



# Research

Best Practices  
For Maintaining And Upgrading  
Aggregate Roads In Australia  
And New Zealand



Minnesota Local  
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Best Practices for Maintaining and Upgrading  
Aggregate Roads  
in Australia and New Zealand

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## Chapter 1. Introduction

International experiences will be helpful in developing better methods to maintain and upgrade aggregate roads. Australia and New Zealand are likely locations to have best practices in this field:

- They have a light population density and an extensive network of roads.
- Many roads have aggregate surfaces.
- Many paved roads are numerous layers of sealcoat that were built up from aggregate roads.

The author spent his Sabbatical at the University of New South Wales from January to June 2001. During his sabbatical, the author interviewed personnel from Australia's six states and two territories, as well as New Zealand.

The best practices in maintaining and upgrading aggregate roads are documented in this report, which is divided into seven Chapters. Chapter 1 is this chapter, the introduction. The balance of this chapter gives an overview of the countries and the roads systems of Australia and New Zealand respectively. Most of the information for these chapters come from Austroads (2000) [AUSTROADS (2000). *RoadFacts 2000: An overview of the Australian and the New Zealand road systems*, (AUSTROADS: Sydney, Australia).] with additional information coming from NOLG (2001) [NLOG (2001) *Local Government National Report: 1999-2000 Report on the Operation of the Local Government (Financial Assistance) Act 1995*, (National Office of Local Government: Canberra ACT, Australia). Chapter 2 describes local roads in Australia and New

Zealand. Chapter 3 describes the design, construction and maintenance of aggregate roads. Chapter 4 describes how aggregate roads are upgraded in Australia and New Zealand. Chapter 5 describes maintenance by contract and Chapter 6 gives the conclusions. The points of contact for these interviews are listed in Appendix A. Appendix B provides a narrative description of selected interviews and field trips that provides greater detail than the summary in the regular chapters.

### **Australia**

Australia (Figure 1.1) embraces a continent, which covers an area 78% as large as the United States, yet its population is only 7% of the US population. It is a land of extremes that includes rainforests, deserts, mountains, temperate areas, and tropical areas that are subject to monsoons rainy seasons and hurricanes. This means that a small population faces extensive challenges in maintaining a transportation network over a vast and difficult continent.

Much of Australia's population is concentrated in coastal areas and in major cities. Eighty five percent of the population lives in urban areas, 72% live in state or territory capitals and 39% live in the two largest cities of Sydney and Melbourne. The country has an 500,000 mi (800,000 km) road network which ranges from urban freeways to trails that receive no maintenance and are only passable by four wheel drive vehicles. Ninety percent of vehicle miles are driven on only 20% of the road miles, leaving the remaining 80% of the roads with only 10 percent of the vehicle miles. Of Australia's roads, 40%

are Bitumen or Concrete, 40% are aggregate or some other improved surface, while the remaining roads are surfaced only with native materials.

Australia has three levels of government that have responsibility for road funding, construction and maintenance: Commonwealth, state or territory, and local. Combined expenditures for roads in 1998 was US\$ 3,507 (AU\$ 7,014) million. This amount was largely financed from general government revenue. Although fuel taxes and various other road-related taxes are levied, Australia does not have a dedicated funding source for roads, such as the Road Use Tax Fund in the US; not all money raised from road sources is returned for road use.

State and territory government agencies have primary responsibility for main roads including urban arterial, and have considerable independence in developing policy. There are seven states and two territories, one of which is the Australian Capital Territory (roughly equivalent to Washington D. C in the US). In 1998, combined expenditures for states and territories were \$US1,689 (AU\$3,378) million. Especially in remote areas, the states maintain and construct aggregate surface roads. In addition, a considerable proportion of main roads are constructed with granular bases (sometimes stabilized) and seal coat or thin hot mix asphalt (HMA) surfaces. In some cases such designs are used for urban freeways. Designs involving structural HMA and Portland Cement Concrete (PCC), except in rare instances, limited to freeways and urban arterials.

With regard to highways and roads, the Commonwealth's role is limited to funding, coordination and encouraging cooperation with national policies (See Appendix C for more information). Total funding in 1998 was US\$ 818 (AU\$1,636) million. It completely funds the maintenance and construction of the 11,200 mi (18,000 km) National Highway System, while state and local governments execute the actual work. Additional funding is provided for targeted safety improvements and Roads of National Importance (a separate category from the National Highway System). The commonwealth also provides grants to local governments that may be used for highways and roads but are not tied to this purpose. In making these grants, the government compares the demand for services and the capacity to raise revenue for each local government. In general, the more remote government units have the largest shortfall and therefore receive the most assistance.

Local government units are primarily responsible for local roads. In addition, some local governments receive state funds in exchange for maintaining main roads. Total local funding in 1998 was US\$1,000 (AU\$2,000) million with 71% coming from local sources (primarily property taxes) and the rest coming from commonwealth, state and private sources. Rural areas received a higher percentage of commonwealth and state funds while urban areas had more private funding. Private funds are usually the result of agreements with developers to improve road access in anticipation of new construction.

In Australia, there are 730 local governments are called councils, shires or aboriginal local government bodies. In most cases, the local government boundaries include several

populated areas and the surrounding rural hinterland. Seldom do separate local governments exist for populated areas and the surrounding countryside, in the way the municipalities and counties exist in the United States. In large urban areas, the area enclosed by what would be a city municipal boundary in the US, often consists of a number of councils in Australia. In certain remote areas local governments do not exist and all services, including roads, are provided by the state or territory. Also, the Australian Capital Territory has not created local governments.

It should be noted that mechanisms for the creation and operation of local governments is completely vested in the state and territorial governments. Therefore, there are considerable differences in local governments for one state to another. There have been efforts to amalgamate local governments in Victoria, Tasmania and South Australia, and to a lesser extent in New South Wales.

There has been a general movement toward greater accountability and less employment for government agencies. In some case, attempts have been made to increase accountability by using measures similar to those used by commercial entities.

Privatizing government operations has also been pursued. In some cases, rules have been developed to corporatise government entities, including road maintenance units, with the expectation that they will compete for work with the private sector.

## **New Zealand**

New Zealand (Figure 1.2) lies 1000 mi (1600 km) east of Australia and consists of two major islands, North Island and South Island. It has a temperate climate, and much of the land, particularly on the South Island, is mountainous. New Zealand has a land area of 110,000 mi<sup>2</sup> (286,021 km<sup>2</sup>) and a population of 3.8 million. Like Australia eighty-five percent of New Zealand's people live in urban areas, with 70% living in towns with a population greater than 30,000. The largest urban areas is Auckland with a population of just over one million is located in the northern part of the North Island. Christchurch, is the largest city on the south island and the third largest city in New Zealand with a population of 340,000. The capital city Wellington, at the southern tip of the North Island, is the second largest city in New Zealand with a population slightly larger than Christchurch.

New Zealand has 57,000 mi (92, 000 km) of roads. Only 11.5 % are state highways, yet they carry 46% of the traffic. Sixty percent of New Zealand's roads are bitumen or concrete. Seventy-seven local units of government and one national agency, Transit New Zealand, administer road design, construction and maintenance. Transit New Zealand is responsible for the state road network, while local government is responsible for local roads. Local government entities in New Zealand are similar to those in Australia.

In 1998, highway expenditures were US\$ 498 (AU\$ 996) million. New Zealand uses a funder/purchaser model to finance road costs. Agencies obtain funding from the National Road Fund, which is administered by Transfund New Zealand. Transfund distributes the

funding amongst all agencies using a structured negotiation procedure. Agencies propose annual budgets to fund projects. The proposals include cost/benefit analyses. Transfund reviews the projects and the cost benefit analyses to ensure that sufficient maintenance is being performed to prevent road assets from being depleted and that sufficient benefit is derived from construction projects. Transfund also watches for overly lavish spending on a small group of assets. Funding from TransFund must be expended by competitive bid. New Zealand leads Australia in efforts to privatize road design, construction and maintenance.

### **Comparisons Amongst Australia, New Zealand and the United States**

Australia and New Zealand have more persons per vehicle (1.7 vs. 1.3) and fewer vehicle miles per capita than the US (5610 and 5157 vs. 9071 mi/capita [9,027 and 8,327 vs. 14,595 km/capita]). The US and Australia's fatality rates per vehicle mile are similar, although New Zealand's is slightly less than 50% higher. Australia has a little more than half the people per mile of road as either the US or New Zealand (37 vs. 67 and 66 people per mi [23 vs. 42 and 41 people per km]). Because the cost of roads is spread out over fewer people and because each person drives less, Australia's cost per mile traveled is much higher than that of either the US or New Zealand (\$US 0.020 vs. 0.013 and 0.015 [AU \$0.041 vs. 0.026 and 0.031]). Australia's per capita expenditure on roads is slightly less than that of the US and considerably higher than New Zealand (\$US184 vs. 196 and 130 [AU\$369 vs. 392 and 261]). Australia's expenditures per mile are somewhat less than those of New Zealand and considerably less than those of the US (\$US 7000 vs. 8653 and 13,000 per mi [AU\$8736 vs. 10,817 and 16,352 per km]).

