The Importance of Materials in Construction

We are on the verge of a technology and materials revolution that promises lower construction costs and a solution to problems such as global warming, waste and housing for the masses.

This article by John Harrison, managing director of TecEco Pty Ltd and the inventor of tec, eco and enviro-cements explains why so.

Construction techniques and materials that have not changed much since the time of the Romans are all set to change.

I was recently in California talking to Behrokh "Berok" Khoshnevis, a Professor in the D. J. Epstein Department of Industrial & Systems Engineering, University of Southern California who has developed equipment and software enabling him to construct much of a building robotically. Although only a small beginning the prospects are very exciting and Berok is being backed by some large companies. Holding up the adoption of robotics for construction entire subdivisions, skyscrapers and even new cities from scratch is not the computer software which does not differ much from the software that drives your printer, nor the hardware which is an adaptation of robotics already used in vehicle assembly. The hurdle is the material that will in future form the substance of much or the built environment. Uniquely new properties are required.

To enable placement and finishing in a single pass of a robotic device materials used will have to behave like toothpaste. They will need what is referred to as a Bingham plastic rheology so that they can be pumped and squeezed out of a nozzle and like toothpaste on the bristles of a brush stay exactly where and how they are placed for finishing by robotic trowels. The TecEco binders I have invented have this property mainly because of the unique affect of a small highly charged Mg ion in solution on water which is a highly polarised molecule required for setting hydraulic cements.

The use of fibre reinforcing of these new cementitous composites will provide the strength necessary. But why manufacture fibres when many wastes have properties including tensile strength such as wood fibre and waste plastic. Considering that today over two tonnes of concrete is made per person on the planet the development of composites for the construction of buildings using robotics also opens up the enormous challenge of effectively using wastes for the physical properties they could contribute to such composites rather than their chemical composition.

Various wastes could provide various properties such as lighter weight, tensile strength of insulating ability. A little like a colour ink or bubble jet printer uses different colours for different parts of a plan printing job so to could a robotic arm working 24 hours a day seven days a week without a break use different materials for different purposes. The built environment is our footprint on the planet and the localised use of low value waste for construction would solve many problems without the added emissions burden of transport to where they could be used for their chemical composition.

At first the concepts of robotic construction left me with doubts about the applicability in poorer countries I have visited as part of my crusade to change the world “materially” for the better. The solution is however far better than the means and a distaste for robotics should not cloud the common sense of a solution providing cheap housing, lower net emissions and utilizing wastes on a localised basis.

Let me now explain how these new wonder materials work. So far there are three main formulations that have been developed.

Tec-cements (5-15% MgO, 85-95% OPC) contain more Portland cement than reactive magnesia. Reactive magnesia hydrates in the same rate order as Portland cement forming Brucite which uses up water reducing the voids:paste ratio, increasing density and possibly raising the short term pH. Reactions with pozzolans are more affective. After all the Portlandite has been consumed Brucite controls the long term pH which is lower and due to it’s low solubility, mobility and reactivity results in greater durability.

Other benefits include improvements in density, strength and rheology, reduced permeability and shrinkage and the use of a wider range of aggregates many of which are potentially wastes without reaction problems.

Eco-cements (15-90% MgO, 85-10% OPC) contain more reactive magnesia than in tec-cements. Brucite in porous materials carbonates forming stronger fibrous mineral carbonates and therefore presenting huge opportunities for waste utilisation and sequestration.

Enviro-cements (15-90% MgO, 85-10% OPC) contain similar ratios of MgO and OPC to eco-cements but in non porous concretes brucite does not carbonate readily and less strength is developed. Higher proportions of magnesia are most suited to toxic and hazardous waste immobilisation and when durability is required.

These new materials are not only an enabling technology for robotic construction but will result in far greater sustainability in the built environment because they reduce lifetime and embodied energies, have the ability to utilise other wastes in their composition and reduce linkages to the environment during the take manipulate and make episode of their life cycle.

How and in what form materials are in when we waste them affects how they are reassimilated back into the natural flows of nature. If materials cannot readily, naturally and without upsetting the balances within the environment be reassimilated (e.g materials containing heavy metals) then they should remain within our technical world to be continuously recycled or permanently immobilised as natural compounds. TecEco binders can themselves continue to be recycled and uniquely utilize wastes for their physical property rather than chemical composition. Because of their extreme durability they have the capacity to permanently immobilise wastes from our technical world harmful if let loose in the global commons.

Besides making much more durable concretes tec-cements that can assimilate wastes result in less net emissions as around 20-30% less is required per tonne or cubic metre of concrete produced.

Eco – cements are uniquely different to other binders in the system in that in porous materials they absorb carbon dioxide to set and gain strength and can therefore potentially sequester large amounts of CO_2 where it will do good as a building material in our built environment. Such a process is little different from the solution demonstrated by nature to previous epochs of global warming wherein carbon became the main building block for life giving trees strength and providing shells and other skeletal systems for living animals. Much was captured and rendered non gaseous as coal, petroleum and carbonate rock particularly during the Permian and Carboniferous epochs. The answer nature has shown us to any waste including too much CO_2 in the atmosphere is to use it. TecEco technology uniquely enables us to do so.

It is time the talkfest around the world about sustainability ended and people got one with it. The new magnesian cement opportunities offer not only sustainability, but given long run economies of scale, lower costs.