PAVEMENT SOLUTIONS THAT ARE STRONGER FASTER CHEAPER AND GREENER

Technical specification for the ground preparation
and lay of Rombus Grid

TA21004_Rombus Grid specification_1.1

DOCUMENT CONTROL

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Name	Position	File Reference
Nigel King	Director	TA21004_Rombus Grid specification_1
Signature		

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1 Introduction

Rombus Grid is a patented surfacing system for pavements over a wide range of applications. It is manufactured in panel sizes of 1 m x 1 m by 40 mm thick and is laid on a prepared surface and the cells filled with a range of materials which can include asphalt, granular materials or concrete.

It is manufactured from Polypropylene. The physical properties are shown in Table 1-1 below.

Table 1-1: Mechanical Properties of polypropylene

Typical properties	Test Method	Specified limit
Tensile Strength	ASTM D638	>19.6 MPa
Izod Impact Strength	ASTM D256	>7kg-cm/cm
Flexural modulus	ASTM D790	>980 MPa
Melt Flow Index	ISO 180/1A	8 – 12 kJ/m^2

The grid is hollow such that it allows contact between the fill material and the base. It can be laid both in situations where the surface remains permeable for drainage, or filled with impermeable materials.

Owing to its structural properties, it remains a highly flexible surface and can accommodate significant deflections under load.

Rombus Grid is a wearing surface and does provide some structural strength to the pavement, and as such, the base, subbase and subgrade preparation are important aspects to correct preparation prior to laying the grid.

NOTE: At present the pavement is recommended to be designed as per a standard thin surfaced asphalt pavement with contribution from the grid ignored. Testing is in progress, and it is expected that some reduction in base and subbase thickness will be identified. Testing has shown that the grid can withstand considerable repeated flexing, which would result in extreme damage to an asphalt surface.

Traffic loading must be understood, and the pavement designed in accordance with the expected traffic. Where normal highway vehicles including trucks are to be accommodated, the Austroads Guide to Pavement Technology Part 2: Structural Design is to be applied.

Where heavy duty loads such as forklifts, reach stackers or mine haul vehicles are operated, appropriate design methods must be adopted. The Barker-Brabstone method as described in R J Thompson, R Peroni and A T Viser (2019) *Mining Haul Roads: Theory and Practice,* CRC Press London should be used, this method can be used for any non-standard vehicle with wheel loads over that of highway trucks.

As loads increase, material properties become increasingly important, and granular layer thickness will increase. Where quality materials are not available, some treatment to improve strength may be required.

2 Subgrade investigation

Subgrade preparation shall be determined by a geotechnical investigation of the site. The detail required for the investigation will depend on the application of the pavement.

2.1 Pavements where settlement can be tolerated

For pavements where some movement or settlement can be accepted, such as hardstands for vehicle parking, a limited investigation as follows will be required:

- Predominantly sand subgrades with % passing 0.075 mm sieve < 15%
  - Perth Sand Penetrometer (PSP) testing shall be undertaken over the proposed area of the pavement to a depth of 0.75 m below proposed subgrade level
  - A minimum of 6 tests should be undertaken for an area of <250m²
  - For an area > 250 m², at least one test per 400 m² should be undertaken
- Predominantly gravel subgrades
  - Dynamic Cone Penetrometer testing shall be undertaken over the proposed area of the pavement to a depth of 0.75 m below proposed subgrade level
  - A minimum of 6 tests should be undertaken for an area of <250m²
  - For an area > 250 m², at least one test per 400 m² should be undertaken
  - Representative samples of the soil should be collected at a density as shown in Table 2-1
  - A Particle Size Distribution should be undertaken and where the percent passing the 0.075 mm sieve is <15%, no further testing is required
- Clay, silts or sands and gravels with >15% passing 0.075 mm sieve
  - Dynamic Cone Penetrometer testing shall be undertaken over the proposed area of the pavement to a depth of 0.75 m below proposed subgrade level
  - A minimum of 6 tests should be undertaken for an area of <250m²
  - For an area > 250 m², at least one test per 400 m² should be undertaken
  - Representative samples of the soil should be collected at a density as shown in Table 2-1
  - Atterberg Limits should be undertaken on selected samples at the lower and upper limits of the percentage passing the 0.075 mm sieve or 1 per 5 samples.

Table 2-1: Sample frequency for gravel, clay and silty soils

Area (m²)	Number of samples
<250	1
250 to 1000	2
1000 to 2000	3
2000 to 5000	4
5000 to 10000	5
10000 to 50000	1 per 2500 m²
>50000	20 + 1 per 3000 m² over 50,000 m²

2.2 Pavements where settlement cannot be tolerated

For pavements where surface finish and levels must be tightly controlled, such as road pavements, container handling facilities or airport taxiways a full geotechnical investigation shall be required. In cases where heavy machinery is used, such as reach stackers or forklifts carrying shipping containers, a higher level of investigation is required.

Where available, geological mapping should be obtained to identify soil types in the underlying strata.

In these cases, test pits should be undertaken to 2 m below finished subgrade level, and on larger areas the test pits should be supplemented with Electric Friction Cone Penetrometer surveys such that test pits can be targeted to cover the range of predicted soil types.

3 Characterisation of subgrade

3.1 General notes

Characterisation of the subgrade is an essential part of the design of pavement structures for any pavement. The extent of detail required will vary according to soil types and application of the pavement.

