# Recycled Aggregates New Zealand

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# Challenge

Aggregates are critical ingredients for New Zealand's roading, construction, and infrastructure

The challenge is that New Zealand has to rely heavily on the importation of construction materials

- Limited natural resources
- The supply of aggregates is increasingly growing in demand

# Purpose

Motivation behind adopting recycled concrete as an aggregate source includes:

- Seeking to find an efficient use of recycled aggregates in infrastructure to preserve natural resources
- Increase financial and energy savings

# New Zealand Information

- Current population of New Zealand: 4.9 Million

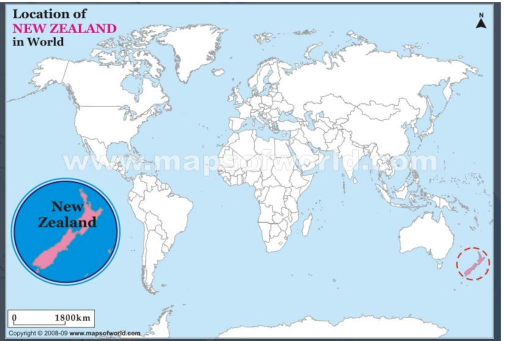
- New Zealand is an archipelago located in Oceania, southeast of Australia.

- 2 main islands consist of

  North Island (Te Ika a Maui)

  South Island (Pounamu),

- Total land area is 268,670 square kilometers



# Recycled Concrete Aggregates (RCA)

Recycled Concrete Aggregates (RCA) can be obtained by crushing both reinforced and plain non-reinforced concrete

- Consist of crushed, graded inorganic particles.
- Graded into the same coarse aggregate sizes as natural crushed rock aggregates
- Surface texture of RCA particles tend to be slightly rougher than natural aggregates

# Benefits of RCA

Using RSA also has potential environmental benefits, including:

- conserving natural resources by decreasing the demand for new materials
- protecting local ecosystems and maintaining biodiversity levels
- reducing energy consumption, transport emissions and disposal of waste to landfill
- avoidance of waste disposal charges and landfill tax
- avoidance of aggregates levy payments - as RCA's are exempt
- reduced costs of transporting aggregates if recovered materials are available locally
- lower costs and shortened timescales associated with some construction techniques: Ex: 'crack and seat' in road maintenance

# Origin and History of RCAs

- In 1970s, recycling concrete aggregates became common practice as landfills located near populated areas started refusing broken concrete [5].

- Construction Industry then started crushing it to make aggregate for use as  compactable fill.

# Production of Recycled Coarse Aggregates

- Evaluation of Source Aggregate
- Pavement Preparation
- Pavement Breaking and Removal
- Removal of Embedded Steel
- Crushing and Sizing
- Beneficiation
- Stockpiling
- In Place Concrete Recycling

# Uses in CE Industry

### Processed Recycled Aggregate

- Construction of shoulders, barriers, sidewalks, curbs and gutters
- Structural work for bridges
- Pavements
- Aggregate in lean-concrete

### Unprocessed Recycled Aggregate

- Types of general bulk fills
- Bank protection
- Fill for drainage structures
- Road construction
- Noise barriers and embankments

# RCA Mix Design

Example mix designs for recycled concrete pavements

| Concrete Ingredients | Minnesota DOT lb per cu yd | Wisconsin DOT lb per cu yd | Grand Forks, ND Int'l Airport lb per cu yd | Wyoming DOT lb per cu yd |
|---|---|---|---|---|
| Cement (Type I) | 472 | 480 | 400 | 488 |
| Fly Ash (Type C) | 83 | 110 | 130 | 133 |
| Water | 255 | 265 | 230 | 258 |
| Recycled CA | 1630 | 1815 | 1650 | 1349 |
| Natural CA | — | — | — | 601 |
| Recycled FA | — | — | — | 253 |
| Natural FA | 1200 | 1315 | 1260 | 882 |
| Admixtures: | | | | |
| Air entrained | yes | yes | yes | yes |
| Water reducer | no | no | yes | yes |

Source: ECCO, Recycling Concrete and Masonry, 1999

# Christchurch International Airport, New Zealand

# Influence of Recycled Aggregate in Concrete

- Compressive Strength
- Flexural and Shear Strength
- Durability
- Modulus of Elasticity
- Shrinkage and Creep
- Workability

Table 7-4 Differences in Recycled Concrete Properties Compared to Concrete with Natural Aggregate, Using the Same Water-Cement Ratio and 100 Percent of Aggregate Replacement

