

Magnesium Oxide, Magnesium Chloride, and Phosphate-based Cements

By: George Swanson

Introduction

Before the widespread 20th century use of Portland cement magnesium oxide and magnesium chloride based cements were numbered amongst the world's popular cement products. Once the introduction of Portland cement essentially cornered the market in the latter part of the 19th century, serious public health issues began to be quietly recognized, documented, and scientifically verified as being directly linked to the use of limestone/gypsum based cement and concrete products. In contrast to this sobering reality magnesium cements have consistently proven to be superior in strength, versatility, and environmental integrity.

So why were these magnesium cements virtually abandoned over the past 175 years? First of all the story of cement and concrete does not have any bad guys, only good guy's. Whether we are discussing Portland cement or any other cement no one ever purposely set out to make a problematic cement; quite the opposite. When Joseph Aspdin invented his water-activated Portland cement in his Leeds England kitchen in 1824, it obviously seemed to be a viable and exciting advance in addressing the accelerated pace of the industrial revolution. And in many respects notably its convenience and availability it was!

It was only as time went on and this nineteenth century cement/concrete innovation spread around the world that the previously unrecognizable, negative side effects would slowly but surely begin to become scientifically scrutinized. It's also important to note that Portland cement manufacturers continuously allocate enormous amounts of R&D funding in a valiant effort to overcome these inherited deficiencies. Literally billions of dollars are spent in an effort to do what magnesium and phosphate-bonded cements do 'naturally'.

To understand this dilemma a discussion of the history of magnesium/phosphate cements is included in this article, which will explain why these ancient magnesium/phosphate building materials are of such great historic importance. And more importantly why these same 'cold-fired' ceramic bonding techniques now hold the key to the future of worldwide, sustainable building practices. This currently available cement alternative (often referred to as ceramic cement) provides unique, short and long term solutions to the adverse effects of Portland cement. The quicker this fact is understood by both the cement/concrete industries and the general public, the quicker we can reverse the deleterious health and environmental effects caused by the contemporary concrete materials to which we are all subjected to.

Availability and Benefits of Magnesium/Phosphate based cements:

Magnesium deposits exist in abundance in every corner of the earth and cover roughly

Building Biology Based New Building Protocol

8% of the world's surface. Depending upon where they are mined, magnesium oxide and magnesium oxide/magnesium chloride cements require only 20%-40% of the energy required to produce Portland cement. Phosphates are available from many sources ranging from phosphoric rock to animal wastes and fermented plants, which historically were used to "react" with various oxides to produce these environmentally friendly, non-toxic cements.

Magnesium-based cements have exceptional health-promoting properties for occupants of homes in which they are used as a building material. For example, research at Argonne National Laboratories has documented that occupants of homes made with traditional cow dung and magnesium oxide located right next to the Chernobyl nuclear power plant had less radiation sickness from the nuclear accident than any other group. Whereas occupants of modern stud frame and concrete homes even miles away succumbed to higher levels of radiation sickness.

These natural cements bind naturally and exceptionally well to all things cellulose (i.e. plant fibers, wood chip, etc.) and are often referred to as "living cements." This is in sharp contrast to Portland cement, which repels cellulose. Often plastic binders are used in Portland cement to assist its 'artificial' adhesion to wood, styrofoam or stone. These petroleum-based binders seriously restrict the capacity of Portland cements to breathe, thereby binding in moisture and increasing the likelihood of mold damage. When the latest, 'water-activated' magnesium oxide-based cement formulas are used as a "cap coat" over damp Portland cement floors, the moisture in the slab can breathe through the magnesium oxide composite, which remains intact rather than delaminating like epoxy/cement composites often do.

Magnesium-based cements commonly achieve compressive strengths of 9,000 to 45,000 psi and tension strength of over 800 psi, many times stronger than that of conventional concrete. Magnesium oxide combined with clays and cellulose form cements that breathe water vapors electro-magnetically, a significant plus. The clay in magnesium oxide balances and enhances the movement of moisture. It never rots because it always expels moisture. Also, unlike Portland cement, MgO cements will not drain the charge out of a car battery left overnight on a floor made with as little as 20% MgO content. MgO cements are completely non-conductive of electricity, as well as heat & cold, and have been used for flooring for radar stations and hospital operating rooms throughout the 20th century.

