

Cassowary Coast Regional Council

Unsealed Roads Gravel Specification Review

Executive Summary

A desktop review of the Cassowary Coast Regional Council's (CCRC) current unsealed road's gravel specification confirms it is in alignment with current industry standards and guidelines.

No detailed assessment of actual gravels used and their subsequent performance has been undertaken in this report.

CCRC operates an excellent management system for unsealed roads, which includes roughness condition data collection, and weekly works programming and condition reporting on their website.



1. Introduction and Scope of Brief

The Cassowary Coast Regional Council requested Road Engineering Services' Principal Engineer, Mr Phil Hunt, to provide a professional Engineering review of CCRC's current unsealed gravel specification against current industry best practice. This brief report outlines the current industry guideline documents (standards), summarises the key fundamentals of unsealed road gravel properties, reviews current recommended specifications and compares CCRC's practice.

2. Current Industry Guideline Documents (Standards)

Current industry documents include the following:

- AGPT-06, Guide to Pavement Technology Part 6, Unsealed Pavements, 2009, Austroads (Current)
- Unsealed Roads, Best Practice Guide 2, 2020, ARRB (Current)
- Road Materials, Best Practice Guide 1, 2020, ARRB (Current)
- Unsealed Roads Manual, Guidelines to good practice, *Revised Edition (2nd) August 2000, ARRB*
- Unsealed Roads Manual, Guidelines to good practice, *2009 (3rd edition), ARRB*

Due to vast gravel material differences, economic factors, climates and traffic situations across Australia, it is worth noting that these 'standards' are all considered guidelines. The reason for this is best summed up by the following statements:

The purpose of the Manual is to provide local government authorities, responsible for the management of unsealed roads, with guidelines on ways to better manage these roads, and to achieve cost-effective outcomes. Arrb URM 2009, Cl 1.1.1

*While the basic principles outlined in the Manual apply to all unsealed roads, **best practice** will be dependent upon local materials, climate, equipment and costs. As a result, there can be significant regional differences in practice. It is left to the practitioner, considering the various principles and approaches outlined in the Manual, to select the best local practice for conditions. Arrb URM 2009, Cl 1.1.2*

In using this Manual, it is essential that the reader bear in mind that unsealed roads are, by definition, a compromise between resources, needs and quality. In a country as large and sparsely populated as Australia, it is impossible to construct sealed roads wherever people wish to drive. Where the economic choices is between unsealed roads and nothing, the former is clearly preferable. Arrb URM 2009, Cl 1.1.2

3. Unsealed Road Gravel Material Properties – Fundamentals

The properties which affect the behaviour of a pavement material depend upon its skeletal structure and the nature of the stone aggregate and fine soil matrix. The principal factors affecting the performance of materials in relation to unsealed roads are:

- **stability** (all pavement layers) is mainly affected by these contributing factors : particle interlock (friction), cohesion (bonding of fine soil – stickiness), moisture content and compacted density.
- **resistance to wear** (wearing course) – tight compacted surface in which the aggregate is held in place as strongly as possible by the fine soil matrix as it is exposed to both weather and traffic forces.
- **impermeability** (all pavement layers) - A relatively impermeable surfacing material is required to protect the underlying material from the entry of water and subsequent loss of bearing strength or stability
- **workability and compaction** (all pavement layers) - The workability of a material relates to the ease with which it can be compacted to a desired density and the nature of the finished surface in terms of tightness and uniformity (no segregated and bony areas).

AGPT-06, Austroads Part 6, Cl 3.1

Specification requirements for unsealed road pavement materials are generally broader than in the case of sealed roads. However, the basic principles in terms of desired performance are the same, being based on the following three intrinsic components:

- **Particle size distribution (PSD)** - where strength is achieved from particle interlock and the maximum density principle (i.e. strength is directly related to density). The PSD also controls the permeability of a soil; particular emphasis is placed on the per cent material finer than 0.5 mm.
- **Plasticity**, where the fine material contributes to densification of the aggregate through the reduction of interlock when wet and the provision of a cohesive strength to hold the aggregate in place when dry.
- **Aggregate hardness**, where the aggregate is of sufficient hardness to resist significant breakdown under compaction and trafficking. In addition, a wearing course is required to have a durability level such that it does not break down when exposed.

