TecEco Cements – A way forward for the Kyoto process?

Summary

In response to the environmental pressures threatening the survival of both the planet and industry today, TecEco Pty Ltd have developed a much more sustainable cement technology suitable for use throughout the global construction industry that has already attracted considerable media interest around the world and has caught the attention of the world's leading cement scientists.

One of the most prominent and exciting advantages of the new technology is its vastly reduced net CO_2 emissions. The impact of this is put into perspective when it is considered that up to 10 percent of anthropogenic GHG emissions can be attributed to the manufacture and use of Portland cement.

Key players in the global construction industry and its supply chain simply can not afford to ignore this hugely significant breakthrough if they wish to maintain their licence to operate in an increasingly sustainability conscious 21st century.

Introduction to the TecEco project: the factors of cement and climate change

The sustainability of the built environment is an essential precondition of a sustainable society. The mass of materials, emissions and wastes consumed and produced by the construction industry simply dwarfs all other industries. As such, it is essential that the built environment begins today on a course towards sustainability. To move forward from where we are now requires considerable research and development into new materials and technologies.

It is with this in mind, that TecEco was established in Tasmania, Australia in November 1999 by John Harrison with a clear mission: to develop sustainable technologies for the manufacturing and construction industries.

The sustainability of the construction industry and associated materials cannot be examined without quickly coming to the realisation that the current enormous use of Portland cement is fundamentally unsustainable.

World wide, it is estimated that 1.8 billion tones of Portland cement are produced annually making it one of the most widely used products in the building and construction industry. The firing process, associated mechanical operation and the release of CO_2 from the chemical setting process accounts for around one tonne of CO_2 emissions to the atmosphere for every tonne of Portland cement manufactured[1]. When the emissions per tonne of Portland cement are considered with the annual production of Portland cement world wide (which is estimated to be around 1.8 billion tonnes[2]) then the scale of the issue can begin to be comprehended.

The consequence is that the use and manufacture of Portland cement is responsible for between 5%[3] and 10%[4] of anthropogenic greenhouse gases emitted to the atmosphere. The reduction of carbon dioxide emissions associated with Portland cement is therefore undoubtably of fundamental importance in making a transistion to a sustainable built environment.

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1 Figures abound and vary from about .7 to 1.3 tonnes to the tonne. A figure of 1 tonne to the tonne is considered reasonable.

2 USGS figure extrapolated

3 Hendriks C.A., Worrell E, de Jager D., Blok K., and Riemer P. Emission Reductions of Greenhouse Gases from the Cement Industry. International Energy Agency Conference Paper at www.ieagreen.org.uk.

4 Pearce, F., "The Concrete Jungle Overheats", New Scientist, 19 July, No 2097, 1997 (page 14).

With the efficiency of traditional cement manufacturing technology reaching it's limits, the time for a new paradigm is ripe. And so it was with this in mind that TecEco set out to find a much more environmentally benign substitute for Portland cement. The resulting investigation has identified that the use of reactive magnesium oxides may indeed reduce the detrimental impacts on the environment associated with conventional cement use by dramtically reducing the amount of greenhouse gas emmisions. The resulting cement technology is astounding in its simplicity and effectiveness and is set to revolutionise the sustainability of the construction and cement industry. TecEco has filed a series of international patents covering this technology[5]

The TecEco technology: a pragmatic approach to improved sustainability in the built environment

Conventional Portland cement is structured around calcium mineral technology[6]. As such a major problem with the production of Portland cement is the release of high levels of carbon dioxide emissions which are formed when calcium carbonate (limestone) is processed through a kiln. The other major problem during its production is that the process consumes a huge amount of energy which is required to raise the system to 1450°C.

The technology being developed by TecEco is based on the use of highly reactive magnesium oxide and related forms of this mineral. The new technology does not represent a radical shift from traditional technology but does offer a considerable number of advantages. Following correct manufacture and design, the blending of reactive magnesia with Portland cement in varying proportions depending on use results in concretes of equal or enhanced physical properties to Portland cement concretes and results in a significant reduction in greenhouse gas emissions. Several formulations have so far been devised of which the most publicised has been eco-cement.

The chemical reaction to allow the process of converting magnesium ore to magnesium oxide requires a temperature of around a low 600^{o}C resulting in a reduction in process energy requirements and opportunities for utilising waste heat with associated reductions in emissions of greenhouse gases such as carbon dioxide.

More importantly however, TecEco eco-cements used in porous materials have the ability to re-absorb significant levels of chemically released carbon dioxide in a sequestration process. Due to the presence of reactive magnesia, the proportion of materials that will carbonate in eco-cements is higher and as such a lot more CO_2 is reabsorbed.

The impact of these combined effects on global net carbon dioxide emissions should not be underestimated. TecEco plan to capture CO_2 during the manufacturing process and if this is the case, total sequestration of CO_2 if eco-cements were adopted for 80% of the current uses of Portland cement has been calculated to be as high as 2 billion tonnes or more. Further sequestration again would result from the inclusion of waste carbon based matter as an aggregate, much of which is currently burnt adding to the global atmospheric CO_2 level. With the inclusion of materials containing carbon the total abatement from the widespread adoption of TecEco eco-cement technology could be as high as 2.5 billion tonnes. As the global yearly increase in atmospheric CO_2 is around 12.7 billion tonnes[7] this would account for over 15% of the annual increase.

With the use of low carbon energy and waste carbon materials, a TecEco eco cement block may even act as a net carbon sink – actually decreasing the global levels of CO_2!