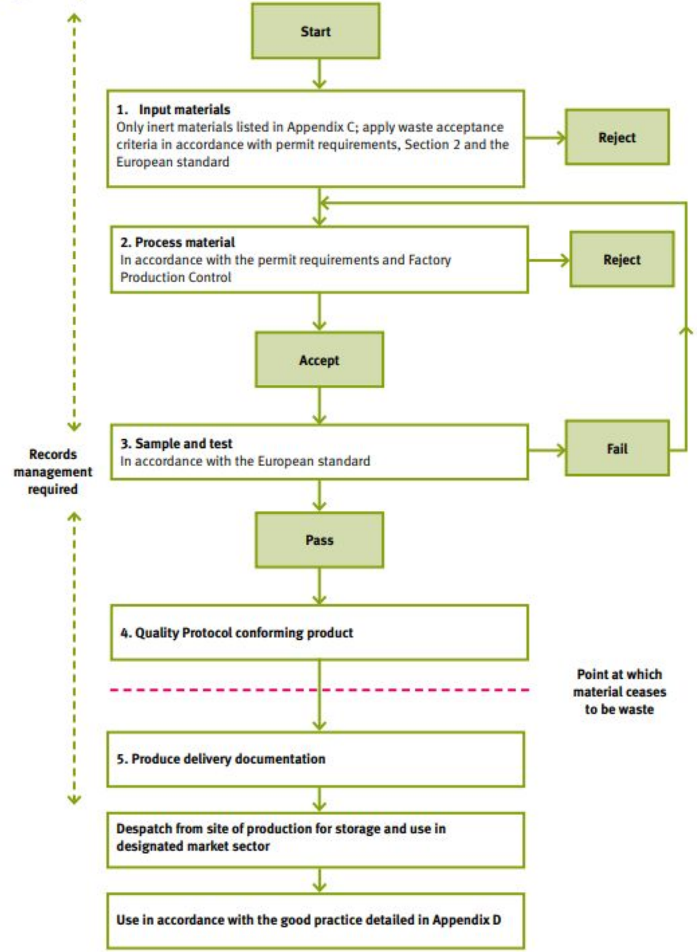
| | |
|---|---|
| Compressive strength | Decrease up to 25% |
| Splitting and flexural tensile strength | Decrease up to 10% |
| Modulus of elasticity | Decrease up to 45% |
| Drying shrinkage | Increase up to 70% |
| Creep | Increase up to 50% |
| Water absorption | Increase up to 50% |
| Depth of carbonation | Similar |
| Freezing and thawing resistance | Decreased |
| Chloride penetration | Same or slightly increased |
| Slump | Same or slightly decreased |

Marinkovi, S.B.2 et al., *Innovative Materials and Techniques in Concrete Construction*, M.N. Fardis, ed., Springer, London, p. 379, 2012.

# Quality Protocol

- This Quality Protocol was funded by Defra, the Welsh Government and the Northern Ireland Environment Agency (NIEA) as a business resource efficiency activity
- It was developed by the Environment Agency and WRAP (Waste & Resources Action Program) in consultation with Defra, the Welsh Government, industry and other regulatory stakeholders
- The Quality Protocol is applicable in New Zealand and United Kingdom

**Figure 1:** Main stages and control mechanisms of the Quality Protocol



| Type and exclusions | Waste code |
|---|---|
| **Waste gravel and crushed rocks other than those mentioned in 01 04 07**<br>May include excavation from mineral workings. | **01 04 08** |
| **Waste sand and clays**<br>Waste sand only.<br>Must not include contaminated sand. | **01 04 09** |

**Wastes from manufacture of glass and glass products**

| Type and restrictions | Waste code |
|---|---|
| **Waste glass-based fibrous materials**<br>Allowed only if:<br>Wastes without organic binders | **10 11 03** |

| Type and restrictions | Waste code |
|---|---|
| **Glass packaging** | **15 01 07** |

**Construction and demolition waste – concrete, bricks, tiles and ceramics**

| Type and restrictions | Waste code |
|---|---|
| **Concrete**<br>Must not include concrete slurry. | **17 01 01** |
| **Bricks** | **17 01 02** |
| **Tiles and ceramics** | **17 01 03** |
| **Mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06** | **17 01 07** |

**Construction and demolition waste – wood, glass and plastic**

| Type and restrictions | Waste code |
|---|---|
| **Glass**<br>Must not include fibreglass or glass fibre. | **17 02 02** |

**Construction and demolition waste – bituminous mixtures, coal tar and tarred products**

| Type and restrictions | Waste code |
|---|---|
| **Bituminous mixtures other than those mentioned in 17 03 01** | **17 03 02** |
| Allowed only if:<br>Bituminous mixtures from the repair and refurbishment of the asphalt layers of roads and other paved areas (excluding bituminous mixtures containing coal tar and classified as waste code 17 03 01).<br>Must not include coal tar or tarred products.<br>Must not include freshly mixed bituminous mixtures. | |

**Construction and demolition waste – soil (including excavated soil from contaminated sites), stones and dredging spoil**

| Type and restrictions | Waste code |
|---|---|
| **Soil and stones other than those mentioned in 17 05 03**<br>Must not contain any contaminated soil or stone from contaminated sites. | 17 05 04 |
| **Dredging spoil other than those mentioned in 17 05 05**<br>Allowed only if:<br>Inert aggregate from dredgings.<br>Must not contain contaminated dredgings.<br>Must not contain fines. | 17 05 06 |
| **Track ballast other than those mentioned in 17 05 07** | 17 05 08 |
| Allowed only if:<br>Does not contain soil and stones from contaminated sites. | |