In summary, even though Australians invest considerably more per mile of travel in their roads, the road network must be sustained for considerably less money per mile of road. Australia misses the economies of scale that come from having a large population with concentrated driving a limited number of roads. New Zealand has more concentrated road use and, therefore, is able to limit road expenditures.



## **Chapter 2. Local Rural Roads in Australia and New**

### **Zealand: General Observations**

In general, there are several differences between local rural roads in Australia and New Zealand and those found in the Upper Midwestern United States. Understanding these differences will help readers understand the possible applicability of Australian and New Zealand methods to roads in the upper mid-west.

Most local roads in Australia and New Zealand started as wagon tracks that followed the contours of the land and avoided obstacles in order to connect users. This is in contrast to the grid system that is prevalent in the upper Midwest. Embankment heights and cut depths lower than those found in the upper Midwest and right of ways are usually smaller.

The author's conversations with road maintenance officials in Australia and New Zealand indicate that aggregate roads are graded with less frequency compared to typical practices in the upper Midwest. The best practice is to provide greater cross fall (4%) to promote drainage and a road surface with a higher clay content to prevent raveling. Well-maintained roads have less loose material compared to US practice, but are more prone to developing potholes in area where water stands. The steeper cross fall was noticeable to the author; however, it did not appear that drivers had a greater tendency to straddle the middle to avoid the tendency for the vehicle to steer to the edge of the road. Although opinions varied, 200 vehicles per day was often considered the upper traffic limit for an aggregate road.

Roads that have bound surfaces are usually an unbound aggregate base covered with seal coat. If hot mix asphalt is used, it primarily functions as a flexible wearing course and seldom exceeds 2 in. (25 mm) in thickness; with only unbound aggregate providing structure. PCC paving is seldom used to upgrade aggregate roads, although the Cement and Concrete Association of Australia has documented some exceptions. (eg. *Road Note*, January 2001, Cement and Concrete Association of Australia, Sydney, Lock Bag 2010, St Leonards, NSW 1590, [www.concrete.net.au](http://www.concrete.net.au)).

Standard nomenclature gives insight into the expectations that Australian and New Zealand Road engineers have with regard to materials. When aggregate is intended to provide structure for a road, it is called a “pavement.” Pavements that carry loads primarily through unbound materials (or materials that behave like unbound materials) are called “flexible pavements.” Roads that carry significant loads in hot mix asphalt layers are called “semi-rigid pavements.” As in the US, PCC concrete is termed “rigid pavement” as well as cementiously treated bases that have relatively high contents to cemetitioius binders.

Differences in axle loads should be considered when comparing road practices between Australia and New Zealand and the US.

	<b>US (Iowa)</b>	<b>NZ</b>	<b>Australia</b>	
<b>Configuration</b>	<b>Max Axle kips (tonne)</b>	<b>Max Axle kips (tonne)</b>	<b>Std Axle kips (tonne) [kN]</b>	<b>Max' Axle kips (tonne)</b>

	[kN]	[kN]		[kN]
Single Axle with Single Tires	20* (9.1) [89]	13.2 (6.0) [59]	11.9 (5.4) [53]	13.2 (6.0) [59]
Single Axle with Dual Tires	20 (9.1) [89]	18.1 (8.2) [80]	18.1 (8.2) [80]	19.8 (9.0) [88]
Tandem Axle with Dual Tires	34 (15.4) [151]	32.0 <sup>1</sup> (14.5) [143]	30.0 (13.6) [135]	36.4 (16.5) [162]
Triple Axle with Dual Tires	42 (19.0) [186]	38.6 <sup>1</sup> (17.5) [173]	40.8 (18.5) [181]	44 (20.0) [196]

\*In many cases, this cannot be achieved due vehicle and tire limitations

<sup>1</sup>Legal under certain circumstances

<sup>1</sup>Axel spacing less than 51 in (1.3 m)

<sup>3</sup>Axel spacing between 94 and 98 in (2.4 and 2.49 m)

#### *Table 2.1 Axle Loads*

Most semi-trailer combinations have triple rear axles at the back end of the trailer. These cause considerable scuffing during turns which affects road surfaces.

Two references give an excellent overview of best practices in local road design, maintenance and construction in Australia and New Zealand. The *Unsealed Roads Manual: Guidelines to Good Practice* (G. Giummerra, ed, rev. 2000, ARRB Transport Research Limited, 500 Burwood Highway, Vermont South, VIC 3133) provides information on aggregate roads. The *Sealed Local Roads Manual: Guidelines to Good Practice for the Construction, Maintenance and Rehabilitation of Pavements* (G. Giummerra, ed. August 1995, , ARRB Transport Research Limited, 500 Burwood Highway, Vermont South, VIC 3133) provides information on seal coat, hot and cold mix asphalt, stabilized and concrete roads. The following narrative summarizes Australian and New Zealand practices that differ from US practices as documented in these

references. Additional insight was obtained from other literature and numerous interviews and personal observations.



## Chapter 3. Aggregate Roads

### Crossfall

In comparison with upper Midwest practices, aggregate roads are designed with a greater cross-fall in order to promote surface drainage. The intention is to provide a four percent cross-fall on a crowned section during most of its life. Conversations with road engineers indicate that roads are sometimes graded initially to a higher cross-fall (up to 6%) with the expectation that the cross-fall will decrease with time. Six percent cross-fall is sometimes specified for curve superelevation. As in the best US practice, parabolic crowns are discouraged to prevent water from standing on the centerline.

### Materials

Prior to material selection and thickness design, a subgrade evaluation is often conducted. Dynamic cone penetrometer tests are often conducted in order to estimate the subgrade California Bearing Ratio (CBR). Actual CBR tests or presumptive values may also be used.

Often, unsealed roads are built in two layers: a structural base layer and a surface layer (Figure 3.1). The base layer is designed for aggregate interlock to provide load-carrying capability. The upper layer is designed to provide a hard crust that will reduce tire wear and raveling. For certain roads built on hard subgrade or with light traffic, only one layer

may be required. In this case, that one layer will have to be a compromise between the two previously mentioned layers.

The *Unsealed Roads Manual* suggests method for determining base course thickness that refers to the chart shown in Figure 3.2. This chart provides a pavement thickness (80% confidence) for a road that is intended to have a seal coat or thin HMA (2 in or 50 mm or less) surface given the number of expected equivalent standard axle loads. For aggregate roads, this thickness is often reduced by 2 to 4 in (50 to 100 mm) because the consequences of failure are not a great for aggregate road compared to bound surface roads. Wheel ruts and other minor imperfections are periodically graded out. There is also the opportunity to easily add more aggregate when necessary. The pavement thickness includes both the base course and the wearing course. An alternative to using Figure 3.2, is to provide a nominal thickness of 4 to 6 in (100 to 150 mm).

The recommended particle size distribution for base course is given in Table 3.1. The CBR should be at least 60% and the PI should be less than 6 in areas where rainfall is more than 24 in (600 mm) per year. The PI should be less than 10 in areas where rainfall is less than 24 in (600 mm) per year.

Sieve size (mm)	Permitted grading of production (% Passing)					
	Nominal size (mm)					
	40 a	40 b	30 a	30 b	20 a	20 b
53.0	100	100	-	-	-	-
37.5	97-100	95-100	100	100	-	-
26.5	90-95	86-95	96-100	98-100	100	100
19.0	-	-	-	-	93-100	93-100
9.5	48-67	50-74	58-75	60-82	64-85	71-87
4.75	31-48	35-59	37-56	42-66	44-64	47-70
2.36	22-34	25-46	28-42	30-52	32-47	35-56
0.425	10-18	10-26	11-20	12-30	13-22	14-32
0.075	4-10	4-17	4-11	4-18	3-11	6-20

*Table 3.1 Recommended grading limits for bases: crushed rock (a) and natural gravels (b)*

(Source: Mulholland 1989)

Wearing courses must be sufficiently cohesive to minimize the amount of loose material, limit permeability and promote compaction. In addition wearing course material must be easily maintained to a smooth condition, have reasonable load carrying capability, and adequate skid resistance. Well-graded gravel with a small amount of clayey fines usually works best. Silt tends to be permeable, ravels under traffic and generates dust. Materials with excessively high clay contents tend to be slippery.

Wearing course should have the following characteristics:

- All materials should pass the 1-1/8 in (26.5 mm) sieve for ease of finishing and grading.
- Twenty to 60 % of the material should be retained on the 2.36 mm sieve. If more than 60% is retained the material has too many stones. If less than 20% is retained, the material may have poor wet stability and be subject to erosion.

