NEW PRODUCTS RELATIVE TO THE CEMENT CONCRETE INDUSTRY

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I appreciate the opportunity to represent the general cement-concrete industry in speaking on the subject of new products relative to our industry. In considering the various products and technology advancements I feel are worthy of some mention in this presentation, I believe they might be best described as “relatively unique” or “nonconventional” rather than new in the sense of just having been introduced.

Some of the items I’ll mention are really about to turn the corner in becoming more extensively, or conventionally, used. They have passed the point of research and development and experimental application and have gained some general acceptance in terms of proven and cost-effective value. These products and technology may be the most important of all to our industry today and in the immediate future.

What are the products and technology advancements worthy of mention here today?

1. SPECIAL CEMENTS

A. Expansive-Shrinkage Compensating, Type K per ASTM C 845.

This product has been extensively promoted by one cement company for a number of years now. This company had exclusive rights in this area to the manufacture of the product when it was called Chem-Comp.

With this product, the concrete expands as it hardens, putting reinforcing steel in tension (reinforced concrete is a requirement for this system to work as it does) and the concrete in compression. Upon completion of the expansion phase, the concrete

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goes into a shrinkage phase that relieves most of the slab compression returning the concrete to a volume equal to, or slightly greater than, its original volume. The result is reduction, or elimination, of cracking due to drying shrinkage and this lower permeability of the concrete leads to less chance of attack on steel by ingress of moisture and chlorides.

The Kentucky Transportation Cabinet has specified this cement under a Class “S” Concrete Specification for a few bridge projects—one in Lexington, Frankfort, and some on upcoming projects in Northern Kentucky.

B. Blended Cement

Certain blended cements have been recognized in an ASTM Standard for some time now. Type IP, IP-C which incorporate Class “F” and “C” fly ash as an interground or blend addition to normal cement have been the most notable, even though not extensively used in Kentucky.

The most recent and often-mentioned blended cement today is Pyrament, a proprietary product manufactured by Lone Star Cement Company.

This is a premium, high-performance cement with a proprietary interground addition which renders a reputed concrete with a compressive strength of 2,000-3,000 psi and flexural strength of 500 psi within four hours of mixing. After 28 days, concrete strength of 10,000 psi compressive and 1,200 psi flexural are expected, according to the manufacturer.

Other claims for this product are as follows:

- Sulfate resistant
- Excellent resistance to freeze-thaw and deicer scaling without adding air entraining admixture.
- Lower than normal volume change
- Gains strength at ambient temperatures as low as 0 degrees F without the need for special admixtures or heating.

The Kentucky Transportation Cabinet has used Pyrament Concrete on at least two projects I know of, the latest of which was a bridge recently constructed over McNeilus Lake in Jefferson County.
C. Regulated Set Cement

Somewhat similar to Pyrament are some other brands that fall into the category of regulated set cements. They are formulated and controlled to produce concrete with unusual set times and most often with early strength gain. To my knowledge, they are not being actively promoted in Kentucky at this time, but that could change as things sometimes happen rather quickly, or unexpectedly.

D. White Cement

White cement is conventional ASTM hydraulic cement whose only real difference is color. This cement used in combination with white (manufactured) sand is produced primarily for architectural purposes. The product has been promoted by one cement company for use in medium barrier walls for improved light reflectance and safety to the traveling public.

Concrete that incorporates this cement with its long-term brightness is cost-effective when compared with routinely maintained medium barrier walls painted white for the same purpose.

2. FIBERS

ASTM recognizes three types of fibers in its C1116-89 Standard. These are steel, glass, and synthetic.

A. Steel Fibers

Steel fibers have structural properties that, according to a manufacturer, accomplish the following in concrete thus reinforced:

- Increased shear strength
- Increased flexural strength
- Increased fatigue resistance
- Increased impact resistance
- Increased toughness
- Increased crack and spall resistance

They are used at a recommended dosage rate 15-135 pounds/cu.yd depending upon the particular application. Various lengths and anchorage systems are available each having its own claims of advantages.
Steel fibers are used principally in industrial floors. At least one manufacturer has promoted their use in a bridge overlay system where high-frequency truck traffic is involved and this composite-type system is deemed essential to performance. The Ohio DOT, I believe, is experimenting presently with this type of system.

