CMIC 06 PARTNERING FOR THE FUTURE

- PARTNERING – working together
- FUTURE – outlook, opportunity, expectation.

Rock Sources I have dealt with:

- Quartzite - 1994
- Meta-Greywacke – 2 - 1996
- Rhyolite -2000
- Sandstone -1992
- Granodiorite –2 - 2001
- Older Basalt - 2001
- Younger Basalt - 2000
- Greenstone - 2006

Why is Manufactured Sand a burning important issue for Us?

- Environmental and commercial demands are being placed on Readymix/Quarrying companies throughout Australia to utilise already available non-primary materials such as Manufactured Sands in preference to winning sands from Sedimentary deposits.
- Today's theme has a strong flavour of Environmental Sustainability – It is my conviction that as an Industry we should be moving to what is called non primary materials such as Manufactured Sand by utilising or converting crusher dust as a manufactured sand.
- As our knowledge of Manufactured Sands as individual companies and as an industry is maturing we have commenced to understand that in many ways most Manufactured Sand are superior to Alluvial Sands particularly when compared to the natural sands now available.

The Historical use of Sand in Concrete:

- Each year over 20 million tonnes of Sand is utilised into Concrete across Australia.
- Historically this Sand has been primarily sourced from deposits where the Sand is naturally occurring. This type of Sand is known as Sedimentary and is the product of hundreds of thousands of years of water movement, wind, chemical breakdown and tectonic plate movement, the use of Sedimentary sand in Australian Construction materials is rapidly being taken over by its in some regards superior successor "MANUFACTURED SAND".
- Major shifts from Alluvial Sands to Manufactured in SEQ commenced in the late 90's due to closing of Dredging on Brisbane River, shifts in nearly all other areas/markets around Australia are also gaining major momentum.

What is Manufactured Sand?

- Manufactured Sand has been defined by the Quarrying Industry as:
- *"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 possibility washing. Separation into discrete fractions, recombining and blending may be necessary."*

- *Definition provided by CCAA Manufactured Sand Technical Committee.*

Who Manufactured Sand Impacts

- Quarry Companies
- Concrete Companies
- Government Specifiers and owners and maintainers
- Standards and all specifications
- Suppliers to Concrete and Quarry Industry
- Cementitous companies
- Contractors
- Builders
- Pump Operators
- Concretors
- Quarry Plant Manufacturers
- Concretors

Key considerations in Managing this Trend Shift as an Industry

- **The shift is happening quickly so:**
- Crushing and Screening Technology have made good improvement's but the next shift is due:


04/10/2006


04/10/2006

Key considerations in Managing this Trend Shift as an Industry

- **The shift is happening quickly so:**
- Specifiers and Industry need to work together at a new level of commitment in terms of R and D – Pacific Motorway.

What is the CCAA doing to manage the change:

- Formation of CCAA Manufactured Sand Sub-Committee and Research and Development Program in 2005 – led by Tony Thomas and Gary Basford, with consultation by Peter Clarke.
- Key Objectives being:
- 1. To determine the most appropriate tests for quality control and specification of manufactured sands
- 2.To determine specification limits for the tests which would ensure the supply of a fit for purpose manufactured sand product

  3.To present a body of research findings to Standards Australia which would be sufficient to support an Industry submission for the specification of manufactured sands as a concrete fine aggregate.

KEY AREAS OF R&D
TEST METHODS

- Particle size distribution to AS1141.11
- Material passing 75micron to AS 1141.12
- Material finer than 2micron to AS 1141.13
- Particle density & Water absorption to AS1141.5
- Clay & Fine silt to AS 1141.33
- Sodium Sulphate Loss to AS1141.24
- Degradation Factor – Fine Aggregate to AS1141.25.3
- Sand Equivalent Value to AS 1289 3.7.1
- Flow time to method NZS 3111:1986 except that in clause 19.3.1(b) do not determine oversize, and in clause 19.3.1 (c), use a constant mass of 1.0kg for all samples.
- XRD for a semi –quantitative mineralogical analysis of the whole sample.