3.2 Pavements where settlement can be tolerated

3.2.1 Sand and gravel subgrades

Where a site investigation has shown that the subgrade is predominately sand or gravel, and where after subgrade preparation has been completed with watering and rolling using an appropriate roller:

- PSP results show a resistance to penetration of >8 blows for a depth of 150 mm to 450 mm below top of subgrade, and >13 blows for a depth of 450 mm to 750 mm below top of subgrade a CBR value of 10% can be applied

- DCP results are analysed and a CBR value calculated in accordance with the following equation for each location:

$$CBR = 315.2(P)^{-1.14} \qquad \textbf{Equation 1}$$

Where P = mm/blow

Then a characteristic CBR value can be estimated as below:

$$CBR_{Des} = \overline{CBR} - ks \qquad \textbf{Equation 2}$$

Where: CBR_{Des} = Design subgrade CBR
k = Constant as per Table 3-1
s = Standard deviation of all results

Table 3-1: k values for number of sample points

Number of CBR tests	k
3	0.11
4	0.21
5	0.27
6	0.32
7	0.35
8	0.38
9	0.41
10	0.43
15	0.5
20	0.54

On large sites, the economics of subdividing areas into more discrete sections of similar CBR values should be considered.

3.3 Pavements where settlement cannot be tolerated

The detail that is required for these conditions will vary according to the type of equipment using the pavement. For axle loads typically equal to the legal loads allowable for highway traffic, the subgrade characterisation should extend to 1.2 m below final subgrade level.

For container terminals and similarly loaded pavements the subgrade should be modelled to a depth of 3 m below finished subgrade level.

Where the subgrade CBR varies with depth, at each test location, the effective CBR is determined as follows:

$$CBR_{eff} = \left[\frac{\sum_i h_i CBR_i^{0.33}}{\sum_i h_i}\right]^3 \qquad \textbf{Equation 3}$$

Where: CBR_{Eff} = Design subgrade CBR
h_i = thickness of layer i >=200 mm
CBR_i = CBR of layer i
And: CBR of layer i + 1 < CBR layer i

Where a layer below an immediately higher layer has a greater CBR than that above, the analysis stops at that level.

The design CBR shall be determined as per **Equation 2** or on large sites, the economics of subdividing areas into more discrete sections of similar CBR values should be considered.

The effective CBR shall be determined after the subgrade compaction has been completed to the requirements of Section 4.3.

4 Pavement materials

4.1 General

Rombus Grid pavements can be of one of two fundamental types:

- Permeable pavements where the grid is filled with permeable material and the pavement is designed to allow free drainage.
- Other pavements, be the fill granular or bound, where the function is support of loads and drainage is provided by surface flow to designated drainage collection locations.

Permeable pavement design is generally not suited to heavy duty applications but does have application in car parks and lightly trafficked roads.

4.2 Subbase materials

There are many materials that are suitable as subbase materials; and these materials can vary from region to region and state to state and are often specified on the available materials in that area. The listed materials below are not exhaustive, and reference should be made to the State Road Authority for the sate/region in which the pavement is constructed.

4.2.1 Laterite gravel subbase

Gravel subbase material shall consist of durable pebble in soil mortar. The material shall be free from cobbles greater than 75.0mm and free from organic matter or other deleterious materials. The subbase material shall meet the grading requirements shown in Table 4-1when tested in accordance with Test Method WA 115.1.

Table 4-1: Particle Size Distribution for laterite gravel subbase

AS Sieve Size (mm)	% Passing by mass Minimum and Maximum Limits
75.0	100
37.5	80 - 100
19.0	50 - 100
9.5	36 - 81
4.75	25 - 66
2.36	18 - 53
1.18	13 - 43
0.425	8 - 32
0.075	3 - 19

The material shall not be gap graded as represented by the grading crossing from the maximum limit for one sieve size to the minimum limit for another sieve size. Other test limits are shown in Table 4-2.

Table 4-2: Other limits for laterite gravel subbase

Test	Limits	Test Method
Liquid Limit	30.0% Maximum	WA 120.2
Plasticity Index	10.0% Maximum	WA 122.1
Linear Shrinkage	4.0% Maximum	WA 123.1
California Bearing Ratio (Soaked 4 days with 6.75kg Surcharge) at 94% of MDD and 100% of OMC	50% Minimum	WA 141.1
Secondary Mineral Content in Basic Igneous Rocks	25% Maximum	AS 1141.26
Accelerated Soundness Index by Reflux	94% Minimum	AS 1141.29

4.2.2 Limestone subbase

The source material for the supply of crushed limestone shall be free of organic material, clay lumps, cap rock or any other foreign material deleterious to its performance in the pavement.

The material shall comply with the grading limits shown in Table 4-3 when tested in accordance with Test Method WA 115.1. Other limits shall comply with those shown in Table 4-4.

Table 4-3: Particle Size Distribution for crushed limestone

AS Sieve Size (mm)	% Passing by Mass Minimum and Maximum Limits
75	100
19	55 – 85
2.36	35 – 65

Table 4-4: Other limits for crushed limestone

Test	Limits	Test method
Los Angeles Abrasion Value of Crushed Limestone	20% Minimum 60% Maximum	WA 220.2
Calcium Carbonate Content	60% Minimum	WA 915.1
California Bearing Ratio (Soaked 4 days with 6.75kg Surcharge) at 94% of MDD and 100% of OMC	50% Minimum	WA 141.1

4.2.3 Crushed rock subbase

All crushed rock subbase shall consist of a uniform blended mixture of coarse and fine aggregate. The mixture shall be free from vegetable matter, lumps of clay, overburden or any other deleterious matter.

