Friction
Supply and Demand Approach
+
Related Updates Within DN PAV 03023

TII Network Management Webinar 15th Jan 2021

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Historical Research – Key Outputs

1988 UK HD 28 based on TRL 334 – "The relationship between road layout and accidents on modern rural trunk roads"

- Fundamentals of Relationship between Skidding resistance /event category/ collisions

2005 TRL 662 – "Accidents and the skidding resistance standard for strategic roads in England"

- "range of risks for different sites within same category"
- "analysis for a defined UK network"
- Texture a significant variable: "highest accident rates from sites with low texture depths and low skidding resistance"
- **Network analysis & site-specific investigation paramount**

2018 TRL PPR 806 – "The relationship between collisions and skid resistance on the Strategic Road Network"

- Overall reflects previous studies, but with some minor changes to motorways
- Introduced cost benefit analysis and sustainable solutions (e.g. lower speed limit)
- Texture has also high influence on "dry" collision outputs – recommends further investigation
- Models exclude influence of weather / vehicle / driver

TII Approach – key changes

Separate “ Policy” issues from “Standard” issues for clarity

- AM-PAV-06045 Skid Resistance Assessment
- AM-PAV-06046 Skid Resistance Management

Enhanced consistency of approach to site inspections and reports

Update urban environments segment based on experience

Improve understanding of how friction is influenced

Move to concept of friction demand vs supply

Philosophy for changes

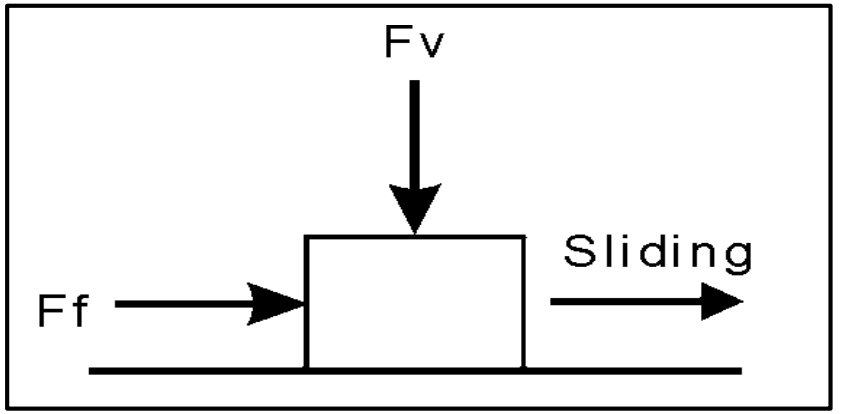
Align underlying theories with current research

Incorporate output from TII research Projects :

- Risk Based Geometric Design
- Friction After Polishing
- Raman Microscopy

Definition of friction

- "the force that resists the relative motion of one object moving against another"

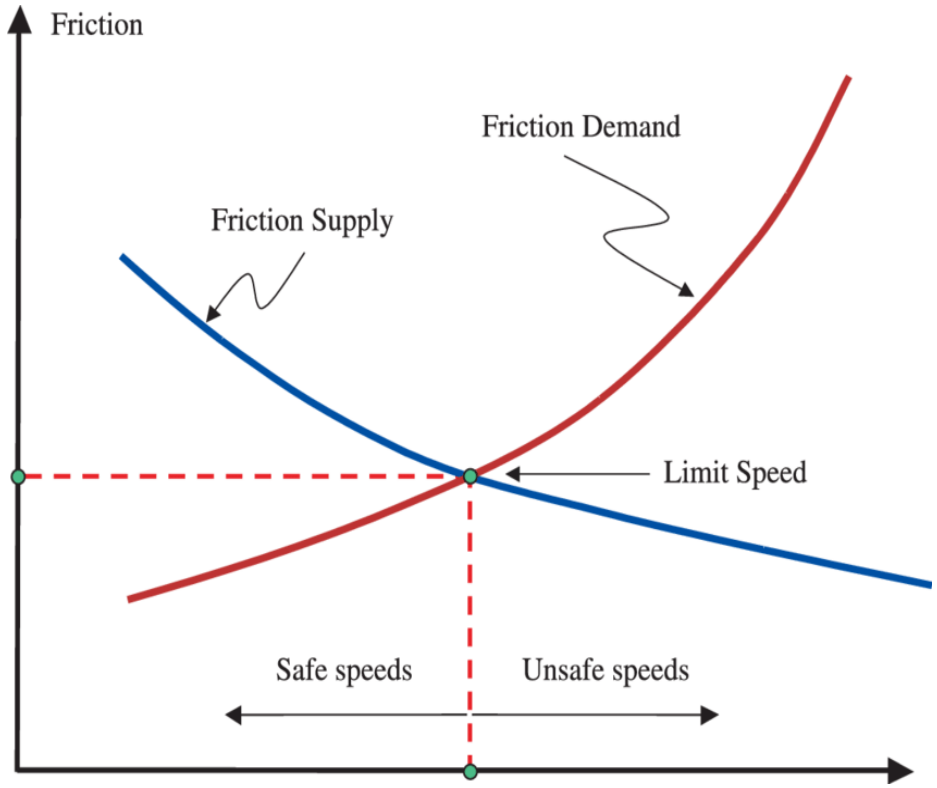


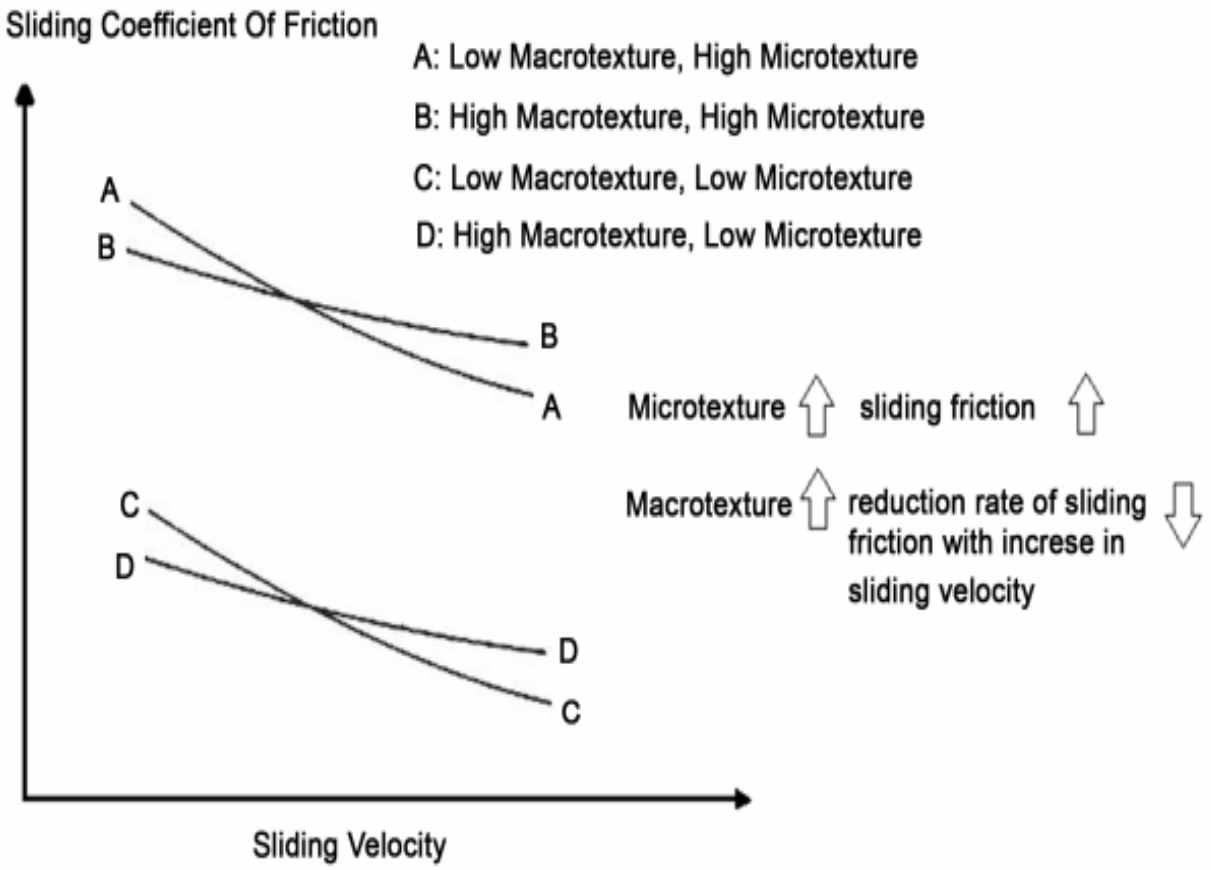
- proportional to the force pressing the two objects together
- proportional to a constant - coefficient of friction