B. Synthetic fibers

These include polyester, polypropylene, and nylon. Some are monofilament (single-cut strand) and others are fibrillated (slit and open up into interconnected network upon mixing in concrete). This latter design is intended to improve mechanical bond with the concrete matrix.

These fibers are usually used at a rate of 1-1/2 pounds/cu. yd. and, according to research by those manufacturing the fibrillated design, accomplish the following in the fibrous concrete:

- Improved toughness
- Improved impact and shatter resistance
- Reduced plastic shrinkage and drying shrinkage cracking
- Lower concrete permeability

Synthetic fibers are being used extensively in the private sector for many applications. To my knowledge, no real promotional effort has been made with the Transportation Cabinet to date for its use.

3. ADMIXTURES

A. Superplasticizers-High Range Water Reducers

I can think of no single generic product that has impacted the concrete industry more in the past decade than these admixtures.

They were first introduced in the 1970s and left something to be desired at that time because of their short pot life (or slump life). They were by necessity added to the truck at the job site and, of course, dramatically changed, or increased, slump but only for a short time (approximately 15 minutes).

Subsequent refinements in the past few years have significantly extended the slump life and make it possible for the product to be better controlled through addition at the batch plant.
These products disperse cement particles through an electrochemical charge process, thus maximizing cement efficiency. Additionally, concrete becomes very workable (slumps up to 9 inches without segregation), which enhances discharge from the truck, placing, consolidation, and other features relating to time and cost to the contractor. Higher achievable strengths (especially early on) through reduced water-cement ratio and greater cement efficiency make it possible to remove forms and put concrete into service sooner than normal.

In consideration of the cost of these products in comparison to established benefits, I believe they can only increase in use with time. Perhaps water tanks on ready-mix trucks will be replaced with superplasticizers in the future in the best interest of economics and quality.

B. Microsilica

Another product, which falls under the category of a mineral admixture, that I believe has reached an acceptance level destined to increase its application is Microsilica (sometimes called Silica Fume).

This is the product that makes possible the highest achievable strength in concretes today. Twenty-thousand psi concrete has been produced using this product.

Where does it come from and how does it work?

The product is largely silica by chemistry. It is produced as a by-product in the silicon metal or ferrosilicon alloy manufacturing process. The material, much like fly ash, is collected as it becomes airborne by special systems.

Microsilica has a grain size 1/100 of that of an average cement grain. It is finer than cigarette smoke, I'm told.

The first investigations of the use of this material began several years ago in Europe. It was known to have exceptional capabilities in increasing strength and lowering permeability in concrete, but a major problem was how to handle and transport it commercially. In its raw form, it has a bulk density of only 10-15 p.c.f. Compare this to 94 p.c.f. for cement and you realize a significant problem in transporting costs, plus the extreme fineness making it so subject to leakage and becoming airborne upon handling.
Improved procedures in this regard, including air densifying or slurrying the material for transporting, has basically eliminated these past concerns of its practical use. The product is usually added at a rate of 5-15 percent of the cement weight and reacts with the by-product (CaOH2) in the cement hydration process to form additional strength-producing compounds. Its microfiller effect makes the concrete extremely impermeable and thus very durable.

Its high strength production capabilities make it economically effective in many designs. Its overall properties make it apparently very desirable in highway bridge construction applications including overlays.

The Kentucky Transportation Cabinet used it only once, to my knowledge, in an experimental overlay application. The Cabinet is presently looking at another project in the immediate future. Many states have begun to specify its use in bridge deck overlays. I see a bright future for microsilica concrete.

C. Corrosion Inhibitor

There are many processes, or products, available to the concrete materials engineer and designer today aimed at reducing, or eliminating, corrosion of reinforcing steel. Some products assist this way while concurrently improving other qualities of the concrete. Special cements, superplasticizers, and microsilica already mentioned are examples of these products. Certain types of surface treatments and overlay systems as well as cathodic protection have their own individual claims to fame. Epoxy-coated steel has been the primary system of choice by the Transportation Cabinet in dealing with the problems of corrosion of reinforcing steel.

