New Zealand

AGGREGATE MINERALOGY AND SKID RESISTANCE PERFORMANCE

28 March 2014

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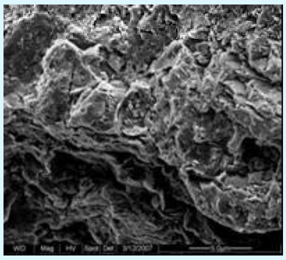

Why is skid resistance important?

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First snow fall in US Winter Season

Skid Resistance Overview & Texture wavelengths

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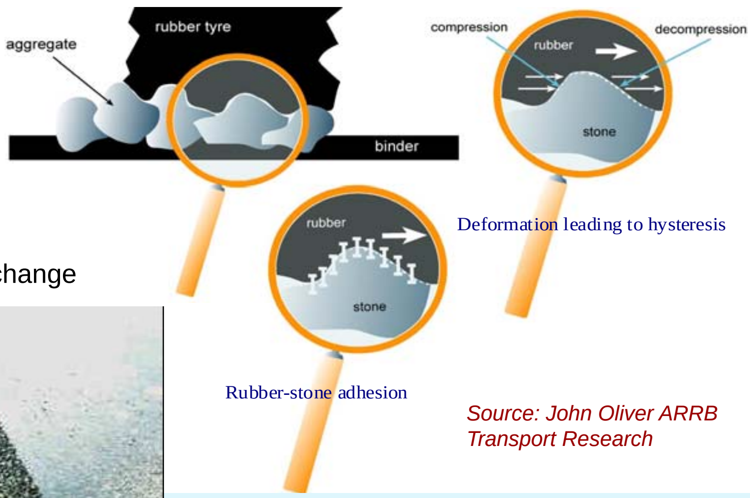
Rubber sliding on pavement aggregate



Source: John Oliver ARRB Transport Research

Macrotexture change

Microtexture changes

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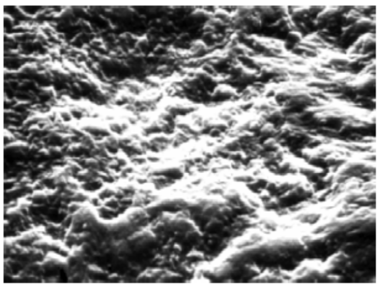
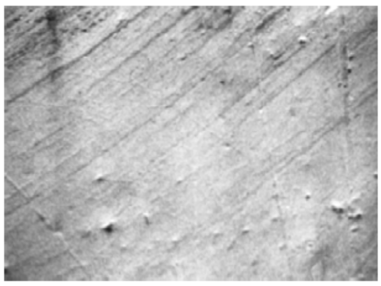
Unpolished ⟷ **Polished**





SEM Photographs

Factors affecting the Friction Potential (CoF)

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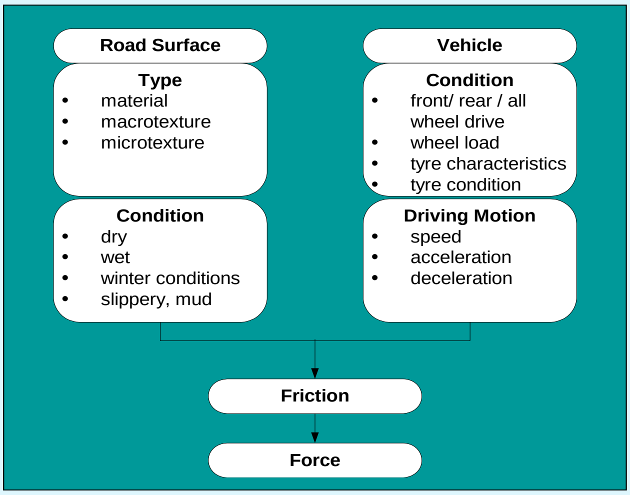

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Skid Resistance & Research Context

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- Importance of Skid Resistance for Road Safety.
- Role of microtexture and macrotexture in Skid Resistance.
- Polished Stone Value (PSV) test to measure Skid Resistance.
- Limitations of the PSV test
- The need for an alternative laboratory based methods to better reflect Skid Resistance.

