Manufactured Sand Uses and Potential for Concrete in Auckland

James Mackechnie [1] – May 2026

Introduction

This report was written to review usage of manufactured sand for concrete in the Auckland region. The report specifically responds to comments made about manufactured sands in the submission by Paul Donoghue for McCallum Bros. Ltd. Statement (Donoghue, 2026).

Conflict of interest statement

The author has previously worked for Allied Concrete (until May 2026) for 15 years and from June 2026 will start work for Busck Prestressed Concrete whose head office is in Whangarei. This report was written as an Adjunct Senior Research Associate at the University of Canterbury and done without payment from any party.

Background information on manufactured sand in concrete

Fine aggregate, sometimes simply referred to as sand, is required in most concrete mixes to provide cohesion and workability to fresh concrete. Sand constitutes part of the fine filler together with cement paste between coarse aggregate (stone) particles such that concrete can be mixed, transported, pumped, placed and compacted into formwork. The quality of the fine aggregate used in the mix design directly affects economics, structural performance and environmental emissions of concrete (Mackechnie, 2023).

Ideal characteristics of the fine aggregate may be summarized as follows:

- Continuous grading of particle sizes from 20 microns to typically 5 mm
- Rounded to cubical shape to allow good particle packing
- Cleanness to control deleterious materials such as clays, silts and salts
- Moisture contents are controlled without significant variations in supply

Many parts of New Zealand still have natural sand available with these attributes and can be used as a single source material (i.e. no blending with a second sand source). Larger metro regions such as Auckland have exhausted much of their natural sands and most readymix concrete suppliers rely on blending of crusher sands (e.g. PAP7 or PAP6) with finer sands, often derived from marine sources (e.g. dune or dredged marine sands). Blending of sand has been done for many years in Auckland, and the following definitions are used in this report to distinguish between different fine aggregate types:

- **Crusher sands** are older technology manufactured sands referred to as PAP7 or PAP6 (Premium Aggregate Passing either 7mm or 6mm) that are typically relatively coarse with angular to sub-angular particle shape and are generally not suitable for concrete unless blended with fine, natural sands
- **Dune sands** are marine sands deposited inland that typically are fine grained, rounded to sub-angular shaped and relatively salt-free from years of rainfall washing through the material
- **Dredged marine sands** are fine grained, rounded to sub-angular shaped and contain relatively high salt levels from seawater with chloride levels reducing when well

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drained or washed (note while gradings may vary, there is little difference technically between dredged marine and dune sand except in source and presence of seawater)
- **Manufactured sands** are made from high quality rock using high-pressure grinding rolls crushers or vertical shaft impactors (VSI), which produce cubically shaped particles with continuous grading used as a single source sand (i.e. no blending)

Crusher sands are typically produced to a relatively coarse grading and are often washed to remove excess fines from the lower particle sizes (i.e. less than 600 microns). The angular and coarse nature of particles makes it important that blending is done with a finer and rounded natural sands to produce something that equates to the ideal characteristics given above (e.g. continuous grading with good packing efficiency).

Modern manufactured sand is increasingly being used in Auckland for the following reasons:
- Potential saving in material cost if cementitious efficiency of concrete can be improved as projected from laboratory trials
- Manufactured sand is free from salt contamination, while other deleterious fines are controlled by washing or air screening
- Resource efficiency since fine and coarse aggregate can be extracted from the same quarry with less material going back as waste

Review of the Donoghue Report (Concrete Suitability Statement for MBL)
Clarification of several issues raised in the Donoghue Report is given with respect to manufactured sand usage and performance in concrete.

<u>Research publications on manufactured sand in concrete</u>
Research on the use of manufactured sand in concrete has shown an exponential increase over the last 10 years (Scopus database). This research interest has been ascribed to the depletion of natural river sands, particularly in Asia, with manufactured sand seen as a possible alternative. Peer reviewed publications on the subject have increased from 7 papers between 1995-2004, to 113 papers from 2005-2024 and 949 papers from 2015 to 2024 (Aboagye et al, 2025). These research papers investigated a multitude of concrete technology applications, with some research looking specifically at 100% replacement of fine aggregate with manufactured sand (Pilegis et al, 2016).

Several recent research papers have shown the technical benefits of manufactured sand as replacement for natural sands in concrete (Mackechnie, 2024, Rathore & Raheem, 2025). Research has also shown that manufactured sand can be used in very high strength concrete applications (Shen et al, 2017). Numerous other research papers also show the suitability of manufactured sand in higher strength concrete applications (e.g. compressive strengths above 40 MPa).

<u>Manufactured sand suitability in concrete</u>
Modern processing of manufactured sand makes this product suitable for all grades of concrete and is not limited to lower strength grades only. Currently a national readymix company uses 100% manufactured sand in most of the concrete mixes produced from their Penrose concrete plant including high strength concrete mixes such as 50 MPa. When the correct controls and processing are implemented, there is no technical limitation to using

manufactured sand. This is because manufactured sand is not inferior to the current blend of crusher and natural sand. Manufactured sand has improved texture compared with most natural sands that is critical when producing high strength concrete. There is also little risk of chloride contamination, which is important for prestressed concrete when the chloride limit in concrete is lower than in general concrete applications (NZS 3101, 2006).

Local and international usage of manufactured sands

Brookby Quarry has a reported production capacity of 210,000 cubic metres per year with potential to increase to 420,000 cubic metres per year dependent on demand (Beca, 2025). Several countries have started using manufactured sand to replace 100% of natural sands as these materials are depleted. While this has been happening in countries such as Japan for some time, it is also increasingly common in Australia. As an example, there is currently a new manufactured sand plant being constructed near Sydney that will supply 500 000 tonnes (roughly 350 000m^3) of manufactured sand for concrete production (TVNZ, 2025).

