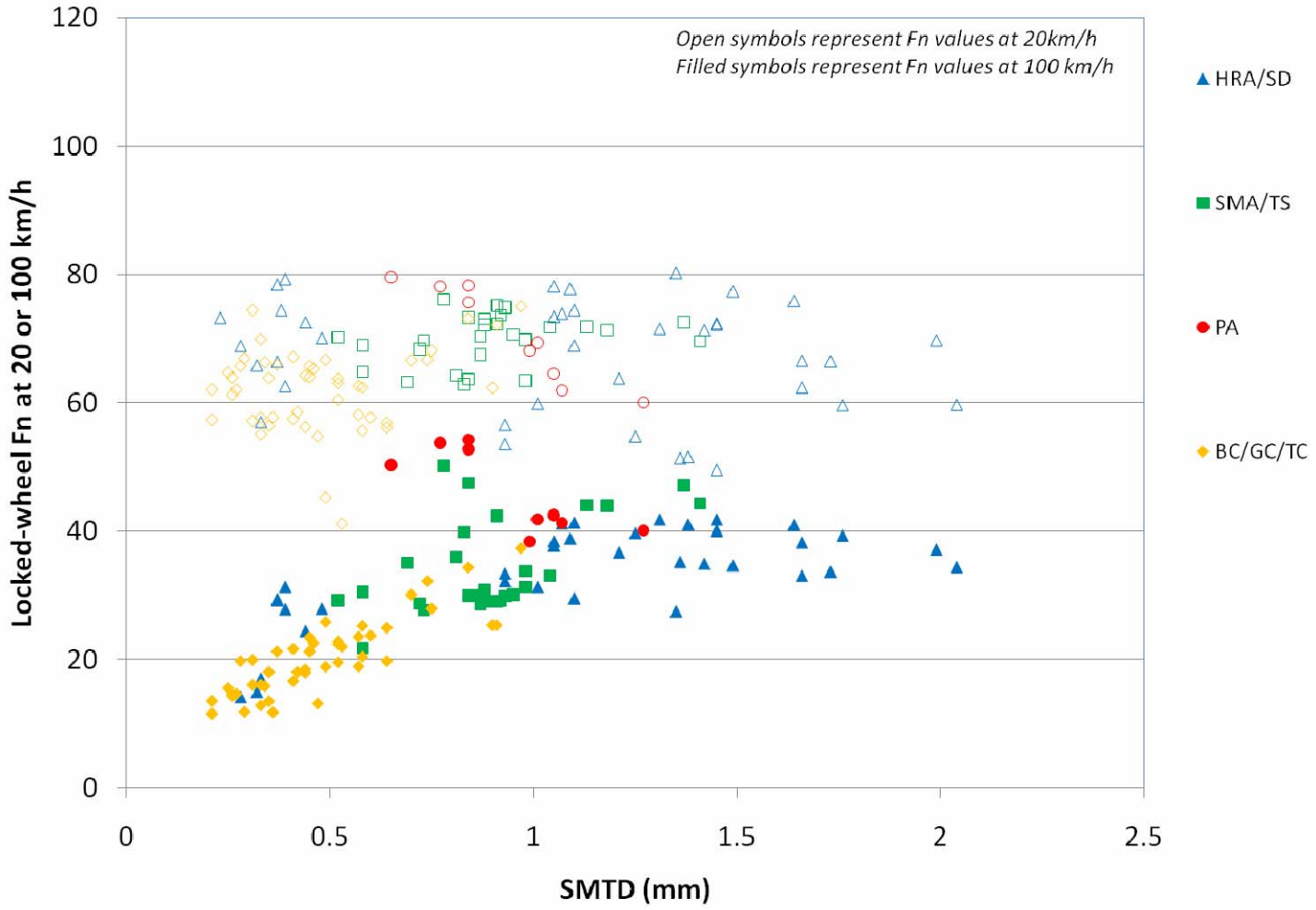


Macrotexture or Texture Depth

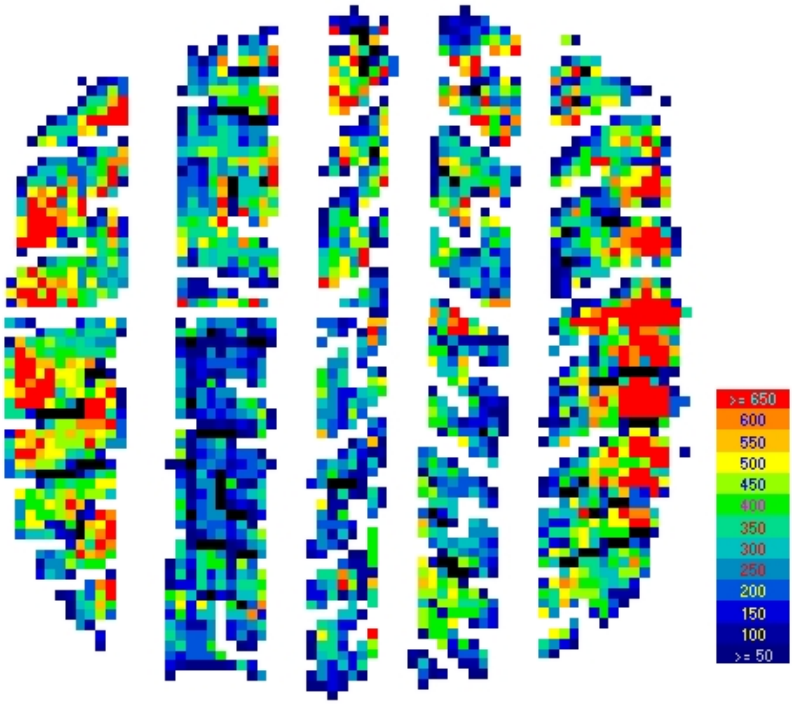
- aids water drainage.
- hysteresis energy loss

What makes a road surface safe? – Surface texture: wet friction, speed and texture

Locked-wheel wet friction at two speeds against texture depth



What makes a road surface safe?
Surface texture and tyre tread depth



Tyre tread adds to road texture

- Comparisons of tyres of different tread depths on different surfaces
- Tyre tread is similar to small amount of macrotexture
- Good tyre tread depth can improve friction performance on low-textured road surfaces
- But worn tyres provide little extra texture and need surface macrotexture to maintain performance

What makes a surfacing safe? Summary

- Microtexture is dominant at low sliding speeds.
  - But is polished away by traffic.
  - Engineers need to choose materials carefully.
  - Match provision to skidding risk.
- Macrotexture becomes increasingly important as speed increases
  - But too much texture may increase noise unacceptably.
  - Depending on surface type, can be worn away or reduced by traffic.
  - Over-provision may also reduce surfacing durability.
- Tyres help, but the road must provide the basic characteristics.
- Current research is suggesting that some newer surfacing types may behave differently to traditional materials!

Monitoring and maintaining skid resistance

Four basic measurement principles

Rubber slider

- Static technique: slider passes over the wetted surface and slows down as a result of friction.
- Linear or rotating systems can be used
- Deceleration, torque or work done are measured to give a number representing skid resistance

Side force

- Free-rotating test wheel set at an angle to the direction of travel under a known load.
- Wheel is forced to slip over the road surface
- Reaction along the axle is measured and used to compute a friction value.

Monitoring and maintaining skid resistance

Four basic measurement principles

Longitudinal controlled slip

- Test wheel parallel to the direction of travel
- Rotates more slowly than the test vehicle speed, so is forced to slip over the road surface.
- Gearing or servo system controls wheel speed
- Usually a fixed proportion of the vehicle speed.
- Reaction force and load are measured to give a fricton value

Longitudinal Locked wheel

- A test wheel in line with the direction of travel is braked so that it is locked.
- Test wheel slides over surface at same speed as test vehicle until the brake is released.
- The reaction force and load are measured to give a fricton value