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The Prediction of Pavement Surface Aggregate Wear and Microtextural polishing

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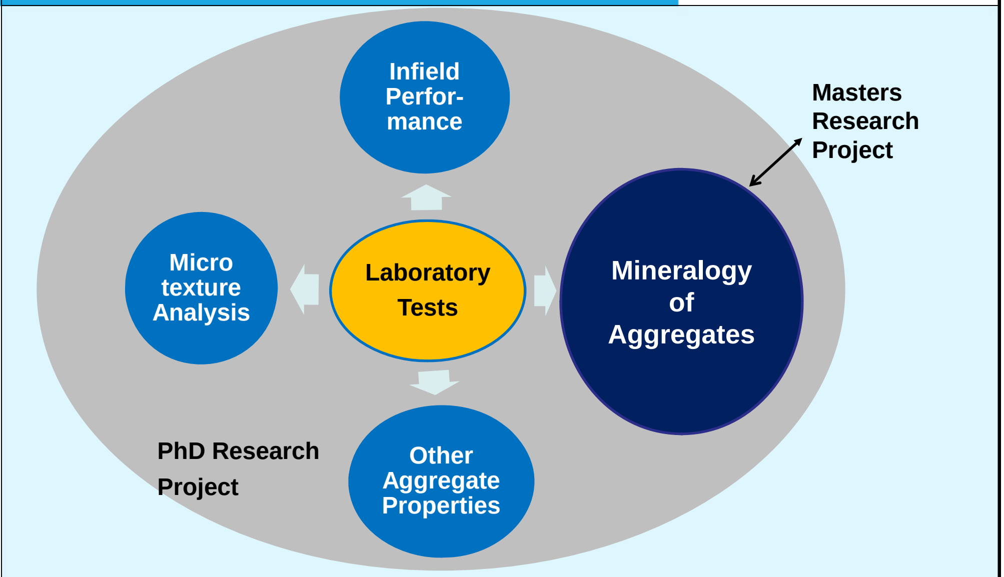

Objective and Scope

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Objective:

- To correlate the infield performance of NZ aggregates to their geological source properties

Scope:

- 6 NZ natural aggregates sourced from quarries around North Island
- Infield skid resistance data was limited to roads around Auckland and Waikato regions

Aggregate Materials

Aggregate Type	Quantity	Notation
Greywacke	3	G1, G2 and G3
Basalt	2	B1 and B2
Andesite	1	D1

Mineralogy of New Zealand aggregates

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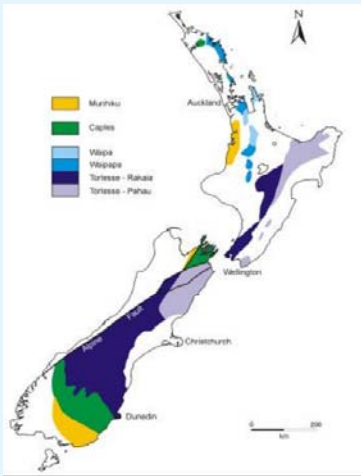
- Aggregates are non-renewable resources.
- NZ aggregates are derived mainly from Greywacke & Volcanic rocks.
- Greywacke in NZ are derived from
  - Murihiku, Caples, Rakia and Pahau, from the North Island,
  - Waipapa and Waipa from the South Island.
- Basalt rocks (Volcanic) comes from the Northland, Auckland, Banks Peninsula, Dunedin and the surrounding islands (Campbell & Chatham Islands)



Mineralogy of New Zealand aggregates

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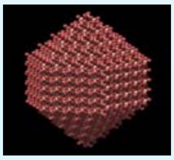
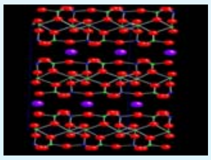
Factors affecting Aggregates durability & infield skid resistance performance:

- Molecular lattice structure of minerals which determines its toughness and hardness properties.
- Regular molecular lattice structure of Quartz makes it a hard mineral compared to Albite.





- The size, shape, angularity of mineral grains, strength of binding cementing content in the rock and porosity of rocks.
- Surface areas of mineral grains in the rocks and their proximity to each other.
- Chemical reaction of the minerals present in the rocks with water.

Mineralogy of New Zealand aggregates - Greywacke

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Differences between the three Greywacke aggregates

	G1	G2	G3
Grain Size	Coarse grained Clast-supported and volcaniclastic sandstone	Medium sized grains	Fine grained
Prehnite Veins	None	Run throughout the rock	Run throughout the rock
Matrix	Mediocre and consists of angular sand grains, dominated by volcanic lithic with some igneous detrital heavy minerals.	Traces of secondary chlorite and pumpellyite are also noticed in the rock matrix.	More quartz-rich and have a lower lithic content in comparison with the previous two samples. The feldspar grains present in the rock are all albitised and have euhedral shape which suggests to a near source rock.