The Particle Size Distribution of the material when tested in accordance with Test Method WA 115.1 shall comply with the requirements shown in Table 4-5.

The crushed rock subbase shall also meet the other limits as shown in Table 4-6. The Secondary Mineral Content in Basic Igneous Rock test is only applicable to basic igneous rock. The Accelerated Soundness Index test is only applicable to basic igneous rock.

Table 4-5: Particle Size Distribution for crushed rock subbase

AS 1152 Sieve Size (mm)	% Passing by Mass	
	Target Grading	Minimum and Maximum Limits
26.5	100	100
19	98	95 - 100
9.5	73	60 - 85
4.75	55	40 - 70
2.36	43	30 - 55
1.18	31	20 - 42
0.6	23	13 - 32
0.425	20	11 - 28
0.3	17	8 - 25
0.15	13	5 - 20
0.075	**10**	**5 - 15**

Table 4-6: Other limits for crushed rock subbase

Test	Limits	Test Method
Plasticity Index	5% Maximum	WA122.1
Linear Shrinkage	2.0% Maximum	WA123.1
California Bearing Ratio (Soaked 4 days with 6.75kg Surcharge) at 99% of MDD and 100% of OMC	70% Minimum	WA141.1
Secondary Mineral Content in Basic Igneous Rock	25% Maximum	AS 1141.26
Accelerated Soundness Index by Reflux	94% Minimum	AS 1141.29

4.3 Base materials

There are many materials that are suitable as base materials; and these materials can vary from region to region and state to state and are often specified on the available materials in that area. The listed materials below are not exhaustive, and reference should be made to the State Road Authority for the sate/region in which the pavement is constructed.

4.3.1 Laterite gravel base

Gravel Basecourse material shall consist of durable pebble in soil mortar free from organic matter or other deleterious materials.

The Particle Size Distribution shall be determined in accordance with Test Method WA 115.1. The Particle Size Distribution of the portion passing a 37.5mm AS sieve shall conform to the grading limits shown in Table 4-7. The grading of material passing the 37.5mm sieve shall vary from coarse to fine in a uniform and consistent manner. The material shall not be gap graded as represented by the grading crossing from the maximum limit for one sieve size to the minimum limit for another sieve size, and shall conform as closely as possible to the specified target grading.

The material shall also comply with the limits shown in Table 4-8. The Secondary Mineral Content in Basic Igneous Rock test is only applicable to basic igneous rock. The Accelerated Soundness Index test is only applicable to basic igneous rock.

Table 4-7: Particle Size Distribution for laterite gravel base

As Sieve Size (mm)	% Passing by Mass	
	Target Grading	Minimum and Maximum Limits
37.5	100	100
19	86	72 - 100
9.5	64	50 - 78
4.75	47	36 - 58
2.36	35	25 - 44
1.18	27	18 - 35
0.6	21	13 - 28
0.425	18	11 - 25
0.3	16	9 - 22
0.15	12	6 - 17
0.075	9	4 - 13
0.0135	6	2 - 9

Table 4-8: Other limits for laterite gravel base

Test	Limits	Test Method
Liquid Limit	25.0% Maximum	WA 120.2
Linear Shrinkage	2.0% Maximum	WA 123.1
Maximum Dry Compressive Strength	2.3MPa Minimum	WA140.1
California Bearing Ratio (Soaked 4 days with 4.5kg Surcharge) at 96% of MDD and 100% of OMC	80% Minimum	WA 141.1
Secondary Mineral Content in Basic Igneous Rock	25% Maximum	AS 1141.26
Accelerated Soundness Index by Reflux	94% Minimum	AS 1141.29

4.3.2 Crushed rock base

All crushed rock base (CRB) shall consist of a uniformly blended mixture of coarse and fine aggregate. The mixture of fine and coarse aggregate forming the rock base shall be free from vegetable matter, lumps of clay, overburden, or any other deleterious matter.

Coarse aggregate (retained 4.75mm sieve) shall consist of clean, hard, durable, angular fragments of rock produced by crushing sound unweathered rock and shall not include materials which break up when alternately wetted and dried.

Fine aggregate (passing 4.75mm sieve) shall consist of crushed rock fragments or a mixture of crushed rock fragments with natural sand or clayey sand. Crushed rock fine aggregate from each source shall, except as to size, comply with all the provisions specified for coarse aggregate.

The Particle Size Distribution of the material when tested in accordance with Test Method WA 115.1 shall comply with the requirements shown in Table 4-9. The grading of material passing the 26.5mm sieve shall vary from coarse to fine in a uniform and consistent manner. The material shall not be gap graded as represented by the grading crossing from the maximum limit for one sieve size to the minimum limit for another sieve size, and shall conform as closely as possible to the specified target grading.

The Dust Ratio, defined as the ratio of the percentage passing by mass the 0.075mm sieve to the percentage passing by mass the 0.425mm sieve, shall be within the range 0.35 to 0.60.

The crushed rock base shall also meet the other limits as shown in Table 4-10. The Secondary Mineral Content in Basic Igneous Rock test is only applicable to basic igneous rock. The Accelerated Soundness Index test is only applicable to basic igneous rock.