Blends of magnesium oxide were used in ancient times in Germany, France, Mexico and Latin America, Switzerland, India, China and New Zealand, among other countries. The Great Wall of China and many of the Stupas in India, still standing today, were all made with magnesium-based cements. Ancient European artisans used a timber frame with magnesium oxide infill in constructing homes. No gaps are visible in these 800-year-old walls that still remain in use.

Germany had craftsmen who blended magnesium oxide for centuries, and right up to World War II this practice had been a labor-intensive family tradition. This tradition was abandoned after the war when Durisol and other fibrous cement companies sprang up

Building Biology Based New Building Protocol

in Germany to facilitate the quick rebuilding of all of Europe.

Until the early 1930's almost all "terrazzo" floors were made with magnesium oxide or magnesium oxy-chloride. It was used extensively throughout the USA until Portland cement offered what appeared at the time to be a less-costly, user-friendly alternative. The successful manufacture, marketing, and proliferation of Portland cement occurred at a time when energy was cheap and health concerns of the public were simply not an issue.

Argonne National Laboratories (www.anl.gov) and others have now licensed several firms to market magnesium-based cements under the name "*Ceramicrete*". These companies have patents on their products. US Gypsum, the original American maker of Portland cement, is also introducing magnesium oxide, first as a non-toxic accelerant and also as a non-toxic additive. "Aquacast" is one magnesium oxide product being marketed by US Gypsum.

Grancrete, a spray-on structural cement, has been developed by scientists at Argonne National Laboratory and Casa Grande LLC as one of the modern applications of a magnesium oxide-based cement. According to a paper released by Argonne National Labs (www.anl.gov, search under "Grancrete") "Grancrete had been labeled as "a tough new ceramic material that is twice as strong as concrete (that) may be the key to providing high-quality, low-cost housing throughout the developing nations."

"According to experiments, Grancrete is stronger than concrete, is fire resistant and can withstand both tropical and sub-freezing temperatures, making it ideal for a broad range of geographical locations." Grancrete is often applied to styrofoam EFS cores, but Dr. Wagh suggests simpler walls, such as woven fiber mats, also work well and further reduce the raw materials required.

Building Biology would certainly recommend this latter approach to avoid using non-breathable petroleum-based products such as styrofoam. This system done over a natural magnesium oxide-treated cellulose core, or "AirKrete" MgO foam (see below) would be excellent.

"With only two days of training, two men can build a non-toxic durable home made of Grancrete in two days that is ready to be occupied by the end of the second day. This is because the material cures within two to four hours, not hours or days like regular concrete. The material is several times less expensive than currently used materials and has been extensively field-tested for structural properties. It provides a very healthy, affordable alternative, particularly when used in conjunction with locally available natural fiber core, rather than non-breathable building materials."

The **Bindan** Company in Chicago (www.bindancorp.com) makes twelve different products with magnesium oxide. Just add water and they are ready to go. Their magnesium oxide/phosphate cements and concrete's are some of the strongest ever tested.

According to the Bindan Company website their formulas use a phosphate binder and additional materials to create their products:

"Our phosphate bonded products typically have faster setting times, higher strength and better adhesive characteristics than products based upon Portland Cement. There is no off-gassing of harmful fumes. Our products are fire proof and are suitable for use both indoors and outdoors.

Building Biology Based New Building Protocol

“...We currently manufacture products for repairing concrete, for repairing roads, for flooring repair and underlayment, for architectural and artistic moldings, for terrazzo flooring, for counter tops, and for fireproof coatings.

“Bindan manufactures its commercial products under the **MONO-PATCH®** brand name. The **MONO-PATCH®** Line of products offers several unique products for both commercial and residential uses including:

MONO-PATCH® Multi-Purpose Concrete Repair,
MONO-PATCH® Fire Stop & High Temperature Refractory Mortar,
MONO-PATCH® Underlayment,
MONO-PATCH® Hydraulic Cement, Neo-Terrazzo, and Mor-Grout.