$$F_f = \mu \bullet F_v$$

- coefficient of friction depends on materials type and textures.

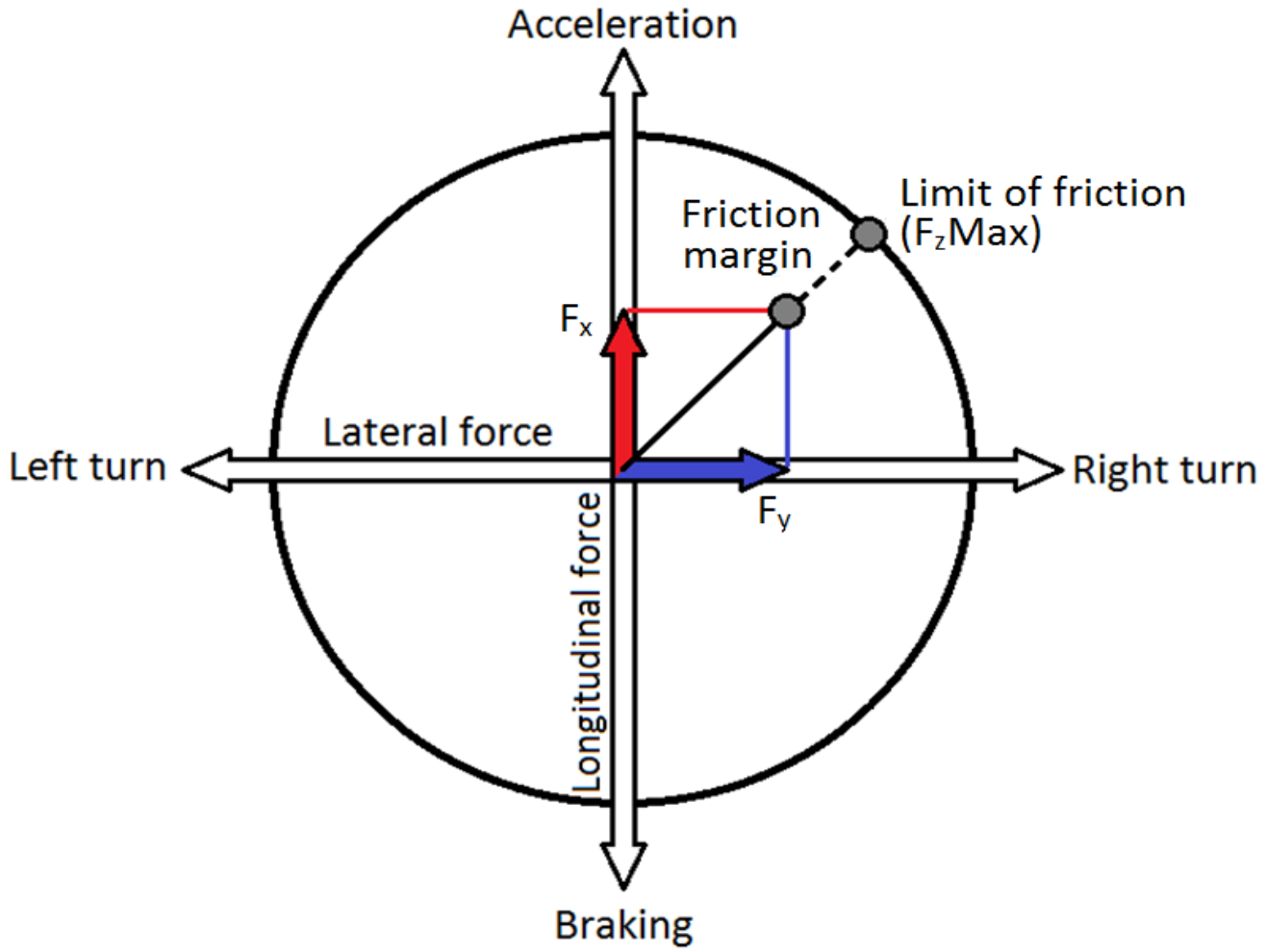
Friction Demand vs Supply





Friction Demand for Manoeuvring

Braking and cornering simultaneously require friction sharing between longitudinal and lateral mechanisms



Friction Demand for Manoeuvring

Friction Demand - level of friction needed to safely perform braking, steering, and acceleration manoeuvres

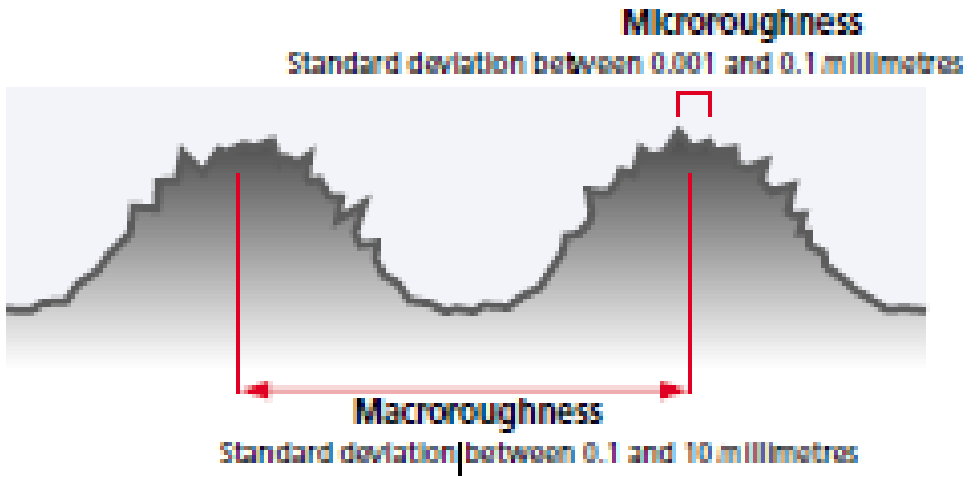
Friction demand factors :-

geometrics (bends, grades, cross-slope, sight distance, etc.),
potential for conflicting vehicle movements e.g. junctions
potential for conflicting with vulnerable road users
vehicle speed
vehicle type
traffic volume,