CCAA RESEARCH METHODOLOGY

- 21 different proposed Manufactured Sands are currently being tested.
- Containing the following rock sources from various states and companies:

- **Meta-greywacke**
- **Meta-argillite**
- **Quartzite**
- **Granitic**
- **Rhyolitic tuff, ignimbrite**
- **Rhyodacitic tuff**
- **Trachyte**
- **Latite**
- **Agglomerate**
- **Basalt**
- **Picrite**
- **Limestone/Dolomite**

Queensland Main Roads position **APPROVAL OF MANUFACTURED SAND**

- **APPROVAL OF MANUFACTURED SAND**
- **MRS11.70 Version 12/99 - Amendment to Clause 6.8.2 - Fine Aggregate**

- **6.8.2 Fine Aggregate**
- Fine aggregate shall consist of natural sand, or a combination of natural and manufactured sands containing not less than 40% natural sands for reinforced or un-reinforced cast in place decks and slabs. All other elements shall contain a minimum mass of 25% of natural sand within the fine aggregate proportion. All particles shall be clean, hard and durable.

Queensland Main Roads position **APPROVAL OF MANUFACTURED SAND**

- **CONDITIONS AND COMMENTS ON THE ABOVE AMENDMENT**
- **1. CONDITIONS**
- The above amendment allows the mass of manufactured sand to increase to a maximum level of 75% in all elements other than reinforced or unreinforced decks and slabs.
- **The amendment is conditional** on the crushed fine aggregate meeting the following conditions :
- **(i) Source Assessment** - **Uniformity**
- Adequate source assessment and auditing of the process of manufacture needs to be
- undertaken to guarantee the uniformity of the source material and resultant manufactured sand.

Queensland Main Roads position **APPROVAL OF MANUFACTURED SAND**

- **(ii) Grading - AS 2758.1** - Table 3 Fine aggregate grading requirements.
- **(iii) Material Finer than 75 microns** - AS 2758.1 Clause 9.2.2 - total of crushed fine aggregate shall not exceed 20 percent.
- **(iv) Material Finer than 2 microns** - AS 2748.1 Clause 9.2.3 - 1% maximum
- **(v) DURABILITY - AS 2758.1 -** Clause 10.1 and additional petrographic analysis to ensure the manufactured sand particles are clean, hard, durable and fit for purpose. This analysis shall determine whether washing of the sand is required to achieve this result.
- **(vi) Water Demand** - not higher than mixes containing 50% natural sand.
- **(vii) Shrinkage** - not higher than mixes containing 50% natural sand.

Queensland Main Roads position **APPROVAL OF MANUFACTURED SAND**

- (**viii) Limitations on Chemical Content of Concrete** - AS 1379
- **(a)** Chloride content - Clause 2.7.1 - 0.8 kg/m3 maximum
- **(b)** Sulfate content - Clause 2.7.2 - 50g/kg of cement
- All concrete shall comply with the above limitations on chemical content detailed in AS1379.

Queensland Main Roads position **APPROVAL OF MANUFACTURED SAND**

- **2. COMMENTS**
- Some issues still need to be addressed in relation to the use of manufactured sands in cast in place decks and slabs. The main concerns are possible increased risks of plastic shrinkage
- cracking in bridge decks, culvert and roadway slabs and reduced abrasion resistance of concrete wearing surfaces as a result of weathering. These issues require further research and documentation and Queensland Main Roads would be interested to review any future information in these areas.
- **Alan Carse**
- **Principal Engineer (Concrete Technology)**

Vic Roads Current Position

General Concerns:

- The life expectancy of commercial class concrete was far less than civil infrastructure.
- 3.1 Section 610 - Structural Concrete: General discussion on this specification outlined concerns relating to placement, bleeding, workability, plastic shrinkage and finishing
- Fred Andrews-Phadoneous. Geopave. 2004

Vic Roads Section 610
Structural Concrete

- **610.11 AGGREGATES**
- (a) General

  Fine and coarse aggregate for concrete shall comply with the requirements of AS 2758.1 unless otherwise specified.

