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Recycled Materials at Main Roads

Reference Guide

January 2021

Contents

Reference Guide

This reference guide outlines the different types of sustainable and recycled materials that are or potentially will be used for building and maintaining the Main Roads state road network. The guide is broken down into the types of materials that can or potentially could be used in different road layers, examples of Main Roads projects that have used this material, and the related specifications allowing the use of these materials. Sustainable alternatives for other materials used for road maintenance are also explored.

Sustainability and Recycling at Main Roads Western Australia

Within a Main Roads context, Sustainability is defined as a commitment to 'creating lasting benefits through an integrated consideration of social, environmental and economic aspects in all that we do'. This is an interpretation of the definition within the State Sustainability Strategy 2003, which defines Sustainability as "meeting the needs of the current and future generations through an integration of environmental protection, social advancement, and economic prosperity." The Main Roads Sustainability Policy outlines six key aspects that guide us to deliver a sustainable road network. These include:

- Sustainable Transport
- Climate Change
- Environmental Footprint
- Behaviour
- Governance and Performance
- Funding and Financing

A large aspect of achieving sustainability comes from the materials we use in road construction and maintenance. This reference guide summarises the opportunities for recycled construction materials to be used in Main Roads' infrastructure projects and highlights future opportunities that may arise from studies currently being undertaken. With a large number of fast-tracked infrastructure projects in the coming years, it is important for Main Roads to seek out recycled materials in many aspects of road construction, all while ensuring long-term performance and maintaining the safety of the road network.

The materials outlined in this report include crushed recycled glass, crumb rubber, crushed recycled concrete and reclaimed asphalt pavement. A key aim of the use of these materials in road construction is to support the circular economy in Western Australia (WA) and where possible to support up-cycling, avoid down-cycling and keep materials circulating within the economy, reducing the need for more raw, virgin materials.

Drivers for the Circular Economy

Main Roads has a number of drivers that are guiding the use of sustainable construction materials and promoting the circular economy for road building materials. These drivers include:

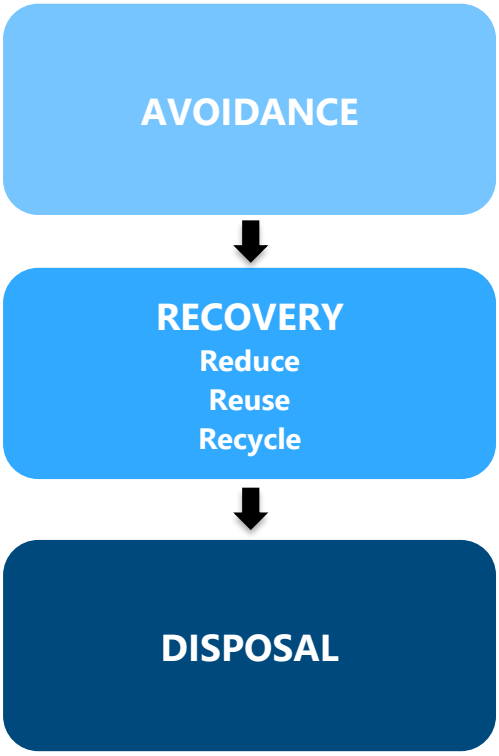
- Western Australian State Sustainability Strategy 2003
- Waste Avoidance and Resource Recovery Strategy 2030 (including Roads to Reuse)
- AAPA commitment to have 50 percent of Metropolitan road projects using crumb rubber
- Using over 1,200 tonnes of crumb rubber by 2021 (achieved)
- Increasing the amount of Reclaimed Asphalt Pavement (RAP) in asphalt mix design to be at least 20-25 percent RAP through the WA Road Research and Innovation Program (WARRIP)
- Increasing the use of Crushed Recycled Concrete on the network to over 200,000 tonnes

- Western Australia's Plan for Plastics (reducing and avoiding single use plastics)
- Council of Australian Governments (COAG) ban on the export of various waste categories

ISCA Resource Efficiency and Recycled Materials

Main Roads has an ongoing commitment with the Infrastructure Sustainability Council of Australia (ISCA) to deliver sustainable road projects. Every Main Roads project valued over $100million is registered with ISCA to receive a Planning, Design and As Built IS rating. Projects valued between $20 million to $100 million are not required to undergo formal IS verification; however these projects complete an internal sustainability assessment to ensure sustainable initiatives are implemented on all projects.