- The sand ratio should be between 0.2 and 0.4. The sand ratio is defined thus:

% less than #200 (0.075 mm)

-----

% less than #8 (2.36 mm)

- Low sand ratios usually result in a porous and raveling surface. In some cases a high sand ratio can be tolerated if the fines have a high binding capability.
- The PI should be between 4 and 15. Use lower ranges for wet climates and higher ranges for dry climates.
- The product of the PI × % passing #40 (0.425 mm) sieve must not exceed 300 to 400 (exact number to be chosen by specifier). This criteria is used to limit the combined effects of high fines and high plasticity.

Jones and Paige-Green (1996) (Jones, D. and Paige-Green, P. (1996). “The development of performance related material specifications and the role of dust palliatives in the up grading of unpaved roads.” *Proceedings of the Roads 96 Conference*, Christchurch, Vol3, pp 199-212. ARRB Transport Research, Vermont South, VIC, Australia.)

developed two additional criteria (Figure 3.3):

- The shrinkage product (linear shrinkage × % passing #40 [.0425 mm] sieve) should be between 100 and 365. The value should be less than 240 if fugitive dust is an issue. If this value exceeds 365, the road will likely be slippery. If the value is less

than 100, the road will likely ravel and corrugate. Linear shrinkage is defined as the percentage of decrease in volume of the fine fraction of a soil after drying. The soil is molded wet at approximately the liquid limit.

- The grading coefficient ( $([\% \text{ passing } 1.06 \text{ in } \{26.5 \text{ mm}\} - \% \text{ passing } \#10 \{2.0 \text{ mm}\}] \times \% \text{ passing } \#4 [4.75 \text{ mm}]/100)$  should be between 16 and 34. If this value greater than 34 the material will likely ravel, while if it is less than 16 it will be prone to erosion.

In a personal communication Dr Alan Ferry provided the author with a copy of New Zealand Main Highways Board Specification for Top-Course [Wearing Course] Construction dated September 1938. It suggests the following gradation:

<b>Size</b>	<b>Percent</b>
Passing $\frac{3}{4}$ in Circular [ $\frac{5}{8}$ in square, 16 mm]Screen	100
Passing $\frac{1}{4}$ in Circular [No. 4 mesh U. S, 4.76 mm]Screen	60-80
Passing No. 10 mesh (U. S. Series) [1.70 mm]	40-60
Passing No. 50 mesh (U. S. Series) [0.30 mm]	25-35
Passing No. 200 mesh (U. S. Series) [0.075 mm]	10-20

*Table 3.2 New Zealand Main Highways Board Specification for Top-Course Construction*

The document also requires a tensile breaking strength for the fine fraction (molded and dried) of not less than 10 lb/in<sup>2</sup> (68.94 Kpa). The mold is shaped per ASTM C190 and the loading rate is 5 lb per sec (22.4 n/sec). The linear shrinkage should not exceed 5%.

This document also provides practical advice obtaining and mixing materials to produce wearing course. This advice is summarized below:

- Approximate proportions are three parts screened gravel ( $3/4 \times \#10$  [ $19 \times 1.70$  mm]), 2 parts graded sand, and 1 part clay.
- Strip the clay borrow area and allow the top surface of the clay to dry. Remove a dry layer of clay. This exposes the next layer allowing it to dry. Repeat the process to obtain additional clay. Alternatively, excavate the clay from a dry vertical face in a borrow pit.
- Place the gravel and sand on the road in a windrow, then flatten the windrow.
- Distribute dry clay on the flattened windrow.
- Mix the dry clay in the flattened windrow (the clay will not distribute and mix easily unless it is dry).
- Start mixing the material
- Add water, continue mixing
- Windrow the wearing course to facilitate the next step
- Scarify and water the base material upon which the wearing course will be spread (prevents delaminating)
- Spread the wearing course material, water to optimum moisture content, compact and finish.

The *Unsealed Roads Manual* documents the Clegg Impact Soil Tester (Clegg Hammer) as an expedient compaction test device. Penetration is inferred from the maximum deceleration of a falling mass giving the Clegg impact value (CIV). The mass may be between 0.5 and 20 kg (1.1 to 44 lb), but 4.5 kg (9.9 lb) is standard. The test is repeated

four times at one location. The higher the acceleration, the lower the penetration and the greater the stability of the compacted material.

## **Maintenance**

Maintenance interventions are considered at four levels:

- Light formation grading – Cutting 1 in (25 mm) into the road surface, redistributing the material and smoothing the road. This is best done when the road surface is moist after a rain.
- Medium formation grading – Cutting the road to a depth of 2 in (50 mm), redistributing the material, watering and compacting the road.
- Heavy formation grading – Ripping the road to a depth of 4 in (100 mm), redistributing the material, watering and compacting the road. If a separate wearing course exists, the ripping depth may be limited to the wearing course depth.
- Resheeting (adding aggregate) – Additional wearing course is added to a maximum depth of 4 in (100 mm). It is watered and compacted.

Based on the author's observations, watering and compaction as part of maintenance are more common in Australia and New Zealand than they are in the upper Midwest. In Australia and New Zealand, it is unusual for aggregate to be added without watering and compaction.

A study conducted in South Australia shows the importance of wet maintenance for aggregate roads (ARRB Transport Research, (1999). *Outback Unsealed Roads*

*Maintenance for North West Region – Preliminary Evaluation: wet versus dry maintenance*” ARRBTR Report RC90175-1). Despite extremely high costs to obtain water in a desert environment (including well drilling, pump installation and holding pond construction), and economic analysis showed that wet maintenance cost was only 2% more per kilometer than dry maintenance. The hard surface that results from wet maintenance provides a better ride and improves aggregate retention. It is expected that re-grading will be required only once per year and that new aggregate will only be required once every 12 to 20 years.

Wet maintenance allows expedient application of liquid chemical stabilizers (dust palliatives) that may be mixed with water and applied with a water truck. Road graders can mix the waterborne chemicals with the road surface. Andrews (Andrews, R. C, (2001) “Opportunities for Improved Unsealed Road Asset Management with Chemical Stabilisation,” 20<sup>th</sup> ARRB Transport Research Conference, Melbourne, Australia) compared a number of proprietary chemical dust palliatives in field trails. After conducting an economic analysis he concluded that some of the products provided additional benefits beyond wet maintenance. Cost savings come from improved aggregate retention and reduction in maintenance interventions. The use of those products would be most helpful in high wear areas. Most of the savings came from reducing the addition of aggregate and reducing the frequency of maintenance interventions.

Foley, *et. al.* (1996) (Foley, G., Cropley, S., and Giummarra, G., (1996). *Dust Control Techniques: Evaluation of Chemical Dust Suppressants' Performance*, Special Report 54, ARRB Transport Research, Vermont South, VIC, Australia) provide additional information on dust suppression techniques in Australia and New Zealand. Note that proper design, construction and maintenance of the wearing course according to the previously described methods is often sufficiently effective to eliminate the need for Chemical Stabilizers.

Because of material selection and maintenance practices, potholes are often the first failure that must be addressed for Australian and New Zealand aggregate roads.

Therefore, maintenance crews will specifically repair potholes.

The author visited one council that had developed a system for scheduling maintenance. Before developing the new system, Cessnock Council, New South Wales performed maintenance on an ad hoc basis, primarily responding to complaints. Vehicle count, road alignment and road materials now determine the time between maintenance interventions. Under normal conditions, road users and neighbors are assured that maintenance crews will return according to this schedule. When bad weather or machine breakdown divert crews, the system provides a structure to help decide how to restart normal operations or how to prioritize stopgap maintenance. When managers field calls from the public, they can refer to a policy that has been thought out ahead of time instead of negotiating each request on a case by case basis.



## Chapter 4. Upgrading Aggregate Roads

When aggregate roads are upgraded to a bound surface in Australia and New Zealand, the upgraded surface is usually a sealcoat. In most cases, unbound aggregate provides structural support; however, stabilization is sometimes necessary in particular circumstances. Before a road is upgraded, consideration is given to realignment to accommodate higher vehicle speed. The cost for grading such realignments is often minimal because most roads are on low embankments that require little earthmoving. There are exceptions in rough terrain and where right of way acquisition is required.

### Aggregate Base and Sub-base

Aggregate base and sub-base are used for both sealcoat roads and thin hot mix asphalt surfacing. Aggregate base and sub-base are similar to those given for aggregate roads (Table 4.1).

