SAFER ROADS FOR TASMANIA
GUNN'S HILL PROJECT – SKID RESISTANCE FIELD ASSESSMENT

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ABSTRACT:

Reports published by DIER (Department of Infrastructure Energy & Resources) have shown that there are significant safety issues related to low skid resistance aggregates.

A quote from issue No. 15 of "Zebra (DIER)" mentioned that: "It is estimated that crashes and injuries cost us the people of Tasmania, $300 million each year"…

The M&R Report 801848 highlights the fact that the useful life of the bitumen component of sprayed seals in Tasmania exceeds 25 years. Therefore there is a need to achieve a balance when the performance of the aggregates matches the bitumen performance.

Reports prepared for DIER (Ref. 983/0010) on the skid resistance issue were aimed at establishing a profile of the polishing resistance of potential aggregates suppliers including and understanding of the variability of products. Furthermore, in 2005 a joint project between DIER, Boral and Roadways started at Gunn's Hill with the aim to determine the benefits of blends of high durability aggregates with high to extremely high skid resistance properties.

The trialled aggregates were placed in a block pattern across both lanes of the western end of the Contract 1045 in strips, alternating control aggregates with trial blends.

This paper presents the results of skid resistance field assessment after 24 months of traffic using the British Pendulum Friction Test. Also, the SCRIM device has been used to assess the skid resistance performance and a correlation between the two tests has been carried out.

It is concluded that both types of skid resistance are showing the blends performing better than control. Furthermore, after 24 months of traffic the skid resistance value "drop" is lower for all blended aggregates sites when compared with the control sites.

The work carried out in this trial will assist DIER in formulating a strategy to manage high skid resistance/risk areas on the State road networks and have the added benefit of extending the resource of high quality and scarce aggregates.

Safer roads can be built in Tasmania in areas where high skid resistance aggregates are not readily available.

1. INTRODUCTION

1.1 General Data on Skid Resistance

The friction between the motor vehicle tyres and road surface depends on two major components, both being related to speed. (1).

- skid resistance between tyres and road surface.
- loss of energy caused by deformation of the tyre.

Skid resistance is a major factor in road safety being a starting point for any traffic accident.

It is very well established that skid resistance performance depends on several factors, such as:

- traffic
- age of pavement
- site geometry (curves, grades)
- type of surfacing (asphalt, spray seal)
- properties of aggregates – microstructure
- road macrostructure.

Also, skid resistance may be affected by other factors such as:

- road condition (wet or dry)
- tyres
- speed of vehicle
- aggregates microstructure
- road macrostructure

Other important factors affecting the skid resistance is the seasonal effect. In dry periods, the road surfaces are more polished under traffic, with the tendency to regain their properties after long wet periods (2).

Work carried out recently in New Zealand (3) has demonstrated once more the "approximately sinusoidal seasonal" effect of low skid resistance in the summer and high resistance in winter period. According to the abovementioned study, "prolonged periods of dry weather in the summer allow the accumulation of fine particles that assist in polishing of the pavement surface". In winter, the aggregate surface is rejuvenated with chemical reactions from the rainwater exposing new particles.

1.2 Methodology of Measuring Skid Resistance

Two preferred methodologies for measuring skid resistance are being used in Australia.

a) Polished aggregate friction value (PAFV) or Polished Stone Value (PSV).
b) Sideways Force Coefficient (SFC).

Although there is not much information linking accidents with skid resistance, the abovementioned methodologies are widely used and standard limits are being provided by road traffic authorities.

a) PAFV/PSV – is a measure of the microtexture of aggregates. The measurement indicates the potential of an aggregate to polish under breaking conditions at less than 20km/hour. The higher the result, the greater is the resistance of aggregates to polishing (4). Although the test does not always reflect the roads in service performance, PAFV/PSV is the only available criteria which is being used in specifications.

b) Sideways Force Coefficient (SFC) – The SFC is being measured with the SCRIM equipment. (Sideways Force Coefficient Routine Investigation Machine), developed in United Kingdom in 1977 (5). The smooth tyres are free rolling parts of a test truck and run at an angle of 20^{o} to the direction of travel in each wheelpath. The operating speed is usually 50 to 80 km/h, with the relative velocity between the rubber and the pavement surface being in the order of 17km/h. The skid resistance is measured at low speed and the results are primarily sensitive to microtexture, similar to PAFV/PSV. However, the measurements are used in conjunction with macrotexture measurements.
(Figure 1).