Mineralogy of New Zealand aggregates - Basalt

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Differences between the two Basalt aggregates

	B1	B2
Grain Size	Fine grained	Coarse grained
Grain Minerals	The quantity of augite supersedes that of olivine in the rock matrix.	Presence of large phenocrysts or olivine can also be seen in most of the chips. Augites of smaller sized phenocrysts are identified in the samples.
Matrix	Traces of augite and black iron-oxide crystals, commonly known as magnetite, are scattered throughout the matrix. Needle-like shape crystals of feldspars are observed in the rock matrix.	Groundmass of the rock is composed mainly of feldspars that comprise of granules of augite, iron oxides (Magnetite), and some brown volcanic glass.

Mineralogy of New Zealand aggregates - Andesite

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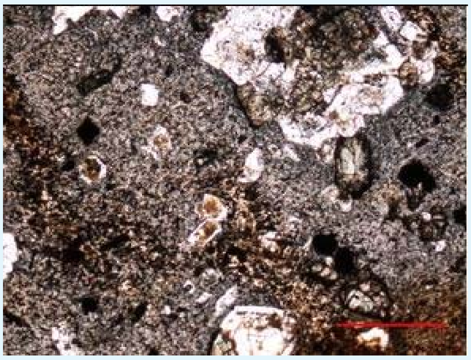
Andesite aggregate (D1)

- Aggregates are made up of large crystals, which are feldspars and are mostly colourless and the presence of pyroxene is profound.
- The matrix of the rock is composed of plagioclase (small needle), granules of pyroxene, iron oxides, and glassy material that seems to have devitrified to cristobalite or tridymite.



Research Methodology

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Microscopic Investigations → X-Ray Diffraction → Rietveld Method (Siroquant Software) → Infield Skid Resistance Analysis

X-ray diffraction

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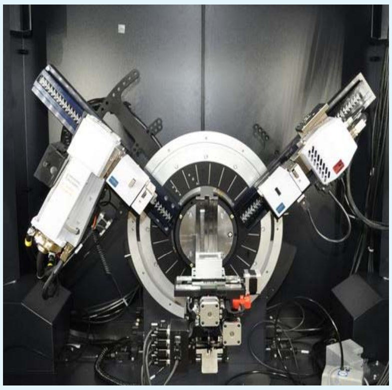
- X-ray diffraction (XRD) to characterize and identify minerals found in the selected aggregates.
- XRD works with principle that every crystalline substance produces a unique diffraction pattern when subjected to incident X-Ray beams.
- Unique diffraction pattern of each particular mineral can be used to identify through peaks comparison using a software database.
- X-ray counts recorded by the arm-sensors of the diffractometer is stored on a computer database



The Bragg Bretona Diffractometer

Rietveld Method

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- Rietveld method is used to analyzed the XRD data using the Bruker AXS Topas package.
- Refinements via the Rietveld methods were conducted to identify minerals from a database
- Different colours on the diffractogram represent the fit for the likely minerals to be found in the sample.

An example of Rietveld refinement results

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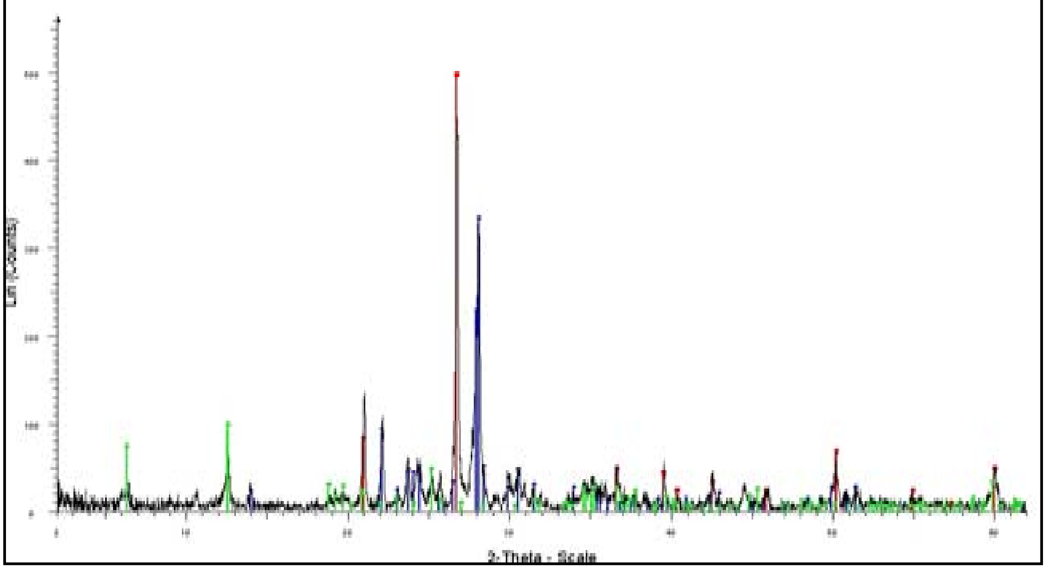