Sieve Size (mm)	Permitted Grading of Production (% Passing)		
	Nominal Size (mm)		
	40	30	20
53.0	100	-	-
37.5	97-100	100	-
26.5	90-95	96-100	100
19.0	-	-	93-100
9.5	48-67	58-75	64-85
4.75	31-48	37-56	44-64
2.36	22-34	28-42	32-47
0.425	10-18	11-20	13-22
0.075	4-10	4-11	3-11

(Source: Mulholland 1989)

*Table 4.1 (a) Recommended Grading Limits for Bases: Crushed Rocks (SA 1983)*

Sieve Size (mm)	Permitted Grading of Production (% Passing)		
	Nominal Size (mm)		
	40	30	20
53.0	100	-	-
37.5	95-100	100	-

26.5	86-95	98-100	100
19.0	-	-	93-100
9.5	50-74	60-82	71-87
4.75	35-59	42-66	47-70
2.36	25-46	30-52	35-56
0.425	10-26	12-30	14-32
0.075	4-17	4-8	6-20

(Source: Mulholland 1989)

*Table 4.1 (b) Recommended Grading Limits for Bases: Natural Gravels (NAASRA 1974)*

Sieve Size (mm)	Permitted Grading of Production (% Passing)		
	Nominal Size (mm)		
	40	30	20
53.0	100	-	-
37.5	90-100	100	-
26.5	80-87	90-100	100
19.0	-	-	90-100
9.5	47-62	52-66	68-78
4.75	32-48	35-51	46-62
2.36	22-38	24-40	32-48
0.425	8-21	9-22	12-26
0.075	3-11	4-12	5-14

(Source: Mulholland 1989)

*Table 4.1 (c) Recommended Grading Limits for Sub-Bases: Crushed Rocks (SA 1983)*

Sieve Size (mm)	Permitted Grading of Production (% Passing)		
	Nominal Size (mm)		
	40	30	20
53.0	100	-	-
37.5	95-100	100	-
26.5	80-97	96-100	100
19.0	-	-	96-100
9.5	48-85	57-87	65-89
4.75	35-73	42-75	47-80
2.36	25-58	30-60	32-67
0.425	10-33	13-37	14-42
0.075	3-21	5-24	6-26

(Source: Mulholland 1989)

*Table 4.1 (d) Recommended Grading Limits for Sub-Bases: Natural Gravels*

Australian standards allow a greater proportion of fine material for natural gravel and sub-bases. Subgrade evaluation procedures are similar to those mentioned for aggregate roads. Thickness design charts are provided in (Figures 4.1, 4.2, and 4.3). The structure is often provided with multiple layers of material that gradually increase in CBR as they

near the surface. The total thickness of combined base and sub-base depends on the CBR of the sub-base. If the sub-base CBR is less than 3%, 6 in (150 mm) of stabilization is required. The sub-base may be a material with a CBR less than 30. If this is the case, higher-grade material must be used for the next layer. The thickness of this high-grade layer is found by assuming that the sub-base is a subgrade with a CBR equal to that of the sub-base. This process is continued until the entire base and sub-base is designed.

The *Sealed Roads Manual* does not explicitly state a minimum CBR for the top layer. An example is provided where the top layer CBR is 80%. The *Unsealed Roads Manual* gives the minimum laboratory soaked CBR for a base course in a rural situation as 60%. The maximum allowable plasticity index for base course in a rainy area is 6% while 10% is allowed in dry areas. A PI of 12% is allowed for sub-base in all areas. Base and sub-base courses are compacted near the optimum moisture content, then required to “dry back” in order to regain stability before surface courses are applied.

The authors observed that in comparison with typical practices in the upper Midwest, practitioners in Australia and New Zealand expend greater effort to ensure the quality of sub-base and base courses. Gradation and compaction requirements are carefully monitored. Also, the dry back requirement enforced in Australia and New Zealand, is not considered in the upper Midwest.

### **Prime or Prime r Seal**

The next step in building a new sealcoat road is to provide a layer of binder that bonds the surface to the aggregate base and penetrates the pores of the base. This is either done

with a primer or a primer seal. If the proposed surface is hot mix asphalt greater than 4 in. (100 mm) in thickness, a primer is not required,

A primer is a layer sprayed cutback asphalt (15 to 20% kerosene). Efforts are underway to use emulsion as a primer. The viscosity and application rate is adjusted for the base course (Table 4.2). No aggregate is provided, except for a small amount of sharp grit if required to maintain local traffic. Primer must be applied to a dry surface during a period of warm weather. Because cover aggregate is not applied, little traffic is allowed (not more than 300 AADT).

Pavement	Cutback Bitumen Primer		
	Grade	Viscosity Pa s. at 60° C	Application Rate L/m <sup>2</sup>
Tightly bonded	Light	0.025-0.05	0.6-1.1
Medium porosity	Medium	0.05-0.08	0.8-1.1
Porous	Heavy-very heavy	0.08-0.4	0.9-1.3
Limestone/sandstone	Heavy-very heavy	0.08-0.4	1.3-1.5*
Stabilized	Very light-light	0.01-0.05	0.5-0.8
Concrete	Very light	0.01-0.02	0.2-0.4

\* Applied in two approximately equal applications, several days apart.

(Source: AAPA 1995)

*Table 4.2 Guide to the Selection of Grade of Primer and Rates of Application*

A primer seal is a layer of cutback asphalt (15 to 20% kerosene) with cover aggregate (Table 4.3). The aggregate size rarely exceeds 10 mm, with 7 mm being common. A primer seal is used when weather conditions are not favorable for a primer or when the road must be trafficked immediately. The use of emulsion is recommended if a final seal coat surface is required within three months of the application of the primer seal. If a sealcoat is applied too early, the primer or the primer seal will bleed through the surface,

because not enough of the kerosene will have evaporated. Note that emulsion should not be used on cement treated bases.

<b>Primerbinder</b>	<b>Grade</b>	<b>When to Use</b>
Cutback bitumen	Light-medium Class 170 plus 20 parts kerosene, approximate viscosity 1.5-3.0 Pa.s at 60°C	Autumn and winter Tightly bonded to medium porosity pavements
	Heavy Class 170 plus 15 parts kerosene, approximate viscosity 4.0-7.0 Pa.s 60° C	Spring and summer Porous pavements
Bitumen emulsion	Generally cationic CRS 60-70% bitumen content	All year, but more suited to cool/damp conditions Porous pavements Final surfacing required within 3 months <b>Not on</b> cement stabilized pavements

*Table 4.3 Guide to the Selection of the Type and Grade of Primerbinder*

During conversations with practitioners in Australia and New Zealand, the importance of properly using primers was consistently a topic of conversation. In the author's experience, this topic is rarely discussed in the upper Midwest. It seems likely that the quality of aggregate road upgrading could be improved in the upper Midwest by considering the use of primers more fully and precisely.

### **Sealcoat**

Because Australia and New Zealand rely heavily on sealcoat roads, sealcoating technology is relatively advanced when compared to the US. However, except for providing sub-base, base and priming (previously described), information given in the *Minnesota Sealcoat Manual* will be adequate for upgrading aggregate roads to sealcoat

roads. This narrative will emphasize information not found in the *Minnesota Seal Coat Manual*.

In general, Australia makes greater use of hot sprayed asphalt cement and cutback binders when compared to the US, especially in the outback. This is done because the transportation costs of emulsion are high compared to those for asphalt cement and cutting oil: The weight of material that must be transported to use emulsion is almost 50% more than that of asphalt cement and cutting oil, given an average project in the Australian Outback [Leach, R., (1998). "A Guide to the Atmospheric Effects and Binder Selection," *Working Document APRG 98/19*]. When sealcoating is executed in the outback, during warm weather, the asphalt cement is not cut back. When the weather cools to the point that cutter is necessary, batches are custom mixed at the construction site to meet the needs of the situation. Thus the amount of cutter used is much less compared to typical operations in the US Upper Midwest. The study found that from an environmental point of view, more hydrocarbons would be released by manufacturing and transporting emulsion than by using cutter oil in the amounts typically used in the outback.

It should be noted that this same study recommends the use of emulsion in urban areas which are close to emulsion manufacturing plants. The author's observations indicated that emulsion was in greater use in densely populated areas and in the colder, southern region. In New Zealand, during interviews the author was told that emulsion is used to

extend the season for sealcoat application, because their emulsions are more robust at low temperature than their cutbacks.

Single size 14mm aggregate is predominantly used in Australia and New Zealand for sealcoat cover aggregate in rural areas. Ten and 7 mm are also used in urban areas.

Some localities are experimenting with graded cover aggregate to reduce noise in urban areas.

Geotechnical fabric seals are in use in Australia and New Zealand. The New South Wales Road and Traffic Authority (NSW RTA (1992) *Guide to the Design, Construction, Maintenance and Management of Clay Pavements with Geotextile Reinforced Seals.*

[Roads and Traffic Authority: Sydney, Australia]) has developed a method for upgrading clay roads using geotechnical fabric. First, the clay base is compacted and allowed to dry back sufficiently to maintain stability but not crack. The geotechnical fabric sealcoat is applied directly to the clay base. The sealcoat maintains the clay at the proper moisture content to maintain stability and avoid cracking. The method appears to be applicable for low traffic roads in hot, dry climates.