Bends and junctions tend to have higher deceleration than other locations and can thus require higher friction

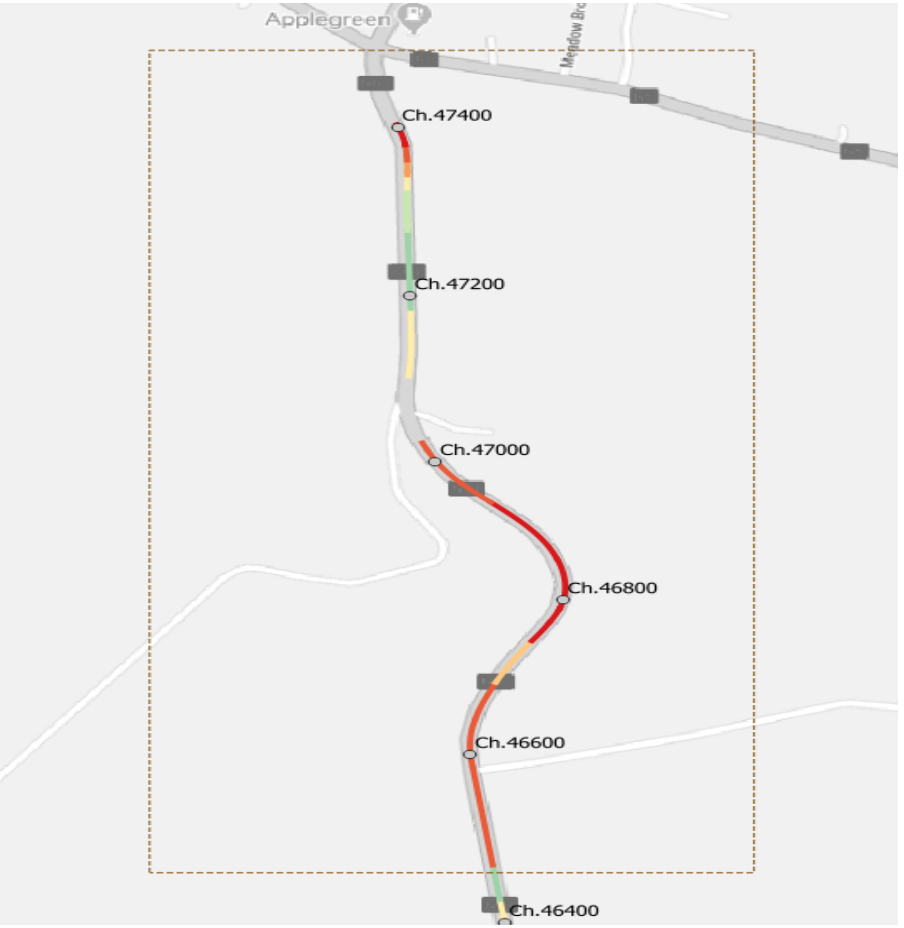
Friction Supply Characteristics of Road Surface

- **Contact** needed between tyre and road for grip
  - **Surface Texture** - measure of roughness
    - **Microroughness**
    - **Macroroughness**
- **Hysteresis –** needs road roughness: asperities "dig into tyre surface" (Macrotexture)
- **Molecular adhesion** needs direct contact - peaks of asperities to stand clear of water (Microtexture)

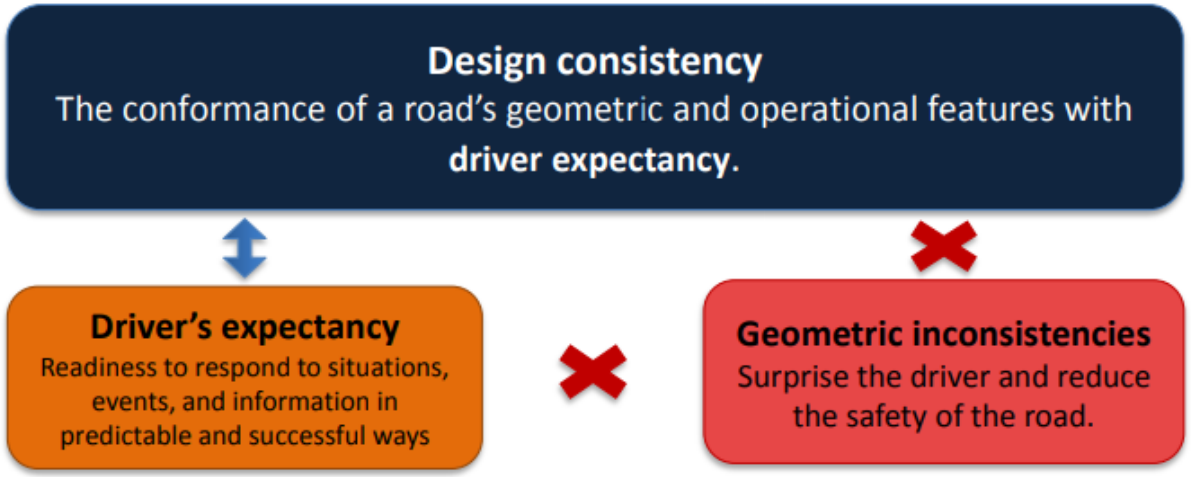


- **Drainage** of the water off the road (camber, banking)
- **Storage** of the water in the surface (porosity);
- **Load bearing surface -** determines local pressures in contact patch.