ISCA rewards the development and implementation of resource efficiency strategy and associated action plans. The aim of the criteria is to recognise the importance of resource efficiency during the planning, design, and construction phases of a major road project. It is important for each Main Roads project to have its own specific Resource Efficiency Strategy, which should include adopting the principles of industrial ecology and maximising the use of recycled construction products. To do this, Main Roads projects should implement the following waste hierarchy where possible:



Road Infrastructure Components

The following figure was supplied by Austroads and provides a schematic look at road infrastructure components. This diagram showcases the different elements within the roadbed environment outlined in this document.

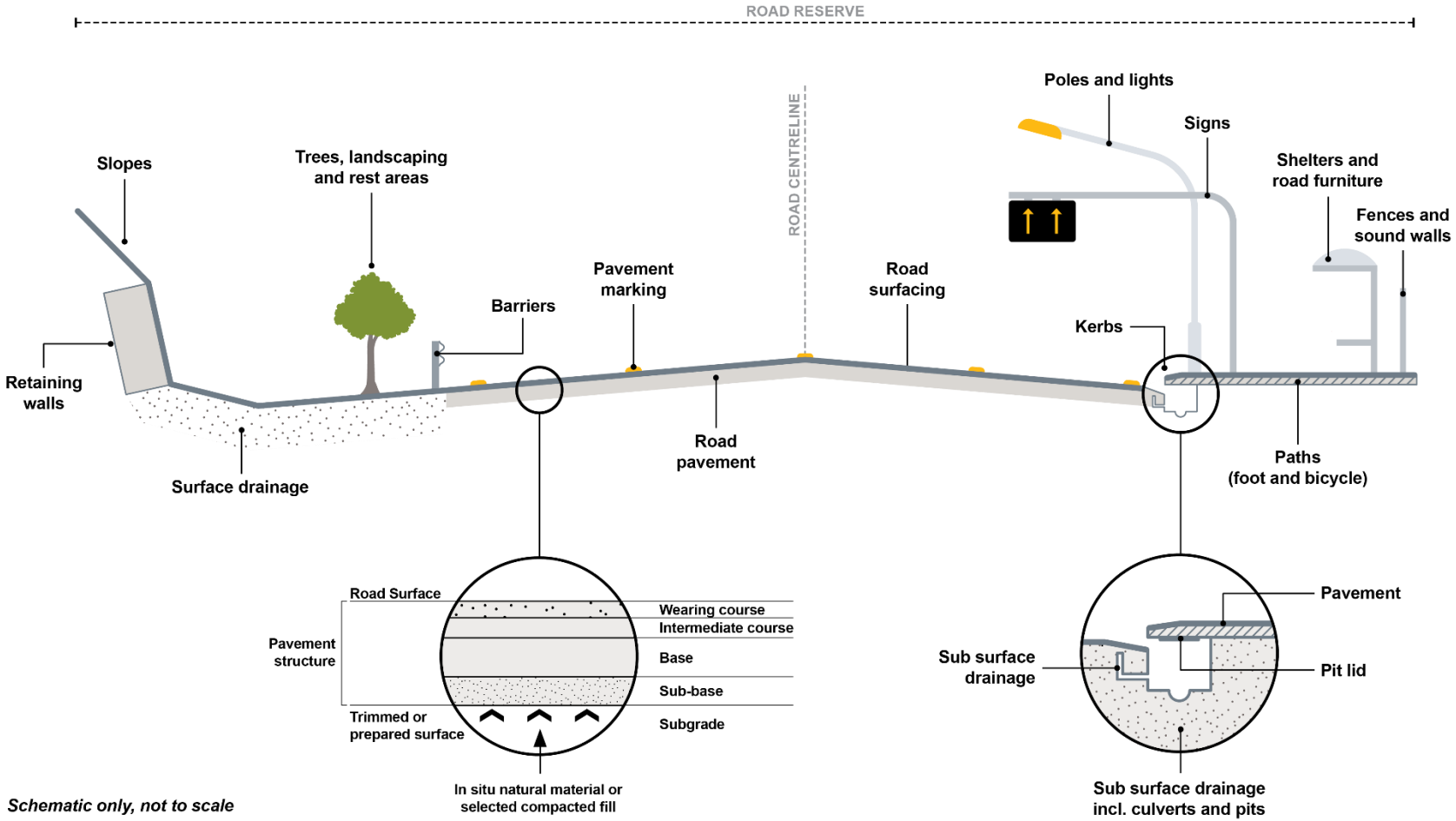


Figure 1: Schematic diagram of a road reserve (source: Austroads 2021)