During interviews in New Zealand the Author was given anecdotal evidence that the geotechnical fabric seals were successful in mitigating reflective cracking and bleeding when applied to distressed pavements. This technique might be helpful in addressing highly distressed pavements when another option would be reversion to an aggregate surface. In cases where severe alligator cracking is an issue, Australia and New Zealand

road engineers sometimes use a strain alleviating membrane (SAM): a 10 or 14 mm sealcoat using polymer modified binder.

Fiber reinforced seals are available in Australia under the proprietary Fibre Dec trademark. The seal is place using a purpose-built vehicle that performs three operations in one pass. The first operation is to spray a layer of emulsion. In the second operation, glass fibers are cut to a length of 1 to 1-1/4 in (25 to 30 mm) and blown onto the emulsion randomly at a predetermined rate. The third operation is to spray another coat of emulsion. The binder is covered with 10 or 14- mm aggregate using the same methods as for a normal seal. The author did not able to obtain information on the field performance of this system.

### **Hot Mix Asphalt Surfaces**

Hot mix asphalt surfaces are rarely used in Australia in programs to upgrade aggregate roads. Hot mix use is usually limited to urban arterial, some residential streets, main highways with high traffic counts and freeways. At this writing, urban freeways are being built in Perth using thin hot mix surfaces as described below.

In Australia and New Zealand, hot mix asphalt usually serves as a flexible surface membrane to protect the granular material beneath that provides structure. In other words, it takes the place of a seal coat in locations where noise, aesthetics, and stresses from turning and accelerating traffic do not allow the use of seal coats. Hot mix asphalt surfaces are usually 1-1/4 to 2-1/2 in (30 to 60 mm) thick. When these roads are in need

of rehabilitation, an overlay is placed over a strain alleviating membrane interlayer (SAMI). A SAMI is constructed in a manner similar to the previously mentioned SAM. The purpose of the SAM is to limit the amount of reflective cracking. This is necessary because the previously constructed hot mix asphalt surface usually fails with fatigue cracks. After one overlay has been placed, the next rehab cycle will be a mill and fill operation. This is done to limit the surface thickness to 4 in (100 mm). It is thought that hot mix surfaces thicker than 4 in (100 mm) will start to act as a weak structural element and will be subject to severe cracking due to fatigue.

## **Stabilization**

Stabilization is a popular technique for upgrading and rehabilitating roads in Australia for several reasons. In many cases, the haul distance for good aggregates is prohibitive, thus stabilization provides a means for upgrading locally available materials. Many of the roadways that require rehabilitation, have seal coat or thin hot mix surfaces that can be easily stabilized. A vibrant stabilization industry has grown up to meet these needs making expertise, equipment and stabilization agents readily available to perform work that would not be considered viable elsewhere. AustStab, the Australian Stabilization Association maintains excellent offerings of technical information. This material may be obtained through their Website <http://www.auststab.com.au/>.

A considerable amount of cementitious and lime stabilization is performed in Australia. Often the goal of the operation is to modify the material rather than to develop a bound material. When a bound material results from a stabilization operation, there are higher

risks that detrimental cracking will occur, especially for strong, thin layers. In general, a material will behave as an unbound material if the unconfined compression strength is less than 1.0 MPa and the design modulus is less than 1500 MPa. To meet this goal, additives are limited to small percentage of the material by weight. In Australia and New Zealand, dry stabilization agents are usually spread using a purpose-built spreader that accurately distributes the product.

Often stabilization agents are blends for cement, flyash, blast furnace slag and lime. Emulsion and foamed asphalt stabilization may be conducted using the previously mentioned blends as part of the process. These blends and combinations have advantages over pure cement because they are more economical, provide longer working time, are less susceptible to shrinkage cracking, and require less water. Most suppliers of stabilization agents have facilities to manufacture blended products.

Lime and cement stabilization is sometimes conducted in a two step process: First the lime is spread and mixed. Then after the lime cures for a day, a cementitious blend is spread and mixed.

Cementitious and lime stabilization is sometimes part of an effort to upgrade aggregate roads. It is used in areas where locally available aggregate is of poor quality. Also it is used in floodways. These are sections of roads, sometimes up to 0.65 mi (1 km) long, that are inundated during high water. At floodways the road usually comes down from

the embankment and is placed flush with the surrounding surface. In floodways, the base course is often cementitiously stabilized reduce moisture susceptibility.

Although foamed asphalt was developed in the 1950's by Csanyi at Iowa State University, it was put to practical, commercial use in Australia. Mobil oil patented the process in and a few Australian projects were undertaken in the late 1960's. Little further development ensued because of high oil prices in the 1970 and lack of interest on the part of the patent holder in the 1980's. After the patent expired there was resurgence in the use of foamed asphalt technology in the 1990's. Foamed asphalt has been primarily used in Australia to rehabilitate seal coat and thin hot mix pavements. However, it is also used occasionally to upgrade aggregate roads.

Asphalt emulsion is also used as a stabilizing agent in Australia and New Zealand, however its use is similar to that which has been well documented in the US.

### **Maintenance**

Maintenance techniques in Australia and New Zealand are responsive to the types of distress that occur in sealcoat and thin asphalt surface roads. Shoving due to base instability is a common failure mode for seal coat roads. Areas where shoving occurs are usually dug out and patched. The patch may be seal coat or hot mix asphalt. In some cases the new base aggregate is stabilized in the area to be patched. If either hot mix or stabilization is used, care should be taken to ensure that the repair does not block drainage within the base course. Such problems often occur when the outside wheel path

(the most likely location for stability failures) is patched and moisture in the center of the road is prevented from draining out. Often the base will soften under the inside wheel path causing a second failure.

When cracks develop on the surface of cementitious stabilized material, it is critical to halt water ingress. Aggressive crack sealing will mitigate further damage if cracks are small (less than 1/8 in [2 mm]). Added performance may be obtained by incorporating a strip of geotechnical fabric in the crack sealing system.



## Chapter 5. Maintenance Contracts

Almost all road maintenance is outsourced in New Zealand; in Australia, outsourcing is a growing trend. In Australia, the state of Victoria has been a leader in outsourcing since legislation was passed requiring all state and local government agencies to review all services provided in house with an eye to outsourcing items where a better value could be obtained from the private sector. Western Australia has outsourced all road maintenance functions on state highways. Most of the other states have outsourced at least some of their road maintenance functions. Local governments have various policies on out sources. Some do almost all operations on an in-house basis, while others outsource almost everything.

A variety of contractual arrangements are used to facilitate the outsourcing. Many of the contracts are variable quantity unit price contracts. Others are completely performance-based contracts. In these contracts, contractor promises to maintain a certain road network and meet or exceed certain key performance measures such as skid resistance, rut depth, structural integrity and stakeholder satisfaction in responding to complaints. The term of the contracts vary from one to ten years. The size of the road network under contract also varies considerably. [*Maintenance by contract: is it delivering best value? Proceedings of the National Workshop, Melbourne, Australia, November 2000, Edited by P. Robinson, ARRB Transport Research: Vermont South, VIC, Australia*] has documented contractual practices for road maintenance.

As noted previously, some state and local government agencies have been converted to enterprises that are allowed to bid against the private sector for work under a set of rules.

## Chapter 6. Conclusions

Compared to the United States, Australia and New Zealand have fewer resources to invest in road construction and maintenance. Therefore, they have developed systems for economically constructing and maintaining roads. Although there are differences in climate, traffic and road user expectations, road authorities in the upper Midwest have opportunities to transfer technology from Australia and New Zealand.

With regard to aggregate roads, significant economies may be possible by making a number of changes. Wearing courses with higher clay contents reduce raveling, dust and corrugation. A rule of thumb is to have 10 to 20% of the wearing course material pass the #200 (0.075mm) sieve (1938 New Zealand Main Highway Board specification). Other criteria regarding clay content are given under the Section on Aggregate Roads, Subsection on Materials. Designing roads with 4% cross fall encourages water runoff and reduces potholes. Wet compaction a part of construction and maintenance provides a tighter surface that is less prone to water take-up and raveling. Urban freeways in Australia are sometimes built with thick granular layers (18 - 24 in [450-600 mm] for both base and subbase) and 2 in (50 mm) hot mix surfaces. Given climate differences and lack of familiarity with such designs, it is unlikely that such technology could be transferred to the Upper Midwest for freeway designs. However, it would be appropriate to experiment with such designs to extend pavements on lightly traveled roads on the urban fringe. Cementitious stabilization using low percentages of blended products may offer possible improvements for clay sub-grades in Minnesota and foamed asphalt might

be another alternative to be considered for granular soils. New Zealand and the state of Victoria, Australia have completely contracted out road maintenance to the private sector for both state and local governments, while Western Australia Main Roads has embarked on a series of 10 year contracts for road maintenance, some of which are performance based. Other states and local governments in Australia have contracted out maintenance to a greater or lesser degree. For agencies that wish to privatize maintenance, personnel in Australia and New Zealand can share their perspective based on considerable previous experience.