“BENEFITS and FEATURES

Fast setting
Non off-gassing of harmful fumes
Superior bonding without priming agents
No special curing needed
Interior or exterior use
Rapid strength gain
Zero shrinkage
One component, just add water
Inorganic and totally fireproof
Freeze/thaw cycle resistant
Can be applied in cold or hot weather”

The cost of Bindan magnesium oxide cement is approximately \$30 per 50-pound bag versus \$5 per bag for Portland cement. But the wide variety of indigenous rock, plant and wood fibers, and other cellulose granules that can be added quickly amortize this discrepancy in cost per pound by extending the basic cement material by up to 95% of the concrete mix. Bindan also produce one of the best products for pouring floors.

CeraTech’s (www.ceratechinc.com) family of products are comprised of MgO natural mineral based non-traditional cementitious materials that are activated by water.

“The result is a slurry mix that, when poured onto the area to be repaired, bonds tenaciously to most construction materials, including steel. When correctly applied, these products are very effective for the repair of vertical, sloped, and horizontal surfaces, to include spall and crater failures; as an overlay; as an anchor for bolts; as a grout; and as a paint for surface striping applications.”

“CeraTech ‘**PaveMend**’ family includes self-leveling products in a graduated range of set times for horizontal repairs, as well as trowelable materials for the repair of sloped surfaces up to 35°. VertiMend™ is a parging material designed for the repair of vertical and overhead surfaces in both thin and thick applications, while AnchorQuick™ is a very rapid-setting anchoring system with exceptional bond strengths.

PaveMend™ 5.0

PaveMend™ 5.0 is an extremely rapid-hardening high early strength self-leveling material for patching and repair of concrete, masonry and structural asphalt surfaces.http://www.ceratechinc.com/pavemend_5.asphttp://www.ceratechinc.com/pavemend_5.asphttp://www.ceratechinc.com/pavemend_5.asp

PaveMend™ TR

PaveMend™ TR is a trowelable rapid-hardening high early strength material for repair and overlaying of sloped

Building Biology Based New Building Protocol

concrete, masonry and structural asphalt surfaces.

http://www.ceratechinc.com/pavemend_tr.asphttp://www.ceratechinc.com/pavemend_tr.asphttp://www.ceratechinc.com/pavemend_tr.asp

PaveMend™ 15.0http://www.ceratechinc.com/pavemend_15.asp

PaveMend™ 15.0 is a very rapid-hardening high early strength self-leveling material for patching and repair of concrete, masonry and structural asphalt surfaces.

http://www.ceratechinc.com/pavemend_15.asphttp://www.ceratechinc.com/pavemend_15.asphttp://www.ceratechinc.com/pavemend_15.asp

AnchorQuik™

AnchorQuik™ is an anchoring system designed to provide exceptional performance with quick turnaround .

<http://www.ceratechinc.com/anchorquik.asp><http://www.ceratechinc.com/anchorquik.asp><http://www.ceratechinc.com/anchorquik.asp>

PaveMend™ 30.0

PaveMend™ 30.0 is a rapid-hardening high early strength self-leveling material for patching and repair of concrete, masonry and structural asphalt surfaces.

http://www.ceratechinc.com/pavemend_30.asphttp://www.ceratechinc.com/pavemend_30.asphttp://www.ceratechinc.com/pavemend_30.asp

VertiMend™

VertiMend™ is a rapid-hardening high early strength patching material for patching and repair of vertical and overhead surfaces.

<http://www.ceratechinc.com/vertimend.asp><http://www.ceratechinc.com/vertimend.asp><http://www.ceratechinc.com/vertimend.asp>

For additional product information: www.ceratechinc.com

Technical Support: Tel: 888-341-2600 **Sales/Marketing:** Tel: 800-581-8397
Fax: 703-894-1068

Magnesium oxide is also available in bags for as little as \$9 per 50 pound bag from several other sources (see list of websites below). These recipes require either liquid fertilizer or special brine “reactors” to harden into concrete and are especially useful for binding non load-bearing straw/clay and woodchip/clay mixes for building construction.

AirKrete (www.airkrete.com) is a natural MgO mineral based blown-in insulation **that combines all the advantages of MgO cement with aeration and spray in place convenience to achieve the highest environmental and technical demands**

Outstanding features of this ceramic cement spray-in foam material include:

Non-Toxic/Environmentally Friendly : study using a microbial test protocol following the requirements of ASTM Guideline D 6329-98 (1) Results show that the “ air krete® Insulation Sample” was resistant to mold growth at both 75% and 95% relative humidities. Neither molds were found to amplify in the materials at either humidity.