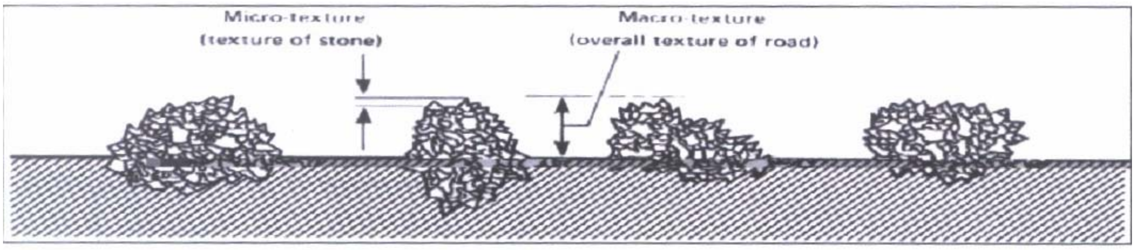

Figure 1. Surface texture

2. BRIEF DISCUSSION REGARDING SKID RESISTANCE

Data about current specifications from various road authorities was recently presented in a document prepared for the CCAA (6). It is important to note that VicRoads does not specify PAFV, which is unique in Australia, but instead specifies PSV, which is a departure from all other States, Territories and also Standards Australia. Most of the traffic authorities provide minimum requirements for PAFV, the exception being VicRoads and Standards Australia. Nevertheless, a Technical Note published by VicRoads and Geopave (4) provides guidance for the specification of aggregates used in chip seal and asphalt pavement surfacing. (Table 1).

Aggregate PSV	Traffic volume vehicles/lane/day	Indicative Friction Life (Years)			
		• Curves with radius m 100 m	Controlled Intersections, Pedestrian X-ing and Roundabouts	Tight Curves (m 250 m radius) Freeway Ramps	Other Intersections
48	5000	NS	NS	3 to 6	9 to 12
	10000	NS	NS	1 to 2	4 to 6
52	5000	NS	NS	6 to 8	15 to 18
	10000	NS	NS	3 to 6	8 to 10
56	5000	NS	3 to 7	14 to 16	>20
	10000	NS	3 to 5	7 to 10	12 to 14
60	5000	4 to 6	12 to 15	>20	>20
	10000	2 to 4	6 to 8	11 to 14	16 to 17

Table 1. Indicative Friction Life

The abovementioned document also highlights the fact that in Victoria there is a limited supply of aggregates with high PSV. It is recommended that the use of high skid resistance aggregates should be restricted to locations with high traffic.

As some of the high skid resistance aggregates may not be economically viable, the alternative is to:

- plan to replace the surfacing on a more frequent basis.
- use artificial aggregates.

The financial implication of this approach is to be noted and an additional option, as highlighted in this paper, is blending aggregates with high durability but lower skid resistance aggregates with lower durability but extremely high skid resistance aggregates.

3. STUDIES/INVESTIGATIONS CARRIED OUT IN TASMANIA

3.1 DIER Investigations

Studies/investigations of road surfaces skid resistance were carried out by the Department of Infrastructure, Energy and Resources (DIER), (7, 8, 9, 10) within 50km of Hobart and also in the NE and NW regions. These studies concluded that:-

- there was a marked difference in the in-service skid performance of basalts and dolerites in and around Hobart. About 18% of the sites containing basalt showed SCRIM results below 35 and only 0.5% of sites using dolerite showed results below this figure.

- there was a significant difference between basalts in the NE and NW, with northern basalts showing superior skid resistance results to those in the South.

In 2001/2002, DIER requested their contractors to carry out PAFV testing of aggregates with no acceptance criteria being set. The purpose of this request was to develop a profile for PAFV from the existing aggregate sources and to use the data for setting compliance limits for PAFV. The aggregate testing results concluded that:

- None of the current major suppliers have aggregates with much above the 48 specified by other road authorities for heavy and very heavy asphalt mixes and Class A aggregate for sprayed seals.
- A number of sources in the NE and NW regions have aggregates that can just satisfy the 48 requirement.
- A major supplier in the South cannot always meet the 45 minimum requirement for other asphalt mixes.

3.2 DIER Strategy

Based on investigations carried out, a discussion paper has been produced (11). The document includes recommendations for the use of the assigned value approach for PAFV and durability. Also, DIER is seeking other potential sources of aggregates that might provide in-service skid resistance performance to current suppliers. Several field test strips have been placed in order to assess the in-service life skid resistance properties of these new resources.