Table 4-9: Particle Size Distribution for crushed rock base

AS 1152 Sieve Size (mm)	% Passing by Mass	
	Target Grading	Minimum and Maximum Limits
26.5		100
19	100	95 – 100
13.2	82	70 – 90
9.5	70	60 – 80
4.75	50	40 – 60
2.36	38	30 – 45
1.18	25	20 – 35
0.6	19	13 – 27
0.425	17	11 – 23
0.3	13	8 – 20
0.15	10	5 – 14
0.075	8	5 – 11

Table 4-10: Other limits for crushed rock base

Test	Limits	Test Method
Liquid Limit (Cone Penetrometer)	25.0% Maximum	WA120.2
Linear Shrinkage	2.0% Maximum	WA123.1
	0.4% Minimum	
Flakiness Index	30% Maximum	WA 216.1
Los Angeles Abrasion Value	35% Maximum	WA 220.1
Maximum Dry Compressive Strength	1.7MPa Minimum	WA 140.1
California Bearing Ratio (Soaked 4 days with 4.5kg Surcharge) at 99% of MDD and 100% of OMC	100% Minimum	WA141.1
Wet/Dry Strength Variation	35% Maximum	AS1141.22
Secondary Mineral Content in Basic Igneous rock	25% Maximum	AS 1141.26
Accelerated Soundness Index by Reflux	94% Minimum	AS 1141.29

4.3.3 Recycled base material

Recycled crushed Construction and Demolition materials sourced from a reputable supplier with a high proportion of crushed concrete provide a very high strength base. Where this material is applied, it should be used as a base and subbase, or a subbase only. The application of recycled materials to a base or subbase depends on traffic loading. Various classes of material are shown in Table 4-11 and composition of those classes shall conform to the limits shown in

Table 4-12.

Particle Size Distribution shall conform to

Table 4-13. The PSD curve shall be classified by the descriptive classification as shown in Table 4-11. The PSD shall be determined in accordance with MRWA test method WA 115.1

Coarse aggregate (retained 4.75 mm sieve) shall consist of clean, hard, durable, angular fragments recycled materials originally made from sound unweathered rock and shall not include materials which break up when alternately wetted and dried.

Fine aggregate (passing 4.75 mm sieve) shall consist of crushed rock fragments or a mixture of crushed recycled concrete, brick, roof tile, asphalt or other products produced by crushing sound recycled materials originally made from sound unweathered rock, clays or natural sand.

Table 4-11: Material class for given application

Level in pavement	Traffic (ESA/day)				
	> 100	50-100	10- 50	5-10	<5
Basecourse < 50 mm asphalt or spray seal	Class 1	Class 1	Class 1	Class 2	Class 2
Basecourse ≥ 50 mm asphalt	Class 1	Class 1	Class 2	Class 2	Class 3
Subbase	Class 3	Class 3	Class 4	Class 4	Class 5

Table 4-12: Limits on constituent materials based on material class

Material	Class 1 (Basecourse)	Class 2 (Basecourse)	Class 3 (Subbase)	Class 4 (Subbase)	Class 5 (Subbase)
	Allowable % by weight retained on 4.75mm sieve				
Crushed Recycled Concrete (CCRB)	70-100	60-100	60-100	0-100	0-100
Recycled Asphalt Pavement (RAP)	0-20	0-25	0-25	0-100	0-100
High density clay brick & tile	0-15	0-20	0-30	0-50	0-100
High density aggregates from roads etc	0-20	0-25	0-25	0-100	0-100
Low density materials (plastic, plaster, etc.) retained on 2.36 mm sieve	0-1.5	0-2.0	0-2.0	0-2.5	0-3.0
Organic Matter (Wood, etc) retained on 4.75 mm	0-1.0	0-1.5	0-1.5	0-2.0	0-2.5
Unacceptable high density materials (metals, glass, ceramics retained on 4.75 mm sieve)	0-2	0-3	0-3	0-4	0-5
Aluminium	0.1	0.1	0.2	0.2	0.2
Asbestos and other hazardous materials	Refer to DWER guidelines				

Table 4-13: Particle Size Distribution for recycled crushed demolition materials

Material Class	Class 1 (Basecourse)	Class 2 (Basecourse)	Class 3 (Subbase)	Class 4 (Subbase)	Class 5 (Subbase)
AS sieve size (mm)	% passing by mass - minimum and maximum limits				
75				100	100
50			100		
37.5			95-100		
26.5	100 - 100	100 - 100	75-95		
19.0	95 - 100	85 - 100	64-90	54-75	54-75
9.50	60 - 80	59 - 82	42-78		
4.75	40 - 60	41 - 65	27-64		
2.36	30 - 45	29 - 52	20-50		
1.18	20 - 35	20 - 41			
0.600	13 - 27	13 - 29			
0.425	11 - 23	10 - 23	7-23	7-21	7-21
0.300	8 - 20	8 - 20			
0.150	5 - 14	5 - 14			
0.075	3 - 11	3 - 11	2-13	2-10	2-10
Dust ratio	0.20 – 0.60	0.15 – 0.60			
Shape variability	Low	Low or medium			

Table 4-14: Shape variability class for PSD

Shape variability descriptor	Shape attributes of PSD curve
Low	Where the grading curve fits smoothly within the envelope, and may gradually move from the high limits to the low limits or from the lower limits to the higher limits but does not wander between extremes
Medium	Where the grading curve changes from the higher limits to the lower limits or the lower limits to the higher limits in one sieve size that is above the 2.36 sieve
High	Where the grading curve fits outside the envelope for one or two sieve sizes above the 2.36 mm sieve, or where the grading envelope changes from the lower limits to the higher limits for any sieve size 2.36 mm or less, or where the grading curve changes from the higher limits to the lower limits or the lower limits to the higher limits on more than one instance

4.4 Permeable base material

In cases where the pavement is required to be permeable, a permeable base and fill material in the grid is required.