Sub Grade Materials

Crushed Recycled Glass
Key Specification: 302.10.1
Used in:

- Fill
- Temporary tracks in heavy clay to reduce bogging of equipment
- Bedding Sand
- Drainage
- Retaining Walls

The use of any glass cullet in road construction must meet the requirements outlined in Main Roads Specification 302 *Earthworks* (302.10.1). Main Roads specifications permit the use of glass cullet in fill material. The preference is for glass to be reused as it contains significant embedded energy and does not degrade over time. Where reuse is not possible, Main Roads recommend recycling glass to produce other new glass products. This is currently not feasible in WA due to the absence of local glass reprocessing facilities. Main Roads accepts that the use of recycled glass in roadbuilding is a low-value application (down-cycling) of the material, but is part of an interim solution to reduce waste glass sent to landfill.

Research and development is underway to enhance the economic sustainability of using crushed recycled glass and glass cullet, with the aim to reduce costs associated with milling the glass to a consistent grading and washing to remove contaminants (e.g. paper, adhesive, organic matter). However, using recycled glass has environmental benefits, including conserving virgin materials and reducing environmental disturbance.

The NorthLink 3 (northern section) Project was able to use approximately 70,000 tonnes of crushed recycled glass as embankment fill. The material was used in earthworks to stabilise clay based soils and materials, and also used for dust suppression in the embankment layer as the amount of water this material holds is greater than limestone. The Contractor on the project (CPB Contractors) adhered to Specification 302, which allows up to 20 percent of the fill content to be crushed recycled glass.

There were a number of considerations and challenges to overcome in using the material. These issues included overcoming the absence of any glass recycling facility in WA, the amount of embodied energy required to process the glass cullet (in terms of the project's environmental footprint), and the cost of using this material compared to using raw materials. Another key issue was whether glass properties would be able to behave in a similar way to the typical raw materials used in this context (e.g. limestone). However, these challenges were overcome to see the use of the material, bringing a number of benefits including:

- A reduction in raw materials used,
- Reduced amounts of land cleared to store raw material stockpiles,
- Show leadership and set a standard for future Main Roads projects,
- Assisted in transforming the WA market of recycled glass products.

Further investigation and research continues on this material to prepare it for use in future road projects.

Subbase Materials

Alcoa Red Sand

Used in:

- Subbase layer

Main Roads have been liaising with Alcoa to evaluate the supply and construction processes associated with the use of red sand residue in road construction. Previous research has gone in to discovering the possibility for using the residue red sand as a subbase material in roads, which is a by-product from the production of aluminium from bauxite.

In 2009, a 500-metre long section of Greenlands Road in Pinjarra was constructed using residue sand from Alcoa's Wagerup site as a subbase material. Approximately 2,000m^3 of material was used to construct a section of subbase on the road. An initial lab trial of the material found that red sand could potentially be used as a subbase material instead of limestone where a minimum 100mm of gravel basecourse is applied. The results of the Greenlands Road trial found that although limestone is a stronger subbase material, red sand also met specific pavement requirements including deflection, roughness and rutting. Falling-weight deflectometer tests were taken every five metres on the red sand subbase trial section to determine the performance strength of the road and compare it to the limestone subbase section.

Monitoring of pavement performance has also been undertaken using a Traffic Speed Deflectometer, indicating that the trial section is consistent with conventional pavement, based on the deflection, roughness and rutting data. The road remains in good, drivable condition today (12-years post-trial).

Main Roads continue to test the suitability of the red sand as a subbase material for future road projects. A key factor outside of the behaviour of the material is the proximity of the Alcoa Refinery in Kwinana to the project site. The economic sustainability of carting the sand to site must be viable to use the material in a project, like that in the Greenlands Road trial.

Excess Site-won Fill

Used in:

- Subbase layer
- Embankment fill

Western Australia passed legislation in April 2018 allowing the use of excess site-won or uncontaminated fill in road construction without having to pay a waste levy[1]. The aim of this legislation was to increase the recycling of materials in construction projects and significantly reduce the amount of material that was headed to landfill. The Department of Water and Environmental Regulation (DWER) determine whether recycled fill is contaminated through the *Landfill Waste Classification and Waste Definitions* document. The guidance was amended in 2019 when this legislation was passed.