AGPT-06, Austroads Part 6, Cl 3.2

In general, bitumen sealed road gravels have greater strength than unsealed road gravels in-part due to lower plasticity (cohesion) values. The bitumen surfacing provides a sound and robust wearing course (transferring the traffic load to gravel pavement) whereas gravel roads rely on a gravel wearing course exposed directly to traffic and the environment (wet and extended dry) with particles becoming dislodged and disaggregated over time. Bitumen sealed road gravels such as QTMR Type 2.1 and 2.2 gravels are considered unsuitable for unsealed roads as they tend to have higher permeability, low cohesion (low plasticity), often have a coarser particle size distribution and accordingly tend not to perform as well over time. Poor performance has sometimes been experienced during DRFA works, where contractor's have used a Type 2.1 or 2.2 material to re-sheet unsealed roads. However, a sealed road gravel can sometimes be useful in an unsealed application if it is well blended with existing finer and more cohesive materials to achieve the unsealed specification requirements outlined in Section 4.

Unsealed roads are most susceptible to rapid deterioration as a result of heavy **traffic** movements, **loss of wearing surface** course material and **damage from water**. Road deterioration cannot be prevented, but what good maintenance practices should aim to do is slow down the rate of deterioration by ensuring good drainage, adequate pavement design, material specifications, construction practice and maintenance standards align with best practice. Effective maintenance practices rely on sound technical know-how and understanding of good design and construction practices. *Arrb URM 2009, Cl 2.1*

4. Recommended Unsealed Road Gravel Properties and Comparison to CCRC's specification

The physical properties recommended by the Arrb and Austroads reference documents for unsealed road gravels includes:

- a) **Particle Size Distribution (PSD)** (sometimes called the material 'grading') - Acceptable minimum and maximum PSD lines which defined the "PSD Envelope" (The area in between the minimum and maximum lines). That is, the PSD envelope allows a range of actual gravel PSD values. The curve should be smooth and not display jagged angle changes at various sieves.
- b) **Plastic Properties:**
 - i. Liquid Limit (LL)
 - ii. Plastic Index (PI)
 - iii. WPI (Weighted Plastic Index = $PI \times \% \text{ pass } 0.425\text{mm sieve}$)
 - iv. Linear Shrinkage (LS)
- c) **Gravel Performance Properties****
 - i. Grading (PSD) Coefficient
 $((\% \text{ pass } 26.5\text{mm sieve} - \% \text{ pass } 2\text{mm sieve}) \times \% \text{ pass } 4.75\text{mm sieve}) / 100$

- ii. Shrinkage Product ($LS \times \% \text{ pass } 0.425\text{mm sieve}$)
- d) **Strength** : CBR (Californian Bearing Ratio)
(95% Modified Compaction, 4 day soaked. Or 100% Standard Compaction, 4 day soaked)

A comparison of the recommended values and those adopted by CCRC shows that CCRC's unsealed road gravel specification complies with the recommended guidelines. Minor exceptions include:

- (i) a slight increase on the 2.36mm sieve (max envelope) of 5%, from 65% to 70%.
This is considered inconsequential and allowable as a local practice.
- (ii) WPI is not specified, however, it is generally considered that WPI has been superseded by the Shrinkage Product calculation, which is specified.
- (iii) A desirable range of CBR 35 min and 45 max is specified by CCRC.
Arrb and Austroads specify CBR 40 min, only.
The CBR is effectively the same, but worded differently.

It is noted that a minimum Linear Shrinkage is not specified by CCRC, however this is effectively controlled by the Shrinkage Product.

Full unsealed road property details are provided in the Table 1 over page and the particle size distribution diagram is provided in Figure 2.

