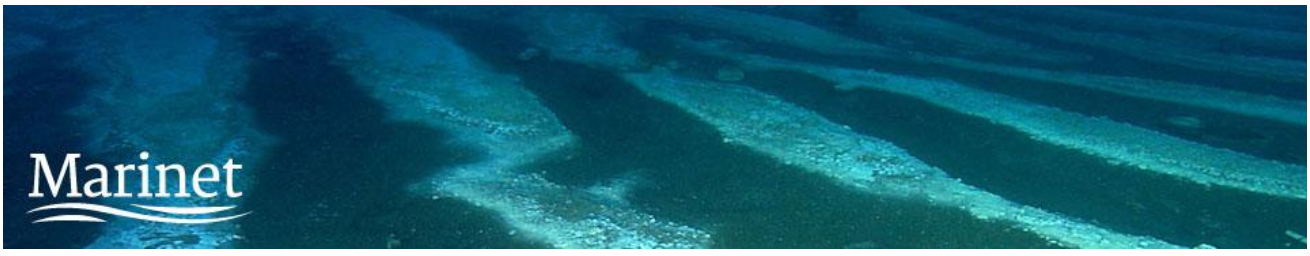
MARINE AGGREGATE EXTRACTION

THE NEED TO DREDGE :

FACT OR FICTION ?

September 2015



1 BACKGROUND

Sand is a critical component in the manufacture of concrete which is, of course, a vital building material in the construction industry.

The United Kingdom is almost the only developed economy which is still expanding the use of offshore marine dredging to source this sand. Most developed countries elsewhere in the world have banned, or at least limited, the licenses and amount of dredging which they allow to be undertaken in their coastal waters. However the UK appears to be a lone voice in its assertion that there is either no impact or only very limited environmental impact from this dredging.

If one believes the dredging companies, the main reason why marine dredging in the UK is being expanded rather than curtailed is because there is no viable alternative and that to limit the marine dredging of sand would significantly increase the costs of building, thus causing significant negative impact on the British building industry and hence the UK economy as a whole.

The purpose of this report is to explore the facts behind these assertions, and to look at the impact on a country which has actually banned marine dredging for sand.

2 IMPORTANT PROPERTIES OF SAND IN CONCRETE

'Sand' is an important component in concrete manufacture, but there is often confusion around what is meant by sand.

Concrete is made up of the following : Coarse Aggregate, Fine Aggregate, Cement, Water and miscellaneous additives and performance enhancers.

'Fine Aggregate' is the fine component of aggregate, and is typically under 5mm in particle size. The properties of this fine aggregate (sand) play an important part in how dense, workable, pumpable and finishable the concrete is. Equally importantly, how much water the concrete requires, how much cement is required in the mixture, and how the concrete hardens along with the strength and other properties of the finished product.

'Fine aggregate' (sand) is typically made up of 2 or 3 components in order to achieve the desired properties. These are: "manufactured sand" (processed crusher dust), "coarse sand" (land-based alluvial sand or marine dredged sand) and "fine sand" (beach or dune sand).

In some cases there is a "natural sand" which is available as a complete fine aggregate (i.e. it spans all the required particle sizes, and its gradation is suitable - 'gradation' is explained below), but where natural sand is used without "manufactured sand" the strength properties of the concrete are usually inferior.

Manufactured sand is a term that is applied to crusher dust (a waste stream in quarries that is typically less than 5mm) which has been processed to make its properties suitable to use as part of the fine aggregate.

There are 2 key properties that are important for fine aggregate (sand) in concrete. These are its gradation and its shape.

2.1 Gradation

Gradation is the distribution of particles sizes in the material. This is important in order to provide the right packing, density and strength. If the material is deficient in small particles there will be voids in the concrete, and the strength will suffer. Often this is overcome by adding more cement to fill the voids. However, at approximately 10 times the cost of aggregates, this is a very expensive fix.

2.2 Shape

The shape of the particles in the fine aggregate has a significant impact on the strength and usability of the concrete. The use of "manufactured sand" in the fine aggregate helps with the strength because the irregular, fractured faces of this material provide useful interlocking properties which add to strength (as opposed to lots of smooth spheres which don't bind together as easily). Natural sand is typically well-weathered and provides smooth round surfaces. However adding excessive angular material makes it very difficult to pump and work the finished concrete as it binds too much.

3 ALTERNATIVES TO MARINE DREDGED SAND IN FINE AGGREGATE FOR CONCRETE

3.1 Land Based Sand Resources

The UK has a number of land-based sand resources that could be opened up, and the sand used to provide a portion of the fine aggregate (sand) needs that are currently met by marine dredging. The environmental, social and economic impact of the mining of these land-based resources depends a lot on the specific locations. The following are key considerations:

- Proximity to the areas of demand
    - There are significant costs involved in the transport of aggregates from remote locations. It is estimated that the cost of transporting aggregates is around £10 for every 30 miles. Given that the cost of sand for concrete is typically around £15 to £20 delivered, the impact of location on cost is significant.
- Proximity to and impact on the surrounding community
    - As is usually the case with quarries, this consideration is typically at odds with the economics in that the areas of demand are usually densely populated areas and it is desirable to be close to these to keep the costs low, but the closer the quarries are then the greater the impact on the local community from trucks, noise, dust etc.
- Quality and accessibility of the resource
    - Size and gradation of the sand particles, shape of the particles and the type of rock, as well as the prevalence of impurities like micas and clays, are all considerations. The ease of recovery (usually simply dug out of the ground) is also important. In many cases there is a layer of covering earth or similar that needs to be removed before the sand can be extracted. Invariably natural sands require to be washed, so they contain few or no particles below 300 microns (0.3 mm).

3.2 Manufactured Sand

"Crusher dust" (manufactured sand) is formed whenever rock is crushed to reduce its size in the quarry, and a well operated quarry with the latest crushing equipment will typically produce crusher dust at a rate of around 40% of rock that is mined.

Most quarries, however, are not operating with the latest equipment, practices or process flows and some will produce crusher dust at a rate as a high as 50% of the mined rock. Crusher dust is typically very angular, has poor gradation, and is high in fine contaminants like micas and clays which cause problems in concrete, and it also often requires washing.

Many of the quarries in the UK have large stockpiles of crusher dust piling up in the quarry, and are producing it much more quickly than they can utilise it. Crusher dust is typically a low value resource which, in many cases, actually results in a net cost to the quarries because they have to store it and then move it around in order to access and develop areas within the quarry. Consequently for several decades there has been a concerted effort to 'manufacture sand' for use in concrete by processing crusher dust in a way that addresses its problematic properties.

Many incremental and innovative advances have been made in addressing this task, and there continues to be substantial effort and investment from quarrying equipment manufacturers in this area. These advances have resulted in moving from an earlier maximum of 10% to 15% crusher dust in Fine Aggregates to the recent introduction of a dry sand-making plant, developed in Japan, which is now capable of producing a complete Fine Aggregate from crusher dust.

The introduction of a vertical shaft impacting crusher (VSI, commonly known as the Barmac) in the early 1980s has been a substantial advance, and has opened up significant opportunities in this area.

The VSI is a centrifugal crusher which works on the principle of rock impacting rock in order to reduce the size of the rock. In doing this, it substantially improves the shape of the rock and the finer grade product is often suitable for use at 20 to 30% of the Fine Aggregate.

The challenge when reaching levels of greater than 30% becomes the levels of deleterious clays and micas in the small particle range (typically less than 75µm / 0.075mm) where they are released from the source rock. In order to increase the percentage level further, this deleterious fine material needs to be removed from the crusher dust produced by the VSI.

This can be done using 'dry classification' (equipment like the Buell made by Metso) or, more commonly, by using a wet washing process. With the fine end removed, this crusher dust material can be used at up to 40% of the fine aggregate.

The limitation at this point becomes the lack of important fine particles which are washed out with the sub 75µm (0.075mm) material, and also the shape of the smaller particles as the VSI crushers do not materially improve the shape below 1mm. These deficiencies are overcome by adding 'fine sand' (beach or dune sand) to the crusher dust. In the late 1990's a Japanese Company, Kemco,[1] developed an improved system for addressing these remaining issues with the sand by combining several material advances and some smart processing.

[1] http://www.kemco.co.jp/eng/pdf/kemco_v7.pdf

Kemco developed a novel combined hammer-mill and VSI crusher,[2] which was able to shape the particles right down to 75µm, and a novel curtain-air-screen and skimmer combination, which was able to accurately and efficiently remove the deleterious material without removing other important particles in the 100µm to 500µm range (0.1 mm to 0.5mm). The result of these advances is the V7.

This equipment is capable of producing a well-graded and shaped sand which independent research by Cardiff University[3] has shown can be used as a complete replacement for natural marine dredged sand, with equivalent usability properties, and usually improved strength.

This V7 sand is now used extensively in Japan as a complete fine aggregate, and the major aggregate companies are beginning to look seriously at this technology/approach outside of Japan.

The economics of this approach compare favourably with marine dredging, but given the investment by major aggregate companies in the UK in dredging equipment and licenses over the last 10 years there is an understandable reluctance to abandon this. Change is therefore likely to be slow unless encouraged with regulatory drivers (i.e. by the UK Government).

Holcim is currently having its first V7 plant installed in New South Wales, Australia, which is expected to be operational before the end of 2015.

The adoption of this technology has the potential to offer both an economically viable and an environmentally attractive alternative to marine dredged sand.

4 A COMPARISON BETWEEN FINE AGGREGATES IN JAPAN AND UK

Because of the environmental impact of marine dredging the Japanese government has, since 1990, banned all dredging other than that required in order to keep shipping ways clear. A consequence of this ban has been an influx of imported river sand for concrete. However this has also spurred innovation by Kemco and other companies to reduce the requirement for natural sand in concrete. The Chinese and Taiwanese governments have also reacted to the export of river sand to Japan, and its resulting environmental damage, by regulating and restricting this export trade.

Today there is virtually no import of natural sand into Japan with all fine aggregates being made using manufactured sand and/or remaining land-based sand deposits. In Japan more than 50% of all manufactured sand made is now produced using the V7 dry sand-making plant developed by Kemco.

Meanwhile the UK is continuing to issue new dredging consents and to open new marine dredging areas and the amount of sand and gravel dredged from British waters has increased from c. 12½ million tonnes in 1990 to c. 17½ million tonnes today.

5 SUMMARY AND CONCLUSION

[2] http://www.kemco.co.jp/eng/hasai/v7_top.htm

[3] http://www.kayasand.com/documents/cardiff/Kayasand%20Cardiff%20final%20report%202013.pdf

It is clear that there are viable alternatives to marine dredged sand for use in the manufacture of concrete and these should at least be assessed objectively and independently before renewing or issuing further dredging licenses. In particular the effective use of crusher dust, largely a waste stream in quarries, is an attractive alternative with economic as well as environmental benefits. The viability of this source has been proven definitively in Japan where it now makes up the majority of all fine aggregate for concrete. Holcim are moving forward with this technology in Australia and it is telling that they have chosen to do this in a country which, despite its poor environmental record in other areas (e.g. CO^2 emissions), has taken a stand against marine dredging for aggregate. However the substantial investment in dredging equipment and licenses by the major aggregate companies over many years presents a substantial barrier to this being adopted quickly in the UK and it is clear that, without regulatory intervention, our environment will pay the price for this poor strategic decision by the aggregate companies.

Unfortunately, the recycling of aggregates in the UK must be considered an over-optimistic expectation when viewed alongside the continuing and expanding world of exploitation of virgin marine sands and gravels. The reason for this imbalance and loss of opportunity – the replacing of marine sand by manufactured sand - is due in large part to most decisions being in the hands of the aggregates industry which provides the materials. Quite simply, they decide.

In terms of the regulator, the Marine Management Organisation (MMO), the reality is that they are almost powerless to enforce recycling alternatives. Only lip service is being made towards such an important conservation issue, and the applicants for marine dredging licences merely have to say they have considered the alternatives. They do this without providing the evidence, and the regulator takes them at their word.

The Crown Estate, which owns the seabed and thus the sand and gravel, is economically run. Therefore there is no incentive to change current practices. In fact, none whatsoever. The MMO is in a comparable position.

Until some agency stands up for the environment, the status quo will continue. Until the public insists that houses are built using sustainable products, the industry will source from wherever they decide.

Out of sight may be out of mind, but the effect on our seas and coasts of these marine dredging practices is more profound than the environmental impact assessments (EIAs) provided by the aggregate companies actually shows. The presentation of the evidence in the EIAs is patchy but accepted as gospel by the regulators, a trend currently seen in many Government documents.

These marine sands and gravels are the precious spawning and nursery grounds for both commercial and endangered fish stocks. Remove these materials, and the habitats they provide are lost. This is a fact.

Are fish stocks receiving the protection they need ?

The discharge plumes of mud and unwanted sand from the aggregate industry's dredgers (dredgers often return over 50% of the material which they suck up from the seabed) cloud the sea before eventually settling back onto the seabed, and these plumes travel further and have a smothering (asphyxiating) effect on the fish spawning and nursery grounds far greater than has been acknowledged. This should be enough of a reason to be investigating the alternatives.

Marinet has put together this document to stimulate discussion. Marinet is arguing for changes in the way aggregates are sourced. This is a document for consideration.

Published by Marinet Limited, 2015. Marinet is a not-for-profit membership based limited company, registered no: 9241919. Website: www.marinet.org.uk