At a Main Roads project level, the Reid Highway Dual Carriageway used excess site-won fill from the Matagarup Bridge Project. It was needed for the construction of the westbound carriageway

[1] Source https://www.mediastatements.wa.gov.au/Pages/McGowan/2018/04/Regulatory-changes-to-benefit-industry-and-the-environment.aspx.

and the Arthur Street Bridge. This opportunity to re-use the material was identified during the tender stage of the Reid Highway Project. The material was fill containing an outer layer of rock armour and inner compacted hardstand.

The contract for this project outlined specifications to ensure the material was successfully implemented. This included the potential need to further crush or blend the material in order to meet both Australian and Main Roads standards.

The material was excavated from the Matagarup Bridge site within a hardstand area established within the Optus Stadium precinct. This hardstand area was built for the project to assemble key Bridge components and to enable construction material to operate under the Bridge. Approximately 100,000m^3 of the material was transported to the Reid Highway Project site for use.

After being awarded the Reid Highway contract, the Contractor tested the stockpile of this extracted material immediately and confirmed that it was suitable to be used on the project. The Contractor found that the larger rock in the stockpile could be used in the first layer of embankment in wetter areas. This allowed the material to 'bridge' the areas of high water table, meaning subsequent layers could be built above this on the dryer earth.

Through using this material in the lower layers of embankment and in the Arthur Street Bridge embankment, all of the 100,000m^3 stockpile was used on the Reid Highway Dual Carriageway. The sustainable benefits associated with re-using this material included delivering significant cost savings, preserving raw resources and reducing the amount of waste sent to landfill.

Crushed Recycled Concrete (CRC)
Key Specification: 501.92
Used in:

- Subbase under full depth asphalt
- Basecourse under low traffic local roads

Crushed Recycled Concrete is a roadbuilding product derived from construction and demolition waste consisting primarily of concrete, but also containing sand, brick, tile, asphalt and glass. Extensive research and long-term trials have demonstrated the material is suitable for use as subbase under FDA (full-depth asphalt) pavements on the Main Roads network. CRC is a high strength and durable product with self-cementing properties, meaning the stiffness of the product increases over time. Crushed limestone is traditionally used in subbase applications beneath FDA. In addition to improved engineering properties, using CRC instead of limestone reduces greenhouse gas emissions and landfill volumes.

In 2019/2020, Main Roads used over 27,000 tonnes of CRC as subbase under FDA pavements. Projects utilising this material included the Kwinana Freeway Widening Project between Russell Road and South Street. The majority of this CRC material was sourced from the demolition of Subiaco Oval, demonstrating the circular economy in Perth. This pilot program was a success, as all the material was compliant. This initiative was delivered under the Roads to Reuse (RtR) pilot program with the Department of Waste and Environmental Regulation and the Waste Authority. This RtR program controls environmental and Occupational Health and Safety risks (e.g. hazardous materials and leachate) associated with CRC. Following this successful trial, Main Roads has set a

target to use 100,000-200,000 tonnes of CRC per annum from 2021/22 onwards and reinstated the Main Roads Subbase CRC Specification (Specification 501).

Construction contractors that have undertaken work for Main Roads have provided positive feedback that CRC is workable and produces a tight surface finish. There is an intent to incentivise the use of CRC by offering a stiffness benefit in design that will result in an approximate 10mm reduction in FDA pavement thickness.

Basecourse Materials

Mining Waste (Overburden)
Used in:

- Basecourse layer
- Embankment fill
- Basecourse on pavement overlay

Mining waste (overburden) can and has been used to extend and maintain the state network across regional WA. Sourcing road building materials is becoming more challenging for all road managers across the state. Main Roads is continually looking for more sustainable alternatives to these traditional road building materials. One of these materials is mining waste from different pits across WA. Each mine produces different materials that can be used in the basecourse, or as fill in the embankment layer (subbase materials) for roads across the state network.

The extraction of traditional road building materials typically requires the clearing of native vegetation, followed by a rehabilitation period once the pit has been exhausted. Using excess mining waste reduces the need to extract virgin material for road construction, while also enhancing the circular economy in WA. This section is broken down into the different WA regions and the mines that have or are going to provide overburden for regional roads.

Utilising waste rock from mine sites is a sustainable alternative compared to sourcing material from gravel and borrow pits. The ability for Main Roads to utilise waste materials for road construction will also benefit mine operators, as it can reduce closure costs given less material will be going into waste rock landforms.