Siroquant Analysis

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- XRD data were further analyzed using the Siroquant Software for the following:
  - Identification of the main minerals in the aggregate sample,
  - Quantification of the main minerals in each aggregate sample.
- Software operates by calculating the XRD profile of each mineral and further refinements are conducted to fit within the recorded patterns in the SIROQUANT database.

An example of the Siroquant software output

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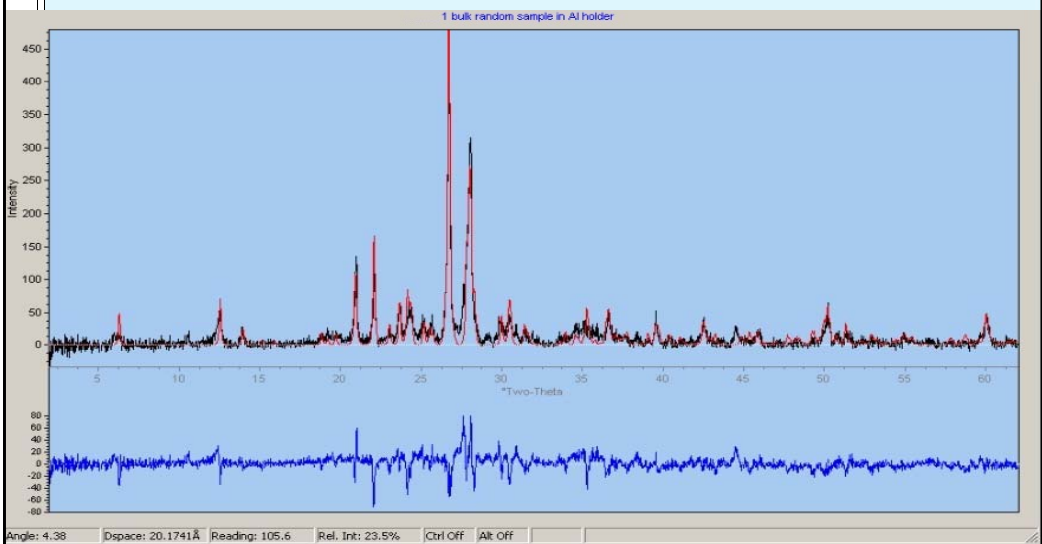

In-field skid resistance performance

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- RAMM database

Aggregates	Number of Road Sections
G2	1
G3	2
B1	1
B2	3
D1	1

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In-field skid resistance performance

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- Resealed surfaces were treated as new surfaces
- Surface Age was calculated using the following equations:
  - **Surface Age (year) = Reading Date – Surface Date** (If the road has not been resealed),
    - *where:*
    - *Reading Date = the date when the SCRIM reading was taken,*
    - *Surface Date = the date when the road was constructed for the first time.*
  - **Surface Age (year) = Reading Date – Reseal Date** (If the road has been resealed).
    - *where:*
    - *Reading Date = the date when the SCRIM reading was taken,*
    - *Reseal Date = the date when the road was resealed.*
- The statistical software R was used to plot boxplot of the infield skid resistance for each sample aggregate.