Friction Demand RibGeom – case study



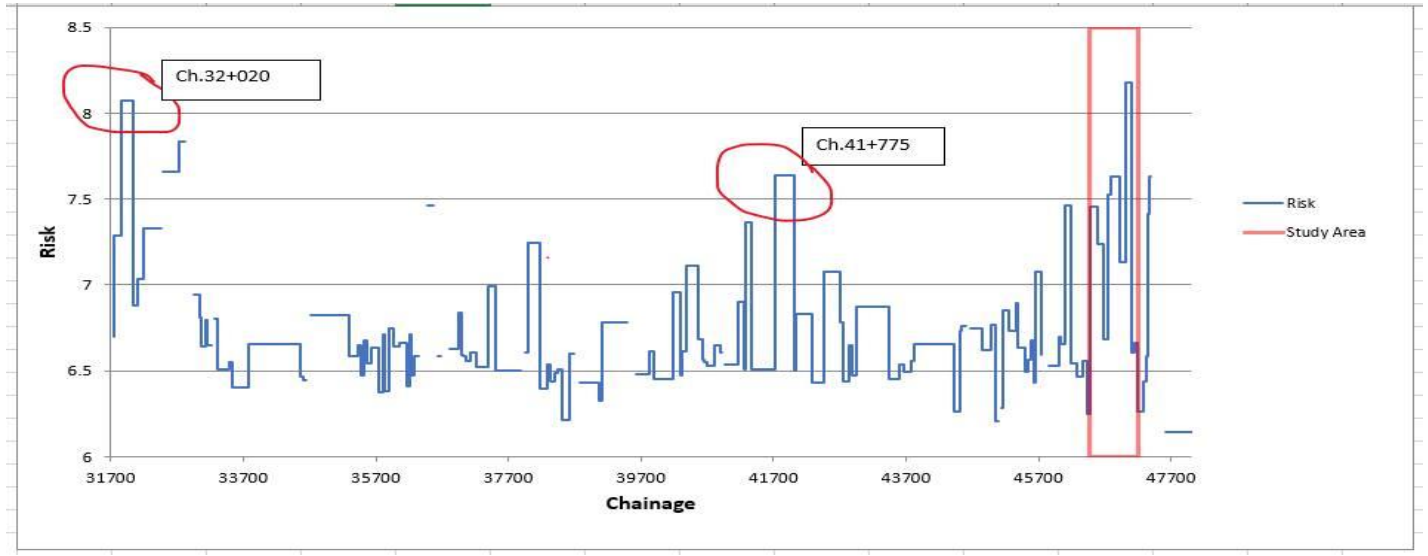
Friction Demand RibGeom – case study

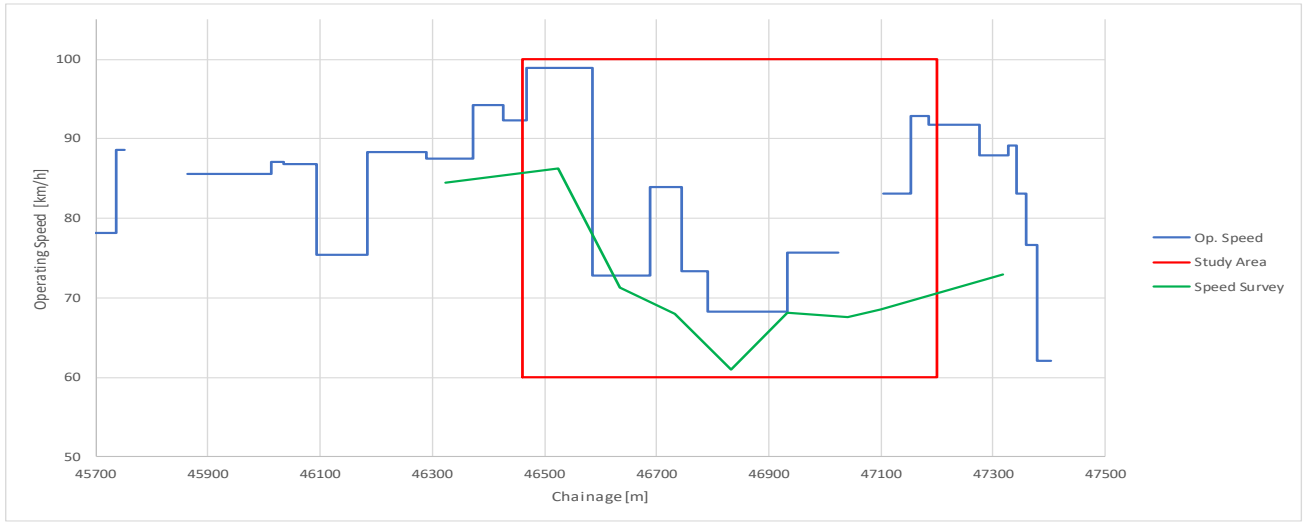


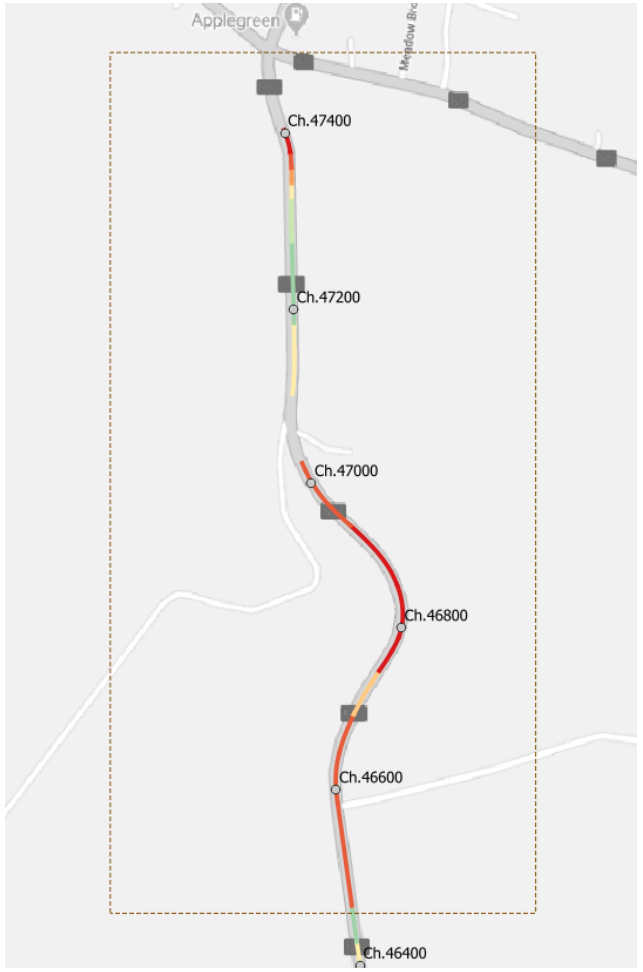
Model created to assess geometric risk using 7 inputs:

1. Speed Variation: Design Speed
2. Speed Variation: Operating Speed
3. Alignment: Horizontal Curvature
4. Vehicle Stability: Side Friction
5. Alignment: Vertical Curvature
6. Sight Distance
7. Driver's Workload (How alert and Active they must be)