An admixture identified specifically as a corrosion inhibitor is available and has been well researched as to its benefits in stabilizing a protective film on reinforcing steel preventing attack by chlorides. This product is now being specified by other state highway departments, perhaps most significantly in prestressed concrete members. It probably warrants additional consideration at this time in terms of cost-to-benefit in relation to other systems, or perhaps in combination with other systems for ultimate insurance purposes.

D. Cold Weather Non-Corrosive Admixture

There is a product on the market today that is being used to some extent (in the private sector) in cold weather to allow for
lower than normal temperatures (down to 20 degrees F) placement of concrete without usual protection. It is referred to by some as an antifreeze. It’s really a non-chloride accelerator that speeds up hydration at low temperatures and reduces pore water to below critical saturation thus reducing damage from early freezing temperatures.

The trend away from chloride accelerators has made this product a somewhat popular one with the industry.

E. Controlled Cement Hydration Systems

Recent developments in admixture technology have made possible significantly greater control of the hydration of cement. This control has enabled concrete producers and users to stop cement hydration indefinitely and be able to restart it at a later time, allowing the concrete to set normally. Cement hydration can be stopped at any time between the initial mixing of the concrete and just prior to initial set. This means that one can make concrete today and use it later in the day, the next day, or some other time in the near future without sacrificing any of the properties of the concrete. This innovation has had a significant influence on not only the production, transportation, and placement of concrete, but also on the environment. One of the most common applications of this technology has been the elimination of waste in the production and use of concrete by essentially changing the perishable nature of concrete. The two-part chemical system allows the use of concrete that would otherwise have to be discarded if, for some reason, it cannot be used as planned.

This level of hydration control is currently achieved by the use of two chemicals. One of them is used to stop or stabilize the hydration of cement when it is mixed in the concrete and the second is used to restart or activate the hydration.

When one interferes with cement hydration in the manner just mentioned, it is natural to wonder how the properties of the concrete are affected. A large number of laboratory and field evaluations have shown that the properties of concrete treated with the chemical system are equal to or better than those of plain concrete.

4. CONTROLLED LOW STRENGTH MATERIAL—FLOWABLE FILL

From the standpoint of material or technology simplicity and a product with greatest acceptance potential by a large number of
people, probably the most important product I have to mention today is what we, in the industry, commonly call, “flowable fill.”

Flowable fill is a low-strength material mixed to a wet, flowable slurry used as an economical fill or backfill material placed by pouring it into the cavity to be filled. It is a self-leveling material with a consistency similar to pancake batter; it can be placed with no vibration or tamping. It hardens and develops strength.

ACI Committee 229 calls it “Controlled Low Strength Material.” It is not considered concrete. The family of mixtures that fall under the general category of Controlled Low Strength material vary in their late age strength from approximately 30 to 1200 psi compressive strength as measured from standard test specimens.

The most prominent use of the product in this state to date has been in backfill operations where utility cuts are made in streets where subsequent ease of removability is a concern. In this case, a late age compressive strength of 100 psi or less is highly desirable. This is usually achieved by a mix of approximately 50 lbs. cement, 250-300 lbs. of Class “F” fly ash, 2800-2900 pounds of sand, and 50-60 gallons of water, all per cubic yard.

The product compacts under the vehicle of water and gravity to a density of approximately 95 percent of its Standard Laboratory Proctor (AASHTO T 99) density.

Under normal, warm weather conditions, settlement of the solids and dissipation of excess moisture occurs in 1-2 hours. It may take 24 hours to dissipate the water under certain environmental conditions. In either case, paving can be accomplished on top of the material upon proper dissipation of water.

This material has excellent load transfer characteristics reducing stresses over the conduit, etc. due to its internal friction and cohesion strength components.