Fire Proof/Sound Proof: Report on surface burning characteristics determined by ASTM-E 84

The normal 10 minute test was extended to 30 minutes with the following results:
Flamespread Factor: 0
Fuel Contributed Factor: 0
Smoke Density Factor: 0

Building Biology Based New Building Protocol

Energy Efficient: R-3.9/inch @ 75degF, according to study test protocol following the requirements of ASTM C-518.76

Cost Efficient: Average cost \$.30-\$.50/board (12"x12"x1"thick) foot installed

For more information contact R.Keen Christopher at: www.aircrete.com (315 834 6609)

Here we begin to address another of the aspects as to why magnesium/phosphate-bonded cements eventually were forced to take a back seat in building the foundations of our modern world. In a nutshell it comes down to the relative cost of the necessary raw materials. Ceramic cements superiority is indisputable, even amongst a growing number of cement/concrete experts throughout the world, but the cost per pound differential with conventional Portland cement continues to relegate the present use of magnesium/phosphate cements to value-added products where Portland cements cannot begin to compete with their quality and strength.

In a dedicated effort to resolve this raw material cost problem, Co-Operations Inc., a Seattle based research and development company, has recently been successful in identifying large, worldwide sources of recyclable MgO's that were inadvertently produced as a by-product of the industrial revolution, and they are helping to develop a significantly less-expensive process for producing the necessary phosphates needed for these innovative ceramic cements. This company is also testing a phosphate-bonded radiation shielding formula that promises a wide variety of uses ranging from nuclear and hazardous waste containment, replacing the lead shielding used in medical and x-ray facilities, as well as safer computer and cell phone casings.

Properties of Concrete Made with Portland Cement:

Let us now turn to concrete made with Portland cement. As a further indication as to why ceramic cement got 'lost' in the shuffle, when a convenient produce such as Portland cement becomes a fixed paradigm within the largest industry in the world, bar none, it stands to order it would take an exceedingly better and easily assimilated alternative to even be considered. When something that successful isn't perceived to be broken, why on earth do anything else but improve it!

Let's start by looking at its health-related properties and performance characteristics of the readily available choices. Portland cement has the tendency to take on moisture and hold it for prolonged periods of time. This is a serious drawback from a Building Biology standpoint. Furthermore, modern polymer additives in Portland cement often further clod its pours causing it to be even less breathable. The most deleterious health effects of concrete occur however, when it's wet: it continuously outgases, and this promotes mold growth, and also becomes a conductor of heat, cold and electricity.

It is now widely recognized that the production of concrete made with Portland cement is a major contributor, up to 12%, to the worldwide global warming crisis. What is less

Building Biology Based New Building Protocol

widely recognized is that the immense amount of energy that it takes to bake a Portland cement "clinker," amounting to roughly 3000 degrees F. for many hours, is routinely purchased at less than 10% of what the average consumer pays for the same amount of energy, and is thus, hugely and outrageously subsidized by the public sector.

A vivid example of this type of subsidy was revealed when Alcoa Aluminum closed several of its plants in California for two years, paying full wages to send home employees. Yet the company had its highest profit years in history these two years by selling its "energy " futures back to the people of California at an average cost of over twenty times what they paid for it.

When building with Portland cement you must use a bonding material to enable cellulose to adhere to it. The lime in Portland cement repels any sugars and acids such as normally found in cellulose. Therefore you need to neutralize the sugars and acids in wood or cellulose before binding them to concrete. This requires the use of an often toxic adhesive, to accomplish. With magnesium oxide and clay-treated wood chips, on the other hand, cellulose will bond to clay without having to go through the expensive patented European neutralization process used to create products such as Durisol, Hardiboard and Wonderboard.

In many buildings today, 50% to 90% of a solid concrete envelope (by weight) is involved in holding up its own "dead weight". This is a very inefficient use of resources. Instead the wise builder should consider using a light insulative exoskeleton filling only about 30% (or less) of the block mass with conventional concrete. Products such as Durisol and AAC can achieve this light exoskeleton while creating enough thermal mass in the inside of the block to provide all the benefits of documented thermal performance, breathability and hygroscopicity discussed in previous chapters. In the future the use of ultra high strength MgO cements could reduce the use of structural cement materials to even less than 10%.