Friction Demand RibGeom – case study

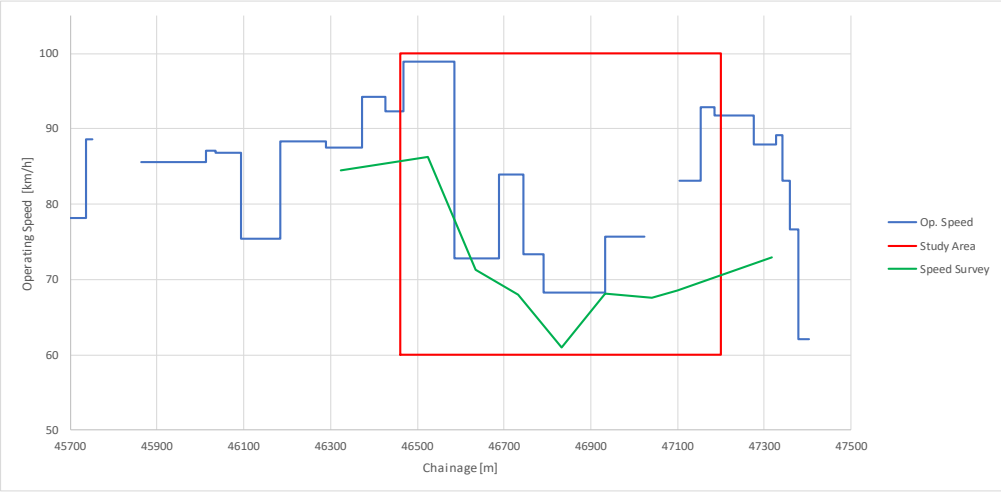


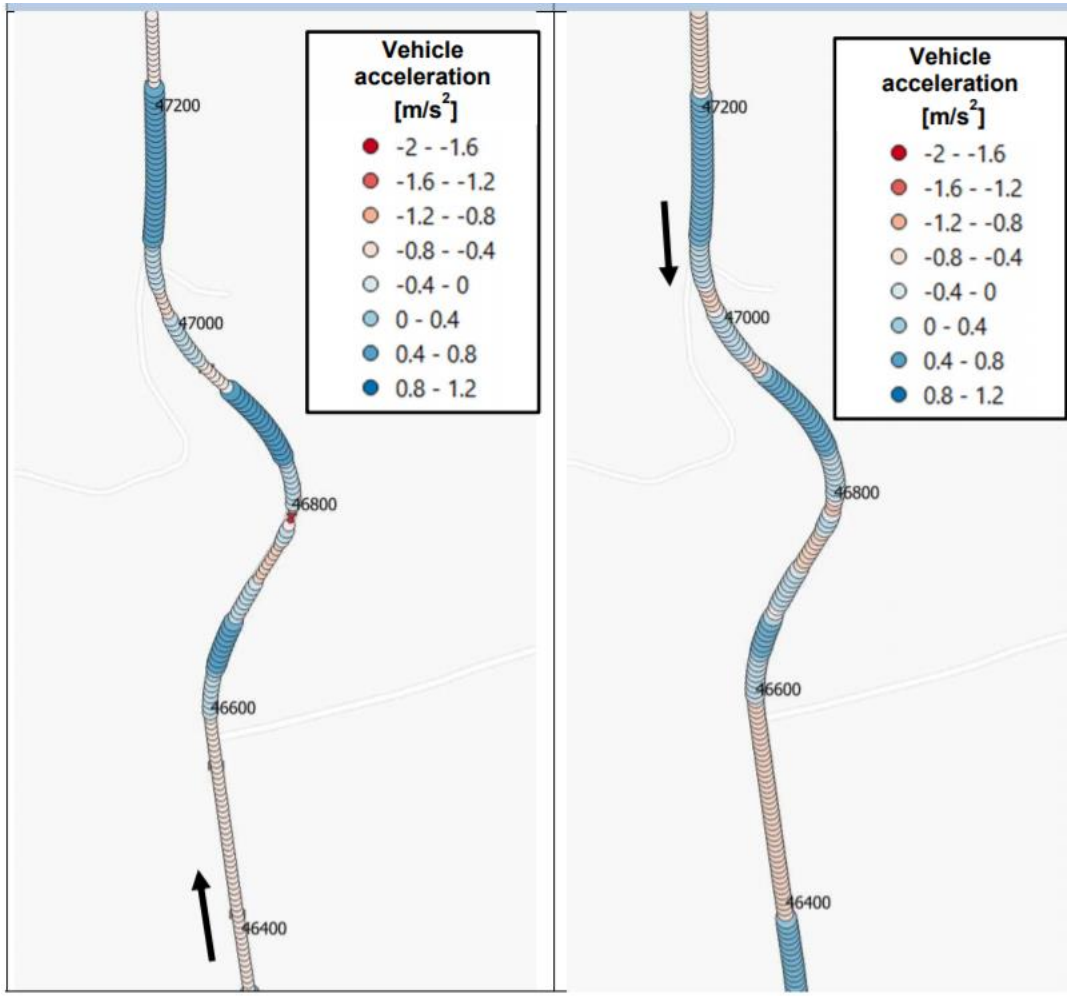




Friction Demand RibGeom Case study

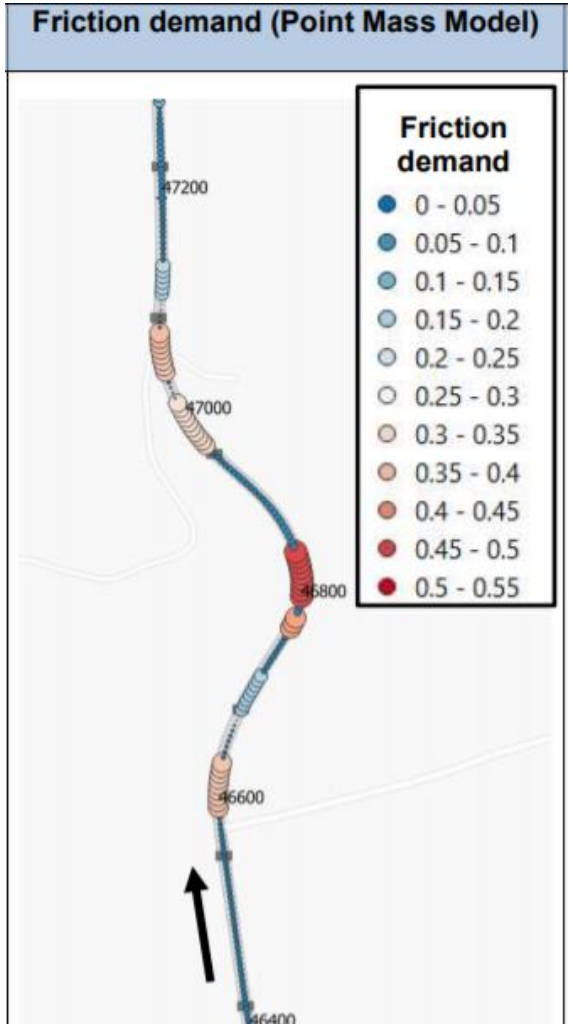
Note:
although bends are all < 250m
the acceleration patterns are significantly different

