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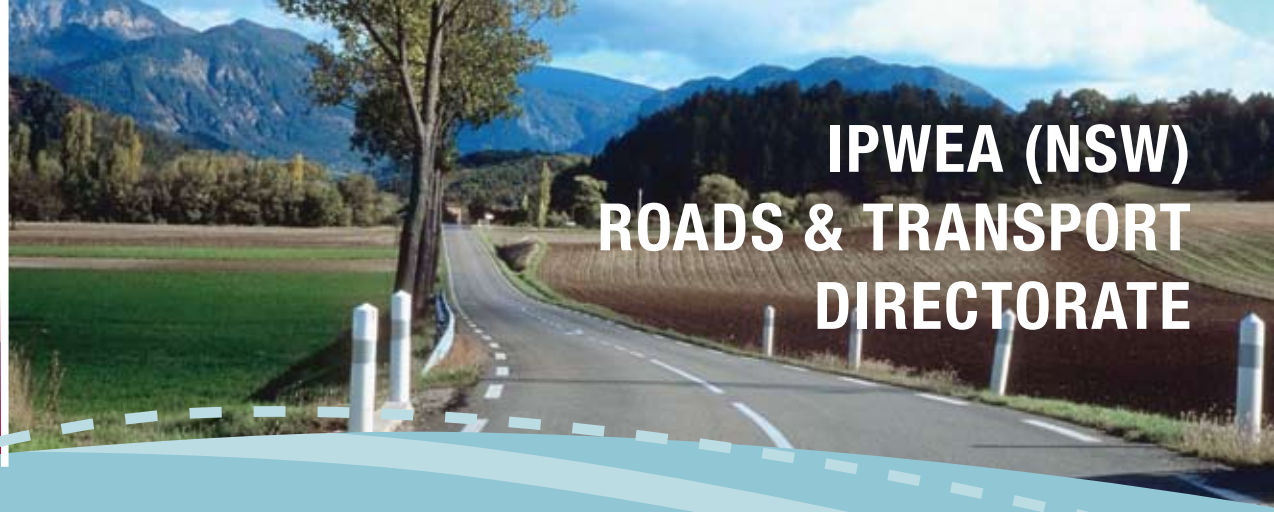

IPWEA (NSW)
ROADS & TRANSPORT
DIRECTORATE

Specification for Supply of Recycled Material

for Pavements, Earthworks and Drainage

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IMPORTANT

This publication is made available by the Department of Environment, Climate Change and Water (DECCW) in conjunction with the Institute of Public Works Engineering Australia (NSW). This updated Specification has been prepared by the Institute of Public Works Engineering Australia (NSW) as part of a project funded and managed by DECCW. The project has had considerable input from a panel of engineers and industry organisations with experience in the recycling of road materials. These organistions are listed in the acknowledgements.

This publication is intended as a guide for the supply of recycled materials for use in pavements, roads and related engineering works. It must not be relied upon solely as a basis for the construction of civil works. It is important that independent engineering advice is obtained in respect of each civil work undertaken.

DECCW makes no representation concerning the accuracy, completeness or suitability of this publication for any particular purpose and does not accept any liability for damage or loss which may occur if you take action or not on the basis of this publication.

Preface

The Department of Environment, Climate Change and Water NSW contracted the Institute of Public Works Engineering Australia (NSW) to update and enhance the Specification published in June 2003, to meet a need for an industry wide specification for the use of recycled materials in a range of public works.

In August 2001 the first version of this Specification (A Draft Specification for Supply of Recycled Materials for Roads, Drainage and Fill) was released. Prior to its release there was no industry wide specification for the use of recycled materials in local roads, other pavements and civil works. The final specification was released in June 2003.

In the six years since the publication of the previous specification there have been significant developments in the science of materials recycling as well as major changes to the legal environment in which recycling takes place. Councils and other government agencies have continued to extend their knowledge in the use of recycled materials in local roads and other construction projects. The existence of an industry specification, coupled with the economic benefits of recycling, has encouraged more councils and practitioners to employ recycled materials in their construction projects.

The aim of this Specification is to encourage local government professionals and other key players within both the private and public works engineering sector to use recycled concrete, brick and asphalt materials. These materials are valuable resources capable of being recovered, processed and used in projects and have important economic, environmental and social benefits.

The Specification sets out the performance standards required of the materials processing industry for the supply of quality recycled materials. This in turn provides the confidence required in the marketplace.

The Specification has been enhanced by the addition of new material to meet the needs of users in two key areas:

- The legal requirements to be met for the recovery and reuse of construction materials; and
- The guidelines for the placement of pavement materials, including recycled materials, to ensure the degree of compaction necessary to achieve design performance.

The initiative supports the Government's policy for the increased recovery and use of recycled materials to minimise the consumption of natural resources. This will make a positive contribution to the protection of the environment and to a more sustainable future.

Acknowledgements

This updated Specification has been prepared by the Institute of Public Works Engineering Australia (NSW) as part of a project funded and managed by the Department of Environment, Climate Change and Water NSW. The project has been carried out under the guidance of a Steering Committee consisting of representatives from:

- **Association of Consulting Engineers Australia (ACEA)**
- **ARRB Group**
- **Waste Management Association of Australia NSW C&D Working Group**
- **Civil Contractors Federation (NSW Branch)**
- **Douglas Partners**
- **DVA Consulting**
- **Fairfield City Council**
- **Roads and Traffic Authority, NSW**
- **Tamworth Regional Council**
- **Waste Contractors and Recyclers Association of NSW**

Contents

PART A

INTRODUCTION

1 Intent

This Guide is to be used for the selection of recycled materials, primarily crushed concrete, brick and reclaimed asphalt blends for use in local road and pedestrian pavements, minor supporting earthworks and as backfill material for drainage lines and drainage structures. Its use is limited to applications having maximum nominal particle sizes of up to 100mm. The use of other recycled materials such as crushed glass fines and flyash as well as blends of recycled and virgin materials is provided for under the Guide.

The Guide is intended for use in light to medium traffic loadings. For design traffic loadings greater than $4x10^6$ ESA other specifications such as RTA Specification 3051 *Granular Base and Sub-Base Materials for Surfaced Road Pavements* should be used.

The Guide is not intended for use in landfill sites.

2 Overview

This document provides a specification for the supply of recycled materials, primarily crushed concrete, brick and reclaimed asphalt blends for the following uses:

- Road base for roads with light to medium traffic
- Bedding material for paving blocks to be used in pedestrian areas, carparks, shopping centres etc
- Select fill for use on subgrades to enhance strength or for raising site levels, particularly in roadways and beneath buildings
- Drainage medium for drainage lines and drainage structures.

The Specification provided in this document has been compiled to encourage local authorities and the private sector to maximise the use of recycled materials in their civil works. Local government and the private sector recognise that there is a need to conserve natural aggregates and to use recycled concrete, bricks, tiles and asphalt to reduce the amounts of these materials going to landfill. Greater recognition and use of recycled materials by these sectors will lead to a more conservative use of our natural resources as well as the continued growth of a professional and cost effective recycling industry.

In addition to these benefits, there is also an environmental benefit arising from the decrease in carbon emissions resulting from the use of recycled pavement materials.

Part A of this document outlines how the Specification was developed along with points to consider when using recycled materials.

Part B contains the technical Specification for 'Supply of Recycled Material for Pavements, Earthworks and Drainage'.

Annexure 1 contains information on current NSW legislation governing materials recycling to assist in the application of existing General Exemptions.

Annexure 2 is provided to assist users in understanding the principles that should be applied to the placement and compaction of recycled pavement materials.

Appendix 3 contains three case studies that demonstrate the use of recycled materials in public works projects and encourage others to utilise recycled materials.

Annexure 4 is provided to enable individual councils or contractors to provide their own additional requirements.

3 Development of the Specification

The original Specification that was issued in June 2003, was compiled by Geotechnical Engineers in conjunction with an expert panel comprising local government engineers, the Pavements Branch of NSW Roads and Traffic Authority (RTA), the NSW Environment Protection Authority (EPA), the CSIRO and the Australian Road Research Board (ARRB).