Energy requirements to process manufactured sand

Manufactured sand is currently produced by high pressure grinding rolls crushing and water screening or using vertical shaft impactors (VSI) and air screening. Claims that the air screening process requires extra energy for drying are incorrect since material is crushed and processed from rock at low moisture contents and currently over 300 similar operations internationally run without any drying. Additional energy costs associated with these modern grinding systems can be partially offset by reduced transport costs for quarries located near Auckland and potentially by improved cementitious efficiency.

Technical suitability

Concrete readymix producers in the Auckland market produce a wide range of mixes that vary in technical demands from residential applications to large infrastructure projects. Manufactured sands are suitable for all applications provided design engineers have confidence in the reliability and consistence of these materials. Modern processing of manufactured sand provides this assurance since grading, particle shape and cleanness can be tightly controlled. Natural sands, in contrast may vary depending on conditions locally, rate of extraction and time available for proper draining and washing before supply to market (Mackechnie, 2023). For prestressed concrete applications it is particularly important that sand is free from excess salt as chloride limits are set at a lower limit of 0.5 kg/m^3 and unwashed marine sands may result in this being exceeded (NZS 3101, 2006).

Potential growth in manufactured sand

Growth in production of manufactured sand is inevitable in New Zealand, particularly in the Auckland region for the reasons listed above. Brett Beatson, who was a highly respected concrete plant engineer, wrote the following in 2008 (Beatson):

The processes associated with acquiring consents and environmental issues are making natural sands more scarce and expensive. Transportation of natural sands (further away from the end use) often makes it the most expensive aggregate raw material. Manufactured sands (MS) are likely to be a reality in New Zealand in the near future. In other countries manufactured sands are now the only option because natural sand reserves are depleted or off limits. While MS have both benefits and negative aspects, with specialist equipment processing it is entirely possible to manufacture sand that will perform equal to that of natural sand.

The need for current extraction rates of marine sands is likely to reduce as a proportion of total fine aggregate supply for concrete as quarries adapt crushing systems to produce more manufactured sand. This crushing technology does require a significant investment in capital but has the advantage of being able to supply more material from hard-rock quarries with less wastage and potentially reduced transport. Comprehensive summaries of fine aggregate resources in the region are covered elsewhere (Beca, 2025)

Conclusions

The growth in production of manufactured sand is inevitable in New Zealand with greater adoption only limited by the capital cost of new crushing technology. Blending of fine sands from dune or marine sources will continue in the interim but reliance on these materials is likely to reduce due to economic, logistic and environmental pressure. The use of fine sands from marine or dune deposits is not intrinsically an essential component in readymix concrete but rather is used to complement existing crusher sand that is produced in a cost-effective manner to be blended with natural sands.

Research both locally and overseas shows that concrete made with manufactured sands can replicate the performance of concrete made using natural sands or sand blends. This has already been shown in Auckland by a national supplier of readymix concrete. Local research by the author also shows that using 100% manufactured sand as fine aggregate in concrete can produce concrete mixes with savings in cementitious materials that would help reduce material costs and lower carbon emissions of concrete.

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PROFESSIONAL QUALIFICATIONS

CPEng	Chartered professional engineer (IPENZ/Engineering NZ)
PhD, 1996 -	University of Cape Town, South Africa, Civil Engineering
	Predictions of reinforced concrete durability in the marine environment
MSc(Eng), 1989 -	University of Cape Town, South Africa, Civil Engineering
	The durability of fly ash concrete in marine and softwater environments
BSc(Eng), 1985 -	University of Cape Town, South Africa, Civil Engineering

PROFESSIONAL APPOINTMENTS

Jan 2022- May 2026	South Island Technical Manager – Allied Concrete Ltd. NZ
Jan 2018 – Dec 2021	Education, training and research manager – Concrete New Zealand
May 2008 – Jan 2018	South Island Plant Engineer – Allied Concrete Ltd., NZ
Apr 2001 – Apr 2008	CCANZ Fellow/Senior Lecturer, University of Canterbury, NZ
Sept 1992 – Mar 2001	Research officer, University of Cape Town, South Africa
Jan 1990 – Sept 1992	Structural engineer, Kantey and Templar, ABC – Cape Town
Apr. 1986 – Mar 1988	Graduate civil and structural engineer, Arup, Zimbabwe
Jan 1986 – Apr 1986	Trainee site engineer, Grinaker Construction, Zululand, South Africa

RESEARCH COLLABORATION

May 2008 –Present	Adjunct Senior Research Associate, University of Canterbury, NZ
Apr 2001 – Present	University of Cape Town, South Africa (Concrete durability)

PROFESSIONAL SERVICE

2017 – 2019	President, New Zealand Concrete Society (CNZ Learned Society)
2005 – 2021	NZ Standards committee, NZS 3101, NZS 3121, NZS 3122, NZS 3104
2018 - 2021	Chairman of NZS 3104 Concrete Production Standard review & CNZ TR3
2001 - 2024	Reviewer for several International Scientific Journals
2011 - 2012	Peer review for Royal Commission on CTV Building – materials report
2011	Volunteer for EQC conducting structural assessments in Christchurch CBD
2013	Peer review of University of Auckland report on bridge durability for NZTA
2014	Peer review for MBIE on imported cement quality issues

RELEVANT PUBLICATIONS

Ensuring affordable concrete post 2020 in New Zealand, BRANZ Project LR 0526, ER38, 2019 – Summary of alkali silica reaction testing of NZ materials in preparation for revising CCANZ TR3.

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