Considering the inadequate supplies of high to very high skid resistance aggregates, blending of aggregates with high durability but lower skid resistance with aggregates with lower durability but higher skid resistance has also been considered.

4. GUNN'S HILL FIELD TRIAL (Contract No. 1045)

4.1 Objectives/Performance/Methodology

In 2005, DIER, Boral Resources, Tasmania and Roadways Pty. Ltd. have decided to carry out a field trial of blended aggregates. (*Figure 2).*

Figure 2. Field Trial, Tasmania

The main objectives of the field trial were:
- assess the laboratory performance of the blended natural aggregates.
- assess the field performance of the high/very high skid resistance aggregates.
- assess the long-lasting skid resistance performance of the blends.

The performance measures refer to the production of a few blends using local high/very high skid resistance aggregates and basalt aggregate as a control with testing to include durability, PAFV, stripping, etc. The methodology proposed involved:-

- Production of necessary certified stockpiles for the project.
- Certificates of compliance.
- Determine the area to be assessed, ensuring that the layout does not discriminate the blends' performance.
- Blended and control aggregates to be placed in a block pattern, across both lanes of the western end of the area (Contract No. 1045) in strips of approximately 100m alternating control materials and blends *(Figure 3).*
- Carry out initial PAFV using the British Pendulum followed by regular tests at different intervals/seasons.
- The usage of SCRIM assessment in order to be able to have two types of skid resistance assessments.

Figure 3. Location of skid resistance value and surface texture depth test sites

An additional 100m strip with one of the blends was placed in the left-hand lane half-way up Gunn's Hill.

4.2 Laboratory Results

A control aggregate (14mm Bridgewater basalt) and several blends of basalt and volcanic tuff have been produced in order to fully assess the physical properties of the spray seal aggregates to be used in the project. The laboratory results of the three blends chosen (85%-15%, 70%-30% and 50%-50%) (the first % being basalt) are presented in Table 2 with a visual presentation of the blends in *Figure 4.*

	85/15 Blend	70/30 Blend	50/50 Blend
DURABILITY			
Wet/Dry %	20	24	27
Los Angeles Abrasion %	14	15	16
Mis-shapen Particles % (2:1 Ratio)	19	18	19
Flakiness Index %	21	22	20
PAFV	48	49	57
Water Absorption %	2.1	2.6	3.5
Stripping	6	6	10

Table 2. Laboratory trial results

Figure 4. Blended products, basalt (control) and volcanic tuff.

All the results are complying with current specification requirements.

4.3 Field Trial

The joint project involving DIER, Boral and Roadways have been carried out over 4 areas (Control, 85/15% blend, 70/30% blend and 50/50% blend (12). No less than 11 sites have been chosen where the PAFV and the surface texture have been measured. Table 3 and *Figures 5, 6 and 7)*.

AREA	NO. OF SITES	SITE NUMBER
Control	3	3, 6 and 9
85/15% blend	2	1, 10
70/30% blend	4	3, 5, 5A and 7
50/50% blend	2	2, 8
NOTE: Basalt/volcanic tuff %		

Table 3. Location and number of sites for skid resistance

Figure 5. British Pendulum test on a 70/30 blend

Figure 6. British Pendulum test on a 85/15 blend

Figure 7. General view of the 50/50 blend and Control (Basalt) at the back.

The field PAFV was measured on the same sites (with the help of GPS equipment) in April 2005, October 2005, May 2006, November 2006 and April 2007. The results are presented in Table 4 and *Figure 8.*

Site	Track Apr-05	Track Oct-05	Track May-06	Track Nov-06	Track Apr-07
Site 3 Control	**70**	58	57	55	**54**
Site 6 Control	**70**	60	58	56	**54**
Site 9 Control	**67**	59	55	52	**54**
Site 1 85/15 Blend	**78**	68	66	63	**65**
Site 10 85/15 Blend	**80**	67	63	62	**63**
Site 4 70/30 Blend	**72**	70	63	59	**63**
Site 5 70/30 Blend	**78**	72	64	62	**60**
Site 5A 70/30 Blend	**72**	67	64	61	**62**
Site 7 70/30 Blend	**81**	69	62	61	**59**
Site 2 50/50 Blend	**84**	75	69	68	**68**
Site 8 50/50 Blend	**85**	75	70	70	**68**