The base material shall be selected on the type of traffic using the pavement. The Particle Size Distribution of the material when tested in accordance with Test Method WA 115.1 shall comply with the requirements shown in Table 4-15. Other specified limits are shown in Table 4-16.

Table 4-15: Particle Size Distribution for permeable base materials

AS 1152 Sieve Size (mm)	% Passing by Mass	
	Heavy vehicles	Light vehicles
40	-	100
31.5	-	98 - 100
26.5	100	-
19	95 - 100	85 - 99
13.2	70 - 93	-
10	-	20 - 70
9.5	55 - 85	
4.75	20 - 75	0 - 15
2.36	10 - 50	0 - 5
1.18	0 - 25	-
0.6	0 - 12	-
0.3	0 - 8	-
0.15	0 - 6	-
0.075	0 - 5	-

Table 4-16: Strength limits for permeable base materials

Test	Limits	Test Method
Flakiness Index	30% Maximum	WA 216.1
Los Angeles Abrasion Value	35% Maximum	WA 220.1
Maximum Dry Compressive Strength	1.7MPa Minimum	WA 140.1
California Bearing Ratio (Soaked 4 days with 4.5kg Surcharge) at 99% of MDD and 100% of OMC	100% Minimum	WA141.1
Wet/Dry Strength Variation	35% Maximum	AS1141.22
Secondary Mineral Content in Basic Igneous rock	25% Maximum	AS 1141.26
Accelerated Soundness Index by Reflux	94% Minimum	AS 1141.29

5 Grid fill

5.1 General

Grid fill can be of several different materials, including concrete, no fines concrete, granular materials, permeable granular materials, stabilised materials, or crushed glass and will depend on the architectural requirements, drainage requirements and traffic types.

5.2 Concrete fill

5.2.1 General

Concrete fill may be no fines permeable concrete or conventional concrete. No fines concrete is applicable where high permeability is required. Conventional concrete can be used in any other application.

Concrete shall only be supplied from a recognised concrete batching plant with Quality Management System certification to ISO 9001:2015.

5.2.2 No fines concrete

No fines concrete shall not be used where heavy vehicle movements such as forklifts or similar equipment is used. It should not be used in locations where oil or other chemicals are transported or used. The effectiveness of no fines concrete will be rapidly diminished if excessive fine material (dust) is present at that site.

No fines concrete shall be a nominal 10 mm maximum aggregate size and have a Particle Size Distribution similar to that in Table 5-1 below and will typically have water/cement ratios between 0.35 and 0.45 and cement contents typically greater than 5%. The unconfined compressive strength should be greater than 2.5 MPa. It shall have a voids ratio of at least 20% and a permeability > 0.3 m/s. Laboratory tests shall be conducted to ensure that the material has adequate permeability and strength to meet in-service conditions.

Table 5-1: Particle Size Distribution for no fines concrete

AS 1152 Sieve Size (mm)	% Passing by Mass
13	100
9.5	85-100
4.75	0-10
2.36	0-2

5.2.3 Conventional concrete

Where conventional concrete is used, the 28 Day compressive strength selected on the abrasion resistance required for the particular application is detailed in Table 5-2.

Table 5-2: Particle Size Distribution for no fines concrete

Traffic type	28 Day compressive strength (MPa)
Light pneumatic-tyred traffic (vehicles ≤ 3 t gross mass)	25
Medium or heavy pneumatic-tyred traffic (> 3 t gross mass)	32
Non-pneumatic-tyred traffic	40
Steel-wheeled traffic	≥ 50*

*To be assessed according to vehicle loads and cycles

5.3 Granular fill

5.3.1 General

Granular fill can be any graded crushed rock or gravel where permeability is not required, or a coarse fines deficient gravel, either natural or crushed where permeability for drainage purposes is required.

5.3.2 Granular graded fill

Owing to the confinement of the grid, grading is not as critical as for the base or subbase where confinement is non-existent, but recognition to erodibility and dust generation should be given. The maximum aggregate size however should be in the range of 7 mm to 10 mm and ideally not gap graded. Table 5-3 gives a recommended Particle Size Distribution for crushed rock granular fill.

Table 5-3: Recommended Particle Size Distribution for granular fill

AS 1152 Sieve Size (mm)	% Passing by Mass	
	7 mm fill	10 mm fill
13.2		100
9.5	100	95 - 100
6.7	80 - 100	80 - 95
4.75	70 - 90	65 - 80
2.36	45 - 60	45 - 60
1.18	35 - 50	35 - 50
0.6	22 - 35	25 - 40
0.3	14 - 25	15 - 25
0.15	8 - 16	7 - 15
0.075	5 - 8	4 - 7

For natural gravels, the Grading Coefficient and Shrinkage Product as described in Equation 4 and Equation 5 and the chart in Figure 5-1 can be used to assess the suitability of a material.