  The maximum amount of water absorption for both fine and coarse aggregates shall not exceed 2.5%.

Aggregates shall not be stored in direct contact with the ground. Aggregates shall be stored in such a manner that they will not segregate, become contaminated by foreign matter, or become intermixed. Stockpiles shall be arranged to prevent entry of adjacent surface or ground water and allow free drainage of rain water.

Vic Roads Section 610
Structural Concrete

- (b) Fine Aggregate
- (i) Description
- The fine aggregate shall consist of clean, hard, durable, naturally occurring grains sands, or a combination of naturally occurring grains sands and crusher fines manufactured sands, and shall be free from clay, dust, lumps, soft or flaky particles, shale, salt, alkali, organic matter, soil or other deleterious substances. Any manufactured sands used as fine aggregate shall be crushed from rock from which it produces aggregate complying with the requirements of Clause 610.11. Crusher fines Manufactured sands produced from any igneous or metamorphic rock shall have a Degradation Factor - Crusher Fines of not less than 60.
- **A maximum of 20% of crushed fine aggregate manufactured sand from a source approved by the Superintendent will be permitted.**

Vic Roads Section 610
Structural Concrete

- ***Consideration may be given by the Superintendent to approve the use of up to a maximum of 40% of manufactured sand if objective documented evidence is provided that concrete made with higher amount of manufactured sand complies with all other requirements of this section both in the fresh and hardened state, including evidence of acceptable performance regarding tendency for segregation, bleeding and plastic shrinkage, satisfactory compaction and finishing properties.***

Vic Roads Section 610
Structural Concrete Grading

- (iii) Grading of Fine Aggregate
- Fine aggregate shall be uniformly graded and shall comply with the limits in Table 610.111 when tested with standard sieves.
- If required fine aggregates can be combined in such proportions that the resulting fine aggregate mix shall comply with the grading requirements.
- (iv) Consistency of Grading

- The grading of fine aggregate shall not deviate from the submitted grading by more than ±5%.

Vic Roads Section 610
Structural Concrete Grading

Sieve Size AS (mm)	Percentage Passing (by mass)
9.5	100
4.75	90 □ 100
2.36	75 □ 100
1.18	50 □ 90
0.6	30 □ 70
0.3	10 □ 35
0.15	2 □ 10
0.075	0 □ 3

Western Australian Specification
Specification 820
Concrete For Structures

- **820.13 Aggregate**
- 1. Fine aggregates for concrete shall be natural sand and shall comply with the requirements of AS 2758.1. The maximum amount of water absorption for fine aggregates shall not exceed 1.5 percent.

RTA QA SPECIFICATION B80
Edition 5/Revision 2 June 2005

2.4.3 Additional Requirements for Fine Aggregate

(a) Fine aggregate must conform to the dimensional requirements of AS 2758.1 except apply Table B80.3 of this Specification in lieu of Table 3 of AS 2758.1.

Where more than one type of fine aggregate is proposed for use in the mix, the resulting blend must conform to dimensional requirements of the above paragraph;

(b) Limit water absorption to a maximum of 2.5%;

(c) Any manufactured sand used as a fine aggregate must be crushed from rock from which is produced aggregate conforming to the requirements of Clause 2.4, and must be non-plastic when tested in accordance with AS 1289.3.

The requirements of Clause 8.2.2 of AS 2758.1 do not apply for manufactured sand. The water absorption of the combined fine aggregate must not exceed 2.5%.

AS 2758 REQUIREMENT

AS Sieve	Typ. Grad.	AS	
(mm)	max deviation	Target	Envelope
6.7	-	100	100
4.75	5	90	100
2.36	10	60	100
1.18	15	30	100
0.600	15	15	80
0.300	10	5	40
0.150	5	0	25
0.075	5	0	20