The Specification was based on earlier work carried out by the Southern Sydney Regional Organisation of Councils and follows on from a previous scoping report co-ordinated by the Institute of Public Works Engineering Australia (NSW) and jointly funded by Resource NSW and NSW EPA. The report recommended that new specifications should be developed for recycled concrete, masonry and reclaimed asphalt materials linked to particular applications relevant to construction works in local government.

The current version of the Specification has been made available by the Department of Environment, Climate Change and Water NSW in conjunction with the Institute of Public Works Engineering Australia (NSW). This updated Specification has been prepared by the Institute of Public Works Engineering Australia (NSW) as part of a project funded and managed by the Department of Environment, Climate Change and Water NSW. The project has had considerable input from a panel of engineers and industry organisations with experience in the recycling of road materials. These organisations are listed in the acknowledgements.

4 A Statewide Approach

The development of the 'Specification for Supply of Recycled Material for Pavements, Earthworks and Drainage' ties in with the NSW Government's Waste Avoidance and Resource Recovery Strategy, which develops targets for waste avoidance and resource recovery in NSW. The Strategy is a framework for action designed to guide all sectors to better deal with products and materials in accordance with the principles of ecologically sustainable development. The Strategy is supported broadly by industry, community groups, environment groups, individual and State and Local governments, all of which have expressed a commitment to working together to achieve the Strategy's goals.

One of the key outcome areas outlined in the 2003 Strategy is the 'Increased recovery and use of secondary resources'. The 2003 Strategy outlined a target for the increased recovery and utilisation of materials from the construction and demolition sector from 65% in 2000 to 76% by 2014. This target has been retained in the subsequent Waste Strategy 2007. Increasing the demand for, and use of, recycled concrete, brick, tile and asphalt materials will make an important contribution towards achieving this target.

The Strategy is available on the Department of Environment, Climate Change and Water NSW website (www.environment.nsw.gov.au).

Photo 1. Typical Recycling Operation. Photo: Tamworth Regional Council courtesy of Jason Stratford

5 The Specification

The Specification, contained in Part B, has been compiled for four main material types, namely:-

Road Base	Class R1 Class R2	Suitable for use on roads with a traffic loading of greater than $1x10^6$ ESA Suitable for use on roads with a traffic loading of less than $1x10^6$ ESA
Select Fill	Class S	Material placed directly on the subgrade to improve subgrade performance. Can also be used as engineered fill to raise site levels
Bedding Material	Class B	Material used as support for paving blocks in pedestrian areas, carparks, shopping malls, footpaths, cycleways or on lightly trafficked accessways
Drainage Medium	Class D10 Class D20 Class D75	Backfilling material for stormwater pipes, sewer pipes or sub-surface drainage lines

For pavement material (Class R1 and Class R2) it was decided that there should be no delineation between basecourse and subbase as it is common practice for suppliers to produce a material that would meet the specification of basecourse only. The other classes of materials (Class S, B and D) are those commonly used in construction practice by local government and contractors.

This Specification has been developed for recycled concrete, clay brick/tile and asphalt as the predominant constituent materials. It also provides for the recycling of other materials such as glass fines and fly ash.

6 Using Recycled Materials

Benefits from using recycled materials in road and other civil works include:

- Protecting stocks of natural resources
- Protecting the environment from further degradation
- Potential cost savings
- Ensuring local government and the private sector work towards international best practice
- Assisting local government and the private sector to ensure development is ecologically sustainable.

Recycled materials behave differently to natural materials in some circumstances. Whilst this is not a problem, it is important to note that recycled crushed concrete, brick and reclaimed asphalt materials have the following characteristics:

- They are generally supplied with an increased moisture content
- They require additional moisture to increase their workability, this is especially noticeable during summer months
- They bind together better to reduce potholes and scouring
- They are capable of being worked in wetter conditions, resulting in less down time in wet weather
- They require less “brooming” to finish
- They are well graded and resistant to wearing
- They have a lower unit weight (i.e. about 20% reduction in weight per m^3) which results in lower purchase and transport costs
- They can provide reduced environmental impacts.

Construction staff should check with suppliers that a consistent material can be supplied for the job.

Users of recycled materials should ensure that appropriate compaction/placing techniques are employed that avoid breakdown of weaker constituents during construction. Some guidance covering these issues is included in Annexure 2.

Further information on using recycled materials can be obtained from:

- Materials suppliers
- IPWEA (NSW) Roads & Transport Directorate
- Experienced council engineers and contractors

PART B

SPECIFICATION FOR SUPPLY OF RECYCLED MATERIAL FOR PAVEMENTS, EARTHWORKS AND DRAINAGE

1. Scope

This Specification covers the supply of recycled materials predominantly comprising crushed concrete, brick and reclaimed asphalt blends for use in pavements and related engineering construction. The requirements of this Specification are appropriate for most engineering projects for local government works and the private sector.

The uses of the materials and their general classification are given in Part B, Section 2. It is imperative for designers of engineering works to be satisfied that the Specification is suitable for their local conditions. Crushed concrete, brick and reclaimed asphalt may be blended provided that Specification limits in Table 2 are adhered to. The designer/specifier should ensure that the inherent material characteristics are appropriate for their intended purposes. Annexure 4 can be used to specify modified material characteristics based on local knowledge or to include any additional requirements.

There are numerous potential uses for recycled materials in engineering construction. The uses outlined below are not intended to limit the utilisation of recycled materials. These applications indicate areas where high potential exists to use recycled materials and avoid the landfilling of valuable resources.

Pavement materials used in motorways, major highways, urban arterial roads or collector roads are covered in Specifications produced by State Road Authorities (e.g. RTA Specification 3051). Recycled materials are suitable for use in these pavements provided they meet the State Road Authority Specification.

This Specification is limited to recycled materials without any additional strength enhancing agents. In pavement construction there may be opportunity to utilise recycled material with additives such as slag, cement, lime, flyash etc., or blends of some or all of these materials to form lightly bound or heavily bound layers. In such circumstances the designer/specifier should consider the fatigue characteristics of stabilised recycled materials to determine whether shrinkage or block cracking may present problems with the life of the pavement. Similarly, some additives can be used to alter the plasticity characteristics of a 'run of crusher' product to make it more suitable for use. Nothing in this Specification limits the scope for adopting innovative strategies for blending materials to achieve the required outcome.

2. Material Classes

The terminology and designated material classes used in this Specification are as follows:

Terminology

Roadbase – A generic term for road making materials which covers both basecourse and sub-base. In this Specification Class R1 and R2 materials are not distinguished by their position in a pavement. Each may be used as either basecourse or sub-base depending upon the traffic loading

Basecourse – The layer of a pavement immediately above the subgrade or sub-base and directly below the pavement wearing surface extending for the full width of the pavement

Sub-base – One or more layers of material placed over the subgrade and below the basecourse layer of a road pavement

Equivalent Standard Axle (ESA) – The number of standard axle load repetitions of 8.2 tonne which has the same damaging effect on a pavement as the load under consideration

Footpath/Cycleway – These are treated as pavements which will be subject to loads from occasional service vehicles

Purchaser – The organisation that contracts to buy materials. In construction contracts, a Superintendent (or Engineer) may be authorised by the Purchaser to make decisions on all matters relating to supply and delivery and reject/accept materials based on test results

Supplier – The organisation, business or individual under contract to the Purchaser for the supply of materials contained in the Specification

Reclaimed Asphalt Pavement (RAP) – Processed asphalt material that has been obtained by rotomilling or through a crushing plant. Reclaimed asphalt must not contain coal tar.

