The Cement & Concrete Industry – Future Developments?

Portland cement (PC) is a widely used building product and is a relatively environmentally friendly material, yet because of the huge volumes used is responsible for approximately 10 % of carbon dioxide (CO_2) emitted to the atmosphere[1]. PC is a global commodity, manufactured in thousands of local plants. Because of its weight and associated transport costs production is generally limited to an area within 300 km on land of any one plant site. The industry is consolidating globally, but large, international corporations such as Holcim, Lafarge, Rugby and Blue Circle still only account for around 30% of the worldwide market. In many developed countries, market growth is slow, with cement mainly used in bulk primarily for infrastructure construction. In developing markets such as China and India, growth rates are much more rapid.

Overall growth since 1926 is shown in Table 1 - Cement Production = Carbon Dioxide Emissions from Cement Production 1926-2002.

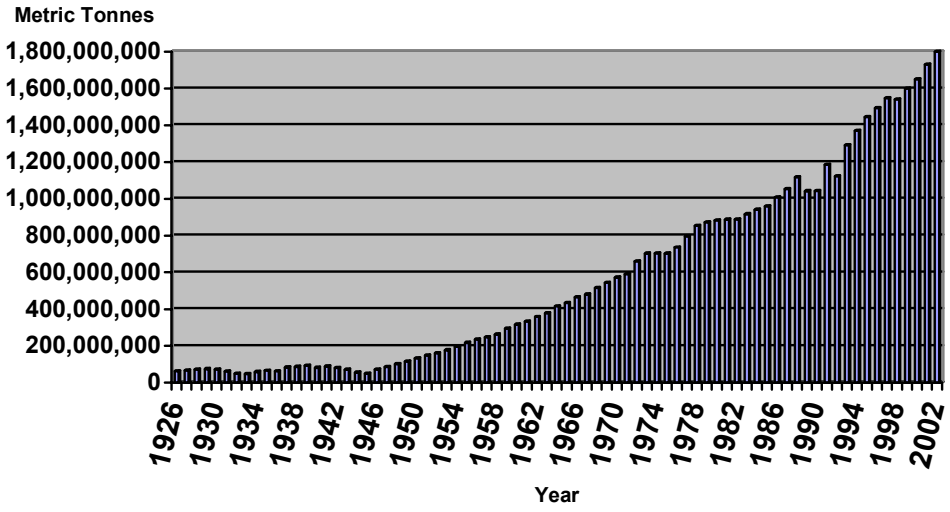

Table 1 - Cement Production = Carbon Dioxide Emissions from Cement Production 1926-2002[2]

The curve shows almost exponential growth and would doubtless please any marketing executive. Governments however, given their interest in sustainability, are seriously questioning whether the use of concrete should continue to grow unabated. The industry needs to consider how it can improve the process and product to minimize the impact of associated carbon dioxide emissions.

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[1] Pearce, F., *The Concrete Jungle Overheats*, New Scientist, 19 July, No 2097, 1997 (page 14).

[2] Cement production = Carbon dioxide emissions at 1 tonne cement= 1 tonne CO_2 Source of data USGS cement XLS file. Data collected by Van Oss, Hendrik G. and Kelly, Thomas D. Last modification: April 15, 2004 Available at http://minerals.usgs.gov/minerals/pubs/of01-006/ as at 29/04/04

Many environmental commentators view efforts towards sustainability by the industry with scepticism. What so far then have these efforts been?

The Battelle report released in 2002 listed 8 major topics that it claimed will shape the cement industry's path toward a more sustainable future in the next 20 years. The five points relevant to this article were:

- Resource productivity: improving eco-efficiency through improved practices in quarrying, energy use and waste recovery and reuse
- Climate protection: understanding and managing CO2 emissions
- Emission reduction: reducing dust from quarrying, NOx, SOx, and other airborne pollutants from cement manufacture
- Ecological stewardship: improving land use and landscape management practices
- Shareholder value: creating more value for shareholders research.