Australia and New Zealand have a wealth of technical information on the topics of this study; this represents an additional resource for practitioners who are interested in this topic.



## Appendix A Points of Contact

Listed below are points of contact made for this study:

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Note:  
Involved with many varieties of surfaced and unsurfaced roads for a council that covers mostly tropical outback area, but also includes some urban area.

## **Queensland**

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Australia

Note:

Works with sealcoat and other surfaces in Queensland

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Note: Works with stabilization in Queensland

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Note:

Has considerable experience with stabilization of expansive soils using cementious/lime agents and road rehabilitation using foamed asphalt.

### **Northern Territory**

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NT

Note:

Aggregate Road Construction in Northern Territory, includes experience with stabilization

### **New Zealand**

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Note:

Interested in the effect of heavy vehicle traffic on low volume roads, particularly logging trucks on seal coat roads.

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Note:

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Note:

Construction materials and road surfacing including hot mix asphalt, slurry seal and seal coat.

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Interested in seal coat roads

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Note:  
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Note:

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Note:

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Note:

Road maintenance issues for a suburban to rural council north of Auckland.

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New Zealand

Note:

Expertise in aggregate road maintenance.



## **Appendix B. Reports on Field Visits**

The following is a summary of some of the field trips and visits that the author undertook as part of this study.

### **Tasmania**

The DIER has several kilometers of aggregate road under its jurisdiction. Occasionally these roads are improved to a bound surface, usually a double or triple seal coat.

The process for upgrading an aggregate road starts with engineering studies. First a safety audit is necessary because it is likely that the average speed of the vehicles will increase when the road is sealed. Before the road is sealed, necessary grading can be accomplished to correct both drainage and safety problems. An economic analysis is also conducted using the Queensland Economic Analysis Method which is based on a procedure developed by the world bank.

Next testing is conducted so pavement design may be undertaken. Benkleman beam tests are executed and test pits are dug to determine available subgrade support. Traffic loads are also considered. In some cases, the upper material is removed because it will be unsuitable to support the improved surface. The objective of the design process is to select the thickness of the granular layer that will underlie the sprayed seal surface.

Common choices are as follows:

- 100 mm for light traffic
- 150 mm for standard traffic
- 200 mm for logging traffic

The construction process is as follows:

1. Grading is executed to correct drainage and improve road alignment and safety.
2. The granular material is placed and compacted
3. A primer seal coat is placed with 10 mm cover aggregate.
4. One year later, the finished seal coat is placed (usually a double seal coat).

DIER has limited experience with stabilization. Most trails have been on main roads.

Cement and bitumen have been used as stabilizing agents. One experience with foamed asphalt was disappointing. Stabilization is currently being conducted for an expressway subgrade west of Launceston.

Tasmania has recently experienced the following costs for work relating to the improvement on unsealed roads:

AUD\$/m <sup>2</sup>	Improvement
2.00	Seal coat
4.50	Reseal including lane markings and traffic control
+1.00	Polymer modified seals
6.00	Geofabric sprayed seal
8.00 – 12.00	Thin asphalt overlay
10.00 - 16.00	Stabilization

*Table B.1 Tasmanian costs for work relating to improvement on unsealed roads.*

DIER maintains its roads by contract with privately held construction companies. The southern region has a lump sum contract with preset intervention levels. The Northern region has a lump sum contract with unit prices for extra items that are ordered by the DIER staff.

Unsealed roads are graded twice a year, once in the autumn and once in the spring. If the roads are graded more frequently, the fine material is lost. Such a loss is especially undesirable in Tasmania, because it is difficult to find road surfacing materials that have fines content that is high enough to cause the surface to set.

Cutbacks are used as binders for sprayed seal work on rural highways. This is because cutbacks have a higher residual bitumen proportion than emulsions and the cost of transportation is relatively high. It is considered uneconomic to transport the water along with the residual bitumen in emulsion.

Snow removal is seldom an issue in Tasmania. Although it does snow in Tasmania, most of the snow occurs in higher elevations where there are few roads and little traffic. Many roads are closed when snow covered. Those that remain open require little snow removal effort.

### **Cardinia Shire Council, Victoria**

Cardinia Shire Council is located at the eastern edge of the Melbourne suburban area. The northern part of the council is a steep, hilly, forested area while the southern part is flat farmland. The middle part has rolling hills and is located along the main transportation corridor to the east of Melbourne; it is experiencing considerable population growth.

In the recent past, the council has provided a salt-based dust control program for aggregate roads. The following problems exist with that approach:

- Grading activities are reduced to conserve the dust suppressant. This results in rougher road surfaces. During wet weather, the road surface softens and ruts unless rock is added.
- Replacement of aggregate surface is expensive; some of the lost aggregate is finding its way into the waterways.
- Currently neighboring property owners only buy the chemical; they do not pay for the additional costs associated with its use
- There are environmental and vehicle corrosion concerns regarding the use of the salt based dust suppressant.

The council has just embarked on a program provide seal coat surfaces for aggregate roads with financial help from the neighboring property owners. It is styled “Black Resheeting.” Resheeting is the Australian term for replacing the aggregate on an unbound road, so “Black Resheeting” communicates to stakeholders that the process saves expense, effort of replacing aggregate on the unbound roads.

The council has tested construction methods on roads in the flat farm area. The process starts by having an engineering firm infer CBR subgrade support values by taking dynamic cone penetrometer readings (typical CBR readings are 8 to 35%). Soil types and aggregate surfacing depths are also noted. Then 50 mm of rock and 1% of cement is added and the road is pulverized to a depth of 250 mm. Then a graded seal coat is

applied (top size 14 mm). These test roads are now a year old and are not showing distress. The graded seal coat provides a dense surface that appears to be appropriate for its intended use.

A process has been developed to allow property owners to request black resheets. First the property owners in an area must organize and request a proposal to upgrade their road. The council will respond with a menu of options (conceptual budget proposals) from a black resheet to full depth pavement, curb and gutter, and underground storm drainage. The property owners may choose from this menu. Because of the low price, it is expected that the black resheet will be preferred in most cases. If the 75 percent of the property owners agree, the council will charge a special assessment and proceed with the project. Property owners are charged \$AU5 /m<sup>2</sup> for their frontage on half the width of the road. If the road handles considerable traffic outside the neighborhood, the council will pay for any extra width that is necessary because of the high traffic load. After construction the council will maintain the road for 5 years at no cost to the owners. The council has a contingency in their budget to pay for the cost of rehabilitating failures over 7% of the surfaces. After five years, the council will make new proposals to upgrade or rehabilitate the road as necessary. It is expected that the typical property owner will contribute \$700 for each project.

One property owner can also request and pay for a black resheet without the help of others, however the minimum length of improvement is 100m.

A contractor who is retained by competitive bidding to provide services for the council at predetermined unit prices for one year will perform the construction. Construction specifications use AUSPEC as a base, so they are harmonized with neighboring councils. It is expected that the council will perform 8k of work this year at approximately \$AU100,000/k.

### **Western Australia**

Western Australia (WA) covers about 33% of the Australian continent, yet it only has 10% of the population and 18% of the road miles. In the area near Perth, its capital, roadbuilders are blessed with strong granular subgrade and a mild climate. Therefore the roads are relatively easy to build and maintain. Strong subgrade also exists in many of the outlying areas also, however in some cases the weather is more extreme. The southwestern corner receives more rain while the north coast has a wet monsoon summer season and occasional visits by cyclones. Natural resources extraction activities (mining and natural gas) have provided a vibrant economy, which support road maintenance and construction activities.

Contacts were made with Main Roads WA, three shires and various contractors.

Road maintenance for Main Roads WA has been contracted out to private industry. This includes on-road and off-road (mowing, trash pick-up, sign maintenance) activities. The road system has been divided into eight networks, and separate ten-year term contracts have been developed for each network.

The 6 networks in the south have been developed as fully performance-based contracts. This means that the contractors' performance is assessed against key performance indicators, such as pavement strength, roughness, rutting, skid resistance and texture on a network wide basis. At the end of the term, the contractor must return the network to Main Roads WA so that a certain percentages of road meet or exceed predetermined measures. The contractor has considerable freedom to select maintenance methods and determine appropriate times to schedule work provided that steady progress is made toward meeting the targets at the end of the term.