Kimberley Region

Savannah Nickel Waste Rock
There is potential to use waste rock in the basecourse on Great Northern Highway Ord River North (stages two and three) from the Savannah Nickel Mine. It was not used on the completed stage one works of the project.
The rock was trialled in 2016 on a short section of Great Northern Highway. This material was nominated in an IfT (Information for Tenders) document for the project contract and Main Roads liaised with the mine to determine a preferred proponent in sourcing basecourse material. This material could also be used for future works in the area south of Warmun. The trial section is now three years old and is performing well.

Pacific Niugini Nicholson's Gold Deposit
The Pacific Niugini Nicholson's Gold Deposit mine is located approximately 50km west of Halls Creek on the Great Northern Highway and initial testing of the waste rock material is showing promise that it could be used as sealing aggregate, in the subbase, and in rock spalls.
This mine site is in close vicinity to the Laura River quarry and would be a suitable replacement for the deposit. It is important to note that there are heritage and environmental constraints with this quarry. Main Roads continue to liaise with the mine to progress a way forward.

Rio Tinto Argyle Diamond Mine
Rio Tinto recently shut down their Argyle Diamond Mine in the Kimberley after 37 years in operation. Main Roads are currently liaising with the Mine Manager to collect samples and evaluate if any waste materials can be used on the road network.

Pilbara Region

Marandoo Rio Tinto Iron Ore Deposit
Main Roads collaborated with Rio Tinto to test the material within their waste rock landforms coming from the Marandoo mine site. The results of this testing were positive and 40,000 tonnes of waste rock was carted to a hardstand area on the Paraburdoo-Tom Price Road for widening work. No further crushing or screening of the material was required, and the rock was used as embankment fill rather than basecourse, given the quantity of the material was relatively small.

In addition to this, the material is being utilised for local upgrades to roads which are frequently used by Rio Tinto. The local community will benefit with local road works being fast-tracked due to the availability of suitable materials. In turn, this creates jobs for local Contractors.

FMG CID deposit
Main Roads have been liaising with FMG to collect bucket samples and undertake a visual site inspection of the CID deposit in the Pilbara. The site is located in a favourable location and the large deposit possesses basecourse quality material. FMG are continuing investigations into what is waste and what may contain low-grade ore.

Novo Resources - Beaton's Creek
The waste material from this mine has been tested and classified as subbase quality. The site is close to Nullagine town site and negotiations are ongoing with Novo Resources, who are also using the majority of the available waste material for their road projects.

Goldfields Region

Austral Pacific ex Paris and HHH mines
This mine site is approximately 30 km east of Coolgardie Esperance Highway near Higginsville. Austral have liaised with DMIRS regarding the reuse of mining waste and have engaged Golder Associates to test and assess the suitability of this waste material. To date, the petrographic testing has come back positive.
A trial crush is to be undertaken to assess whether crushing will generate fines with plasticity to improve the properties of the material. Austral are interested in pursuing the materials potential to supply it to projects in the Kalgoorlie – Norseman area.

Wheatbelt Region

Old Mine at Pithara
The Pithara upgrade of Great Northern Highway used material from an old open-cut gold mine that is close to the Pithara town site. Material was used as rock protection and blended with local gravel to be used as a basecourse material for the upgrade in 2018-2019.

Great Southern Region

Mt. Cattlin Mine site – Galaxy Resources, Ravensthorpe
Granite and basalt from rock and soil waste stockpiles were used as rock protection, while crushed product was used as embankment fill for bridge approaches and basecourse for pavement construction on the Phillips River Bridge Project. A blend of crushed waste rock and imported laterite gravel was also used as basecourse on pavement overlay works in the region.

Mid-West Gascoyne Region

Plutonic Mine
The Plutonic Mine is located east of Great Northern Highway near Kumarina. Overburden stockpiles from the mine and some rehabilitated areas may potentially be used as basecourse or subbase on Great Northern Highway. A small quantity was used for pavement repairs in 2017 and is currently performing well. Further mines north of Meekatharra on Great Northern Highway were contacted in the 2019-2020 financial year to discuss potential rock protection and construction material for floodway upgrades in the vicinity of the Gascoyne River.