** The relationship between shrinkage product and grading coefficient calculations versus wearing course gravel performance (Good, Slippery, Erodible, Ravels, Corrugates and ravel) is displayed in Figure 1 below. The specification requires gravel to be in the "good" zone.

Figure 1 : Unsealed Road Gravel Performance

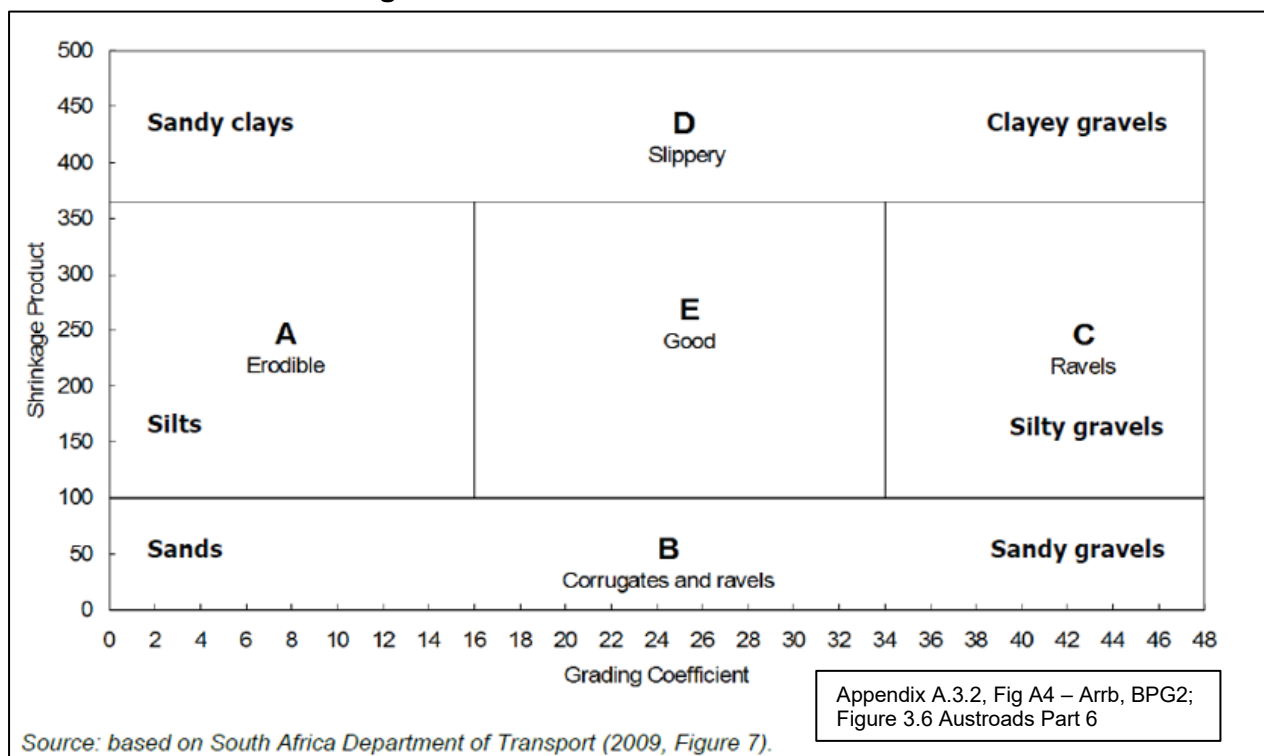
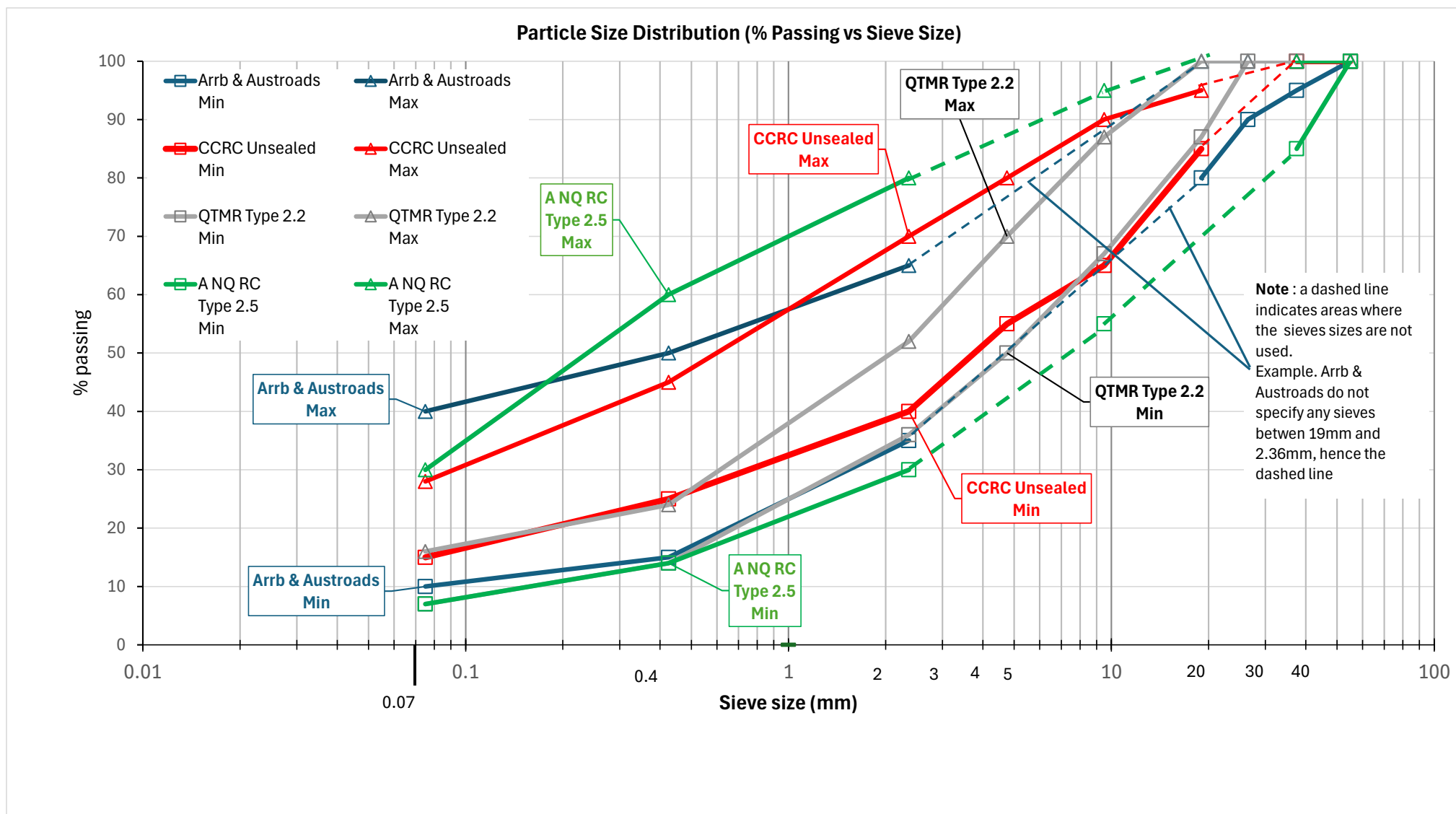