The two contracts in the north are mixed contracts using a performance based orientation for the off road portion of the contract and unit prices for the on road portion. Mixed contracts were used in the north, because it was judged that private industry could not take the risk of guaranteeing performance in an area subject to cyclones and tropical storms. For unit price activities, Main Roads WA personnel schedule maintenance activities while the contractor performs the activities for the unit prices.

The successful bidder for the mixed contracts was BGC Contracting. I interviewed Joe Stervaggi, network manager for Network 1 which includes the Broome and Kimberly area in the north east corner of WA. The BGC staff includes 8 to 12 road workers who perform patrol work (minor daily maintenance), four office personnel (engineers and managers) and one secretary. Most road maintenance work is subcontracted out to local contractors who have had prior experience maintaining roads or Main Roads WA. Local

contractors are not available to perform certain tasks such as seal coating and stabilization. Contractors from Perth or outside WA perform these activities.

The contracts had only been in place since November 2000, so there is little history on which to judge the successfulness of the program. However BGC and WA main roads has had previous experience with shorter-term maintenance contracts in other parts of WA. Mr. Stervaggi noted that previous construction experience does not necessary transfer easily to maintenance projects. Currently the biggest challenges are developing experience with a new geographic area and a new contract delivery vehicle as well as mobilizing equipment from outside the area on a timely basis.

Regarding pavement design I met with Binod Sapkota, Geotechnical Engineer – Pavements and Structures for Main Roads, WA. I also met several staff members at the Main Roads Lab.

When pavements are designed, Main Roads assumes that the structure is provided by granular base and sub-base courses. Surfaces are added to prevent surface wear and to seal out moisture. Seal coats are used for most surfaces. Hot mix asphalt is used in places where a seal coat would be too noisy, in areas where traffic is turning, such as intersections, and for heavier duty roads. Most urban arterial streets and many urban side streets have HMA surfaces.

A typical road section is as follows:

- Prepared subgrade (usually sand, design CBR = 12%)
- Limestone sub-base (150 mm typical)
- Crushed granite base (200 mm typical)
- Primer seal
- ACC 37 (mm) or sprayed seal surface

Sub-base and base courses are compacted under moisture controlled conditions. In the Perth area this usually requires the addition of water. For crushed rock granite base course, it is specified that water shall be added off site using a pugmill. To ensure stability after the surface is place, there is a dryback requirement; that is the surface cannot be placed until underlying materials have dried back as shown in Table B.2.

<b>Material</b>	<b>Dryback moisture ratio (% of OMC)</b>
<i>Basecourse</i>	
Normal crushed rock (CRB)	60% (Mandatory)
Hydrated cement treated crushed rock (HCTCRB)	85% (Mandatory)
Cement treated crushed rock (CTB)	85% (Mandatory)
Bitumen stabilised limestone (BSL)	85% (Mandatory)
Natural laterite gravel	85% (Mandatory)
Crushed ferricrete gravel	85% (Mandatory)
<i>Sub-base</i>	
Limestone and laterite gravel	85% (desirable)
<i>Subgrade</i>	
Top 150mm – all types	85% (if practicable)

*Table B.2 Required Dry Back Moisture.*

The typical failure mechanism is fatigue of the surface course for HMA surfaces. For sprayed seals the typical failure mechanism is raveling (after several years) or rutting and shoving (shear failure in the base course).

When the HMA surface fatigues, a sprayed seal is placed to act as a bond breaker between the original surfaces and then an overlay (37 to 50 mm) is placed. The reason bond breaking is to prevent the surface from developing structural strength, so it is subject to cracking failures. When the overlay fails, the surface is milled and inlaid, again to prevent the development of structural strength in the surface layer.

Floodways are areas that are especially prone to rutting failure. Floodways are places where storm water is intentionally allowed to flow over the road surface, are a common site in WA. It is uneconomical to convey the large amount of runoff that occurs during tropical storms through culvert pipes. Instead a small culvert is usually placed near each waterway to convey water for the more numerous small events and a floodway is provided on one side or another of the culvert. At the floodway the road comes down off the embankment so that the road surface is level with the surrounding land. In most cases, a stabilized base is provided. Some floodways are longer than 0.5 miles in length.

Previous to the author's trip, the northern part of WA had experienced wet conditions that had softened base courses. The author personally observed one severely rutted floodway. Anecdotal evidence suggested that some floodways in the Kimberly District were completely destroyed when trucks (road trains) bogged down.

Main roads WA has three sets of test sections in the Perth Area. I visited two of them.

## Tonkin Highway Trial Sections

The Tonkin Highway Trial sections compare various types of surfaces and base courses. Traffic is 18,000 VPD per direction, 10% commercial, Commercial growth rate is 3%, 70% of commercial traffic in left (outside) lane of four lane divided highway. The test sections were constructed in 1980 to 1981. Table B.3 summarizes the design of the test sections.

No	Section	Pavement
1	21520	60 mm DG Asphalt 75 mm Bitumen Stabilized Limestone 195 mm Limestone White Sand Subgrade
2	21600-21720	20 mm OG Asphalt 30 mm DG Asphalt 75 mm Bitumen Stabilized Limestone 225 mm Limestone White Sand Subgrade
3	21720 – 21840	20 mm OG Asphalt 30 mm DG Asphalt 75 mm Bitumen Stabilized Limestone 225 mm Limestone White Sand Subgrade
4	21840-21940	30 mm DG Asphalt 75 mm Bitumen Stabilized Limestone 225 mm Limestone White Sand Subgrade
5	21940-22040	30 mm DG Asphalt 75 mm Cement Stabilized Limestone 225 mm Limestone White Sand Subgrade
6	22040-22140	30 mm DG Asphalt 75 mm Crushed Rock Base 225 mm Limestone White Sand Subgrade
7	22140-22280	30 mm DG Asphalt 75 mm Crushed Furnace Slag 225 mm Limestone White Sand Subgrade
8	22280 – 22380	60 mm DG Asphalt 270 mm Limestone White Sand Subgrade
9	22380-22530	200 mm DG Asphalt Yellow Sand Subgrade
10	22530-22700	Primerseal and Seal 200 mm Crushed Rock Base Yellow Sand Subgrade

11	22700-22800	100 mm	DG Asphalt Yellow Sand Subgrade
12	22800-22900	100 mm	Crushed Rock Base Yellow Sand Subgrade
13	12700-12900	75 mm 150 mm 100 mm	2% Tar Stabilized Limestone Base Limestone Sub-base Yellow Sand Improved Subgrade Yellow Sand Subgrade
14	12900-13100	100 mm	2% Flyash 1% Lime Stabilized Limestone Base
15	13100-13300	100 mm	2% Cement Stabilized Limestone Base with Subgrade

*Table B.3 Tonkin Highway Trial Sections*

### **Reid Highway Trial Sections**

The Reid Highway trial sections compare several different thickness and types of base courses. Traffic is 9000 VPD per direction, 5% commercial, Commercial vehicle growth rate 10%. This is a two lane road, so the test lanes take all commercial traffic. The test sections were constructed in mid 1996. The surface is 37 mm of HMA. Table B.3 summarizes the design of the trial sections.

Section	Chainage (m)	Basecourse Type	Nominal Pavement Thickness (mm)		
			Basecourse	Sub-base	Total
1	11630-11540	2% Hyd CRB	100	230	330
2	11540-11450	2% BSL	100	230	330
3	11450-11350	CRB	100	230	330
4	10700-10580	CRB	200	130	330
5	10580-10490	1% Hyd CRB	200	130	330
6	10490-10400	2% Hyd CRB	200	130	330
7	10400-10300	0.75% Cem Stab CRB	200	130	330
8	10300-10200	2% Cem Stab L/stone	200	130	330
9	10200-10120	LIMUD	200	130	330

*Table B.3 Reid Highway Trial Sections*

The abbreviations are as follows:

- CRB = Crushed rock base (usually granite)

- L/stone = Limestone (more friable than typical limestone in the US)
- Hyd CRB = Hydrated cement crushed rock base. This base is produced off site in a pugmill by adding and mixing cement and water. The product is allowed to cure in a stockpile. When compared to standard crushed rock, this product exhibits greater shear strength because smaller particles are bound to the larger particles; this increases inter-particle friction.
- Cem Stab = In-situ cement stabilized material.
- LIMUD = Lime stabilized base course.

A report will be published at the end of the observation period. Currently none of the sections are exhibiting distress except for minor cracking. In particular, it was noted that cracks were developing in the 2% Hydrated CRB and not in the 1% Hydrated CRB.

Canning shire is a suburban council located southwest of the Perth CBD. Colin Leek, Council Engineer provided a tour of the shire. Canning has a tradition of developing designs in house and executing construction with their own workers.