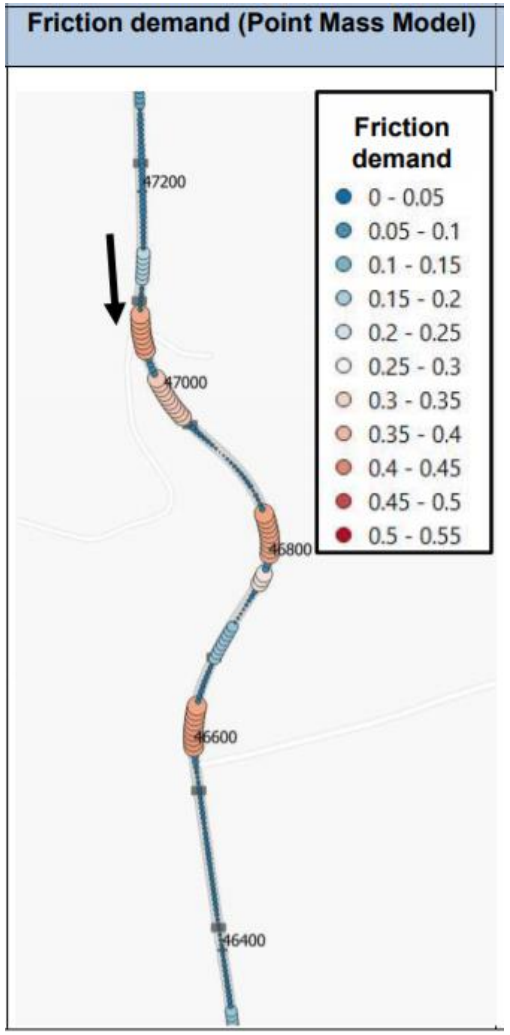




Friction Demand RibGeom – case study

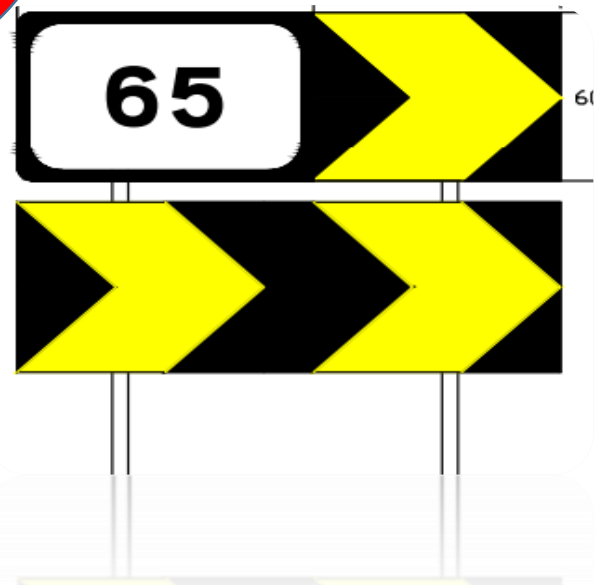
Note:
although bends are all < 250m
The friction DEMAND patterns are significantly different





Friction Demand Reduction Trial

Solution:
Improve drivers' kinaesthetic feedback



Friction Supply Aggregate Properties

Key aggregate properties :-

- Mineralogical and petrographic properties– aggregate composition/structure and mineral hardness
- Physical and geometrical - angularity, shape. (FI)
- Mechanical - abrasion/wear resistance; polish characteristics. (PSV, AAV, and FAP)
- Durability - soundness.

Surfacing Materials for New and Maintenance Construction for Use in Ireland DN-PAV-03023

Friction Supply Aggregate Properties

Table 5.2 Characteristics, tests and test frequencies for aggregate for surface course and surface treatments registered for use by TII

Characteristic	Test description	Test	Test method	Size for test	Test Frequency
Geometrical	Grading	Grading	EN 933-1	6/10; 10/14; 14/20[1]	1 per week
	Fines content	Grading	EN 933-1	6/10; 10/14; 14/20[1]	1 per week
	Particle shape	Flakiness	EN 933-3	6/10; 10/14; 14/20[1]	1 per week
Physical	Resistance to fragmentation	Los Angeles coefficient	EN 1097-2	As per standard	1 per 6 months
	Particle Density	Density	EN 1097-6	6/10	1 per 6 months
	Water absorption	Water Absorption	EN 1097-6	6/10	1 per 6 months
	Resistance to polishing	Polished Stone Value	EN 1097-8	As per standard (passing 10mm retained 7.2mm flake sieve)[2]	2 suites per 12-month period (See DN-PAV-03023 Cl 4.18)
	Resistance to surface abrasion	Aggregate Abrasion Value	EN 1097-8	As per standard[3]	2 per 12-month period
	Friction after polishing	Performed on aggregate mosaic	EN 12697-49 & Annex A	6/10; 10/14; 14/20[1]	1 per year
Durability	Resistance to weathering	Magnesium sulfate soundness	EN 1367-2	6/10	1 per year
Chemical & Geological classification	Geological assessment of raw material	Identify and map lithologies and proportions	IS EN ISO 14689-1 & see 5.5.4.1	Quarry deposit	1 per 3 years & see 5.5.4.1
	Geological examination of the finished product	Identify lithologies and proportions	IS EN ISO 14689-1 & EN 932-3 & see 5.5.4.2	6/10[2]	Quarterly
	Petrographic assessment of the finished product	Thin sections	BS 812: Part 104 & ASTM C295 & see 5.5.4.3	6/10	See 5.5.4.2

Notes

Geometrical	Grading	Grading	
	Fines content	Grading	
	Particle shape	Flakiness	
Physical	Resistance to fragmentation	Los Angeles coefficient	
	Particle Density	Density	
	Water absorption	Water Absorption	
	Resistance to polishing	Polished Stone Value	
	Resistance to surface abrasion	Aggregate Abrasion Value	
	Friction after polishing	Performed on aggregate mosaic	

Durability	Resistance to weathering	Magnesium sulfate soundness	
Chemical & Geological classification	Geological assessment of raw material	Identify and map lithologies and proportions	
	Geological examination of the finished product	Identify lithologies and proportions	
	Petrographic assessment of the finished product	Thin sections	

Notes

Friction Demand vs Supply

Factors which affect pavement friction supply / demand levels :-

(i) pavement surface characteristics;
(ii) vehicle operational parameters;
(iii) vehicle tyre properties;
(iv) environmental factors.