A working group comprising the 10 member companies responded to the Battelle recommendations by issuing an Agenda for Action, outlining individual and joint actions by the industry. Launched in July 2002, the Agenda for Action pledges efforts in six priority areas:

- Climate protection.
- Fuels and raw materials use.
- Employee health and safety.
- Emissions reduction.
- Local impacts.
- Reporting and communications.

According to the WBCSD web site[3] "A considerable degree of mitigation can be achieved by adopting principles of sustainable waste management, not only by reducing emission of CO_2 at source, but also by reusing or recycling it (waste) where possible. Significant (CO_2) reduction might (also) be achieved by:

- Burning alternative fuels;
- Extending cement with supplementary materials; (by supplementary materials the industry mean fly ash and blast furnace slag in particular)
- Using low grade, low energy cements;
- CO_2 stripping from gas stacks;
- Developing CO_2 neutral and geo-polymer type cement systems;
- Promoting carbonation of cementitious materials."

The new TecEco calcium-magnesium blended cements offer opportunities for the industry to demonstrate its seriousness about sustainability as they allow more supplementary materials to be used without loss in rate of strength gain or alternatively carbonate hence sequestering from the environment chemically released CO_2.

[3] http://www.wbcsdcement.org/about_cement.asp valid 27/05/04.

Given the size of the industry, cash flows involved and commitment by major players, TecEco managing director John Harrison is excited about the potential for research funding.

TecEco's innovation represents a paradigm shift in cement technology and involves the blending of reactive magnesia (MgO) with PC (or most other hydraulic cements) and usually a pozzolan such as fly-ash. Substantial increases in the technical performance of the resulting concrete and markedly improved sustainability are the result.

Using the new technology technically superior concretes can be produced at a cost which, in the short term, is comparable to the price of PC based concretes and, in the medium term, is expected to be cheaper. TecEco cements utilise wastes and can also be made with conventional equipment using standard manufacturing processes. This would result in a lower cost base for binders and increased profitability within the industry.

The recent confirmation by third parties of significant tensile and compressive strength gain with TecEco tec-cements, even with added pozzolans, means that less limestone needs to be burned per tonne of concrete and that more supplementary materials can be used and these advantages are entirely within the stated objectives of the industry.

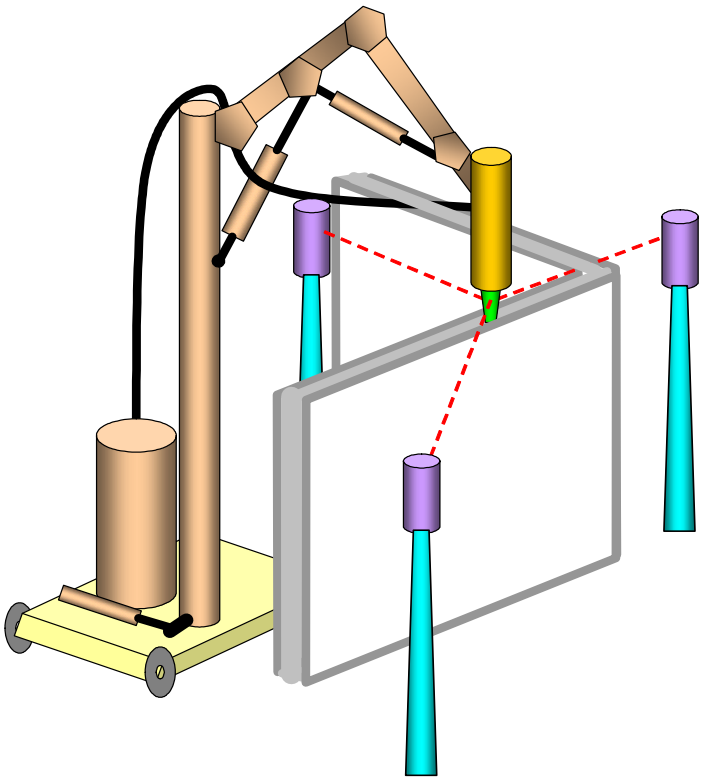
Waste is an issue particularly in Europe where governments are getting serious about environmental sustainability. In the UK for example, 60 million people on a small island produce more than 470 million tonnes of waste , with about 140 million tonnes (30%) coming from, in one way or another, the construction industry. European regulations and progressive taxation on landfill are clear signals that society demands more efficient recycling.