Grading coefficient: $(Gc) = (P_{4.74}(P_{26.5} - P_{2.0}))/100$ **Equation 4**

Shrinkage product $(Sp) = LS(P_{0.425})$ **Equation 5**

where: P_x = %age passing sieve size x mm
LS = linear shrinkage

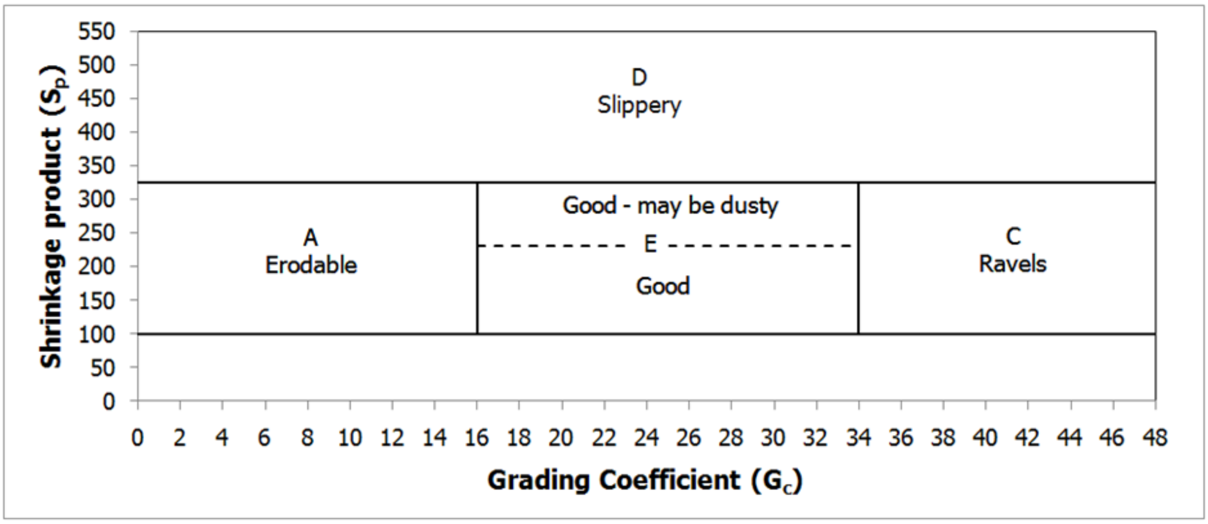


Figure 5-1: Materials suitability chart

5.3.3 Permeable fill

Where a permeable pavement is required, grid fill should be undertaken with crushed rock material meeting the requirements of Table 4-16 but with a maximum aggregate size of 7 mm and 0% passing the 0.075 mm sieve.

6 Installation of Rombus Grid

6.1 General

Installation of Rombus Grid is the final stage of the pavement construction. It is essential that all steps in the subgrade preparation to base preparation be followed; the material selection and preparation detail will vary according to the importance of the pavement. Where some deflection can be tolerated, a lower standard can be applied than would be the case when very heavy traffic or a stable final surface is required.

6.2 Design of pavement layers

Where a lasting pavement with resistance to permanent deformation is required, the pavement design must be undertaken in accordance with one of several recognised methods according to the materials selected.

Where a granular pavement is proposed, the following methods shall be applied:

- Where loading is from highway type traffic, pavement design shall be undertaken in accordance with Austroads (2017) Guide to Pavement Technology Part 2: Pavement Structural Design Section 8.3
- Where loading is from vehicles with axle loads heavier than highway traffic loads, pavement design shall be undertaken using:
  - i) the Barker-Brabstone method of sub layering
  - ii) Leigh Wardle, Ian Rickards, John Lancaster and Susan Tighe (2007) *Heavy Duty Industrial Pavement Design Guide,* Mincad Systems, Melbourne (HiPave design software (uses Barker-Brabstone method))
  - iii) Roger Thompson, Rodrigo Peroni, Alex T. Visser (2019) *Mining Haul Roads Theory and Practice,* CRC Press
- In airport pavements, any CASA approved methods may be applied. The product would be suitable for taxiways and aprons, however consideration is required for the application in the touchdown areas of runways where further analysis will be required.

Where underlying layers are to be stabilised with cement or bitumen, the following methods shall be applied:

- Where loading is from highway type traffic, pavement design shall be undertaken in accordance with Austroads (2017) Guide to Pavement Technology Part 2: Pavement Structural Design Section 8.2
- Where loading is from vehicles with axle loads heavier than highway traffic loads, pavement design shall be undertaken using Leigh Wardle, Ian Rickards, John Lancaster and Susan Tighe (2007) *Heavy Duty Industrial Pavement Design Guide,* Mincad Systems, Melbourne (HiPave design software (uses Barker-Brabstone method))

In any airport runway application, either flexible or bound, design shall be undertaken in accordance with Civil Aviation Safety Authority (2011) *Advisory Circular Strength Rating of Aerodrome Pavements.*

7 Preparation of subgrade

7.1 Clearing

All Clearing must be undertaken in accordance with Specification 204 and Specification 303. Clearing activities includes, but is not limited to:

- the felling, cutting and removal of all trees standing or fallen;
- the removal of rubbish and debris;
- the removal of surface boulders and boulders dislodged during vegetation removal; and
- the grubbing out of all stumps and roots larger than 80mm in diameter or with any dimension greater than 300mm,
  - to a depth of 300mm below either the existing surface or the finished subgrade surface, whichever is the lower for pavements where axle loads are equivalent to normal highway axle loads
  - to a depth of 500mm below either the existing surface or the finished subgrade surface, whichever is the lower for pavements where axle loads are greater than normal highway axle loads

Tree roots from retained vegetation must be pruned in accordance with accepted industry standards to ensure clean cuts to roots to minimise entry of disease to the cut root and prevent tree damage.