Within each category there are multiple contributory factors

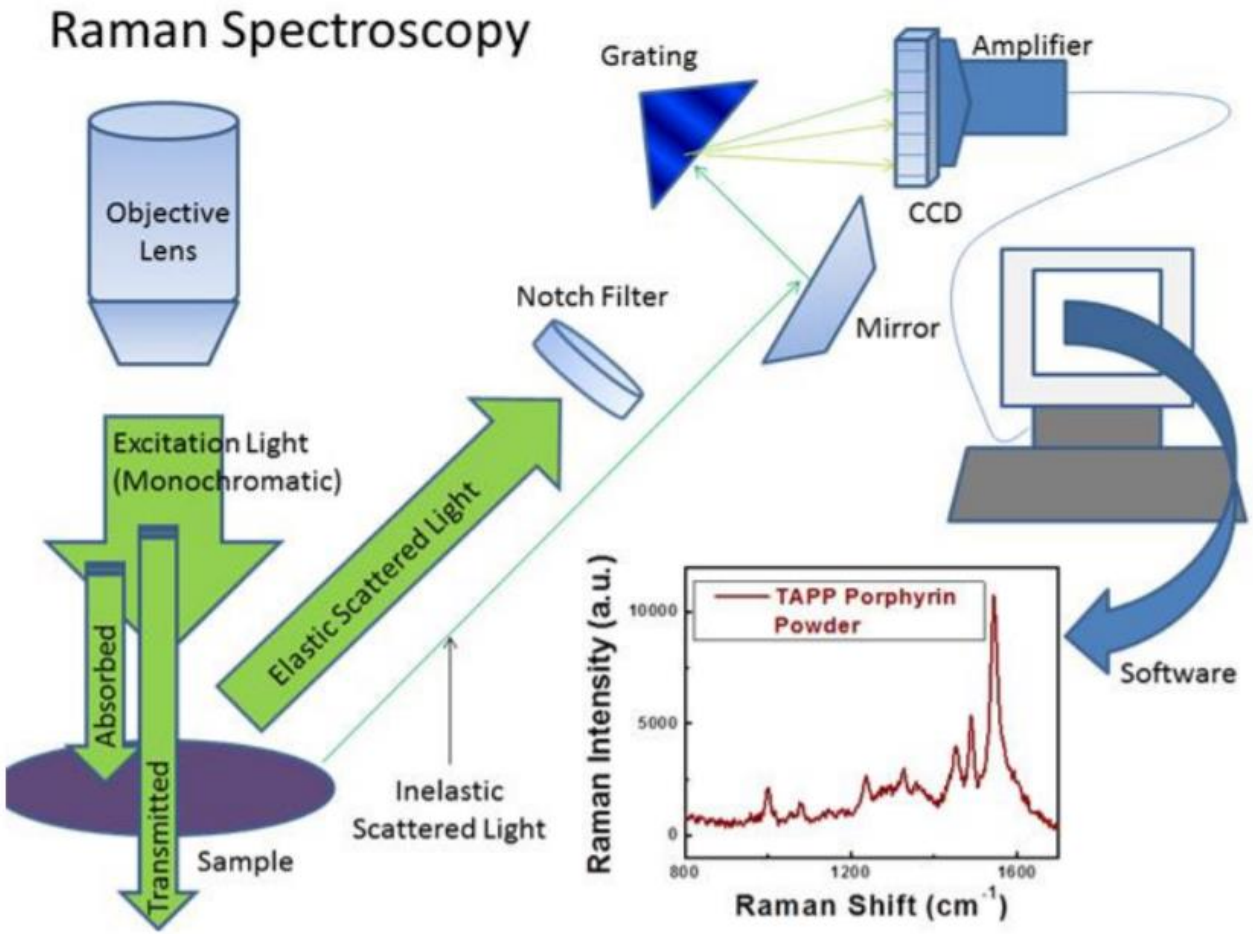
Road Management ideal –

- Develop friction supply categories that reflect the underlying demands
- Key influence - pavement characteristics

Friction Supply Characteristics of Road Surface

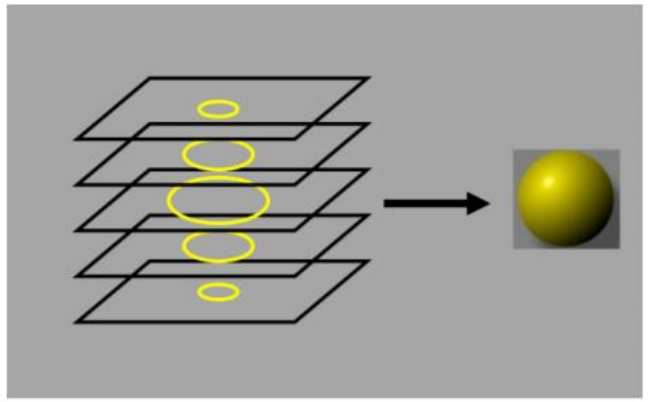
Raman Spectroscopy

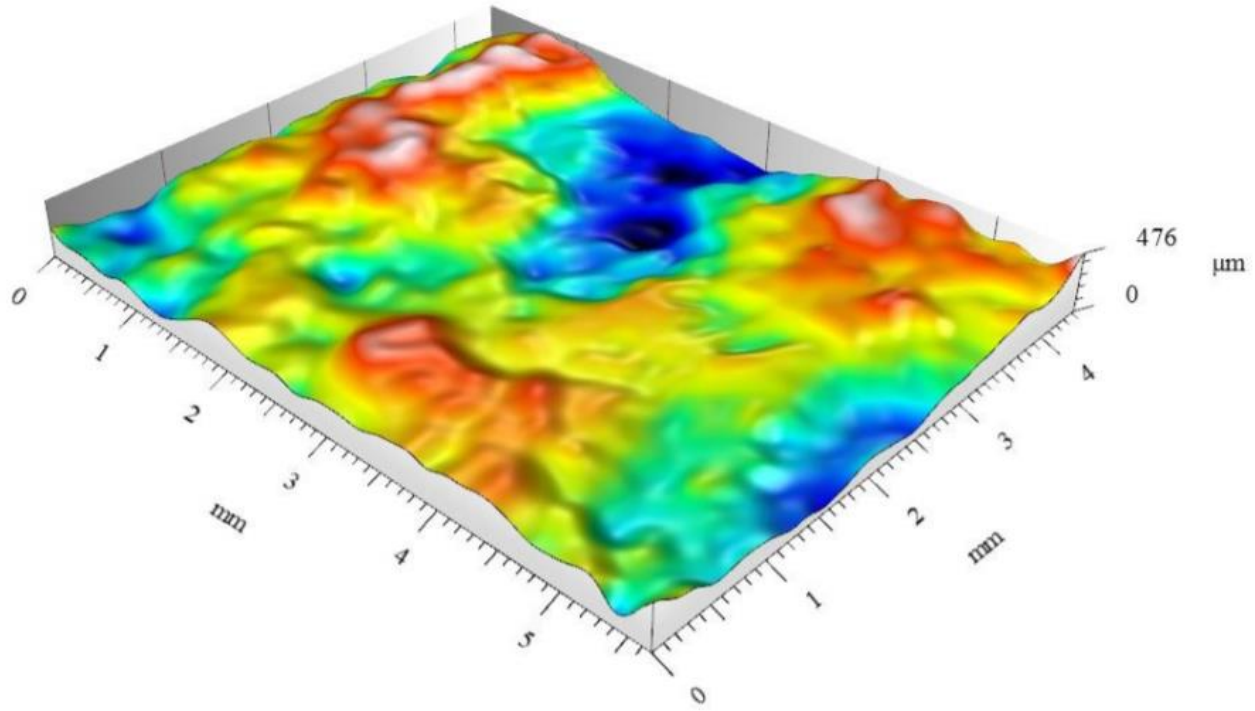
- Raman Spectroscopy – expose mineral to a light source of specific wavelength (laser). The light interacts with molecular vibrations causing a shift in the energy of the laser photons and is recorded as a spectra.
- Generate mineral maps of thin sections and aggregate particles