Wearing and Intermediate Course Materials

Reclaimed Asphalt Pavement (RAP)
Key Specification: 510.32
Used in:

- Structural layers of asphalt pavement

Reclaimed Asphalt Pavement (RAP) is the material reclaimed from an asphalt wearing or intermediate course by cold planning that is re-processed by crushing and/or screening for recycling into new asphalt. There are strict specification requirements surrounding the use of RAP. Main Roads specifications allow up to ten percent asphalt reclaimed from existing pavements (RAP) to be incorporated into the structural layers of full-depth asphalt (FDA) pavements without additional mix design requirements. Through the WARRIP, new specifications have been developed in consultation with industry for higher (11-40 percent) RAP content asphalt mixes.

FDA pavements on the Main Roads network typically have greater than 250mm total asphalt thickness. It is important to note that the specifications for the use of RAP outline that the material is not permitted in the production of wearing course (surfacing) asphalt for the Main Roads network. This is due to the potentially negative impact on cracking and skid resistance.

Main Roads used 42,000 tonnes of RAP in projects in 2019/2020. For the NorthLink 2 (central section) project, RAP made up approximately ten percent of the mass of the structural pavement layers. A trial on the NorthLink 3 (northern section) of higher RAP content asphalt mixes was undertaken where the amount of RAP used in the lower structural layers was increased from ten percent to 25 percent. Some 30,000 tonnes of high RAP content asphalt was placed during the trial.

There are three local suppliers in Perth that have Main Roads approved mixes with 20-25 percent RAP content. It is anticipated that a mix with approximately 22 percent RAP will deliver positive design outcomes, be manageable with respect to mix design, and maintain a balance between the supply and use of RAP.

Crumb Rubber
Key Specifications: 509.21, 516,
Used in:

- Sprayed seals
- Open-graded asphalt
- Gap-graded asphalt

Crumb rubber is produced from the sustainable recycling of waste vehicle tyres. Crumb rubber contains valuable polymers and carbon black that, when combined with bitumen, produce more durable roads that have improved skid resistance and drainage performance. The use of this material in road construction also helps to solve the challenge of dealing with the large number of tyres sent to waste each year. Other benefits of using crumb rubber include longer service life, higher air voids, resistance to crack reflection, and greater aggregate adhesion.

Main Roads has a long history of using crumb rubber in sprayed bituminous seals, with 600-700 tonnes of scrap rubber used annually for this application. Granulated rubber is used in seals to

reduce reflection cracking and improve stone retention. Crumb rubber modified (CRM) bitumen is typically used for water proofing membranes on bridge decks, limited surfacing applications and widespread resealing where cracking is known to occur. Crumb rubber has predominantly been imported from Victoria, however there are two suppliers currently being established in Perth:

- RubberGem Kwinana; expected to produce 2000 tonnes/annum from early 2021
- 4M Waste Malaga; processing truck and passenger tyres, capacity to produce 600 tonnes/annum expected to increase to 2000 tonnes/annum

Main Roads have recently created new methods of utilising crumb rubber in asphalt mixes through WARRIP. Similar to its use in sprayed bituminous seals, CRM bitumen in asphalt produces more durable roads that are resistant to oxidation, cracking and ravelling. It also plays a key role in further reducing the large volumes of tyres sent to landfill each year.

During 2019/20, Main Roads used approximately 1,900 tonnes of crumb scrap rubber across the state-controlled road network. This equates to the equivalent of 380,000 passenger car tyres. This has met Main Roads' intent to double usage of crumb rubber from 600 tonnes to 1,200 tonnes by 2021, as outlined in the Western Australia Waste Strategy 2030.

Road Structures and Furniture

Cementitious Products – Concrete
Key Specification: 820
Used in:

- Precast structural elements
- Piles
- Buried structures

Main Roads WA uses S50M (50 MPa class concrete) that is a blended cement comprising 32 percent type GP (General Purpose) cement, 60 percent Ground Granulated Blast Furnace Slag (GGBFS) and eight percent silica fume. Silica Fume is a by-product of the production of silicon metal electric arc furnaces. S50M concrete is used for mass concrete placement, as it has reduced thermal expansion and a consequent reduction in cracking. This type of concrete is also implemented in environments that have been or are exposed to sulphate and chloride attack, due to its high tolerance and resistance levels.

GGBFS, when in the presence of an activator such as hydrated lime, has cementitious properties. GGBFS is a fine pozzolanic material that is a result from the steel smelting process. The material has been previously used successfully on Lancelin Road, where a 70/30 blend of GGBFS and Quick Lime was applied at three percent by mass to the upper 100 mm of a limestone basecourse.