When cutting significant tree roots, an arborist should be consulted to determine the structural integrity of the tree.

Burning of cleared vegetation shall be in accordance with local authority guidelines.

The Contractor must take all precautions necessary to prevent damage to all vegetation tagged for retention and protection within the Limits of Vegetation Clearing. If necessary, the Contractor must install fence palings or other protective measures around the trunks of trees tagged for retention to prevent damage. Protective measures must be approved by the Superintendent prior to any Clearing operations.

7.2 Removal of topsoil

Topsoil shall be removed to a depth such that all surface vegetation and root matter is removed and clean soil containing only minor roots of <1% organic content to a depth of 300 mm remains in any square meter.

The Contractor must ensure that appropriate plant and equipment are utilised by competent operators to ensure that the topsoil and subsoil layers are not mixed and the subgrade integrity is not affected during the stripping and stockpiling process.

7.3 Subgrade compaction

Where imported fill is required, materials shall be placed to the shapes and levels shown in the drawings. Where the imported material is greater than 500 mm thick, the existing natural ground (foundation) shall be compacted 92% Characteristic Density Ratio for sands or 90% Characteristic Density Ratio for other materials.

Where the imported fill material is less than 500 mm thick, the existing natural ground (foundation) shall be compacted 95% Characteristic Density Ratio for sands or 93% Characteristic Density Ratio for other materials. The Characteristic Density Ratio shall be determined in accordance with the following MRWA test methods:

- WA 133.1: Dry Density/Moisture Content Relationship: Modified Compaction (Fine & Medium Grained Soils)
- WA 133.2: Dry Density/Moisture Content Relationship: Modified Compaction (Coarse Grained Soils)
- WA 134.1: Dry Density Ratio

Imported fill material shall be worked in compacted layers not greater than 300mm or less than 100mm for cohesive material and not greater than 450mm or less than 100mm for sand. Where less than 100mm is required to be worked the underlying material shall be grader scarified or stabiliser mixed to such a depth that the resulting thickness of the layer to be worked is greater than 100mm.

Each layer worked shall be generally parallel to the finished pavement surface and shall where practicable extend to the full width of the proposed pavement at that particular level. No layer of material shall be placed until the preceding layer conforms to all requirements. Fill material shall be placed uniformly without abrupt changes in material type, quality or size.

The final 300 mm layer of subgrade, whether natural ground, exposed subgrade after cut and fill, or imported material shall be compacted 95% Characteristic Density Ratio for sands or 93% Characteristic Density Ratio for other materials.

The prepared subgrade shall extend at least 1.0 m past the bottom of the base or subbase material laid on the subgrade.

7.4 Subgrade preparation on wet ground or peaty soils

When it is required to construct over soft wet ground or peats such as swampy ground, and the soil cannot be drained, consideration should be given to the use of geotextiles with geogrids and building a platform over the wet ground, but without clearing of grasses and sedges which will add support to the overlying pavement structure. Long term settlement and shape loss can be expected.

8 Pavement construction

8.1 Subbase preparation

The subbase is generally laid directly on the prepared subgrade unless otherwise specified by the pavement designer. Cases where this may not be the case are where:

- Geofabrics and/or geogrids are specified.
- A drainage blanket is specified.

The subbase shall be selected from materials conforming with the requirements of Section 4.2, Section 4.3 or section 4.4. Base material may be substituted for subbase material.

The subbase shall be mixed and compacted in layers not exceeding 250 mm and not less than 100 mm. Each layer shall be thoroughly mixed and water added to between 90% and 110% of Optimum Moisture Content for that material. Each layer shall be placed generally parallel to the completed pavement surface and with a uniform compactive effort applied longitudinally and transversely to the road alignment to achieve the density as shown in compacted to a Minimum Characteristic Dry Density Ratio of 94%.

The shape of the subbase in granular pavement shall be judged to be acceptable when the maximum deviation from a 3 metre straight edge placed in any position on the surface does not exceed 6 mm and shall be graded to a tolerance of +10 mm to -25 mm of the specified level.

8.2 Base preparation

The base is generally laid directly on the prepared subbase unless otherwise specified by the pavement designer. Cases where this may not be the case are where:

- A pavement design is such that the subbase is of such a thickness that it is omitted and the base layer is placed directly on the subgrade
- Geofabrics and/or geogrids are specified and the subbase is omitted
- A drainage blanket is specified and the subbase is omitted

The subbase shall be selected from materials conforming with the requirements of Section 4.2, Section 4.3 or section 4.4. Base material may be substituted for subbase material.

The base shall be mixed and compacted in layers not exceeding 250 mm and not less than 100 mm. Each layer shall be thoroughly mixed and water added to between 90% and 110% of Optimum Moisture Content for that material. Each layer shall be placed generally parallel to the completed pavement surface and with a uniform compactive effort applied longitudinally and transversely to the road alignment to achieve the density as shown in compacted to a Minimum Characteristic Dry Density Ratio of 98%

The shape of the subbase in granular Pavement shall be judged to be acceptable when the maximum deviation from a 3 metre straight edge placed in any position on the surface does not exceed 10mm and shall be graded to a tolerance of +5 mm to -5 mm of the specified level.