Table 1 – Material Classes

Material	Class	Description
Road Base	Class R1	Suitable for use on roads with a traffic loading of greater than $1x10^6$ ESA as either basecourse or sub-base. This material has similar characteristics to RTA 3051 for dense graded basecourse (DGB).
	Class R2	Suitable for use on roads with a traffic loading of less than $1x10^6$ ESA as either basecourse or sub-base. This material has similar characteristics to RTA 3051 for dense graded sub-base (DGS).
Select Fill	Class S	Material placed directly on the subgrade to improve subgrade performance. Can also be used as engineered fill to raise site levels, particularly in road embankments or beneath buildings. Engineered fill should have a CBR of at least 5%.
Bedding Material	Class B	A material with about a 7 mm maximum particle size used as support for paving blocks in pedestrian areas, carparks, shopping malls, footpaths, pipe bedding, cycleways or on lightly trafficked accessways.
Drainage Medium	Class D10 Class D20 Class D75	Backfilling material for stormwater pipes, sewer pipes or sub-surface drainage lines (except for pipelines covered by AS3725 – Loads on Buried Concrete Pipes). In some circumstances, geofabric separators may be needed.

3. Material Quality

Each material class must conform to the properties outlined in Table 2. If required, the Supplier must provide test certificates from a NATA accredited laboratory confirming that the material complies with the Specification. The minimum testing requirements are set out in Part B, Section 5.

If required, the Supplier shall make available, written notification to the Purchaser of the proportions of recycled concrete, brick/tile, reclaimed asphalt and other relevant materials in the material to be supplied.

The Specification requirements for particle size distribution given in Table 2 show the limits for each individual sieve size. The particle size distribution curve shall be smooth and free from abrupt changes from one side of the grading envelope to the other to avoid gap grading.

The material property [% passing 0.425 mm sieve x PI] is specified to ensure that both individual properties are not at the upper limit of the specified range. If the percentage passing 0.425 mm sieve is near the upper limit there must be an appropriate reduction in the Plasticity Index to ensure that the material does not have the potential to lose strength on saturation.

The requirement for a maximum unconfined compressive strength is to ensure that the residual cementitious binder in the crushed product does not cause pavements to act as semi rigid structures and hence suffer possible fatigue cracking. Unconfined Compressive Strength tests shall be carried out after 7 days accelerated curing or 28 days moist curing.

4. Other Materials

The Supplier shall have in place screens and storage facilities to keep foreign matter in the final product to an absolute minimum. Only small amounts of timber, steel and plastic will be permitted, as indicated in Table 2. The material should be asbestos free.

Testing for the presence of other materials shall be in accordance with RTA test method T276. The groupings and limits in Table 2 are not identical to the classifications in T276.

Table 2 – Specification Requirements for Supply of Recycled Material

Constituent/Property	Test Method	Material Type						
		Road Base		Select Fill	Bedding Material	Drainage Medium		
		N>10^6ESA	N<10^6ESA					
		Class R1	Class R2	Class S	Class B	Class D75	Class D20	Class D10
Suggested Material Proportions (max% by mass)								
Concrete[1]		100	100	100	100	100	100	100
Reclaimed asphalt		40	40	50	20	5	5	5
Clay brick tile, crushed rock, masonry		20	30	100	100	100	100	100
Run-of-station Flyash[2]		10	10	5	5	5	5	5
Crushed Glass Fines[3]		10	10	10	50	50	50	100
Maximum Allowable Contaminants (max% by mass)								
Asbestos		0	0	0	0	0	0	0
Metal, glass and ceramics[4]	T276	3	5	5	5	5	5	5
Plaster, clay lumps and other friable materials	T276	0.2	0.2	1	0.5	0.5	0.5	0.5
Rubber, plastic, bitumen, paper, cloth, paint, wood and other vegetable matter	T276	0.1	0.2	0.2	0.5	0.5	0.5	0.5
Particle Size Distribution								
% passing 100 mm	AS1141.11, AS1141.12 or AS1289.3.6.1			100		100		
% passing 75 mm				95-100		80-100		
% passing 53 mm sieve								
% passing 37.5 mm sieve								
% passing 26.5 mm sieve		100	100				100	
% passing 19.0 mm sieve		95-100	85-100	50-85		5-10	80-100	
% passing 13.2 mm sieve		70-90	70-90				5-10	100
% passing 9.5 mm sieve		60-80	60-80	40-80	100			
% passing 4.75 mm sieve		40-65	40-65		80-100			0-10
% passing 2.36 mm sieve		35-55	30-55	35-70	50-80			
% passing 0.425 mm sieve		10-30	10-30		10-35			
% passing 0.075 mm sieve		5-15	5-15		5-20	0-5	0-5	0-5
Atterberg Limits								
Liquid Limit %	AS1289.3.1.1	27 max	27 max	NA	30 max	NA	NA	NA
Plasticity Index (%)	& 3.2.1	5 max	6 max	12 max	12 max	NA	NA	NA
% passing 0.425 mm sieve x PI		120 max	180 max	300 max	240 max	NA	NA	NA
Strength Properties								
CBR (%) – 4 day soak	AS1289.6.1.1	NA	60 min	30 min	NA	NA	NA	NA
Wet Strength (kN)	AS1141.22	70 min	70 min	NA	NA	70 min	70 min	70 min
Wet/Dry Strength Variation (%)		35 max	40 max	NA	NA	35 max	35 max	35 max
Maximum Dry Compressive Strength (MPa)	T114	1.7 min	1.0 min	NA	1.0 min	NA	NA	NA
Unconfined Compressive Strength (MPa)	AS1141.51	1.5 max	1.5 max	NA	1.5 max	NA	NA	NA
Particle Shape								
% Misshapen (2:1)	AS1141.14	35 max	35 max	NA	NA	NA	NA	NA

NA – Not Applicable

Any changes to material characteristics for specific applications are shown in Annexure 4.

Notes:

1. The design of pavements using high percentages of crushed concrete must take into account the amount of available cement which may rehydrate when subject to moisture to create a rigid or semi-rigid pavement which may result in subsequent shrinkage cracking.
2. The design of pavements using flyash must take into account the possibility of hydration and binding when subject to moisture which may create a rigid or semi-rigid pavement which may result in subsequent shrinkage cracking.
3. Crushed Glass Fines refers to clean glass, which has been processed to produce an aggregate product for which an Exemption has been issued.
4. Glass referred to in *Maximum Allowable Contaminants* is unprocessed glass which has been roughly crushed but has not been processed to produce an aggregate product for which an Exemption has been issued.

5. Sampling and Testing (Quality Assurance)

In carrying out conformance testing, the current issue of the following Standards and Test Methods shall be used unless otherwise specified:-

AS1141	Methods for Sampling and Testing Aggregates
AS1289	Method of Testing of Soil for Engineering Purposes
RTA T102	Pretreatment of Road Materials by Compaction
RTA T103	Pretreatment of Road Materials by Artificial Weathering
RTA T114	Maximum Dry Compressive Strength of Road Materials
RTA T116	Determination of Unconfined Compressive Strength of Remoulded Road Materials which are Self Cementing
RTA T276	Foreign Material Content of Recycled Crushed Concrete

The Supplier shall provide test certificates for each material class prior to delivery. The minimum sampling and testing requirements are set out in Table 3.

Table 3 – Minimum Number of Tests per Stockpile (4000 tonnes)

Total Mass of Stockpile (tonnes)	Class R	Class S	Class B	Class D
Property				
Particle Size Distribution	5	5	5	3
Atterberg Limits	5 (2)	5 (2)	5 (2)	NA
MDCS	3 (1)	3 (1)	NA	NA
UCS	5	5	NA	NA
Aggregate Wet Strength	3	NA	NA	3
Wet/Dry Variation	3	NA	NA	3
Particle Shape	3 (1)	3 (1)	NA	NA
Foreign Materials	3 (1)	3 (1)	3 (1)	3 (1)
CBR	Annexure 4	3	NA	NA

NA – Not Applicable

Where specified in Annexure 4, samples from blends containing clay brick, tile, crushed rock or masonry shall be subjected to ten cycles of wetting and drying in accordance with test method T103 followed by three cycles of repeated compaction in accordance with test method T102.

The Supplier must provide the Purchaser with test certificates and an estimation of the stockpile tonnage in each certified stockpile (see Part B, Section 6).