Since the Kyoto Protocol has been ratified by many nations, materials scientists around the world are examining alternatives to sequester carbon leading to a reduced impact of any potential CO_2 taxes. The idea of sequestering carbon dioxide from the atmosphere is gaining

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5International patent number PCT/AU01/00077.
6In combination with other minerals present as a result of the constitution of the raw materials, silica, aluminium and iron.
7 http://www.whrc.org/science/carbon/carbon.htm.

currency as governments show themselves unwilling or unable to reduce emissions. The sequestration method offered by the TecEco technology may well prove to be the most practical way forward. The built environment is our footprint on earth and offers immense potential for sequestration and this has been recognised by the Australian, British and many other governments.

It is not only carbon management at which TecEco technology offers sustainability advantages. The flow of materials through society is a growing area of concern for governments across the world. The take-make-waste linear system, which underpins the majority of the world's economies, is slowly being redirected towards a closed loop system where wastes are utilised and new products are designed with the end of their life in mind.

The TecEco technology has been developed with the intention of being suitable for the utilisation of large amounts of waste material including the encapsulation of industrial wastes. When used in the manufacture of concrete, the technology has been established to work well in combination with supplementary cementicious (pozzolanic) materials, such as fly ash and ground blast furnace slag (gbfs). Many of these materials are waste products from other industries and using them in the manufacture of concrete is an effective manner to reduce the burden on the environment. In addition to the use of waste material, the raw materials for this technology are abundant. Magnisium ore(s), in particular magnisite, are common as magnesium is the worlds eighth most abundant element.

At the other end of the life cycle, products made using TecEco technology can be recycled into useful reactive forms after their initial use as a building or other structure. Traditional Portland cements are not reusable in this manner.

Rolling out the technology

This is a technology that has the potential to manage the global flow of carbon as well as offering a technically feasible path to a closed loop flow of cement and concrete based construction products. However this potential is merely conceptual if the technology is not adopted by the market place.

The company's approach to placing the technology into the market place is initially based around the introduction of building products, applications in the waste encapsulation field, and following further research, the premixed concrete industry where smaller proportions of less reactive magnesia can be used for more durable concretes resulting in greater sustainability through less resource use over time.

Initial research has been carried out to investigate different mixes of TecEco eco-cement combined with fly ash to produce a suitable brick mix. The results have shown that the required strength is easily reached by bricks made using a commercial brick machine. Even the global use of bricks that have a significantly reduced environmental impact will be of tremendous importance in redirecting the construction industry and our built environment towards sustainability.

Another route to market is through the growing trend towards waste encapsulation. The waste industry is one of the fasting growing sectors in the world, indicating a growing need for the immobilisation of wastes, including toxic and hazardous wastes and related technology. Large producers of waste are beginning to experience stricter waste related legislation and associated non-compliance. This driver, together with potential carbon taxes is prompting waste companies to explore new technologies that can embrace these requirements. The low permeability and high stability of the matrixes produced by TecEco technology makes this a logical area for future development.

For the world to truly benefit from TecEco's promise, the ultimate market is concrete. Currently Portland cement is the main binder, however other pozzalanic materials such as fly ash and gbfs are being used more. The potential for using TecEco's technology in a pre-mixed concrete application is hugely promising as sustainability can also be achieved by increased durability. Perhaps the key differentiator for the technology will actually be its

technical merits. Durability, resistance to salts[8], dimensional stability, high bonding capacity and strength are all properties that can be improved by the new technology.

Adoption by third world countries is likely to be rapid because project technologies involve the utilisation of hazardous wastes such as fly ash and because given economies of scale they are likely to improve their economic welfare.

To make inroads into the intensively conservative construction industry will not be easy. This is an industry where innovation is the exception, not the rule. But TecEco is optimistic. The company is at an exciting time of its development with extensive world wide publicity[9] and considerable and growing research being carried out into the technology[10].

Conclusion

Probably the most important outcome of the project will be a way forward for the Kyoto Protocol process. The advantages of the new technologies embraced by the project are that they involve only our built environment, not the environment on a wider scale. Scientists around the world are recognizing that a multifaceted approach is necessary to reduce or even halt, global warming. The project will catalyse the acceptance of the new technologies and lead the world in sustainable building methods and materials, offering huge opportunities for sequestration.

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8 In TecEco cements, lime is replaced by magnesium hydroxide (brucite), which is much less soluble. Resistance to salts is much greater than in Portland cements. Brucite also has an open layered structure and is capable of absorbing many extraneous cations.

9 Articles have appeared in a diverse range of publications including New Scientist (Fred Pearce, "Green Foundations ", New Scientist, vol 175 issue 2351, 19 July 2002, page 39 and Tam Dalyell, "Westminster Diary", New Scientist vol 176 issue 2368, 09 November 2002, page 55), the Toronto Star (National Report, Saturday, July 27, 2002, p. F05), Margaret Vine-Hall, The Next Generation Cement, Clever Devils, A Mercury Supplement, The Mercury, Thursday August 22, 2002, and more recently in The Guardian (Owen Dyer, A Rock and a Hard Place, Eco-cement yet to cover ground in the building industry, The Guardian, Wednesday May 28, 2003) and Climate Change Management, June 2003 issue.

Electronic Publications have included, John Harrison, One Way to Make More Environmentally Friendly Housing, On Line Opinion, 15/03/02, http://www.onlineopinion.com.au/2002/Mar02/Harrison.htm

Elizabeth G. Heij, Green entrepreneur in action: introducing Network member, John Harrison of TecEco, CSIRO Online Sustainability Network Newsletter 16E, 14 October, 2002, and many others not as yet catalogued.

A film about block making using the technology has also been shown by Discovery Channel Canada and more recently in the USA. The technology also won the Tasmanian Innovation of the Year Award in 2002 with considerable associated publicity.

10 Research is being carried out and/or proposed at the University of Technology, Sydney, The UK Building Research Establishment, Cambridge University and Michigan Institute of Technology.