9 Laying grid

9.1 General

It is important that the grid be well supported across the base of the grid, with each panel laying directly on the base with minimal gaps under the grid base. The grids shall be placed and clipped together using the inbuilt clips provided. Each grid must be clipped to the preceding grid on two sides such that when the grid laying is complete, all grids are continuously connected.

On the edges of the completed paved area, purpose made edge beams are to be clipped to the circumference of the grids.

9.2 Filling the grid

9.2.1 Granular fill

The grid shall be filled with the selected fill material and allowance shall be made such that after compaction, the material completely fills each grid.

When graded granular fill is used, it shall be mixed off site to Optimum Moisture Content prior to spreading and compaction. No fines granular material does not need wet mixing.

After filling, the completed section shall be rolled using a twin drum vibrating roller using high frequency low amplitude vibrating mode. Four complete passes of the roller shall be undertaken. After compaction is completed, the area shall be trimmed to remove any surplus material sitting proud of the grid.

9.2.2 Concrete fill

Where the gid is to be filled with concrete, the concrete shall be supplied with a superplasticiser such that it is self-levelling and compacting. Concrete shall be screeded to the level of the grid.

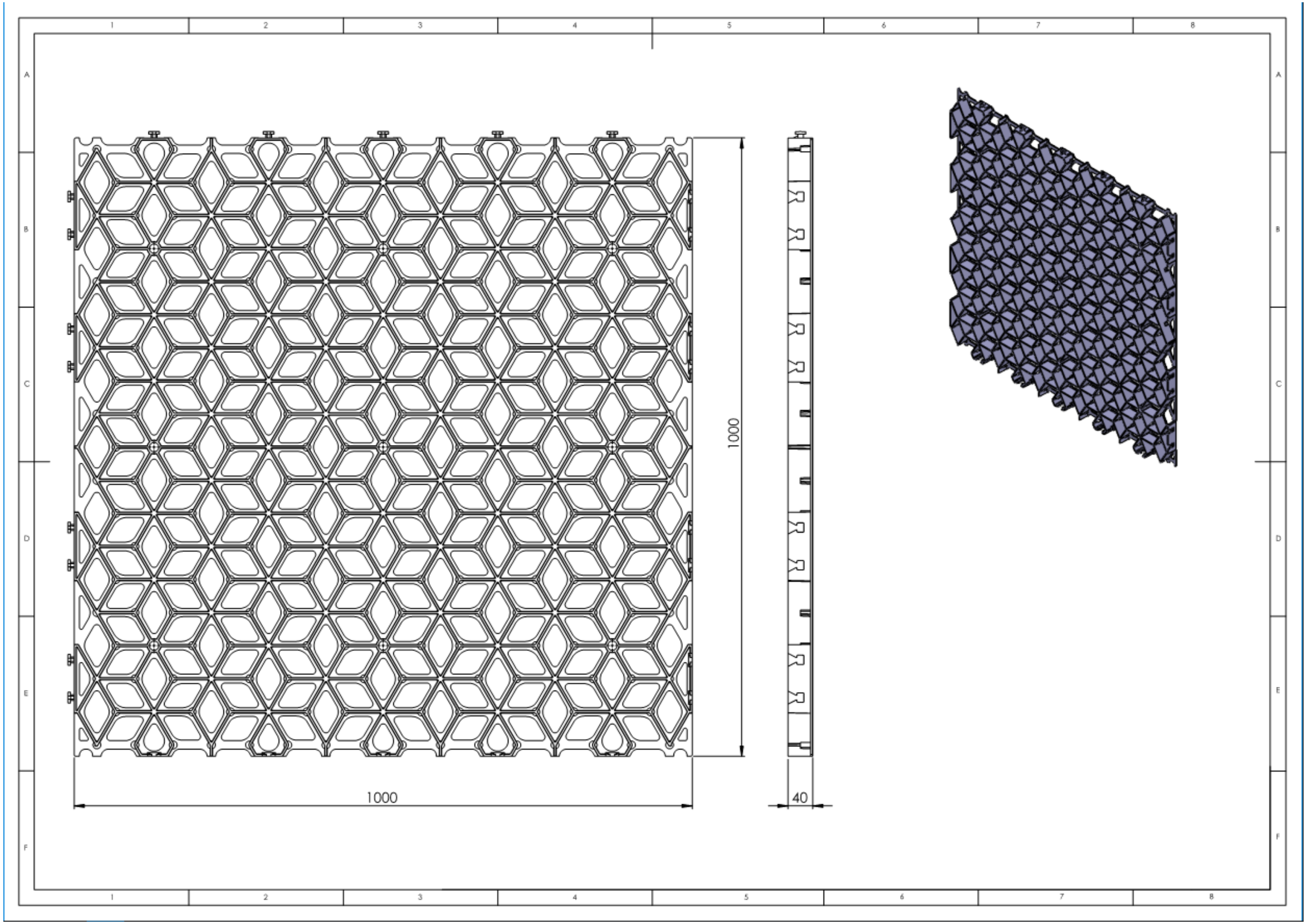
At this stage any decorative requirements such as exposed aggregate finish and colouring can be undertaken. It is essential in any heavy duty application that the concrete be cured.

All designated areas are to have a liquid curing compound applied to the freshly finished concrete. The curing compound will be based on wax emulsion, have a water retention efficiency of not less than 90% when tested to AS3799 and have a weight solids content of not less than 30%

Where high abrasion resistance is required, a surface hardener can be applied prior to the curing compound.

APPENDIX A

Plan and cross section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