

MANUFACTURED SAND - A SUSTAINABLE SOLUTION?



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Background

- The Australian Premixed Concrete industry consumes over an estimated 20 Millions tons of sand in the manufacture of concrete annually.
- In the past the overwhelming majority of this sand has been “natural” sand derived from land based and marine sources (typically originating from Estuaries, Dunes, Lakes, Rivers and streams).
- The industry has tried to utilize some sand from hard-rock quarry sources over the last 30 years with varying success.
- With the diminishing availability of natural sand resources that can be accessed in many regions it has become increasingly necessary from both Environmental and Economic reasons for the industry to consider increasing its use of manufactured sands.

“Road-Blocks” to the Wider Use of Manufactured Sand

- Conservative nature of most pre-mixed users and specifiers.
- Specifications for the use of Manufactured Sands in concrete were not well developed.
- Some major Specifying Authorities either limiting the use of Manufactured Sand or ruling it out as an option.
- The inappropriate use of poorly specified “waste” Quarry Dust sometimes leading to poor performance of the premixed concrete utilising it as a natural sand replacement.

Activity to Develop a Specification for Manufactured Sand

- In November 2004 the CCAA formed a Manufactured Sands Technical Committee with the brief:
 - *Determine suitable test methods to assist specification and quality control of Manufactured Sand for Concrete.*
 - *Determine suitable specification Limits*
 - *Provide a body of research data to Australian Standards to support incorporation of these tests and limits into relevant standards*
- The first report of the Manufactured Sands Technical committee has been available on the CCAA web-site for about a year and the second report along with a “Guide to the Use of Manufactured Sand in Concrete” document are going through final review now.
- Some major Specifying Authorities carried out work researching specific issues relating to the specification of manufactured sand for specific concrete products.

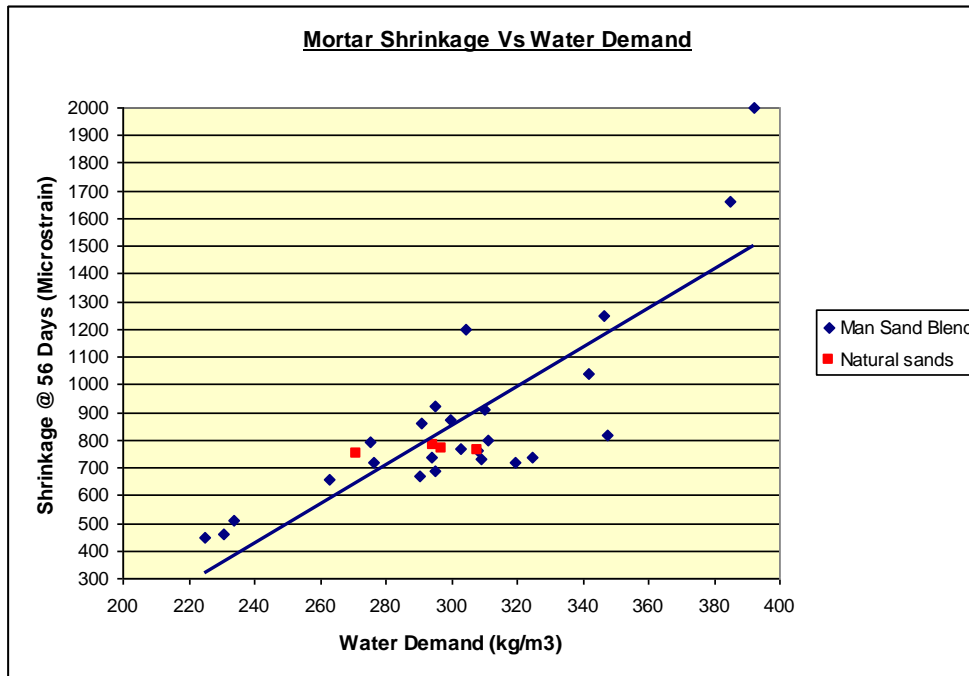


What is a Manufactured Sand?