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In-field SR Performance Key Assumptions

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- RAMM data in terms of surfacing dates correct to determine surface age
- Aggregates sourced at the same quarry are homogeneous
- Repeatability of of SCRIM network data
- Seasonal Variation
- Traffic Loading
- Road Curvature

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Results & Discussion

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X-ray Diffraction Results for Greywackes G1, G2 & G3

	Percentage Weightage for each aggregates			
Minerals		G1	G2	G3
Quartz	Weight %	28	28.4	37.2
Albite	Weight %	61.5	59.4	52.8
Chlorite	Weight %	10.5	12.2	10

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X-ray Diffraction Results for Basalt Samples B1, B2 and Andesite D1

	Percentage Weightage for each aggregates			
Minerals		B1	B2	D1
Albite	Weight %	29.9	16.6	89.1
Labradorite	Weight %	23.5		
Nepheline	Weight %	19.3	17.7	
Pyroxene	Weight %	27.2		
Diopside	Weight %		53.8	
Forsterite	Weight %		11.9	
Tridymite	Weight %			10.9

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Infield Skid Resistance Performance of the Aggregates (G2)

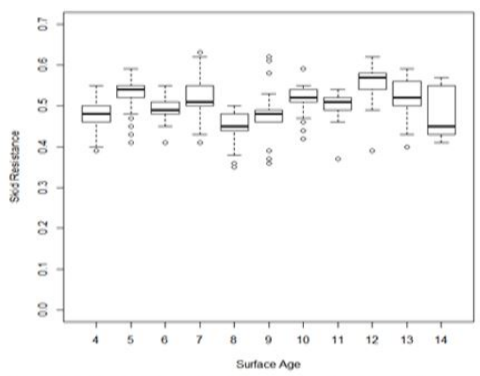

Figure 6: Skid resistance data for G2 aggregates (LWP)

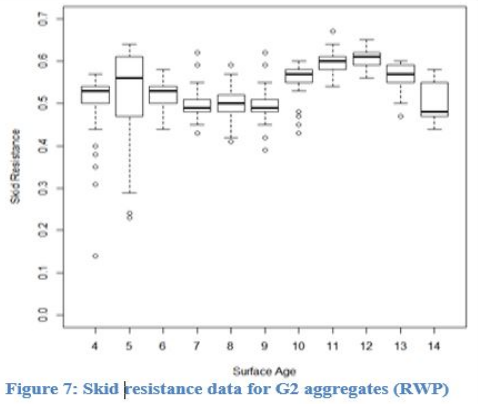

Figure 7: Skid resistance data for G2 aggregates (RWP)

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Infield Skid Resistance Performance of the Aggregates (G3)

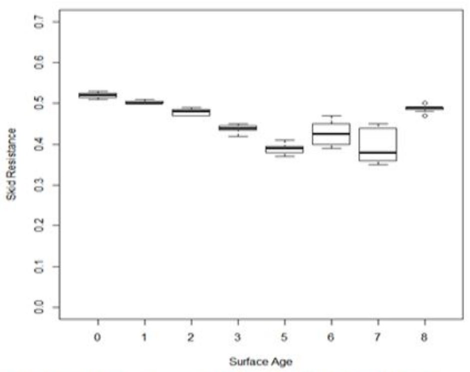

Figure 8: Skid resistance data for G3 aggregates (LWP)

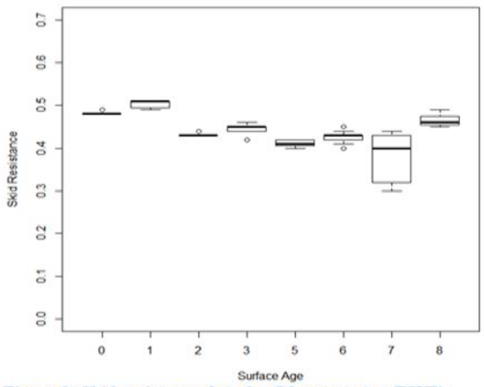

Figure 9: Skid resistance data for G3 aggregates (RWP)

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Infield Skid Resistance Performance of the Aggregates (B1)

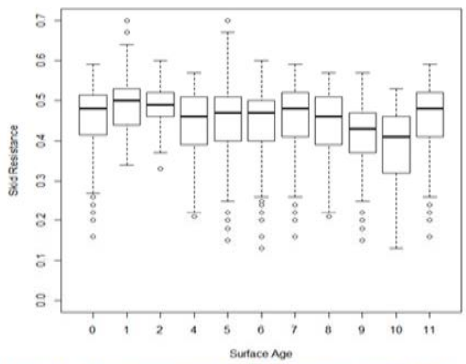

Figure 10: Skid resistance data for B1 aggregates (LWP)

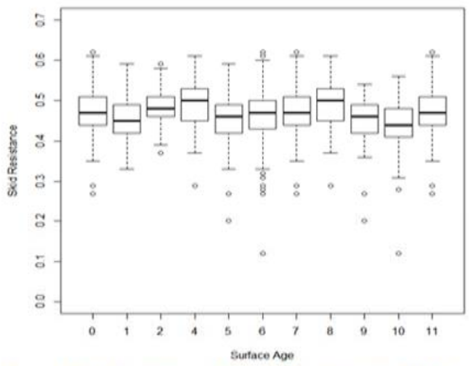

Figure 11: Skid resistance data for B1 aggregates (RWP)