Table 4. Friction Mean Value (British Pendulum)

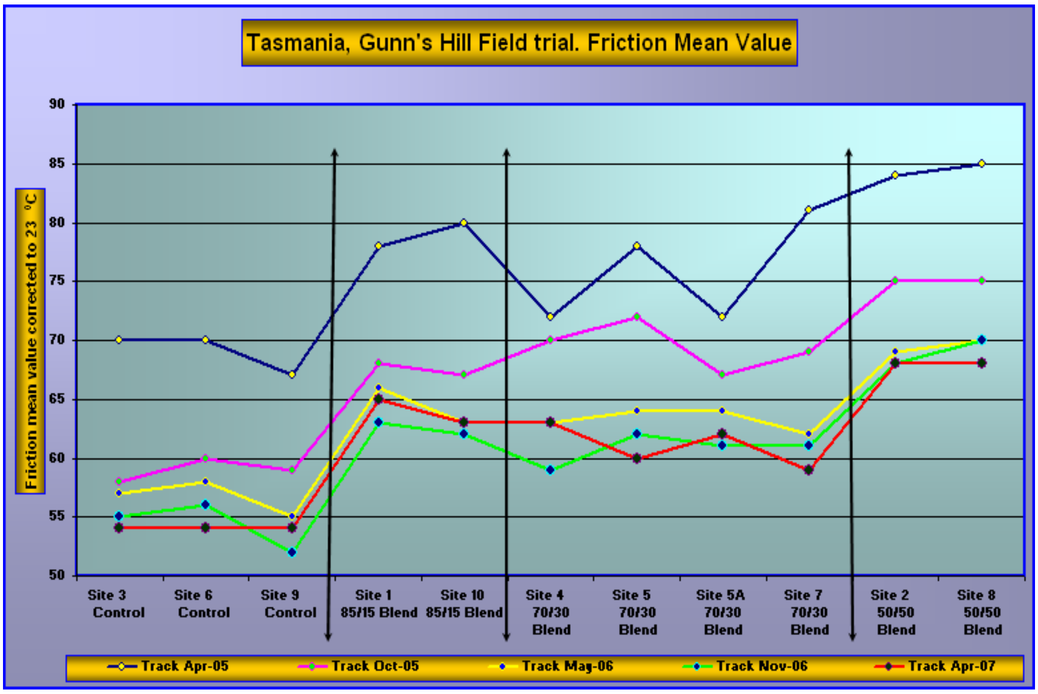

Figure 8. Friction Mean Value

4.3.1 Friction Value Results

The skid resistance monitoring of the sites took place over a 24 month period of traffic. It was concluded that:

* After 24 months of heavy traffic, the skid resistance of the 3 blends is higher than control
  18.5% higher for 85/15 blend
  12.5% higher for 70/30 blend
  25.9% higher for 50/50 blend

* Over the same period of time the drop in the friction value was 21.6% for control (basalt) and at around 19-19.5% for the blends.
* There was a relatively low drop in the friction value in the last 6 months of the assessment for control areas and blends as well.

4.3.2 Texture Depth

The surface texture depth carried out as per the RTA T240 test method was measured over the 24 months of assessment on the same sites.

The surface texture results are presented in Table 5 with a graphical representation in *Figure 9*.

The results are above the indicative investigation levels (0.6 – 0.9mm) for control and blends as well.

Site	Track Apr-05	Track Oct-05	Track May-06	Off May-06	Track Nov-06	Off Nov-06	Track Apr-07	Off Apr-07
Site 3 Control	**4.3**	3.5	1.9	4.4	1.6	2.4	**1.0**	2.2
Site 6 Control	**3.4**	3.6	2.6	4.7	2.5	3.2	**2.8**	3.6
Site 9 Control	**3.6**	1.9	1.1	4.0	1.5	2.9	**1.1**	2.8
Site 1 85/15	**3.6**	3.6	2.5	3.4	2.3	3.3	**2.3**	3.1
Site 10 85/15	**3.8**	3.3	2.3	3.5	2.3	2.7	**2.4**	3.0
Site 4 70/30	**4.5**	3.5	2.6	4.1	2.1	3.4	**2.4**	3.9
Site 5 70/30	**3.9**	3.8	2.3	3.8	2.0	3.0	**2.4**	3.6
Site 5A 70/30		3.4	2.5	4.2	2.0	3.9	**2.8**	3.6
Site 7 70/30	**3.2**	3.6	2.3	4.4	2.4	3.7	**2.5**	3.6
Site 2 50/50	**4.2**	3.1	2.0	4.0	2.0	3.2	**2.1**	3.3
Site 8 50/50	**3.1**	3.2	2.7	3.9	1.6	3.6	**2.2**	3.6

Table 5. Surface texture depth over 24 months of traffic.