Table 1 – Comparison of Unsealed Road Gravel Properties

	Sieve size (mm)	Unsealed Road Gravel										Sealed Road Gravel	
		Arrb & Austroads	Arrb & Austroads	Austroads Part 6 2009	Austroads Part 6 2009	Arrb BPG1 2020	Arrb BPG1 2020	CCRC Unsealed	CCRC Unsealed	A NQ RC Type 2.5	A NQ RC Type 2.5	QTMR Type 2.2	QTMR Type 2.2
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Particle Size Distribution	55	100	100	100	100	100	100	100	100	100	100	100	100
	37.5	95	100	95	100	95	100	100	100	85	100	100	100
	26.5	90	100	90	100	90	100					100	100
	19	80	100	80	100	80	100	85	95			87	100
	9.5							65	90	55	95	67	87
	4.75							55	80			50	70
	2.36	35	65	35	65	35	65	40	70	30	80	36	52
	0.425	15	50	15	50	15	50	25	45	14	60	14	24
	0.075	10	40	10	40	10	40	15	28	7	30	7	16
Plastic Properties	Liquid Limit (LL) (< 500mm rainfall/yr)								30 (DRFA 40)		40		25
	Liquid Limit (LL) (> 500mm rainfall/yr)										40		25
	PI (<500mm rainfall/yr)		20		20		20						
	PI (>500mm rainfall/yr)		12		12		12 (DRFA 3)	12					
	LS (<500mm rainfall/yr)									4.0	7.5	1.0	3.5
	LS (>500mm rainfall/yr)							0.0	7.5			1.0	3.5
	WPI (PI x 0.425mm) (< 500mm rainfall/yr)	may be specified 300 min to 400 max			500		500						
Performance Properties	WPI (PI x 0.425mm) (> 500mm rainfall /yr)	(no rainfall categories)			250		250		(DRFA 250)				
	Shrinkage Product (Urban)	100	240	100	240								
	Shrinkage Product (Rural)	100	365	100	365	100	365	100	365			WLS	85
	Grading Coeff Gc	16	34	16	34	16	34	16	34				
Strength	CBR (95% Mod ; 4 day skd)	15		40		40		35	45	15		60	
	Other tests							Green Highlight indicates conformance				Wet Strength, Wet/dry Variation; Deg Factor; Water absorption	

Figure 1 – Comparison of Particle Size Distributions



5. Gravel Performance

This review has not undertaken a detailed assessment of the actual properties of gravels currently used and their performance over time.

It is acknowledged that CCRC's management of their unsealed road network, using roughness data collection, and the subsequent weekly condition and works program reporting on their website, is considered an excellent standard. In time, this current management practice may very well be proven as best practice.

6. Conclusions

A review of the Cassowary Coast Regional Council's (CCRC) current unsealed roads gravel specification (gravel properties) confirms it is in alignment with current industry standards and guidelines for a high rainfall zone.

Continued improvement in performance of actual gravels is always encouraged. This may include the review and monitoring of the length of time current Grading and Resheeting treatments adequately perform in varying Traffic Volume and Levels of Service environments. The gravel properties at these sites should be monitored and maybe experimentally changed to investigate whether improvements can be made in the duration of good performance (reduce roughness deterioration), minimise dustiness and minimise gravel loss.

7. About the Author

Phil Hunt is the owner, Director and Principal Engineer at Road Engineering Services in Toowoomba Queensland. He is a Certified Professional Civil Engineer (CPEng) and Registered Professional Engineer Queensland RPEQ and has worked for 35 years in the roads industry. His experience covers areas of concept, planning, design, construction, maintenance, paving materials, pavement performance, asset management, asset renewal, pavement research and industry training. Phil's experience also covers unsealed roads practice.

Phil has presented training in unsealed roads to the roads industry for :

- the National Transport Research Organisation (NTRO, previously Arrb Group) between 2019 and 2023, across Australia.
- The Institute of Public Works Engineers Australia – Queensland and Northern Territory (IPWEA-QNT) since 2024.

Phil has assisted Austroads national research efforts, working with NTRO (Arrb) in a number of pavement research programs including non-standard gravel materials (margin materials), cement modified stabilised pavements and Foamed Bitumen Stabilised pavements intermittently between 2014 and 2024.

Qualifications and Professional Memberships:

Master of Engineering (Research), Queensland University of Technology, 2003

Bachelor of Engineering (Civil), Queensland University of Technology, 1990

Registered Professional Engineer, Queensland, No. 6061

Chartered Professional Engineer, No.381915

Member, Institution of Engineers Australia

Appendix A – Particle Size Distribution with Material Types and Traffic Application Notes

(Figure 3.7 , Arrb USRM, 2009)