Harmful Health Effects of Concrete Made with Portland Cement:

Making the "clinker" in Portland cement at 3000 degrees creates a missing unstable isotope which gives it an unbalanced charge. Concrete made from Portland cement is therefore very electrically unstable causing these isotopes to always seek electrons in neighboring objects in order to stabilize themselves electrically.

These isotopes created in the manufacture of Portland cement draw electrons out of anything with an opposite charge in close proximity to a concrete slab or wall, including people, animals or the cellulose in plants. This causes fatigue and other health problems in people who stand or work near concrete over prolonged periods of time.

Concrete will also drain a standard car battery placed on it over a period of time. If you place that same battery on magnesium oxide cement, however, it does not drain electrically. The same is true with the human body; that is, magnesium oxide used as a building material will not drain the electrical charge out of a person standing over floors made with it, and you therefore do not feel fatigued. You can put this benefit of

Building Biology Based New Building Protocol

magnesium oxide to use as part of your slab protocol as you will see in the next section.

Some of the most harmful effects of concrete made with Portland cement come when it is “enhanced” with plastics. The concrete never cures, or does so extremely slowly, which may enhance the strength of the concrete but is not healthy for the occupants of the building. Furthermore concrete outgases and is toxic, particularly when it mixes with mold. (The use of concrete inside clay-treated wood chip wall forms is an exception because they allow the concrete contained within them to cure fully, drying out all their initial moisture and any new moisture that enters later through wicking by capillary action or through water leaks.)

The high temperatures used in the making of Portland cement makes it extremely hydrophilic, causing a number of problems including the promotion of mold growth. Helmut Ziehe, Founder and former Director of the International Institute of Bau-biologie and Ecology, explains this in a recent email correspondence:

“When cement is made they use very high temperatures which in turn gets rid of the crystal water in the limestone molecule. In making concrete, water is added and comes in contact with that cement. Now the cement has the tendency of holding on to that water. This is an explanation for the long drying out time of concrete. The health effect is connected to living in wet conditions (promoted by the continual wetness of concrete) with the possibility of mold growth.”

Studies in Germany have shown that factory workers standing on concrete for more than one hour develop a condition whereby the communication of information between cells is interrupted in the body of the worker. This appears to cause the information exchange from cell to cell to reduce by 30-50%. Also the “wetness” of the human cells decreases and they become dehydrated. As a result the cells do not function properly leaving the worker feeling fatigued.

As a remedy to this employers in Germany have made cut outs in the concrete floor of assembly lines and replaced them with cork covered clay-treated wood chip over direct earth for workers to stand on. By doing this the workers have been shown to increase their productivity and decrease their absenteeism and medical expenditures. For this reason industrial laws now exist in Germany limiting the amount of time workers can stand on concrete to no more than one hour per day.

To remedy this in our own homes in North America we must avoid these harmful effects and simulate the natural relationship that exists between bone and tissue by replacing concrete with natural mineral enhanced clay and cellulose wherever possible. Our cells know what is going on behind walls or below floors in the houses we build and much of our general lack of health in society shows it.

Clay-treated wood chip is much closer to the ideal as a building material and has none of the deleterious effects seen with concrete alone. This is because electron-hungry concrete contained within a clay-treated wood chip wall draws electrons from the clay and wood chip encasing it rather than pulling electrons from the bodies of people standing, sitting or sleeping nearby.

Building Biology Based New Building Protocol

The same holds true if you place pieces of crushed Durisol or Faswall under a concrete slab. The concrete in the slab will pull electrons out of the crushed Durisol below it rather than from the feet of occupants standing above it, as you will see in the next section, Clay-treated Wood Chip Under Concrete Slab. This is a significant way to reduce fatigue produced by living on a concrete slab in a home built slab-on-grade or spending much time in a finished basement.

For more information about magnesium based cements, mixing recipes, and ordering information, contact George Swanson at: 512-288-9097; 512-653-8624 cell; gps@flash.net or on the web at: www.geoswan.com