TecEco: Cements Based on Magnesium Oxide

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1. Background

The writer of this report, Dr Leon Burgess-Dean of 64 Cambra Road, Belmont Victoria, Australia, is a materials scientist. He holds a PhD (Deakin University) and BSc-Hons (Queensland University of Technology). His PhD study was on the mechanical properties of porous, brittle materials such as fired clay bricks. In more recent times he has taken a stronger interest in cementitious materials

Dr Burgess-Dean was approached by TecEco Pty. Ltd. for an independent evaluation of their proprietary developments. In this capacity he has received both confidential and non-confidential material from Mr John Harrison, the managing director and inventor. The following evaluation and appraisal is based on Dr Burgess-Dean's knowledge of developments in the field of cementitious materials as well as information received from TecEco. The report makes use of confidential and proprietary information but such information is not reproduced in this report, which may be freely communicated. Its contents may be reproduced or quoted in context provided acknowledgement of source is made.

2. Traditional Cement Production

Large volumes of cement production make substantial environmental impacts such as solid and liquid effluents from quarrying and gaseous and particulate effluents from pyroprocessing. The production of Ordinary Portland Cement, which dominates, consumes much fuel and ties up vast capital investment in plant and transport. The science and technology of Portland cement production is reasonably well understood and even though incremental savings can still be made, more radical changes consistent with the research objectives of the industry such as improving durability and sustainability are welcome.

3. The TecEco Development

TecEco have developed cements based on magnesium oxide that are based on the MgO – $Mg(OH)_2$ – $MgCO_3$ reaction system that are recyclable with less thermal processing and environmental impact. Magnesium is an abundant element in nature. Magnesite that is not suitable for the production of magnesium metal and hence a by-product of mining in that industry can be used. In summary the raw materials for the new cement system, code named eco-cements are either wastes or readily available and easily extracted by known methods.

A number of magnesium based cement formulations have been suggested by TecEco and there are two in particular that stand out.

The most practical formulation type with enormous potential for abatement is one based on adding magnesium oxide and varying amounts of other hydraulic cements to waste products such as coal combustion fly ash, iron blast slag, and other waste materials containing silica and alumina. The concept embraces the reactivity of magnesium oxide to carbonate reaction with grain size refinement. The formulation strategy results in an alkaline environment in which other silicification reactions also occur given time.

A second, more conservative option, is to add small amounts of highly reactive magnesia in the correct proportions and grain size to ordinary Portland cement and supplementary materials. TecEco claim to have engineered around the problem of dimensional distress by a combination of grain size modification and adding reactive magnesia after the OPC clinker production stage.

Lower costs, emissions reductions and some improved properties such as resistance to sulfates appear to be the outstanding features of eco-cements. Cost savings occur in the reduced need for plant and equipment to fire and grind the cement compared with ordinary Portland cement. There will be savings in the fuel because of lower firing temperatures. Savings on plant construction will accrue due to less insulation being required compared with OPC plants. The use of wastes, the costs of which have been accounted for in other industries, and for many of which there are opportunity costs, will further improve the cost base.

The technical proof of these cements has partially been demonstrated by TecEco with limited resources. Cements have been made with properties that would be suitable for many non-load bearing applications. In summary eco-cements have been demonstrated to:

- Be workable and flexible in terms of formulation,
- Have adequate compressive strength with time,
- Be durable in common environments.
- Be compatible with mineral aggregates, fibres and steel.

Furthermore eco-cements and eco-cement products can be made using similar equipment and methods currently employed for OPC.

There are some factors that remain to be addressed in more detail. These include:

- Long-term dimensional stability and durability, particularly in aggressive environments.
- Corrosion resistance
- Load-bearing performance when blended with waste materials
- Fire resistance and thermal dilation coefficients.

4. Summary

The environmental policies of industrialized nations will continue to penalize those users of energy and producers of pollution and greenhouse gas emissions. Recycling and re-use is likely to become increasingly important. With the lower firing temperatures and associated lower costs of grinding and reactivating, MgO-based cements should have better potential for recycling. The added advantage of in-situ carbonation in products such as masonry units increases the durability and strength of MgO-based cements and will reduce the net CO_2 emissions associated with manufacture compared with Portland cement.

MgO based cements have the capacity to be made in large volume production situations and used for a variety of commercial applications. TecEco have shown their technology can be transferred directly to a plant process as is evidenced by small production runs.

I suggest that cash flow should be generated through market penetration of products for non-load bearing applications, providing revenue to support ongoing research and development.

TecEco's holistic approach to cement production utilizes a broad range of physical and chemical processes that add to strength, durability, and overall usability. The use and combination of processes such as magnesia carbonation, OPC cementation and silicification including geopolymerisation is practical and should enable a wide variety of waste materials to be utilised. MgO-based cements have the potential of being useable over a wide range of applications with the added benefit of lower cost, less environmental impact and a higher level of recycling. TecEco have combined these and other factors to achieve the goal of a more sustainable building material. TecEco are also suggesting the use of waste fibres such as cotton, wool and cellulose to capture even more carbon with the added benefit of additional strength being added. To this end confidence needs to be shown in the TecEco approach and investment made so that work can continue to be done to produce the most sustainable cementitious building material possible.

The concept of a partially carbonate based built environment has tremendous potential for abatement and TecEco's pioneering work is to be commended.

Comments and queries on this report may be sent to the writer at burgessd@deakin.edu.au. The opinions expressed here are entirely those of the writer.

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