**Construction and demolition waste – other construction and demolition wastes**

| Type and restrictions | Waste code |
|---|---|
| **Mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03** | 17 09 04 |
| Allowed only if:<br>The waste is generated from utilities trenchings.<br>The waste consists of sub base aggregates i.e. granular material.<br>The waste contains only materials that would be described by entries 17 01 01, 17 03 02 and 17 05 04 in this appendix if the waste was not mixed. | |

**Wastes from the mechanical treatment of waste not otherwise specified (for example sorting, crushing, compacting, pelletising)**

| Type and restrictions | Waste code |
|---|---|
| **Glass**<br>Does not include glass from cathode ray tubes. | 19 12 05 |
| **Minerals (for example sand, stones)**<br>Must not contain contaminated concrete, bricks, tiles, sand, stone or gypsum from recovered plasterboard. | 19 12 09 |

**Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions**

| Type and restrictions | Waste code |
|---|---|
| **Glass**<br>Must not include fibreglass. | 20 01 02 |
| **Garden and park wastes (including cemetery waste) – soil and stones**<br>Must not contain contaminated stones from garden and parks waste. | 20 02 02 |

# NZTA STANDARDS

### M3 - Sub-base aggregate

| Material type | Allowed | % by mass | Comment |
|---|---|---|---|
| Various | Yes | No restriction | There is no standard TNZ/M3, as the variety of materials satisfactory for sub-bases is too wide to set a national or regional standard specification.<br><br>TNZ/M3, however, provides guidance on developing a local specification for sub-base aggregates.<br><br>Generally, there is no upper limit for recycled material content.<br><br>Local specification using recycled material other than glass will need to be approved by the appropriate regional council. |

[8]

# ASTM STANDARDS

# Economical Factors

- Cost of disposal
- Cost of new materials
- Material scarcity

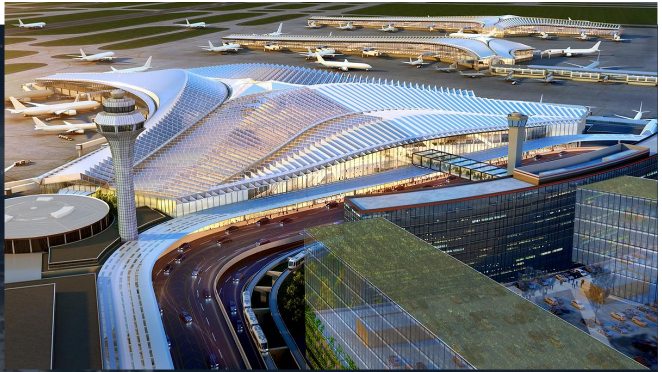
# Policy and Perception Factors

- Government policy
- Perception

# Technical Factors

- Product size
- Operational design
- Labor
- Feed Source Material Characteristics
- Energy
- Infrastructure life

# Case Study: O’Hare Modernization Project



- Recycled concrete aggregates were being considered for use in the O'Hare Modernization Project (OMP)
- Laboratory testing using a two-stage mixing method showed that using RCA from Chicago O’Hare International Airport for the coarse aggregate reduces bleeding and segregation and produces similar workability, compressive strength, and shrinkage as new aggregates
- In October of 2009, a field test of RCA was initiated in two lanes at Gate F7B.
- A side-by-side comparison, a lane of concrete using new aggregates was placed next to a lane of concrete using RCA.
- The RCA was produced on-site using concrete removed at the airport.

- Including RCAs as a required component when designing new build projects will drive demand for recovered material, inspiring better practice from demolition contractors
- Making cost-effective, quality recovered material readily available through better demolition practices will encourage developers to include it in their projects
- The Institution of Civil Engineers (ICE) Demolition Protocol sets out best practice for recovering material from demolition works and reusing aggregates

# Future Work

Demolition Recovery of Recycled Aggregates

In order to recover as much reusable material as possible from demolition works,

Follow these three main steps:

- Pre-demolition audit - assessing the potential of the building to recover resources, the likely quantities and any potential problems, eg contamination of one material with another
- Demolition site layout plan - design the layout of the site to allow recovered materials to be collected, stored, processed and transported
- Evidence of material recovery - demonstrate how much material has been recovered Ex: by measuring quantities stored or moved

# Future Work

Procurement of Recycled Aggregates

Three stages practice when using RCAs recovered from demolition in new build projects:

- Design - think about opportunities to use RCAs and how they could be supplied at the right quality, quantity and price
- Supplier assessment - carefully assess the potential of suppliers to provide and work with recovered materials
- Evidence of recovered material procurement - demonstrating how much RCA material has been procured

# Conclusion

Sustainability

- Recycling concrete provides sustainability
- Recycling the concrete reduces the amount of material that must be landfilled
- Reduces the economic impact of the project
- Reduces the need for new aggregates
- Reduces both the waste disposal and new material production needs = reduced transportation requirements for the project
- Recycled concrete aggregates absorb a large amount of carbon dioxide from the surrounding environment.

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## New Zealand

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