Recycled Tyre Rubber
Used in:

- Guideposts

Guideposts produced from waste tyre rubber are preferable over timber guideposts due to their durability, service life, and resistance to impact and termites (compared to timber posts). These posts have been used across many projects across the state network. The type of recycled rubber guidepost commonly used is comprised of a plastic sleeve on a rubber leg drilled into the ground. Rubber guideposts are able to recover to their original upright position after being hit by a motor vehicle, and are less likely to crack or split upon impact from a vehicle or extreme weather. They also positively impact the circular economy as recycled tyres get a second use.

Recycled Glass Beads
Used in:

- Road marking paint

Recycled glass is used to manufacture glass beads that are applied to road marking paint to provide better visibility at night and in wet conditions. They act as a reflector to vehicle lights in the paint. There is potential for heavy metal contaminants to be present in some recycled products. The exclusion of heavy metals in glass beads is managed through a specification for the supply of glass beads for pavement markings, allowing them to be used on WA roads.

Reconstituted Structural Blocks
Key Specification: 905.07
Used in:

- Retaining Walls

Main Roads uses limestone retaining walls for a number of projects every year. There has been research into making retaining walls out of eco-friendly recycled materials, such as crushed recycled concrete, rubble, and crushed recycled glass that may be used in these retaining walls. The combination of these recycled materials can minimise the use of concrete in footings, reducing the amount of cement used on Main Roads projects. This initiative reduces the environmental impacts associated with cement production, including carbon dioxide emissions and chemicals leaching into waterways. It is important to note that crushed recycled concrete used in retaining must meet Main Roads specification 501.92.

Eco-blocks are a reconstituted structural block made of recycled materials including crushed recycled concrete. The Kwinana Freeway Northbound Widening Project (Russell Road to Roe Highway) used over 35,000 eco-blocks in the construction of the retaining walls. Eco-blocks replaced the need to use reconstituted limestone blocks on the project, avoiding the use of the limited limestone resource. Eco-blocks have the same texture and appearance as reconstituted limestone, and are favourable given the quality and consistency of these blocks compared to traditional limestone.

Geopolymer Concrete
Key Specification – 820 (Concrete For Structures)
Used in:

- Bridgeworks
- Pedestrian overpasses/underpasses
- Manufacturing box culverts
- Major structural works

Geopolymer concrete is made in a similar fashion to concrete, however it consists of waste materials. Commonly, activated waste fly ash is used as the binder. Fly ash is a by-product from coal burning power stations used to generate electricity. Reusing by-products supports the circular economy. Geopolymer concrete used in Main Roads projects must consist of a mixture of fly ash, slag, sodium silicate and sodium hydroxide in solution or solid form, and extra water constituting alkaline solution comprising of coarse aggregate and fine aggregate. Geopolymer concrete is a low-calcium product and is resistant to sulphate attack.

Main Roads have undertaken a number of feasibility studies and trials of Geopolymer concrete. These investigations found that Geopolymer concrete could be used in structural works, providing a more environmentally sustainable alternative to commonly used Ordinary Portland Cement (OPC). OPC emits approximately one tonne of carbon dioxide per one tonne of cement produced. Main Roads are also working with Curtin University to assess the performance of Geopolymer concrete in precast applications. Investigations to date have shown that it is feasible to produce high strength box culverts using Geopolymer concrete with some modification of current precast concrete practices.

Ongoing research will assess the long-term strength and durability of box culverts (used in road works and drainage) using Geopolymer concrete. The primary objectives of this research are to:

- Investigate the long term strength of Geopolymer concrete
- Assess precast construction requirements

- Assess the durability of Geopolymer concrete in normal and aggressive environments compared to conventional concrete
- Develop a specification for box culverts

Sustainable Stabilisation Methods

Foamed Bitumen Stabilisation

Foamed Bitumen Stabilisation (FBS) has been used over the past 30 years in WA, mainly by Local Government Authorities (LGAs). LGAs initially adopted FBS to fix local roads with bitumen that is prone to cracking. The first initiative of FBS in Perth was pioneered by the City of Canning and Downer Engineering.

The Materials Engineering Branch within Main Roads has undertaken a number of trials of FBS across the state network, including at the following locations:

- May 2009: Tonkin Highway Trial (300 m of the eastbound carriageway near Perth Airport)
- February 2010: Kwinana Freeway Trial (300 m of the northbound carriageway near Mundijong Bridge)
- October 2014: Thomas Road Trial (340 m of the left lane westbound was bitumen emulsion stabilised, 200 m of the left lane eastbound was foam bitumen stabilised)

The Kwinana Freeway trial near Mundijong Road treatment program comprised of in situ mixing of existing pavement material and thin asphalt surfacing with three to four percent foamed bitumen and 0.8 percent quick lime. The purpose of these trials was to assess the performance of this method of pavement recycling in different pavement stabilisation depths and bitumen contents.