The number of tests identified in Table 3 may be reduced in the following circumstances:

- Where the Supplier demonstrates to the Purchaser, at the tender stage, that process control for the previous six certified stockpiles of the same material has achieved a consistent product, a reduced number of tests can be adopted as shown in brackets in Table 3
- Where certified stockpiles are smaller than 4000 tonnes, a proportional reduction (rounded up) is permitted to the number of tests required by Table 3, with a minimum of at least one test for stockpiles of less than 1000 tonnes.

For Class R2 sub-base material, California Bearing Ratio tests may be substituted for strength properties, if specified in Annexure 4.

Sampling must be carried out in accordance with the requirements of AS1141. The testing must be undertaken by a NATA accredited laboratory, which must supply certificates identifying:

- The Supplier's name
- Material type and blend constituents
- Bulk sample number and certified stockpile identification number
- Quantity of material represented by the test results
- The Specification limits.

In addition to the above materials testing requirements there are also sampling and testing requirements contained in the General Exemptions provided under the Protection of the Environment Operations (Waste) Regulation 2005. Please refer to the current General Exemptions available on the DECCW website at: http://www.environment.nsw.gov.au/waste/RRecoveryExemptions.htm

6. Certified Stockpiles

Material must be supplied from stockpiles that have been tested and shown to conform to the requirements of this Specification prior to incorporation in construction work. The maximum size of each individual stockpile should not exceed 4000 tonnes unless otherwise agreed in writing by the Purchaser. Certified stockpiles must be created for each material class to prevent segregation or mixing with other materials and must be clearly signposted with unique identification numbers.

Certified stockpiles must be formed on firm ground that is clean, well-drained and free of all foreign material which might contaminate the material to be certified. This includes but is not limited to all forms of vegetation both dead and alive, topsoil, material containing oils or oil deposits and remnants of previous stockpiles of dissimilar material. Stockpiles must be constructed in horizontal layers. Additional layers shall be fully contained on the underlying layer.

Once a stockpile has been tested and certified, further material must not be added to the stockpile.

7. Transport

Material shall be transported from the source of supply to the work in vehicles constructed to prevent loss of material.

Material shall be suitably dampened to prevent segregation during transport, with the moisture content not greater than the optimum moisture content as defined in AS1289 or as requested by the Purchaser in Annexure 4. The material may be either discharged from the transport vehicle into stockpiles or at the locations where it will be finally used in construction work.

The Supplier must provide delivery dockets to the Purchaser for each truckload of material identifying the material type, the certified stockpile identification number, the Supplier's name, the tonnage of material being delivered and a Recovered Aggregate Exemption Statement.

8. Glossary

Terms used in this document include:

Term	Definition
California Bearing Ratio (CBR)	The ratio, expressed as a percentage, between a test load and an arbitrarily defined standard load. This test load is required to cause a plunger of standard dimensions to penetrate at a specified rate into a specifically prepared soil specimen.
Deflection	The vertical movement of a member or pavement due to the application of a load. It is an indication of the rate at which permanent deformation will occur under traffic, or due to other environmental or physical factors, over time.
Earthworks	• All operations involved in loosening, removing, depositing, shaping and compacting soil or rock. • The structure resulting from this operation.
Fill	• The depth from the subgrade level to the natural surface. • That portion of road where the formation is above the natural surface. • The material placed in an embankment.
Run-of-station fly ash	When coal is burnt in a modern pulverised fuel furnace, two types of ash are produced. The fine ash, which is recovered from the flue gas, is called fly ash. The second, coarser ash produced, which is recovered from the base of the furnace, is called bottom ash.
Waste	Any material that is no longer needed for its original purpose. For many of these materials there may be preferred options of reuse or recycling, with disposal to landfill the last resort. The complete definition can be found in Annexure.

ANNEXURE 1

LEGISLATION GOVERNING MATERIALS RECYCLING

Background

Since the release of the "Specification for Supply of Recycled Material for Pavements, Earthworks & Drainage" in June 2003 there have been significant changes to the legislative provisions covering the recycling of materials. The main elements of the current Protection of the Environment Operations Act (POEO) classify all excavated material as waste unless it is covered by a general exemption or a specific exemption. These matters are discussed in more detail in the following sections.

Background to NSW 'Resource Recovery Exemptions'

Several Australian state and territory governments have introduced new regulatory systems to encourage the recovery of resources from waste where this is beneficial and does not harm the environment or human health.

In April 2008, the NSW Department of Environment and Climate Change (now the Department of Environment, Climate Change and Water NSW (DECCW)) introduced 'Resource Recovery Exemptions' under clause 51 and 51A of the Protection of the Environment Operations (Waste) Regulation 2005 to facilitate the environmentally appropriate reuse of waste materials. DECCW is able to exempt the use of waste or waste-derived materials from the waste regulatory framework in certain circumstances when a material is assessed as being fit for its intended purpose.

DECCW are able to grant general or specific exemptions:

- **General Exemptions** are developed by DECCW with input from industry groups for commonly recovered materials such as concrete, brick and asphalt. General Exemptions can be used without notifying DECCW provided the conditions of the Exemption are met. DECCW publish General Exemptions in the Government Gazette as they become available or when the Exemption is amended or revoked. Resource Recovery Exemptions can be amended from time to time and generators, processors or consumers of waste derived materials should reference the DECCW website for the latest versions. DECCW uses a simple date scheme for each of the general exemptions by incorporating a year into the exemption title e.g. 'The recovered aggregate exemption 2010'. www.environment.nsw.gov.au/resources/waste/ex10aggregates.pdf

  The list of current General Exemptions is available on the DECCW website at: http://www.environment.nsw.gov.au/waste/RRecoveryExemptions.htm

- **Specific Exemptions** are developed by organisations and granted by DECCW for recovered materials that are not covered by a General Exemption or do not meet the definitions or conditions that are prescribed in an existing General Exemption. DECCW does not publish or make Specific Exemptions available on the DECCW website or publish Specific Exemptions in the NSW Government Gazette.

DECCW will assess applications for proposed waste or waste derived materials to be applied to land for use in pavements and related construction material against the criteria outlined in the publication 'Guidelines on Resource Recovery Exemptions (Land Application) (April 2008) www.environment.nsw.gov.au/resources/waste/08232resrecoverexempts.pdf

Note: All the following information contained in this Annexure is provided as a guide only to provide users with a basic understanding of the POEO Act 1997 and Regulations as they pertain to the use of recycled materials. It is incumbent upon the reader to refer at all times to the current information contained in the DECCW website:

http://www.environment.nsw.gov.au/waste/RegulateWaste.htm to ensure strict compliance with the current definitions provided and requirements imposed by the Act and Regulations.

What is Waste?

The Dictionary contained in the POEO Act 1997 defines waste as:

"waste" includes:

(a) any substance (whether solid, liquid or gaseous) that is discharged, emitted or deposited in the environment in such volume, constituency or manner as to cause an alteration in the environment, or

(b) any discarded, rejected, unwanted, surplus or abandoned substance, or

(c) any otherwise discarded, rejected, unwanted, surplus or abandoned substance intended for sale or for recycling, processing, recovery or purification by a separate operation from that which produced the substance, or

(d) any processed, recycled, re-used or recovered substance produced wholly or partly from waste that is applied to land, or used as fuel, but only in the circumstances prescribed by the regulations, or

(e) any substance prescribed by the regulations to be waste.

A substance is not precluded from being waste for the purposes of this Act merely because it is or may be processed, recycled, re-used or recovered.

This definition is clarified by the provisions of the Protection of the Environment Operations (Waste) Regulation 2005 - Regulation 3b which states:

3B Definition of "waste"

(1) For the purposes of paragraph (d) of the definition of "waste" in the Dictionary to the Act, the following circumstances are prescribed:

(a) in relation to substances that are applied to land, the application to land by:

(i) spraying, spreading or depositing on the land, or

(ii) ploughing, injecting or mixing into the land, or

(iii) filling, raising, reclaiming or contouring the land,

(b) in relation to substances that are used as fuel, all circumstances.

(2) Subclause (1) (a) does not apply where the substances concerned are either bulk agricultural crop materials or manure.

The types of materials covered by this specification are clearly captured within the above definition of "Waste". In order to recycle these materials it is necessary to ensure that they fall within the provisions of an exemption.