- Manufactured Sand is defined as a purpose-made crushed fine aggregate produced from a suitable source material.
- Production will generally involve crushing, screening (and possibly washing), testing and assessing against a suitable specification for acceptance.
- Production may also involve blending of several materials including other manufactured sands and natural sands.
- Traditionally the quarrying industry has produced such a product as a by-product of crushing rock to produce coarse aggregates but this may not meet all of the requirements of a manufactured sand suitable for concrete production.

Benefits - Technical

- Manufactured sands can be blended with natural sands to provide improved water demand and concrete shrinkage values.
- Many hardened properties of concrete (Strength, Shrinkage, Density) are directly related to mix water demand and so reduced water demand will provide beneficial hardened properties.



Benefits - Economic

- The economic benefit of manufactured sand over natural sand is dependant on several factors:
 - Proximity of sources to the premixed concrete plant
 - Relative production costs of both materials
 - Relative costs of concrete produced with both material options (impact of increased cement use or increased admixture use)

Benefits - Economic

- If the nearest suitable manufactured sand source is closer to the premixed concrete supply plant then significant cartage cost savings are available.
- If a suitable manufactured sand can be produced that meets the recommended standard with little additional processing beyond that already used to manufacture coarse aggregates then its cost of production can be competitive with that for many natural sand sources.
- If there are mix cost impacts (positive or negative) from the use of a specific manufactured sand over the use of natural sand then this needs to be weighed up against the whole concrete mix cost including reduced or additional cement demand and or admixture requirements.

Benefits - Environmental

- The environmental benefits of manufactured sand can potentially come from the following sources:
 - *The utilization of existing suitable process by-products*
 - *Reduction in transportation related energy input*
 - *Possible reduction of water use in the concrete production process*
 - *Less dependence on sourcing sand from the natural environment*

Benefits - Environmental

- In the process of crushing coarse aggregate there will always be a fine product produced. This may not always have a ready market to take all production and as such will be viewed as waste – provided it is tested to meet the specification and managed in stockpile it can be a suitable manufactured sand for concrete.
- As natural sand sources become less accessible then it is likely that the distances required to transport this material becomes greater – higher carbon emissions per tonne and more truck movements required to support demand.

Benefits - Environmental

- Careful blending of manufactured sand with natural sand and also certain manufactured sands can produce concrete with significantly lower water demand than regionally available natural sands – placing less stress on available water sources.
- Replacement of natural sand with manufactured sand will concentrate manufacturing regionally and may take strain off ever diminishing available natural resources.



CCAA Guidelines and Specification

Barriers to the wider use of Manufactured Sand in Concrete as a natural sand replacement have come from several areas:

- *Inadequate coverage of manufactured Sand in Australian Standards*
- *Low confidence in the quality controls applied to manufactured sand by certain key specifiers.*
- *Uncertainty over the impact of manufactured sand on hardened concrete properties.*

CCAA Guidelines and Specification

The CCAA have now carried out a program of research and produced a recommended specification for manufactured sand to be used in concrete and a Guidelines document.

The Guidelines document will view product control measures in three levels:

- *Minimum Specification (Proposal to AS 2758.1)*
- *Properties that are reportable and form part of a supply contract.*
- *Properties that are part of a supplier's quality control assessment*



CCAA Specification

The CCAA have proposed manufactured sand specification recommendations to Australian Standard committee CE-012 for inclusion in AS 2758.1 as demonstrated in the following slides of the key changes proposed:

CCAA Specification

Definitions:

Manufactured sand: A purposeful made crushed fine aggregate produced from a suitable source material designed for use in concrete or for other specific products. Only source materials with suitable strength, durability and shape characteristics should be considered. Production generally involves crushing, screening and possibly washing. Separation into discrete fractions, recombining and blending may be necessary.

Sound, durable stone or source: For the purposes of this specification sound and durable stone or a sound and durable source shall mean source rock or stone that can be shown to comply with the durability clause (Clause 9) of Australian Standard AS 2758.1 for exposure classification B1 or B2.