These trials continue to perform and are maintaining well. Foamed bitumen stabilisation is being used successfully in other states, but the pavement materials are different and therefore the procedures and outcomes achieved elsewhere cannot be simply transferred to Western Australia. Although this stabilisation treatment is being used elsewhere in Australia, an Austroads method of thickness design has not been developed and consequently there is currently no method to estimate the design life of FBS pavements. There are also limitations that Main Roads faces regarding the use of FBS to rehabilitate roads in the Perth Metropolitan area, including:

- The length of time required to complete repairs before opening to road to traffic (typically around four to seven days)
- The established costs for FBS treatment are high and not always economically sustainable
- The costs of FBS treatment are higher than a thick asphalt inlay treatment for short sections of pavement repair

Emulsion Stabilisation

Emulsion (bitumen) stabilisation is applicable to granular materials that have low cohesion and plasticity. This method is used to agglomerate the fine particles in the bitumen together, decreasing the permeability and moisture sensitivity of the granular material. The cohesive strength of the mixture increases, meaning the condition of the road surface remains in an acceptable condition for a longer period.

The Main Roads Wheatbelt Region have been undertaking extensive pavement repairs using different emulsion stabilisation methods for over three years. In the 2020/21 financial year, an area of 2300m^3 of pavement is to be treated by stabilising the basecourse.

Further stabilisation techniques used on Wheatbelt roads have included Foam Bitumen Stabilisation, which (in regional environments) is economically sustainable and a time efficient process to stabilise the road surface. Over 6200m^2 of area has already been treated using this

stabilisation method. Foam Bitumen Stabilisation completed on this area used 1.5 percent bitumen and 0.8 percent hydrated lime. Hydrated lime is commonly used as an activator to stabilise road surfaces and form a cemented finish.

Lime Stabilisation

Main Roads includes hydrated lime in all metropolitan and most regional asphalt mixes. It is an activator, meaning the product promotes bonding between bitumen and aggregate materials. It also assists in managing stripping in the pavement, which is caused from a loss in the bonds between the aggregate and bitumen.

Some suppliers in the Perth Metropolitan area use lime kiln dust in their asphalt mixes, however Main Roads does not currently allow suppliers to substitute hydrated lime with lime kiln dust. Main Roads is currently liaising and working with Curtin University to evaluate the use of lime kiln dust in asphalt.

Summary Reference Table

Road Layer	Recycled Material	Use / Main Roads Project Example
Embankment (sub-grade)	Crushed Recycled Glass	56,000 tonnes in the NorthLink WA Northern Section (Ellenbrook to Muchea)
	Excess Site-Won Fill	100,000m^3 of excess site fill from the Matagarup Bridge Project was used as embankment on the Reid Highway Dual Carriageway
Subbase	Alcoa Red Sand/Mud	2,000m^3 area of subbase under Greenlands Road (Pinjarra)
	Crushed Recycle Concrete (under full depth asphalt)	27,000 tonnes of CRC was used as subbase on the Kwinana Freeway Widening Project (Russell Road to South Street)
	Mining Waste (overburden)	Mining waste has been used as basecourse, sealing aggregate and subbase on a number of regional roads across the state
Basecourse	Reclaimed Asphalt Pavement	RAP made up ten percent of the structural pavement layers in the NorthLink WA Central Section (Reid Highway to Ellenbrook)
Road Surfacing	Crumb Rubber	Crumb rubber used on one third of the Metropolitan Freeway resurfacing projects in 2020
	Cementitious Products	Used for mass concrete placement, still undergoing investigation
Structures	Recycled Tyre Rubber	Used in guideposts along the regional road network
	Recycled Glass Beads	Used in road marking paint
	Reconstituted Structural Blocks (Limestone)	Metropolitan Road Improvement Alliance Projects and the Kwinana Freeway Northbound Widening used reconstituted blocks in the retaining walls
	Geopolymer Concrete	Used to make structural products e.g. box culverts, pedestrian over/under passes, and bridgeworks. Undergoing investigations for future projects including the Tonkin Highway Extension (Thomas Road to South Western Highway)