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Infield Skid Resistance Performance of the Aggregates (B2)

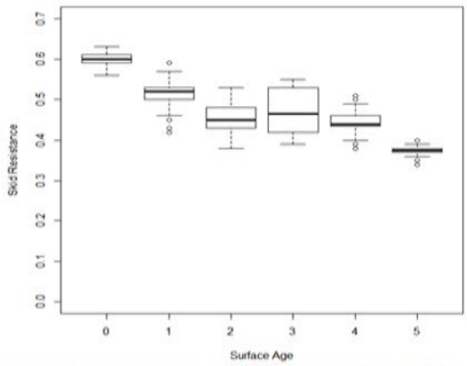

Figure 12: Skid resistance data for B2 aggregates (LWP)

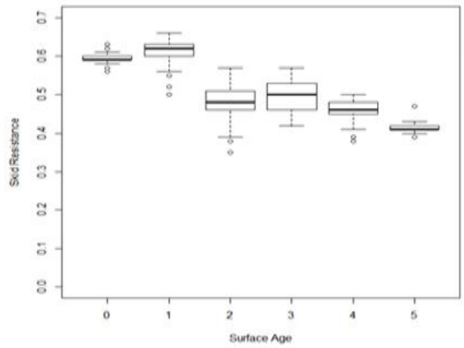

Figure 13: Skid resistance data for B2 aggregates (RWP)

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Infield Skid Resistance Performance of the Aggregates (B3)

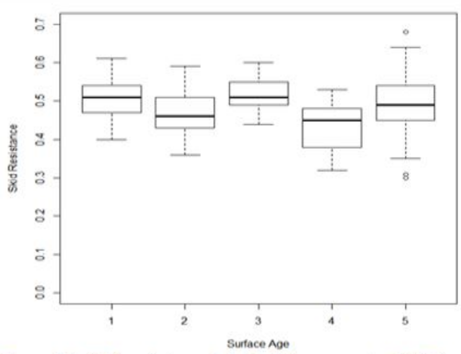

Figure 14: Skid resistance data for D1 aggregates (LWP)

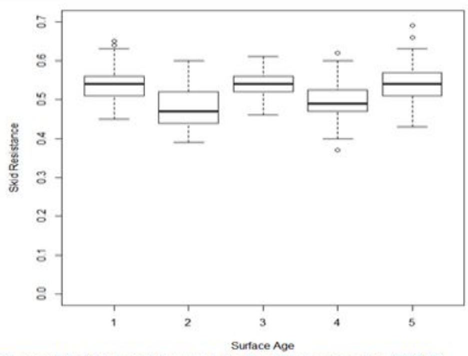

Figure 15: Skid resistance data for D1 aggregates (RWP)

Conclusions…1

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Greywacke:

- Infield skid resistance data plots have revealed that some types of greywacke tend to perform better compare to other greywacke types.
- There is a decreasing trend in skid resistance performance over time, but the trend is slower in some greywacke types which has a higher content of hard minerals like quartz.

Basalt:

- Basalt aggregate tends to show a slight variation against each other for their infield skid resistance performance although a decreasing trend is observed for both aggregates. The slight variation may be attributed to the difference in the mineral composition of their rock matrix. Some basalt aggregate types which are rich in albite content, will generally exhibit greater skid resistance performance due to its hard cementing materials.

Conclusions…2

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- Analysing the thin sections of sample aggregates can provide clear images that can be used to conduct a preliminary assessment of the likely minerals to be present in these aggregates.
- The X-ray diffractometer has been successful in characterizing the dominant minerals inherent in the sample aggregates and computing the ratio of their respective percentage weightage.
- Skid resistance performance in-field is complex and is not bi-variate in nature, however aggregate mineralogy is one of the key inputs that needs understanding
- Research is continuing

Future research

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- Quantifying the percentage of dominant minerals to the volume of the sample aggregates
- Analysing thin section images by colour to determine the percentage of these minerals in the sample aggregates in a more accurate way
- To understand how other geological properties of aggregates, such as groundmass of the rock and the porosity of aggregates, affects skid resistance performance

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What happens when you loose both macrotexture and microtexture?

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Thank you

Questions?

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