In a traditional recycling paradigm, wastes are sorted for their molecular value rather than their general class of properties. With over two tonnes of concrete per person on the planet produced annually on a global basis, it is an obvious move for the cement industry to look at how to incorporate both more, and a wider range of waste. If wastes were sorted in accordance with their properties rather than their molecular constitution then they would become a cheap resource to make various cementitious composites.

Ongoing technology evolution is essential

Cements and concretes are changing to better meet the needs of customers ahead of the competition. The construction industry is conservative and the changes have been slow, such as the increase in the alite/belite ratio over the last twenty years and the incorporation of supplementary cementitious materials and various fibres. Cements and concretes probably need to change much more quickly to meet the challenges of the future.

Challenging the traditional construction paradigm is robotics. In the USA and elsewhere in the world researchers are looking at using robots to literally print buildings. It is all quite simple from a software, computer hardware and mechanical engineering point of view. The difficulty is in developing new construction materials with the right Bingham plastic rheology so they can be squeezed out like toothpaste, yet retain their shape until hardened.



TecEco believes its cement concretes have the potential of achieving this kind of rheology.

The one material fits all purposes approach will increasingly have only limited relevance. Concretes will need to evolve from being just a high strength grey material, to a smorgasbord of composites that can be squeezed out of a variety of nozzles for use by a robotic workforce for the varying requirements of a structure.

Figure 11 - Robotic Construction of Cementitious Composite Walling.

The main inhibiter to evolution in the industry is the formula-based approach to standards which grew out of the industrial environment of the early twentieth century. Standards are important for society's protection, but if prescription based, stifle creativity and innovation. Readers would no longer have ancient remedies applied to their ills than fly to the moon so why the industry is so bound to the past must be questioned. Performance based standards are a much better servant to society.

Apart from formula or prescription based standards the cement and concrete industry has other inherent charactieristics that restrict the rate of adoption of new technologies required to meet the challenges of the future and achieve greater sustainability . These include:

- Expensive manufacturing infrastructure.
- Low margin product.

- Industry dogmatism and culture tied to the belief that "it has always been done this way".

The answer lies in culture change. Given the need to profitably survive in a new sustainability focussed business climate the industry needs to throw of the shackles of restrictive conservatism and consider the natural forces that will take it into the future such as:

- The necessity of converting waste to resources
- The acceptability of improved materials.
- The introduction of robotics into construction.

The catalyst is economics. Moves to change cement as a binder and concrete as a material have to be more economic than not changing them.

Given long run economies of scale the new calcium-magnesium cements from TecEco are more economic:

- There are existing and growing stockpiles of magnesite found often as an overburden to other ores for which there is negligible demand suitable for TecEco formulations[4].
- The energy required to manufacture TecEco formulations and process temperatures required are much lower than for making lime or Portland cement.

A fundamental unbiased re-examination of the science of concrete as a material would confirm the merit of the new TecEco technology and value to the industry as a means of achieving its stated aims. Superior strength gain even with added pozzolans must be an advantage. Perhaps what is needed as a first step is to adopt performance as the sole criteria for specification.

[4] Examples include BMR Savage river in Tasmania, Australia and Luzenac Inc. Timmins, ON, Canada. Shortly significant quantities of MgO will be a by-product of a nickel cobalt recovery process in Canada and thus cheap.