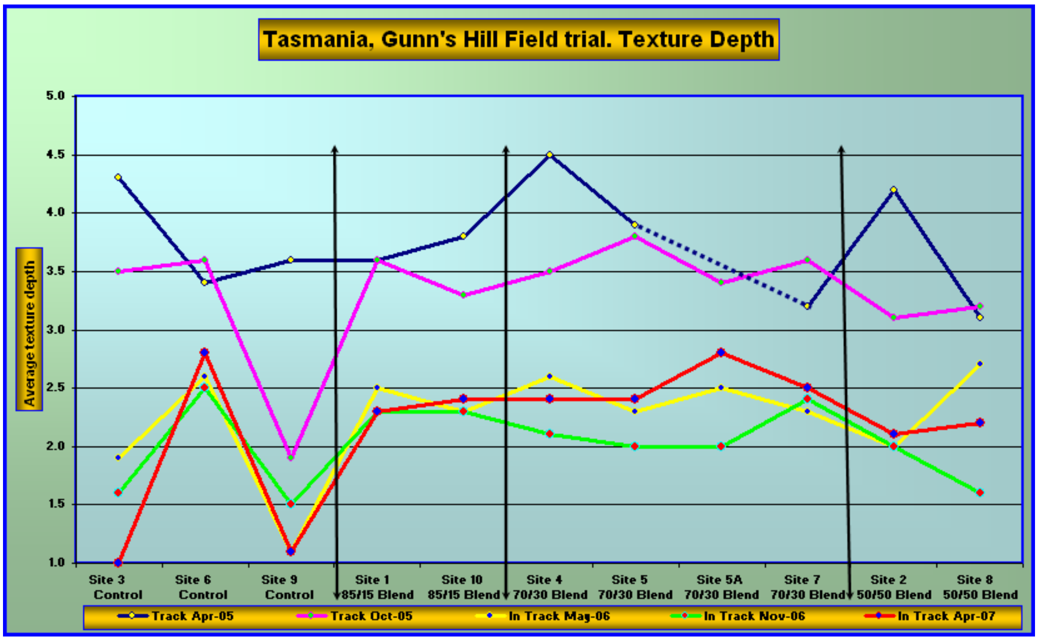

Figure 9. Graphical representation of the Texture Depth

4.3.3 Sideways Coefficient of Friction (SCF) Assessment

SCF assessment over part of the trialled area was carried out in March 2006 by DIER using SCRIM equipment. The results presented in Table 6 and *Figure 10* clearly demonstrates that the blend materials areas are performing better than the control areas for both PD and CD directions.

	PD			CD			Chainage
	Left	Ave.	Right	Right	Ave.	Left	7.195km
Control	64	64	65	65	64	63	6.995km
Blend 70/30	63	64	66	68	67	66	6.895km
Control	63	64	65	66	64	63	6.795km
Blend 50/50	67	68	68	70	70	69	6.695km
Control	61	62	64	67	64	61	6.595km
Blend 85/15	61	62	63	68	65	63	6.495km
Control	61	62	63	69	65	61	6.395km