AS 2758 REQUIREMENT

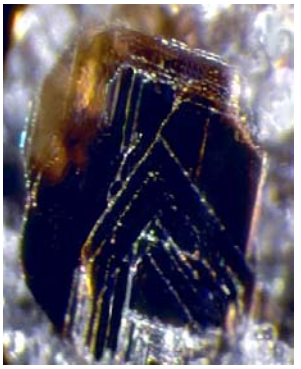
AS2758 REQUIREMENTS	
<2um as per AS1141.13 max allowable	1.00%
Sodium Sulphate Unsoundness max allowable c	12.00%

CASE STUDY GRANITE OAKLANDS JUNCTION

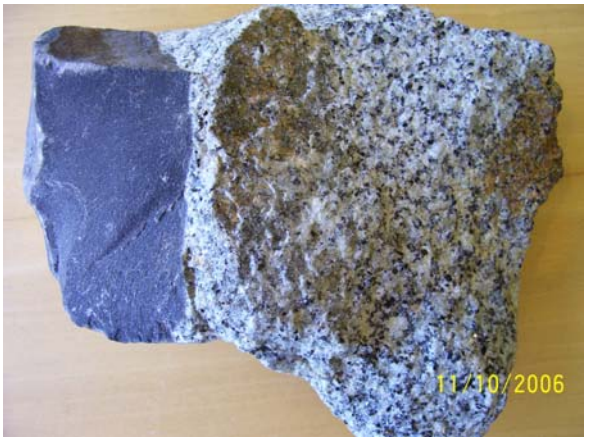
Granodiorite Unprocessed Dust Mineralogy

19%	Quartz as free unstrained to mildly strained single grains and a few simple crystalline composite grains
15%	Feldspar as free grains (11% plagioclase and 4% orthoclase)
11%	Biotite mica as free flakes
<1%	Other free mineral grains (including opaque oxide, sericite and chlorite)
55%	Lithic clasts of granodiorite (composed of 18% quartz, 16% plagioclase, 12% orthoclase, 5% biotite, 1% muscovite, 2% sericite, 1% chlorite, <1% opaque oxide and <1% other minerals)

MICA BIOTITE



Oaklands Granite/Hornfels



MICA References:

- Neville Internationally renown Concrete Technologist;
- *"Fooks and Revie found that a 5 percent content by mass of mica in sand reduced the 28 day strength of the resulting concrete by about 15 percent, even when the water cement ratio was kept constant. The reason for this is probably poor adhesion of the cement paste to the surface of mica particles. It appears that MICA in the form of muscovite is much more harmful than biotite"*

MICA References

- Stan Joyce - Australia's foremost Petrologist in assessing quarrying materials.
-
- *"Mica flakes are considered to be undesirable in concrete sand because they represent weak, flexible, cleavable and water absorbent minerals, and because the experience with natural sands is that they may segregate by floating during placement or working of concrete to weaken joints or finished surfaces. For natural sands it is commonly expected that mica flakes should amount to less than about 2% in good quality concrete sand."*

MICA References

- Fultons – Concrete Technology South Africa
-
- ***The influence of different types of mica on the behaviour of concrete differs considerably and for this reason it is necessary to judge each type of aggregate on its own merits.***

MICA TARGET

- We wanted to get the Mica content to under 5 % so when we blended this with an alluvial sand the total mica content was less than 2%.
- We achieved total mica content of around 1.5% at 40% natural sand replacement.

Granodiorite Washed Manufactured Sand Mineralogy

20%	Quartz as free unstrained to mildly strained single grains and a few simple crystalline composite grains
20%	Feldspar as free grains (17% plagioclase and 3% orthoclase)
4%	Biotite mica as free grains
<1%	Other free mineral grains (including opaque oxide, sericite and chlorite)
56%	Lithic clasts of granodiorite (composed of 15% quartz, 25% plagioclase, 12% orthoclase, 3% biotite, <1% opaque oxide, <1% sericite, 1% chlorite and <1% other minerals)

Secondary Processing

Secondary Processing

Secondary Processing

Physical Dimensional Analysis

- PSD inc < 75 and 2um
- Flow Cone
- Voids
- Visual Assessment
- Shape of Coarser components