General:

Manufactured sand shall be produced from crushing and screening of sound and durable source rock. Crushing shall include processes to improve the particle shape of the manufactured sand. Production processes shall ensure that sand stockpiles are not contaminated with weathered or highly altered rock or with clay seams or other contaminants. Crushing of multiple source rocks into a single sand stockpile shall not be permitted unless it can be demonstrated that such a process is under blend control and produces a consistent product. In accordance with Clause 13 of AS 2758.1, volcanic breccia, mudstones, shales and highly weathered or altered rocks shall not be used as source rock for manufactured sand.

CCAA Specification

TABLE A4.1 – General grading limits

Sieve size	Cumulative percentage passing
4.75 mm	90% to 100%
0.6 mm	15% to 80%
0.075 mm	0% to 20%

The producer of manufactured sand shall review the current 'submitted grading' and shall advise all customers whenever a grading result departs from the submitted grading by more than the deviation limits given in **Table A2** at any sieve size.

TABLE A4.2 – Grading variation limits

Sieve size	Maximum deviation, percent
9.5 mm	–
4.75 mm	± 5
2.36 mm	± 10
1.18 mm	± 15
0.60 mm	± 15
0.30 mm	± 10
0.15 mm	± 5
0.075 mm	± 3



CCAA Specification

Deleterious Fines

There are two options proposed

1. MBV x Passing 75 Micron < 150
2. Sand Equivalent (AS1289.3.7.1) > 60

Durability

There are two options proposed

1. Sodium Sulphate Soundness < 6%
2. Degradation Factor (AS1141.25.3) > 60

The CCAA have reviewed a Micro Deval test as a possible assessment of durability but have recommended more research on this to obtain suitable limits.

CCAA Guidelines

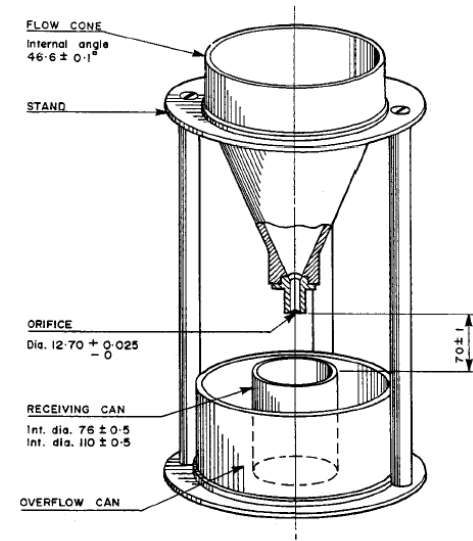
The CCAA have currently a draft
“Guide On The Use Of Manufactured Sand in Concrete”.

This Guide will cover the following issues:



CCAA Guidelines

- General definitions & blending sand guide
- Properties of manufactured sand
- Suitable specification and quality control tests
- Use of mortar testing to assess sand performance
- Effects of manufactured sand on concrete properties
- A specification for manufactured sand
- Performance criteria for manufactured sand blended with natural sand
- The use of manufactured sand in specific special purpose concrete



Current use of Manufactured Sand for Concrete in Australia

- Current use of sand in Premixed concrete is estimated as approximately 20 million tons per annum.
- Quarry sand has been used in small quantities in Australian concrete for more than 30 years with a steady annual increase as sources of natural sand diminish and the industry has moved to use manufactured sand.
- An estimate suggests that the proportion now may be between 15% and 25% nationally in 2008.
- With continuing reduction in accessibility of new natural sand reserves near to key centres of concrete demand this proportion will continue to rise.

Summary

Manufactured sand is a suitable replacement for increasingly limited sources of natural sand for premixed concrete.

The industry through the CCAA have carried out research and provided the data and developed the guidelines to support the replacement of natural sand with manufactured sand.

Reduced reliance on more limited natural sand resources in the future is seen as a more sustainable solution to producing sand suitable for concrete.