What is an Exemption?

The general conditions concerning exemptions are contained in Protection of the Environment Operations (Waste) Regulation 2005 - Regulation 51 which states:

51 General provisions relating to exemptions

(1) The EPA may grant an exemption under this clause if authorised to do so by any provision of the Act or by another provision of this Regulation.

(2) An exemption may be granted in relation to:

(a) any person or class of persons, or

(b) any premises or class of premises, or

(c) any area or class of areas, or

(d) any activity or class of activities, or

(e) any other matter or thing or class of matters or things.

(3) An exemption granted under this clause may be a "general exemption" or a "specific exemption".

(4) A general exemption may be given by way of notice published in the Gazette. A specific exemption may be given after an application is made to the EPA.

(5) An application for a specific exemption must:

(a) be in the approved form, and

(b) be accompanied by such fee (if any) as the EPA may determine, and

(c) be accompanied by such information, documents or evidence as may be required by the EPA for the purposes of determining whether the exemption should be given.

(6) An exemption under this clause is subject to such conditions as may be imposed by the EPA.

(7) In giving an exemption under this clause, the EPA may, in relation to a general exemption, and must, in relation to a specific exemption, identify a person (or class of persons) to whom the exemption relates (the "responsible person").

(8) A general exemption may be amended or revoked by the EPA by way of notice published in the Gazette

(9) A specific exemption may be amended or revoked by the EPA by way of written notice given to the responsible person.

(10) If an exemption is given under this clause for which a responsible person is identified, the responsible person must comply with the conditions to which the exemption is subject.

Maximum penalty: 400 penalty units in the case of a corporation, 200 penalty units in the case of an individual.

What does a General Exemption Look Like?

In applying this Specification to recycled materials for pavements, earthworks and drainage it is most likely that the Recovered Aggregate Exemption will be employed. Accordingly, a copy of this exemption is included below to show the typical format and content of General Exemptions.

The recovered aggregate exemption 2010

Name

1. This exemption is to be known as 'The recovered aggregate exemption 2010'.

Commencement

2. This exemption commences on 1 April 2010. 'The recovered aggregate exemption 2008' which commenced 29 August 2008 is revoked from 1 April 2010.

Duration

3. This exemption is valid until revoked by the Environment Protection Authority (EPA) by notice published in the Government Gazette.

Legislation

4. Under the *Protection of the Environment Operations (Waste) Regulation 2005* (the Regulation):

4.1 Clause 51 authorises the EPA to grant an exemption in relation to any matter or thing including an activity or class of activities, and

4.2 Clause 51A authorises the EPA to exempt a person or class of persons from any of the following provisions in relation to an activity or class of activities relating to certain waste that is to be land applied or used as a fuel:

- the provisions of sections 47 to 49 and 88 of the *Protection of the Environment Operations Act 1997* (the Act),
- the provisions of Schedule 1 to the Act, either in total or as they apply to a particular activity, and
- the provisions of Part 3 and clauses 45 and 47 of the Regulation.

Exemption

5. In this Notice of Exemption:

5.1 The responsible person listed in Column 1 of Table 1 is exempt from the provision/s listed in Column 2 of that table but only in relation to activities involving the relevant waste and only where the responsible person complies with the conditions referred to in Column 3 of the table.

However, this Notice of Exemption does not exempt the responsible person from the provisions specified in Column 2 where the relevant waste is received at premises that are, despite this exemption, required to be licensed for waste disposal (application to land) activities under the provisions of the Act.

5.2 Where a responsible person complies with the conditions of this Notice of Exemption, the activity referred to in Schedule 1 from which that person is exempt is taken to be a non-scheduled activity for the purposes of the Act.

Table 1

Column 1	Column 2	Column 3
Responsible person	**Provisions from which the responsible person is exempt**	**Conditions to be met by the responsible person**
Processor	section 48 of the Act in respect of clause 39 of Schedule 1 to the Act	all requirements specified in section 7 and 8
Consumer	section 48 of the Act in respect of clauses 39 and 42 of Schedule 1 to the Act section 88 of the Act clause 47 of the Regulation	all requirements specified in section 7 and 9

This Notice of Exemption is a general exemption for the purposes of clause 51(3) of the Regulation.

Definitions

6. In this Notice of Exemption:

Characterisation means sampling and testing that must be conducted on the recovered aggregate for the range of chemicals and other attributes listed in Column 1 of Table 2.

Composite sample means a sample that combines 5 discrete sub-samples into a single sample for the purpose of analysis.

Consumer means a person who applies, causes, or permits the application to land of recovered aggregate within the definitions of "application to land" in accordance with the Act. The consumer may be the landholder responsible for the land to which recovered aggregate is applied.

Once-off sampling means sampling and testing that must be conducted only once on a batch, truckload or stockpile of recovered aggregate that is not repeated, reproduced and does not form part of a continuous process.

Processor means a person who processes, mixes, blends, or otherwise incorporates recovered aggregate into a material for supply to a consumer.

Recovered aggregate means material comprising of concrete, brick, ceramics, natural rock and asphalt processed into an engineered material. This does not include refractory bricks or associated refractory materials, or asphalt that contains coal tar.

Relevant waste means recovered aggregate that meets the requirements of Section 7.

Routine sampling means sampling and testing that must be conducted on the recovered aggregate on an ongoing and regular basis.

General conditions

7. This Notice of Exemption is subject to the following conditions:

7.1. The chemical concentration or other attribute of the recovered aggregate listed in Column 1 of Table 2 must not exceed any of the following:

7.1.1. the absolute maximum concentration or other value listed in Column 4 of Table 2,

7.1.2. for characterisation or once-off tests, the maximum average (based on the arithmetic mean) concentration or other value listed in Column 2 of Table 2, and

7.1.3. for routine tests, the maximum average (based on the arithmetic mean) concentration or other value listed in Column 3 of Table 2.

7.2 The recovered aggregate can only be applied to land for road making activities, building, landscaping and construction works. This approval does not apply to any of the following applications:

7.2.1. Construction of dams or related water storage infrastructure,

7.2.2. Mine site rehabilitation,

7.2.3. Quarry rehabilitation,

7.2.4. Sand dredge pond rehabilitation,

7.2.5. Back-filling of quarry voids,

7.2.6. Raising or reshaping of land used for agricultural purposes, and

7.2.7. Construction of roads on private land unless:

(a) the relevant waste is applied to land to the minimum extent necessary for the construction of a road, and

(b) a development consent for the development has been granted under the relevant Environmental Planning Instrument (EPI), or

(c) it is to provide access (temporary or permanent) to a development approved by a Council, or

(d) the works undertaken are either exempt or complying development.

Processor responsibilities

8. The following conditions must be met by the processor for this exemption to apply:

8.1. The processor must implement procedures to minimise the potential to receive or process waste containing asbestos. These procedures must be formally documented and the records of compliance must be kept for a period of three years.

8.2. Sampling must be undertaken in accordance with Australian Standard 1141 Methods for sampling and testing aggregates (or equivalent). Sampling and information on sample storage and preparation must be detailed in a written sampling plan.

8.3. Where the recovered aggregate is generated as part of a continuous process, the processor must undertake characterisation and routine sampling according to the requirements listed in Column 1 and Column 2 of Table 3.

8.4. Where the recovered aggregate is not generated as part of a continuous process, the processor may undertake once-off sampling of a batch, truckload or stockpile of recovered aggregate according to the requirements listed in Column 3 of Table 3, for the range of chemicals and other attributes listed in Column 1 of Table 2.

8.5. Where there is a change in inputs that is likely to affect the properties in the recovered aggregate, characterisation must be repeated. Characterisation samples can be used for routine testing and subsequent calculations.

8.6. Processors must keep a written record of all characterisation, routine and/or once-off test results for a period of three years.

8.7. Records of the quantity of recovered aggregate supplied to the consumer and either the consumer's name and address or the registration details of the vehicle used to transport the recovered aggregate, must be kept for a period of three years.