Table 6. SCRIM Assessment Average Results

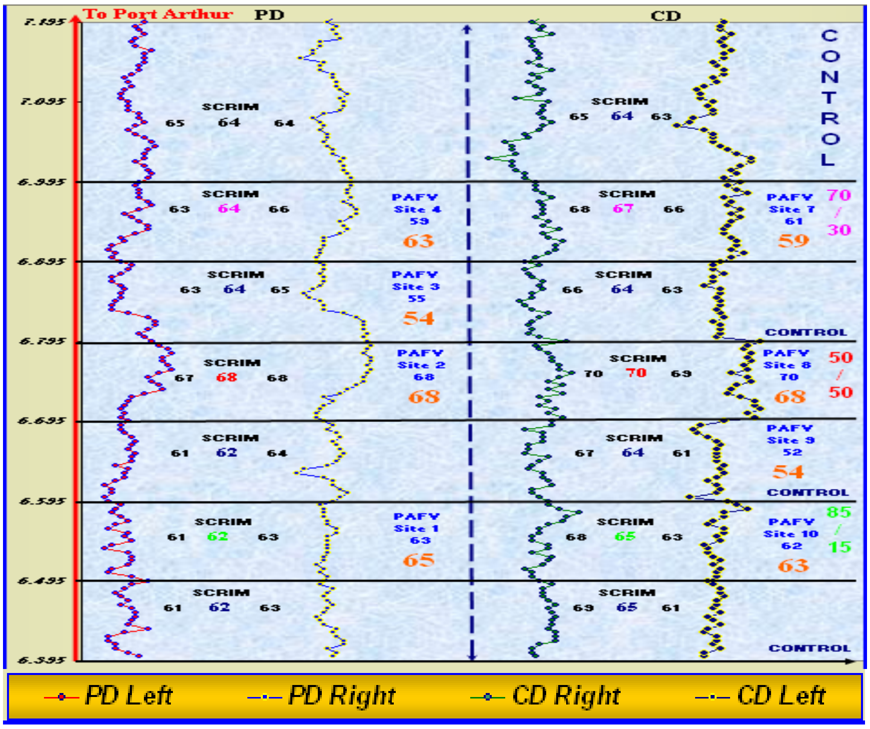

Figure 10. SCRIM – Assessment of Skid Resistance

The SCRIM results are following the PAFV trend as measured using the British Pendulum. After 24 months of traffic, the SCRIM results are well above the indicative investigation level of 35 and the blends results are higher than the control.

The high skid resistance for the 50/50 blends is to be noted for both British Pendulum and SCRIM tests.

5. CONCLUSIONS AND RECOMMENDATIONS

There is not enough information linking skid resistance with traffic accidents. However, it is important to note that at the 12th ARRB Conference, 1984 in Hobart, one of the publications concentrated on the evaluation of four pavement treatments in Sydney in relation to crash reduction skid resistance and cost (13). Based on data accumulated over a period of time, it was concluded that the area where a volcanic rhyolitic tuff was used, the change in accident frequency showed a 28% decrease (Table 7).

Treatment type	Change in Accident Frequency	Level of significance
River Gravel	10% decrease	Not significant
Rhyolite (tuff)	28% decrease	90%
Sand/Tar Plant Mix	24% decrease	83%

Table 7. Statistical analysis of crash reduction

According to the abovementioned document, "in August 1983, the decision was made for Rhyolite asphalt to be used routinely by the Department (now Roads Traffic Authority) as the surface treatment when surfacing or resurfacing the approaches to traffic control signals and similar regulated sites". The treatment is extended approximately 50m from the stop-line on the approach sides of sites and is also being used over bridges areas.

Based on work carried out at Gunn's Hill field trial in Tasmania, it is concluded that:

Although the PAFV of road-making aggregates is not a sole parameter for acceptance or rejection of the skid resistance of a road surface, the field assessment using the British Pendulum has clearly demonstrated that:

- After 24 months of traffic all blended materials areas are performing well, with no further visual stripping and no signs of rutting.
- The average skid resistance value is the lowest for Control areas and highest for the 50/50% blend area. The skid resistance is 18.5% higher for the 85/15 blend, 12.9% higher for the 70/30 blend and 25.9% higher for the 50/50 blend.
- The "drop" in the skid resistance value after 24 months of traffic is lower in all blends areas when compared with the control areas.

- SCRIM assessment carried out by DIER in March 2006 also demonstrated that the skid resistance for the blended materials areas are higher than for the Control areas. Although there are no direct ways to compare the SCRIM data with the British Pendulum results, the high skid resistance results for 50/50% blend area is noted for both methods.
- The Surface Texture Depth after 24 months of traffic shows that the results for all Control and blends areas are above the Indicative Investigatory Level for Texture Depth "in" wheel path. The blended aggregate areas are performing better than the Control areas.
- Blended aggregates are highly recommended for busy intersections, roundabouts, well known traffic accident spots.
- The work carried out at Gunn's Hill is to assist DIER in formulating a strategy to manage high skid resistance/risk areas in the State roads networks and will have the added benefit of extending the resource of high quality and scarce aggregates.
- Safer roads can be built in Tasmania in areas where high skid resistance aggregates are not readily available.

Note:
We would like to express our gratitude to DIER's experts involved in this project, for their effort in making it a success. We also would like to thank Roadways for ensuring excellent traffic control during field work.

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