Oaklands Washed Concrete Sand Properties

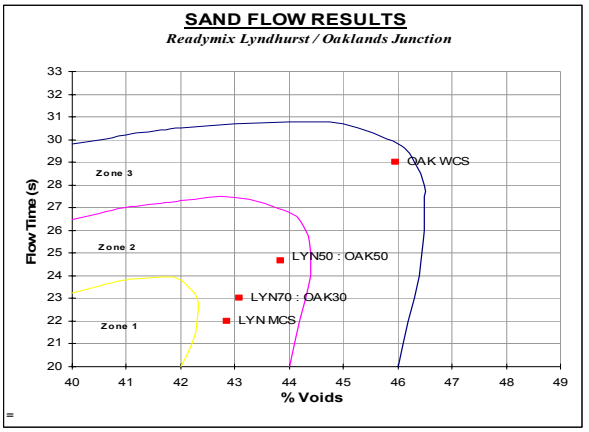
AS Sieve (mm)	Typ. Grad. (% Passing)	Readymix Target Envelope	
6.7	100	100	100
4.75	100	98	100
2.36	85	80	90
1.18	62	55	65
0.600	40	35	45
0.425	29	25	35
0.300	20	16	24
0.150	9	6	12
0.075	5	2	7

Oaklands Washed Concrete Sand Properties

Properties	OAKWCS	UNPROCESSED
Sand Equivalent	60	60
Degradation Factor	**85**	75
Plastic Limit (%)	18	18
Liquid Limit (%)	Not Obtainable	Not Obtainable
Plasticity Index (%)	Non Plastic	Non Plastic
Bulk Density (t/m^3) - Loose / Compacted	1.40 / 1.55	1.40 / 1.55
Apparent Particle Density (t/m^3)	2.64	2.69
Dry Particle Density (t/m3)	2.62	2.58
Saturated Surface Dry Particle Density (t/m3)	2.64	2.62
Water Absorption (%)	**1.0**	1.4
Sodium Sulphate Soundness (% loss)	**1**	1.5

SAND FLOW AND VOIDS

SAND FLOW AND VOIDS RESULTS



IMPACT OF BARMAC ON SHAPE + 2.36

IMPACT OF BARMAC ON SHAPE - 2.36+1.18

Laboratory Concrete Trial mixes and optimisation

- Trial mixes required for various applications across the grades
- Full Plastic property analysis
- Compressive Strength
- 2 Durability Measures
- Drying Shrinkage
- Tensile Strength
- Flexural Strength
- Abrasion Resistance

Vic Roads 32MPa 330 Results

SLUMP			
-	85	80	NA
TOTAL WATER			
-	165	151	172
TOTAL CEMENTITIOUS CONTENT			
-	345	345	330 Min
WATER CEMENT RATIO			
	0.48	0.44	0.5 Max
STRENGTH			
7	31.7	28.9	
7	33.0	31.2	
28	44.9	43.3	32 Min
28	46.4	42.9	
FLEX @ 28	5.8	4.9	
Shrinkage	676	656	750 max
AVPV - 1	12.7	13.2	
AVPV - 2	13.1	13.2	
AVPV - AVge	12.9	13.2	15 max

After dozens of Lab Trials it was time to go to go to the next step in the field

After dozens of Lab Trials it was time to go to go to the next step in the field

- Pakenham Trials – Nov / Dec. 2003

N202FT Mix

Full Slab at Lang Lang

The Biggest Obstacles

- **<u>Material Handling Issues</u>**

- Stockpile Room
- Moisture Control
- Water Supply / Reticulation Quarry Plant
- Concrete Plant bin configuration

ADVANTAGES OF MANUFACTURED SAND

- CONSISTENCY
- ROCK FLOUR HELPS THE PLASTIC CONCRETE – PUMPING AND FINISHING
- CONCRETE PROPERTIES NEARLY ALWAYS IMPROVED
- ENVIRONMENTAL

Key Challenging Issues for Industry

- Manufactured Sand in Concrete Pavements
- Development of Specifications and Tests
- Removal of deleterious fines without water/ dry extraction
- Uses for Ultrafine Dusts – materials washed from Manufactured Sands