8.8. The processor of recovered aggregate must provide each consumer with a copy of this exemption and inform them of the consumer responsibilities contained within this exemption. The processor must also provide a written statement of compliance to the consumer with each transaction, certifying that the recovered aggregate complies with the relevant conditions of this exemption.

8.9 The processor of recovered aggregate must make information on the latest characterisation and routine test results available to the consumer.

Consumer responsibilities

9. The following conditions must be met by the consumer for this exemption to apply:

9.1 Records of the quantity of the recovered aggregate received by the consumer and the suppliers' name and address must be kept for a period of three years.

9.2 The consumer must land apply the relevant waste within a reasonable period of time.

Chemical and other material property requirements

10. This Notice of Exemption only applies to recovered aggregate where the chemical and other attributes listed in Column 1 of Table 2 comply with the chemical concentrations and other values listed in Column 2, Column 3 and Column 4 of Table 2, when analysed according to test methods specified in Column 5 of Table 2.

Table 2

Column 1	Column 2	Column 3	Column 4	Column 5
Chemicals and other attributes	**Maximum average concentration for characterisation** (mg/kg 'dry weight' unless otherwise specified)	**Maximum average concentration for routine testing** (mg/kg 'dry weight' unless otherwise specified)	**Absolute maximum concentration** (mg/kg 'dry weight' unless otherwise specified)	**Test method specified within Section**
1. Mercury	0.5	Not required	1	12.1
2. Cadmium	0.5	0.5	1.5	12.2
3. Lead	75	75	150	12.2
4. Arsenic	20	Not required	40	12.2
5. Chromium (total)	60	60	120	12.2
6. Copper	60	60	150	12.2
7. Nickel	40	Not required	80	12.2
8. Zinc	200	200	350	12.2
9. Electrical Conductivity	1.5 dS/m	1.5dS/m	3 dS/m	12.3
10. Metal	1%	1%	2%	12.4
11. Plaster	0.25%	0.25%	0.5%	12.4
12. Rubber, plastic, paper, cloth, paint, wood and other vegetable matter	0.2%	0.2%	0.3%	12.4

Sampling and testing requirements

11. This Notice of Exemption only applies to recovered aggregate sampled according to the requirements in Table 3.

Table 3

Column 1	Column 2	Column 3
Characterisation frequency	**Routine sampling frequency**	**Once-off sampling frequency**
20 composite samples, by taking 1 composite sample from a different batch, truckload or stockpile. This must be repeated every year.	5 composite samples per 4000 tonnes or 5 composite samples per 3 months.	10 composite samples per 4000 tonnes.

Test methods

12. All testing must be undertaken by analytical laboratories accredited by the National Association of Testing Authorities, or equivalent. All chemicals and other attributes listed in Column 1 of Table 2 must be measured in accordance with the test methods specified below:

12.1. Test methods for measuring the mercury concentration in recovered aggregate:

12.1.1. Particle size reduction & sample splitting may be required.

12.1.2. Analysis using USEPA SW-846 Method 7471B Mercury in solid or semisolid waste (manual cold vapour technique), or an equivalent analytical method with a detection limit < 20% of the stated absolute maximum concentration in Table 2, Column 4 (i.e. 0.2 mg/kg dry weight).

12.1.3. Report as mg/kg dry weight.

12.2. Test methods for measuring chemicals 2 - 8 in recovered aggregate:

12.2.1. Particle size reduction & sample splitting may be required.

12.2.2. Sample preparation by digesting using USEPA SW-846 Method 3051A Microwave assisted acid digestion of sediments, sludges, soils, and oils.

12.2.3. Analysis using USEPA SW-846 Method 6010C Inductively coupled plasma - atomic emission spectrometry, or an equivalent analytical method with a detection limit < 10% of the stated absolute maximum concentration in Table 2, Column 4, (i.e. 0.15 mg/kg dry weight for cadmium).

12.2.4. Report as mg/kg dry weight.

12.3. Test methods for measuring the electrical conductivity in recovered aggregate:

12.3.1. Sample preparation by mixing 1 part recovered aggregate 'as received' with 5 parts distilled water.

12.3.2. Analysis using Method 104 (Electrical Conductivity) *in* Schedule B (3): Guideline on Laboratory Analysis of Potentially Contaminated Soils, National Environment Protection (Assessment of Site Contamination) Measure 1999 (or an equivalent analytical method).

12.3.3. Report in deciSiemens per metre (dS/m).

12.4. Test method for measuring the attributes 10 - 12 in recovered aggregate:

12.4.1. NSW Roads & Traffic Authority Test Method T276 Foreign Materials Content of Recycled Crushed Aggregate (or an equivalent method), for the materials listed in 10 - 12 of Column 1, Table 2.

12.4.2. Report as %.

What is a Specific Exemption?

It is anticipated that some materials will not meet the requirements of a General Exemption but could still be recycled subject to appropriate conditions. In these circumstances it is possible to apply for a Specific Exemption.

The Department of Environment, Climate Change and Water NSW website provides that:

> *Specific exemptions will be approved in certain circumstances in recognition of intellectual property rights or where it is necessary to impose specific conditions on the use or application of low-risk waste-derived material.*
>
> *It should be noted that exemptions are limited to the release of the specific waste from the waste regulatory framework only.*

More detailed information can be obtained from the Department's website.

Summary

This section provides a brief overview of the legislative provisions that must be met to allow the recycling of materials for roads, drainage and fill.

More detailed information is available from the Department of Environment, Climate Change and Water NSW website at: http://www.environment.nsw.gov.au/waste/

ANNEXURE 2

THE PLACEMENT AND COMPACTION OF RECYCLED PAVEMENT MATERIALS

Background

Many Construction Engineers and Civil Engineering Contractors have requested information on the handling, placement and compaction of road pavements. A literature review confirms that information on the principles of compacting gravel road pavements is not readily available. As a consequence, this brief summary has been prepared by ARRB to guide builders of road pavements in the placing of recycled road base to produce a sound road pavement.

Construction of unbound road bases using recycled materials

The general principles of road construction are:

Do	• Follow the designer's intent – check the assumptions used in preparing the design • Manage stockpile to keep different source materials separate • Check the design of pavements using flyash and / or free cement to determine the possibility of hydration and binding when subject to moisture which may create a rigid or semi-rigid pavement which may result in subsequent shrinkage cracking • Ensure appropriate grading for workability (about 10% fines) • Consider blending concrete with other materials with no lime content (e.g. RAP, natural quarry products) • Avoid generating fines during storing, transporting and compacting the material • Compact layers in small lifts – not more than 150 mm layers • Ensure bonding of layers by scarifying the surface at the interface • Water to ensure the optimum moisture content (OMC) • Protect the unbound layer with a primer or primer seal • Ensure adequate drainage during and after construction • Check subgrade moisture content • Check temperature variations during construction.
Do not	• Overwork the material – excessive compaction will crush the larger materials making compaction difficult • Build layers in more than 150 mm thickness • Use materials of unknown composition and source • Use water to compensate for inadequate grading • Allow forming of a thin fine layer (slurrying) on the surface.
General	Unbound road bases have been built over many years all over the world. As a result of extensive experience, specifications and guides are finely tuned to match locally available materials and resources. Most of these refer to natural quarry products and do not take into account the specific characteristics of recycled materials that recently became available for road builders. The most critical issues are briefly presented in the following sections.
Function	Road bases have two fundamental functions: 1. as a structural layer providing strength and load bearing capacity to the pavement by accepting compressive stress and 2. as a working platform for upper layers and the wearing course.