Its road surfaces are a HMA for urban arterials and seal coat for side streets. The shire has several industrial areas that are subjected to heavy truck traffic. Rehabilitating and maintaining these roads is a significant challenge. For example, a divided arterial street was reconstructed using the standard material and methods for the Perth area. One side was reconstructed several years before the other. However, the newer section is starting

to show evidence of fatigue failure. In reviewing construction records, Mr. Leek can no obvious reason why the newer side should fail first.

Canning shire has recently undertaken two foamed asphalt rehabilitation projects on busy urban arterials. Foamed asphalt was selected because it reduced road closure time. The projects successfully limited road closure time and the pavements have been performing well. Some hairline transverse cracks were noted on one job. It is possible that the foamed asphalt base is acting as a rigid pavement and that the cracks are thermal cracks. Details for this project for provided in [Leek, C., (2001). "In situ foamed stabilisation – the City of Canning Experience," Proceedings: 20<sup>th</sup> ARRB Conference, Managing Your Transport Assets, (ARRB Transport Research: Vermont South, VIC, Australia)]

Serpentine Jahrradale Shire is located south of Perth. It encompasses much rural area so the council maintains many unsealed roads. Simon Kenworthy, Shire Design Engineer provided a tour of unsealed roads in the Shire. In general, his crews follow the procedures for road maintenance given in the Unsealed Roads Manual. In general, the roads were smooth and there were few corrugations or potholes. Lattorite gravel is used for the aggregate surface.

Tree encroachment in the shallow roadside ditches is a constant problem. They tend to grow because the ditches are moist. After the trees are established, members of the public object when they are removed. When roads are regarded in anticipation of sealing

the surface, replacement trees must be planted at a different location to make up for the trees destroyed by construction.

The shire has a number of single lane sealed roads with wide granular shoulders. These roads have been in place for many years. Maintenance is limited to resealing and restoring the shoulder. Mr. Kenworthy noted that the shoulder could go without maintenance for several years at a time. When the shoulders are maintained, they are boxed out (old material removed) and replaced with new material. Often the sealed pavement is in poor condition at the edge of the shoulders and a drop off may exist from the sealed surface to the aggregate. Budget restrictions do not allow as much maintenance as would be desirable for these roads.

The Shire of Broome is located on the north coast of Western Australia. It includes the urban area of Broome and an extensive outback area. Large portions of the shire are completely inaccessible by motor vehicle. There are two seasons in Broome: a wet monsoon season in November, through March and a dry warm season from April to October. Most road construction occurs during the dry season. Allan Ralph, Shire Engineer discussed road construction and maintenance practices.

The town of Broome is founded on red pindan soil that is a mixture of clay and sand. Pindan is used for the surface of many unsealed roads. During the dry season the pindan becomes extremely hard. As traffic uses the road, the clay blows away in the wind and sand is left of the road surface. The sand corrugates quickly and is bladed to the side of

the road, exposing another hard pindan surface. Over the years, these roads sink noticeably and become the main drainage way for the surrounding land. A chemical dust palliative treatment has been successfully used at this location. It provides a hard surface and seals the clay into the road surface. This product has been successfully used on a road that provides access to a horse racing track that attracts 4000 vehicles per day during its short racing season.

Road closures are common during adverse weather. Roads which are subject to closure include the Gibb Highway which is maintained under the auspices of WA main roads. Many roads to cattle stations are only maintained once or twice a year to allow movement of livestock by truck. Closures protect the public by ensuring that they are not stranded during a journey and protect the road from traffic when it is weak. However, sometimes there is considerable difficulty enforcing closures.

A recent cyclone forced the shire to improve the unsealed road that provides access to the 80 Mile Beach Caravan (motor home, trailer and tent camping) Park. Rainwater from the cyclone backed up behind the sand dunes that line the beach because it could not get past the higher elevation of the dunes and into the Indian Ocean. The shire mined limestone rip rap using a D9 with a ripper. This was pushed out into the water. Pindan and latorite gravel was used for surfacing. Approximately 1K of the road was restored using this technique. The cost was approximately AU\$100,000 (US\$50,000).

When a sealed surface is required, seal coat is used almost exclusively. HMA is usually not an option because of the expense of mobilizing a plant. Gravel is produced from a few sources near Broome and an igneous rock is available for seal coat cover aggregate. Most roads are 150 mm (6 in) of gravel base with a seal coat surface. For urban sections, the seal coat is construction with sufficient width to allow a concrete curb to be placed on top of the seal coat. However the alignment of the curb is compromised by the quality of blade finishing during base course preparation.

Urban storm drainage is on the road surface. Eventually the water is diverted to ditches. Some of the ditches are broad, grassed swales that serve as recreational areas during the dry season. It would be uneconomic to provide pipe that could handle peak flows during the monsoon season. Often water runs 1 ft deep during typical rain showers.



## Appendix C. Commonwealth

National Office of Local Government (NOLG) in Canberra, “manages key elements of the day to day contact between the Commonwealth and local government, and assists with the implementation of Commonwealth objectives at the local level. It is responsible for providing the Commonwealth Government with independent and expert advice on local government<sup>1</sup>.” Among its interests is upgrading and maintaining aggregate roads. This agency does not dictate policy to the local governments. Instead it administers certain federal funds, encourages harmonization with national policies, and produces an annual report<sup>2</sup> on local government activities. One of its recent activities was to share in the financial support for revising the *Unsealed Local Roads Manual*<sup>3</sup> and the *Sealed Local Roads Manual*<sup>4</sup>.

It is generally agreed that the local road stock is deteriorating. Government in Australia is in a downsizing mode. The national government is encouraging local governments to consider outsourcing maintenance and construction activities to private contractors. The expectation is that the private sectors could perform these services more efficiently and improve the local road stock within currently available funding. There is some concern in rural areas that the local employment base will be eroded by such actions. Private contractors counter by offering contractual arrangements that are intended to mitigate the loss of local employment.

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<sup>1</sup> <http://www.dotrs.gov.au/nolg/aboutus.htm>

<sup>2</sup> <http://www.dotrs.gov.au/nolg/publications/index.htm>

<sup>3</sup> The *Unsealed Roads Manual: Guidelines to Good Practice* G. Giummerra, ed, rev. 2000, ARRB Transport Research Limited, 500 Burwood Highway, Vermont South, VIC 3133

<sup>4</sup> *Sealed Local Roads Manual: Guidelines to Good Practice for the Construction, Maintenance and Rehabilitation of Pavements*. G. Giummerra, ed. August 1995, ARRB Transport Research Limited, 500 Burwood Highway, Vermont South, VIC 3133

The following sources of funding are available from the national government:

- \$AU400 (\$US 200) Million yearly that is distributed amongst councils based on the commonwealth's assessment of the relative need of the councils with regard to road networks and traffic. It was noted that this funding could be used for any council expenditure.
- \$AU1.3 (\$US 0.65)Billion yearly to councils that have the greatest need with regard to transportation infrastructure. Two thirds of this funding goes to councils with relatively low populations.
- Currently \$AU1.2 (US\$0.60) Billion is available in the road to recovery program which is a one time offering. This money must be spent on the road infrastructure.

The following additional items were noted during the discussion:

- The Australian Local Government Association is cautious about extending the sealed road network. There is concern that the local governments will not have the resources to maintain such roads in the future.
- In total, \$AU3 (\$US1.5) Billion dollars is spent on local roads:
  - \$AU365 (\$US182) million from Commonwealth Sources
  - \$AU293 (\$US146) million from State Sources
  - \$AU125 (\$US62) from private sources
  - \$ AU1.9 (\$US0.95)Billion from local sources (includes discretionary funds provided by the Commonwealth)
- Some former state and local government maintenance and construction units have converted to enterprises and have started to submit competitive tenders on

maintenance and construction contracts. A Competitive Neutrality policy sets standards in effort to encourage fair competition between these government enterprises and private sector companies.

- Tasmania, Victoria, and South Australia have been mandating that councils amalgamate to reduce the number of local governmental units.
- In New South Wales, some councils have amalgamated on their own accord.
- In the region south of Sydney, NSW, several councils have pooled their buying power to obtain better contract prices.
- Brisbane, Queensland, is the Biggest Council in Australia. Such size may enhance this council's political power.
- In Northwest NSW, an area with few good aggregate sources, there have been experiments of placing geotextile seals directly on prepared subgrades.
- Ownership of state routes varies from state to states. In NSW, ownership was recently transferred from the state to the councils. Victoria retains ownership and funds the councils to provide maintenance for state routes.
- Land tax increases in some jurisdictions have been capped so they cannot raise faster than the consumer price index. This has put many councils that are experiencing considerable growth in a bind.

- In New South Wales, a council can insist on upfront payment for development authority. This can be used to assure there is sufficient money to upgrade transportation infrastructure.



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