Friction Supply Characteristics of Road Surface

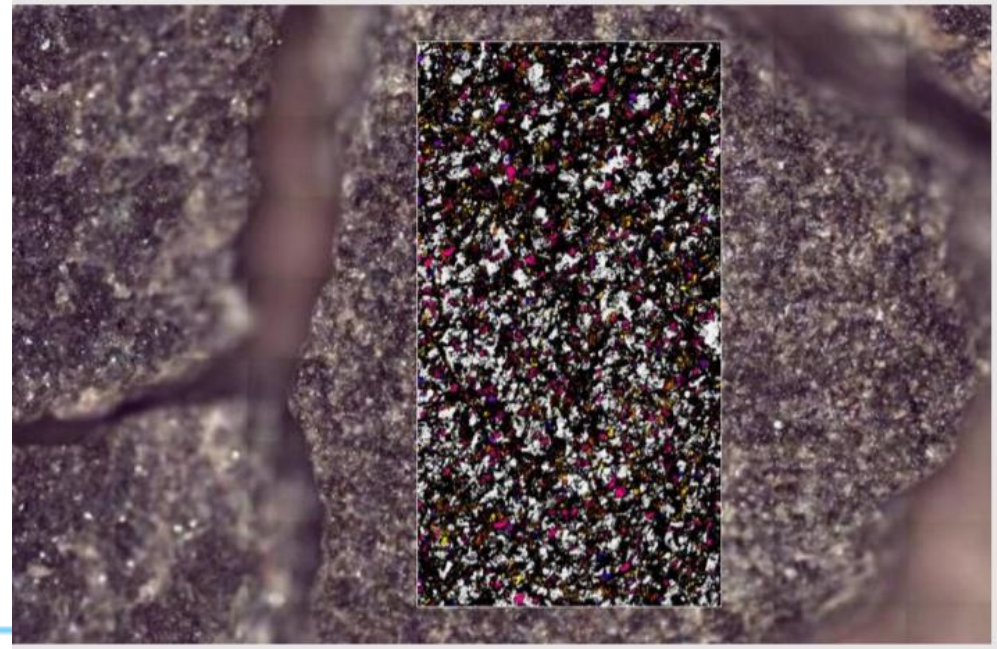
Focus Stacking – Z-stacking

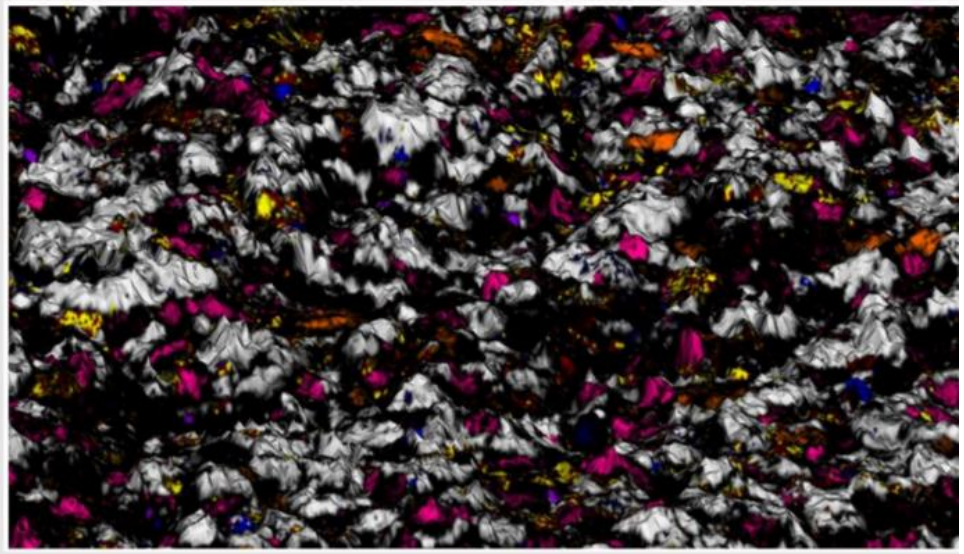




Friction Supply Characteristics of Road Surface

3D Imaging

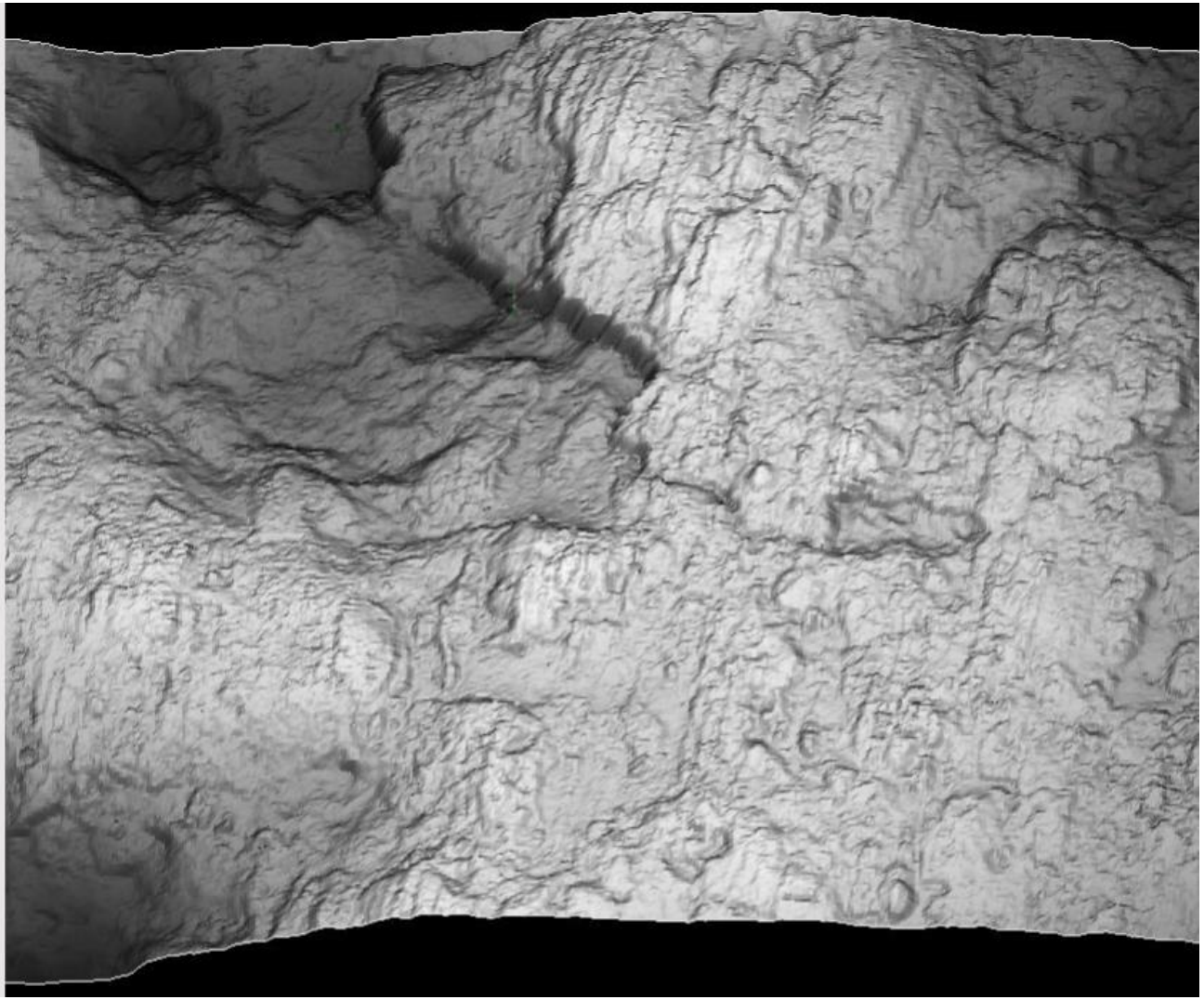




Friction Supply Characteristics of Road Surface

Laser Generated Topographic Maps

Provide detailed information on the microtexture (roughness)



Bonneagar Iompair Éireann
Transport Infrastructure Ireland