Working of recycled road base	Pavement designers select materials for each layer according to their anticipated function and working mechanism. The design takes into account the strength of the material as well as its behavior and expected performance. It is vital that the fundamental properties of the used material are not changed accidently during or after construction. Unbound sub-base and base courses provide load bearing capacity or 'strength' to the pavement by forming an interlocking lacework of the constituent aggregates without cohesion. Unbound layers resist tensile forces – causing cracking – by: 1. horizontal compressive forces; and 2. distributing tension over a large area. The distribution of tensile strains over a large area prevents the concentration of horizontal movement that would result in cracking of the pavement.
Avoid bonding	Conventional materials – natural quarry products – are mostly chemically inert and the likelihood of developing cohesion during or after construction is very low. Recycled materials, whilst their grading may be similar to those of quarry products, may contain chemical components that are active and may contribute to developing cohesion during or after construction. To meet the pavement designer's intent, it is paramount to prevent the development of cohesive strength within the material. The most common cause of recycled materials developing cohesive strength is the presence of free lime. Lime or various forms of free calcium oxide are present in concrete, mortar and other recycled building materials. Though lime is bound in the recycled material, it becomes free when the material breaks up. The smaller the size of the broken material, the larger is its propensity to bond with other materials and develop strength. (See *Laboratory testing* below)
Stockpile management	Different building materials contain different types and quantities of lime. It is good practice to keep these products in separate stockpiles as their propensity to carbonation is quite different, e.g. kerb and gutter concrete usually contains less lime than structural concrete. Bricks and brick walls have significantly higher lime content due to the mortar attached to the brick. By keeping these materials in separate stockpiles a better control of lime content can be achieved. Cleanliness of the material is essential. Regular turning over of the pile assists in removing contamination and preventing bonding in the pile.
Laboratory testing	Laboratory checking of the calcium oxide content of the blend may assist to estimate the propensity for bonding and may provide valuable warning for the user. Testing of unconfined compressive strength (UCS) is recommended to check the propensity for bonding. If the UCS is significant (larger than about 1.5 MPa) the blend needs to be reviewed.
Grading	The grading of the crushed recycled material is prescribed in the specification. The specified grading represents an ideal particle distribution. It is advisable to check workability with laboratory compaction before commencing construction. Typically, 10% fines content assures good workability. Insufficient fines content in a material with relatively low crushing strength tends to cause the breakdown of the larger size aggregate during transport and compaction. This breakdown will change the grading of the material, thus may cause non-compliance with the specification and ultimately the underperformance of the pavement.
Fines are essential	Fines in the mixture may be natural or a man made product, such as fly ash. Besides its cost, the bonding propensity of the blended material needs to be considered. Grading of the blend must be designed, checked and controlled. Appropriate grading is vital to ensure workability and to reduce the breakdown potential of the material during compaction.

Moisture content	Good workability requires moisture content close to the Optimum Moisture Content (OMC). This is significantly more than the OMC for natural materials, which are usually compacted at about 3-4% below the OMC. Water should not be used to improve workability to compensate for lack of fines.
Workability	Water acts as a lubricant and assists in achieving the desired level of compaction. Unfortunately, at the same time it may also contribute to the hydration of the lime and may accelerate bonding. The use of significant quantities of water may also require subbase drainage as the permeable base material will let water through that may be retained at the top of the subgrade, causing inherent weakness of the base.
Compaction practice	Breaking down of the recycled material during delivery must be avoided. Long distances, heavy handling and large trucks may contribute to the breakdown of the material. Further breakdown occurring during compaction may be minimised by limiting the compaction effort, i.e. by avoiding the use of heavy vibrating rollers and equipment that is designed for compacting clayey soils or bound materials (e.g. vibrating tampers, padfoot roller etc.). The limited compacting force can be compensated by ensuring good workability of the blend and by placing the material in no more than 150 mm thick layers.
Maximum layer thickness	If the design thickness exceeds 150 mm, the full thickness can be achieved by placing the material in several lifts. Adequate bonding between the layers is paramount; otherwise the layers may work separately and not according to the design assumption. Adequate layer bonding can be achieved by scarifying the top of the layer before placing the next one.
Watering during construction	Reclaimed concrete aggregate can be expected to exhibit higher absorption than natural crushed aggregate. Accordingly, the moisture content during construction should ideally be close to the optimum moisture content (OMC). It is usually assumed that water below the OMC lubricates the material, above OMC it acts as a displacer. The optimum moisture content is usually higher than that of natural crushed materials. As recycled materials tend to be more permeable, it is likely that the material in situ will not be able to hold the optimum moisture content. Typically, the moisture content should be close to or slightly below the OMC. Moisture content can easily be checked in situ with a suitable nuclear gauge or in the laboratory using the microwave method.
Slurrying	Adding water will improve workability but excessive water will wash fines to the surface causing slurrying. A thin layer of fines on the surface prevents the penetration of the primer and may cause delamination of the seal.
Weather conditions	Placement and compaction of pavements should be programmed to ensure that unfavourable weather conditions do not impact on the process. Rain or extreme temperatures can quickly change the moisture content of materials being placed resulting on unsatisfactory compaction results.

ANNEXURE 3
RECYCLED MATERIALS CASE STUDIES

Three case studies are provided to demonstrate the use of recycled materials in public works projects and encourage others to utilise recycled materials.

A3.1 FAIRFIELD CITY COUNCIL – DELGARNO ROAD, BONNYRIGG HEIGHTS

This project involved the rehabilitation of an existing pavement in a residential street. Work was carried out in 2002 and involved the removal of 175mm of failed pavement material and replacement with 150mm of crushed concrete.

Inspection after seven years shows that the pavement is still in excellent condition with no defects being observed. Deflection and roughness measurements confirm that the pavement has performed to design expectations.

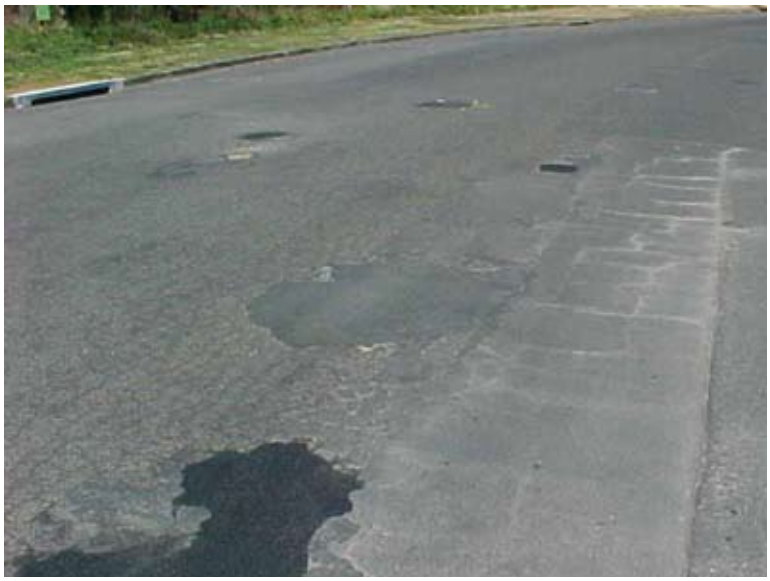

Photo 2. Delgarno Road before reconstruction

Street Name	Delgarno Road, Bonnyrigg Heights (Childers St-Greer St)
Council	Fairfield, NSW
Construction Date	2002
Project Type	Road Pavement Rehabilitation
Reason for Works	Existing Pavement had failed
Length/area of Project	350m long
Layer constructed from recycled material	Base
Details of site investigation and pavement design	Design Traffic: 5 x 10^5 ESA Design CBR: 4% Subgrade Type: Brown soft clay, moist and plastic Existing pavement composition: 400mm Sandstone base 35mm AC10 Wearing Course Pavement Design: Remove 175mm of Sandstone and replace with: 150mm Recycled Crushed Rock Concrete 35mm AC10 Wearing Course
Strength of material	Recycled Concrete met the requirements of RTA 3051 Spec.

Testing	Char Deflection – 0.80mm (9 Months after construction) Char Curvature- 0.19mm (9 Months after construction) NAASRA Roughness – 65 counts /km (2007
Current Condition	The pavement appears to be in sound and good condition. No pavement defects were noted at the time of inspection (August 2009)
Would you use this product again on similar projects?	Yes
What is your overall view on recycled materials.	Recycled concrete is a viable and cost effective product for use in road construction

Photo 3. Delgarno Road – Road condition 7 years after the rehabilitation work

A3.2 TAMWORTH REGIONAL COUNCIL – ARMSTRONG STREET, GLEN ARTNEY ESTATE

This project involved the planned extension of the road network within an industrial estate on the outskirts of the city. A new two lane / two way road for use by B-Double trucks and similar heavy traffic was to be constructed on the site.