The material is cost-effective when compared to conventional backfilling materials and means, when proper consideration is given to labor and equipment costs for compaction. A critical backfill item is the OSHA regulation regarding shoring or cutting side slopes for safety of people in trenches. Eliminating compaction efforts in trenches could alleviate some of these safety requirements. Trench widths (and thus excavation) can be reduced when using flowable fill since a wider trench is not required to achieve adequate compaction around a conduit.
Another feature of this material is that it can be poured directly into water in a trench thus eliminating the need to pump a trench prior to backfilling.

All in all, I have heard of no significant complaints from anyone choosing to use this material for backfill in street repairs. Some may question the cost in comparison with native material but, again, if proper analysis is made of costs involved with proper compaction of other materials and consideration given to the frequency of call-back repairs in streets where backfill settles and leaves a bump, I believe flowable fill will be understood as the most cost-effective material in backfilling street repairs in the future.

The product can be altered slightly in mix design to make it suitable for use in other applications as strength requirements within this band of 50-1200 psi dictate. Other uses found for this material include:

**Backfill for:**
- Bridge abutments
- Pile excavations
- Retaining walls
- Sewer trenches

**Structural Fill for:**
- Foundation subbase
- Subfooting
- Floor slab base
- Pipe bedding

**Miscellaneous Uses:**
- Abandoned underground storage tanks
- Wells
- Voids under pavement
- Sewers and manholes
- Contend with mudding conditions

5. **CONCRETE PAVEMENT OVERLAYS**

Naturally, we in the concrete industry are vitally interested in the use of concrete for pavements even though our share of this market is less than 10 percent.

We are interested in not only new construction, but reconstruction or rehabilitation of existing facilities—resurfacing with concrete, if you will.
Bonded overlays of new concrete over old certainly allows one to use thin section (1-1/2 to 2 inches) in many cases since a large portion of the old becomes a part of the new composite pavement in generally accepted pavement design equations. The biggest problem here is catching an existing concrete pavement in a suitable condition when the overlay is applied in order to utilize a bonded concrete approach in construction. Often, we wait until a pavement shows serious distress before deciding on rehabilitation, therefore, eliminating the possibility of a bonded concrete overlay. So, we end up with many cases in which an old concrete pavement is ready for rehab, and an unbonded approach is the only choice. Naturally, when an asphalt pavement is overlayed with concrete, it is also an unbonded design.

A question we’ve encountered in the private sector repeatedly is how thick, or more appropriately, how thin can I make the concrete overlay? Usually, the design approach is to consider the existing pavement as a base course and design accordingly. However, with concrete technology as it is today, is it possible that potential performance is upgraded to a point beyond existing history’s ability to guide us adequately in overlay design? Can we, in fact, design some rather thin unbonded overlays that will perform well under certain loading conditions to be experienced.

What has any recent work shown and what is being done to investigate possibilities for the future?

In Kentucky during the past 2-3 years, unbonded concrete overlays that have utilized 4-inches of concrete (which carry truck traffic without distress) have been constructed over old concrete streets. This design has been very successfully employed in concrete over asphalt in certain parking lot situations such as at schools, hospitals, and business locations, and, in one case, in an entrance road location to and from a ready-mix plant. Heavy truck loads have been endured without distress. How thin then can we go? We plan to further investigate this matter in the immediate future by constructing a section of 2-inch and 3-1/2 inch thick concrete over asphalt at a landfill entrance road site used by approximately 600 heavy trucks per day. We don’t know what will happen, but we look forward to the experiment. This project will be instrumented for stress-strain determinations. Loads endured will be carefully monitored. If this is a success, you probably will hear about it. If it is not, we’ll try to further experiment in determining more exact limits with which we might work in overlays with concrete for various loading applications.
CONCLUSION

In conclusion, we in the cement concrete business have an exciting product—one which can be made bad by improper material choices, or construction abuses—but one which cannot only be made good, but exceptionally excellent through knowledge and experience of the past and advancements of the present and the future. Concrete still remains, in my judgment, the single most important and diversified building material on the earth.

My boss, Mr. Jim Deters, and I consider it a privilege to work with anyone involved with us to help in any way in answering questions, making presentations or anything for which you might call upon us.