Monitoring and maintaining skid resistance

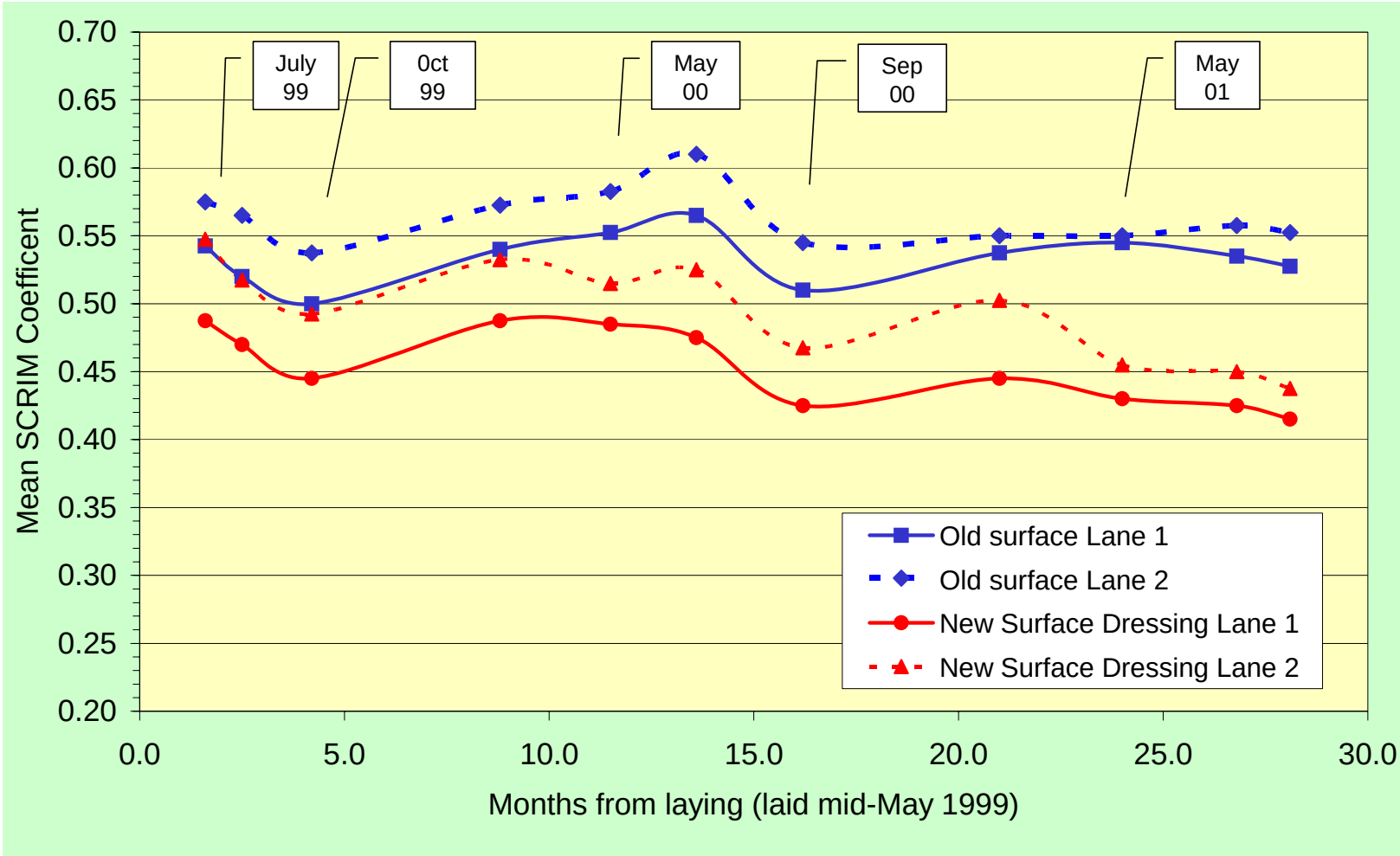
Many different devices and applications

Some provide continuous, some localised measures...

... over 24 types in Europe alone!

Monitoring and maintaining skid resistance

Providing microtexture – polishing and seasonal variation



Monitoring and maintaining skid resistance

Providing macrotexture

Forms of surface texture	
Random Positive	▪ A succession of peaks above a generally level surface. ▪ Examples include hot rolled asphalt, surface dressings, dense asphalt concrete.
Random Negative	▪ Depressions or voids beneath a generally smooth upper surface, sometimes interconnected. ▪ Examples include porous asphalt, stone mastic asphalt (SMA), thin surfacings.
Linear	▪ A succession of ridges and troughs across or along the road. ▪ Examples include transverse brushed PC concrete, sawn grooves (transverse or longitudinal)

Monitoring and maintaining skid resistance Summary

- Roads change over time
  - Polishing, seasonal effects, surfacing types
- So road engineers assess underlying surface conditions
  - Not the same as a police investigation, for example
  - Consider implications of skidding risk factors
- Different measurement results under different test conditions:
  - Need to standardise conditions.
  - Different measurement principles give different values.
- Need for harmonisation
  - Of measurement techniques
  - And policies
  - Hence the need for TYROSAFE project

Towards optimisation

Optimising roads and tyres is potentially difficult

Widely varying road conditions

- Traffic levels and behaviour
  - weight, speed …
- Location
  - rural, urban, coastal, mountain…
- Climate
  - Cold/Hot, wet, arid……
- Geometry
  - straight, bends, gradients, junctions…

Technical issues

- Setting requirements appropriate to risk.
- Balance of provision of micro/macro texture.
- Practicalities of supply and maintenance of materials.
- Durability versus safety performance.

Towards optimisation

Optimising roads and tyres is potentially difficult

Safety / Environment

- Balancing safety performance and environmental impact
- Limitations of finite local and global resources
  - both materials and money
- What characteristics should be optimised?

History / culture

- Many decades of local practice/experience.
  - May lead to entrenched views.
- Prioritisation in favour of major routes/networks?
- Pressure to keep roads open with short maintenance windows.
- Some options may not be possible in some places.

Towards optimisation

- So, while new developments may come, there will always be many types of road surface on our networks.
- How much scope is there for optimisation of tyres?
- Are potential barriers real or imagined?

The final question…

- Tyre manufacturers have commercial pressures…
- Road engineers have political masters and public safety concerns…
- Can they work together to develop the ultimate tyre/road combination
- ***And solve "the problem of the road"?***

Thank you

Presented by Peter G Roe
Senior Academy Fellow – 11 Feb 2110
Tel: +44 1344 770286
Email: proe@trl.co.uk