The works had progressed to box out stage before being delayed for two years. Local soils showed high organic matter and low wet bearing strength, moderate to high foundation hazard, high shrink swell potential, seasonal waterlog and erosion risk. Accordingly, the pavement design was for a 300mm sub-base (recycled concrete materials), 150mm gravel base (quarried limestone) and 40mm Asphaltic overlay.

In anticipation for use in this project (and other Council road construction / maintenance works), recycled concrete roadbase was produced at the Council's waste management facility, to the R1 standard of the Greenspec.

Photo 4. Armstrong Street road reserve prior to construction.

Photo 5. Recycled Sub-base ready for compaction

Street Name and Suburb	Armstrong Street – Glen Artney Estate
Council	Tamworth Regional Council
Construction date	February to June 2006
Project Type	Industrial Subdivision
Reason for Works	Construct new two lane-two way road for use by B-Double trucks and similar heavy traffic.
Length/Area project	680 m roadway, 13 m wide
Layer constructed from recycled material	Sub-Base (~300mm)
Details of site investigation and pavement design	• Site had been excavated to subgrade (2 years previous) • Soils showed high organic matter and low wet bearing strength, moderate to high foundation hazard, high shrink swell potential, seasonal waterlog and erosion risk. • Pavement design, 300mm sub-base (recycled C&D), 150mm gravel base (quarried limestone) 40mm Asphaltic overlay.
Strength of material	• Benkelman Beam tests (deflection) • Relative strength of material not tested by receiver. Supplier provided test results
Construction benefits or issues	• Environmental advantages of reusing material. • Level of contamination (metal, dirt, waste) were considered to be high by construction staff although material test results returned contaminant results well below acceptable levels for R1 / R2 (perception after long term use of quarried 'limestone' virgin materials) • Operators expressed some difficulty in 'working up' material and balancing moisture content • Difficulties overcome as experience with material developed as job progressed.
Cost savings	• Estimated $20,000 savings after 6,000 tonnes laid
Testing	• Benkelman Beam Testing
Material Properties: Liquid Limit Plasticity Index Wet Strength (kN) Wet/ Dry Strength Variation (%) Max Dry Compressive Strength (MPa)	 • 15 • Non plastic • 91 • 15 • 3.9

Sieve Analysis	Size (mm)	26.5mm	13.2mm	4.75mm	0.075mm
	% passing	100	85	55	5
Would you use the product again on similar projects?		Yes			
What is your overall view on recycled materials?		Generally positive for those staff who have first hand usage experience. Additional publicity required to alleviate negative perceptions of some staff. (A previous production run was not quality controlled / produced to Greenspec and when used performed poorly. This led to negative perceptions from staff that recycled material was inferior to quarried gravels). Use of the Greenspec to guide production has fully overcome the initial issues experienced with recycled roadbase products mentioned.			

Photo 6. Completed, sealed Armstrong Street

A3.3 WYONG SHIRE COUNCIL – NORTH WYONG INDUSTRIAL PRECINCT

This project involved a land release for an industrial precinct which included creation of lots by a private developer and the encouragement job generation. These works are in the North Wyong Industrial Precinct and were part of a greenfield development site which was started in September 2005 and, except for some minor works, was completed in October 2006. The project consisted of four streets:

- Amsterdam Circuit
- London Drive
- Naples Place
- Brussels Road

Photo 7. Early site works

Street Name and Suburb	Amsterdam Circuit London Drive Naples Place Brussels Road North Wyong
Council	Wyong Shire Council
Construction date	September 2005 – October 2006
Project Type	Industrial subdivision by private developer
Reason for Works	land release for an industrial precinct,
Length/Area project	Approx 1470 metres
Layer constructed from recycled material	• Select (subgrade replacement) • Sub-base

Details of site investigation and pavement design	• Design traffic: » 5 x 10^6 ESA • Design CBR: » 2.5% and 3% (4 day soak) • Subgrade type: » moist silty clay • Pavement design: » 500mm select layer recycled concrete (50-75mm) » 100mm sub-base layer recycled concrete (RTA QA 3051 compliant) » 160mm Base-course layer DGB 20 (RTA QA 3051 compliant) » 7mm primer seal » 40mm AC14 wearing surface
Strength of material	Recycled products were tested and satisfied strength requirements for materials for Traffic category 2(a) in accordance with RTA QA 3051.
Construction benefits or issues	Users need to be aware of different construction practices.
Cost savings	It is estimated that there was an approximate 20% saving.
Testing	• Char deflection: » 0.330mm (at completion of construction) » 0.420mm (at 3 years) • Char deflection: » 0.302mm (at completion of construction) » 0.180mm (at 3 years) • Char deflection: » 0.310mm (at completion of construction) » 0.210mm (at 3 years) • Char deflection: » 0.067mm (at completion of construction) » 0.180mm (at 3 years) » Roughness count not tested
Material Properties: Liquid Limit Plasticity Index Wet Strength (kN) Wet/ Dry Strength Variation (%) Max Dry Compressive Strength (MPa)	Not Available
Would you use the product again on similar projects?	I would use this product again, however will keep an eye on the pavement performance to reinforce this decision.

Photo 8. Site Filling and Recycled Concrete – Note depth of Fill

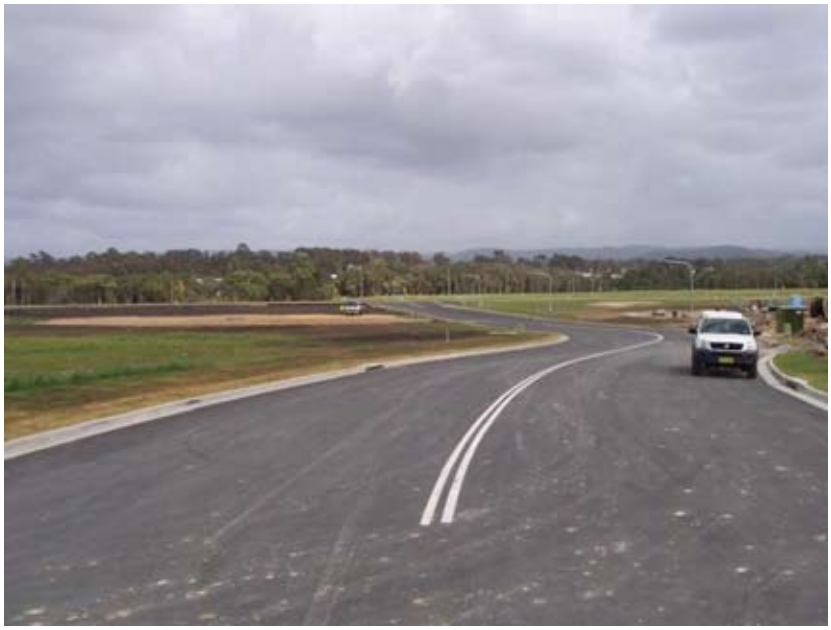

Photo 9. Finished roadway

ANNEXURE 4

MODIFIED RECYCLED MATERIAL SUPPLY REQUIREMENTS

ANNEXURE 4 AMENDED RECYCLED MATERIAL SUPPLY REQUIREMENTS

PURCHASER:	
PROJECT/CONTRACT NUMBER:	
PROJECT DETAILS:	
COUNCIL/LOCATION:	

MATERIAL CLASS	**QUANTITY TO BE SUPPLIED**

Clause 6: Maximum moisture content at delivery:

Clause 7: Responsibility for preparing stockpile location:
PURCHASER ☐ **SUPPLIER** ☐ **CONTRACTOR** ☐ **NA** ☐

AMENDED SPECIFICATION REQUIREMENTS

	Material Class					Comments
	R1	R2	S	B	D75/D20/D10	
ADDITIONAL TESTING CBR (%)						
TESTING NOT REQUIRED						
Particle Size Distribution						
Atterberg Limits						
Strength Properties						
Particle Shape						

OTHER REQUIREMENTS: