The Future of the Sand Industry

Introduction

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To review the developed Global Sand Industry, I plan to look at specific markets that are at different stages of development for both environmental and resource availability reasons, to enable us to see where the Industry is heading. These markets are the UK, Australia and Japan, and to finish a short review of the NZ situation. However, first we need to understand what we are looking for in a sand, and to do that I will focus on sand as a component of concrete, the major use for sand. To support this presentation I have included a number of slides with the electronic version of this slide show that I will not have time to show today, but which provide more details of sand characteristics and of the tests we are undertaking in Cardiff, amongst other slides of interest.

Concrete Sand

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Concrete has been made since the Roman times using natural river sands, that in the main were well shaped and evenly graded; the basis of most sand specification envelopes. In recent times sands are won from differing deposits, with varied gradations, being washed to remove clays and other deleterious fine materials. In the last several decades there has been an increasing need to use manufactured sands to reduce the growing surplus of fines produced in the crushing process, to minimise the demand for the natural alternative, and indeed to increase concrete strength with the introduction of fractured faces in the fine aggregate component.

Good concrete sand requires an even gradation, including minus 1mm particles, good particle shape throughout and a controlled volume of filler (minus 75 micron content). The gradation is important to achieve a close packing of the aggregate matrix and to minimise voids, which could otherwise be filled by cement. The particle shape improves the packing but also makes the concrete more workable and easier to pump. The shape determines the surface area of the

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aggregate that needs to be covered by the cement paste, the smaller the particle relatively the bigger the surface area to be covered. Murdock showed that although the effects are not directly proportional to the surface area, the shape of the smaller particles have by far the greatest effect on cement demand. SLIDE 9

Filler content is of critical importance and will be talked about later as part of the Welsh Research Program, but simply if the filler contains clays or deleterious components, it has to be removed or limited. If there is excessive filler in the fine aggregate component, then commonly segregation occurs in the matrix, and surface cracking may become a problem.

Crushed fine aggregates, although consistent, are known for both their bad shape and uneven gradation. The blending of this sand has been limited as it reduces the workability of concrete, increases water demand and cracking while finishability becomes a problem. Indeed the increasing need to pump concrete in the post war years resulted in the development of Vertical Shaft Impact crushers, and in particular the Barmac, to reprocess irregular aggregates and improve particle shape. This secondary process reduced and shaped the particles, but it also generated more filler product, however we are still left with a typical crusher gradation which is commonly short of the 75 micron to 1mm sized particles. The improved shape certainly enables the proportion of the manufactured product to be increased by either blending with a fine sand or by washing out the surplus filler – or both.

Today this balance of natural to manufactured product is constantly being modified by concrete technicians around the world, developing their own mix designs to meet demand. Natural sands have become less consistent, as we reach the edge of deposits, and moisture contents can vary on a daily basis. The variations in available resources have meant more and more complicated mix designs with the addition of fillers, ground slags and ad mixtures to name but a few.

While this a brief and simplistic overview, I hope it puts the demand for different types of sand into perspective. The key factors to keep in mind are:

Gradation
Particle Shape
Filler Content

Changing market situations

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1. Demand – All markets move through cycles, indeed the current global predicament has seen nearly all markets around the world affected.
2. Availability – A growing green lobby is making the development of new resources difficult, time consuming and costly and with no guarantee of success. Universally new legislation has made that increasingly more difficult in developed markets. The existing resources are actually now severely depleted.
3. Environmental – As a result of the scarcity of local resources, sands are being sourced from further afield, or from environmentally sensitive areas (dredging for instance). These are invariably more expensive to win, and nearly always require growing transport costs, or in a politically correct description – a larger carbon footprint. The concept of sustainability is not going away, and over time will be forced upon our industry.

Existing market situations

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1. The UK – After some good years of production in the middle of the first decade, the GFC hit the UK very hard, with total volumes down 30 – 40% in the last few years. However the downturn was not evenly spread through the market, with major infrastructure projects keeping some quarries very busy, while others were extremely quiet. The 2009 Minerals UK survey shows Sand and Gravel sales falling 36%, but those in Wales fell 50%, while dredged sand sales fell 24%. There

are now signs of some growth in construction, and a more widespread gradual increase in activity, albeit from a lower base.

Availability still exceeds demand, which has certainly depressed prices, but the ability to gain new resources has become slower and more restricted. The cover of available reserves for Sand and Gravel has fallen by 7% in the last 4 years, which represents 12 years use at current sales levels.

Aggregate availability has become more focussed on the big 5 operators in the UK who account for more than 80% of output, and the majority of that comes from a growing number of so-called Super Quarries, with an output capacity in excess of 3 million tonnes per year.

Green interest in minimising transport costs and new resource locations lead to the focus on larger quarries (with rail or sea access).

As the demand for sand exceeded supply in the eighties and nineties, it was met by an increase in dredging.

However, dredging sources in particular have come under more pressure, after some evidence has been seen of beach erosion resulting in licences not being renewed. An article from a Swansea newspaper refers, which is also included in the electronic copy of this presentation. The next alternative is to dredge in deeper waters further out to sea (in fish breeding areas), which means bigger dredges, a larger carbon footprint, and no less Green concern for the depletion of fish stocks.

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2. Australia – the only official numbers regarding the market size relate to 1999 through 2001, from the Institute of Quarrying Australia. Despite Queensland hardly missing a beat from the ravages of the GFC, NSW and Victoria have both seen a dramatic slowing in recent years. In Sydney the reduced output from the major source at Penrith Lakes has coincided with the lower demand. As in the UK, national supply is dominated by the big players. There are now signs that the market is slowly picking up while the Penrith Lakes replacement Quarries will come on line in the next two years.

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Availability of resources which have been in surplus of late are likely to come under more pressure as the general economy (other than mining) begins to grow again, as in the rest of the Western world, the ability to open new resources is becoming more difficult, both in terms of time and cost.
Environment – despite an abundance of rain in 2010/11, water supply is becoming a major issue in Australia, and the ability to process dirty water, more problematic. Quarries are being pushed further from the cities they supply, and dredged sands have a limited life under green scrutiny.

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3. Japan – Demand grew at a huge rate after the second war, but began to slow down in the early nineties, when the government invested huge amounts into infrastructure projects in an attempt to kick start the economy (bridges and tunnels in the main), but by the beginning of the nineties, the funds were running out, and what was once the second largest aggregate industry in the world (to the USA) became a shadow of its former glory. The major suppliers went bankrupt, but of particular interest was the increased strength of the local Green parties. Land based sand extraction was severely limited and dredging was banned. When the cessation of Chinese imported sand happened, the supply of manufactured sand was the only growth sector in a decimated industry. This has continued through until today, the demand for aggregates subsequent to the Sendai disaster not withstanding.
Looking at availability, with a hugely reduced demand, most quarries were limited to just one or two days work per week. Rather than the stronger companies buying out the weak, there have been a significant number of quarries closed, improving the market share of the larger operators. The only area in which demand threatens to effect supply, is indeed the sand sector.

The common themes are:

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Supply currently exceeds demand, depressing prices
Legislation is making new resources harder to win
Existing permitted resources are shrinking

The markets are not ready for a resurgence in demand

Alternative Solutions

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Sands can be graded by quality and price. Whichever the sand, its value relates to the properties it brings to the product in which it is but one component.

1. Slags and other industrial bi-products are already in use, but despite the low value of the raw material, they are expensive to process and deliver and are only ever likely to supply a segment of the market.
2. Recycled products are already in good use as regards coarse aggregates, but good quality fine aggregates are not yet commercially available from the processes currently in use. A new Kemco plant which can provide virgin sand from Concrete can be seen on the Kayasand website.
3. Crusher dust has been used increasingly to add fractured faces to the fine aggregate content and strength to concrete, however its use has been limited to around 20 to 25% of the fine aggregate. As the % of crusher dust used increases, the workability of the concrete is reduced and the water demand increases (so more cement is required).

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4. Reprocessed crusher dust, through an autogenous VSI, has seen the % of blended manufactured sand used increase as the particle shape is improved, however often too much filler is generated in the process, and has to be removed through washing or dry air classification. The amount of reprocessed crusher dust that can be used depends upon the quality and gradation of the natural sand that is available to the ready-mix plant. Crusher dust tends to be deficient in the particle sizes under 1mm, which are the sizes that have the biggest effect on workability and the required cement content. It is of utmost importance that in order to optimise the use of crusher dust, the combined blended sand must have a good even gradation to ensure an ideal matrix within the concrete.

Too much filler will result in segregation and surface cracking, while too little will require more cement to fill the voids. A good mix of this reprocessed sand with a natural sand can see up to 80% of the blend being reprocessed crusher dust, while commonly we are seeing 50 – 70% being used.

5. Kayasand is the name given to a manufactured sand that has been reprocessed by a Kemco V7 dry sand making plant. The plant is a simple closed circuit crushing and screening plant, but with two unique elements – a crusher that can generate and shape minus 1mm particles and a screen that can not only separate the oversize for recirculation to the crusher, but also control the amount of filler (minus 75 micron) that is removed and do it dry. The recirculation allows for the oversize to be recrushed to fill the "belly" of the gradation curve – the minus 1mm particles that are inevitably short in a traditional manufactured sand gradation.

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   Kayasand is not made to fit within a gradation envelope, rather to make a specific gradation, consistent to within 0.1 FM, and with a set moisture content.

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   This unique plant was developed in the late nineties to meet the demand for a sand to replace natural sand in Japan.

   The V7 plant produces a sand that is well shaped throughout the spectrum - Kayasand is often used as a 100% replacement for natural sand.

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   When the plant was developed Kemco made an assessment of sand qualities produced through differing technologies and what the market potential might be for each. Their conclusion was that Kayasand, or rather V7 superior sand, might have the potential to take up to 25% of the total manufactured sand market.

6. Chemical ad mixtures too have changed dramatically in the last decade enabling more and more use of crusher dust in concrete mix designs, however if the sand is evenly graded and well shaped, the chemical requirement can be dramatically reduced.

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Of particular importance for these alternative sands are:

To replace as much natural sand as possible

To better use surplus crusher dust and reduce disposal requirements

Market Development Summary

1. The UK is seeing land based resources being used up faster than new resources become available, and green pressure is building on the dredged alternatives. Increasing use of crusher dust is apparent, but the stockpiles are still growing, there appears a bigger reliance on admixtures than in Australasia. Specifications already allow for more filler use than in Japan. A predicted fall in asphalt demand will only increase the volume of surplus crusher dust. Hence increasing pressure to dispose of it responsibly.
2. Australia has had a well balanced supply and demand over the past two decades, the biggest change has been in NSW where the Penrith Lakes pits are due to be closed by 2013. That being said new deposits have been opened to meet current and future coarse aggregate demand while pressure is coming on fine aggregate supply. Until 2010 water shortages had become critical, so future water use will be tightly controlled. Opinions vary, but it seems clear that sea and seashore resources are coming under green pressure, finding and developing new localised resources is very expensive and time consuming – a common problem in all of the Western World.
3. Japan would appear to be the most advanced market in the world as regards to environmental issues of resource availability. Legislated restrictions on alternative resources (dredging and imported sands) and environmental issues of dust emissions, water use and sludge disposal have been applied due to the proximity of quarries to populated areas. We can see how the % of manufactured sand used has increased in the last 20 years. However manufactured sand still represents less than 40% of total sand used. Their mix designs are still restricted in the amount of

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filler that can be used in the fine aggregate component. On the East coast in particular, cement companies saw the opportunity to manufacture sand from their Limestone deposits, before the local quarries took up the concept. They now dominate that particular market supplying sand alongside the cement they deliver by sea along the coast. The slide shows one particular installation, now producing 400 tonnes per hour of Limestone Kayasand around the clock, some 2,000,000 tonnes per year.

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The Green, Sustainable imperative is not going away
Pressure to better use crusher dust will continue

Welsh Research Program

In 2002 the Welsh Assembly commissioned the National Geological Association to investigate if crusher dust could replace natural sand in concrete, as sand supplies were becoming depleted, and dredging was causing beach erosion. At the same time the Green Party was becoming established in the Assembly. The National Geological Report advised that the available crusher dust was not suitable for use in concrete due to its shape and gradation, and at best could only be used at a very low blend %. In 2008 one of the major dredging licences was cancelled due to severe beach erosion, fortunately at the same time demand fell due to the GFC, so the market has not felt the shortfall. In 2009 Kayasand arrived on the scene and were approached by the Assembly to see if Kayasand might replace natural sand in the Welsh market. With the help of a Welsh Aggregate Levy Fund grant, Cardiff University is working with Cemex, Holcim, Hanson, Grace and Kayasand to test a range of aggregate sources, to see if Kemco's new V7 technology will be able to effectively replace natural sand without any negative effects on the concrete made.

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From the tests already conducted on Kayasand from UK, Irish, Australian and NZ sourced stone, that has been processed in Japan and returned to the customers, it is clear that Kayasand

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performs at least as well as its natural cousin, mimicking the results already being achieved in Japan. From these results, we believe that unique gradations can be found to optimise mix designs for each stone type and characteristic, rather than use gradation envelopes that take no account of material characteristics. The goal is to generate a model that will provide the ideal gradation for every rock type. It is predicted that we could average a cement reduction of 5%, by using optimised gradations for each stone source that the V7 plant can uniquely create. There is evidence however that cement savings could be significantly more because:

1. Existing mix designs often include extra cement due to the component aggregates having both inconsistent gradations and moisture contents.
2. When recycled concrete is crushed, between 20% and 40% of the resulting filler has been found to be un-hydrated cement.

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Added to this research has been the opportunity to develop new admixtures to suit the Kayasand from each rock type, in particular to enhance the use of filler in the mix designs. Grace has recently developed an admixture to enable a higher proportion of filler to be used, by "turning off" or coating the clays that absorb the water and increase water demand. To help in the application of this admixture they have developed a new Meth Blue testing device that provides almost instant results. There is some belief that ideal gradations can be produced that will also use significant volumes of filler to greater effect, so minimising waste.

For Kayasand the main Goals of this research (other than to show that Kayasand can replace its natural cousin) is to create: SLIDE 47

A model to characterise each rock resource
A model to predict the ideal concrete sand gradation
A model to optimise the ad mixtures used

SUMMARY

The global movement toward a sustainable future, and the increasing protection of all natural resources, will continue to pressure all markets to make the best use of the resources we have, albeit at their own pace. This will include minimising the carbon footprint of what we have to extract, and to make concrete more efficiently than we currently do. The Kemco V7 dry sand making plant appears to offer at least part of the solution being able to make sands, that will not only solve the growing sand supply issues, but which will also make better use of the existing hard rock deposits, reducing delivery costs and move toward a more efficient use of cement.

Some 47 plants operating in Japan now produce about 5 million tonnes of Kayasand per year, over 30% of the manufactured fine aggregates used in the country, turning Kemco's original projection on its head. Japan has now specified Kayasand as the only sand to be used in concrete for the construction of nuclear power stations due to the increased density and strength of the concrete. China took delivery of its first V7 plant in 2010, and soon after ordered a second. India too has ordered their first plant. SLIDE 48

Kayasand has already tested stone from more than 20 quarries in both Europe and Australasia, the resulting Kayasand has produced concrete and asphalt sands of superior quality. However, we also share the issues that are apparent in Japan, in the relationship between Aggregate and Concrete producers, which are "both close and distant". The transfer value of superior products will take some time to be agreed upon. Certainly there is a movement toward specifications based on performance, that will justify the premium for quality products. Perhaps it is only a matter of time before the Western World begins to follow suit. SLIDE 49

Sustainability demands will not go away SLIDE 50
A shortage of supply will see prices increase again
Quality aggregates will justify higher prices

New Zealand

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The New Zealand market has more in common with Australia than other Western economies, not least because it is the home of the Barmac. New Zealand leads the world in blending reprocessed crusher dust, or manufactured sands, with single sized natural sands, to produce evenly graded blends of fine aggregates. That said, these still rely upon the availability of suitable blending sands, which have a limited life. There appears no summary of the overall available permitted resources, but it is likely that will vary greatly from area to area. As transport costs increase, the economic areas of supply will contract.

While the supply and demand for aggregates is evenly balanced, there is unlikely to be any pressure to make changes. However tests on some New Zealand deposits have shown that the Kayasand produced can certainly replace the sand blends we currently use, with no effect on workability or water demand. Indeed where coarse sands are used, such as we have in abundance in the Waikato, a potential significant saving in cement content already exists.

The growing demand for a sustainable future and an increase in green pressure, will surely push us to make better use of our existing resources. At some time even New Zealand will need to find an alternative to natural sand.