Innovations in Concrete: **June 4, 2019**

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Competition is the Driver of Innovation

Durability has always been the mainstay of the concrete industry. Concrete means permanent, built to last.

Pavement warranties are having the impact they were designed for. As we moved from a state-controlled system to one where the contractors have been given some control along with added responsibility, the demand for innovation has increased.

The environment that we operate our roads in has changed - in the interest of the traveling public, a zero-ice policy has been implemented. In the past, sodium-based rock salt was spread on the roads after the snow had started to fall, and much of it was plowed off during the snow event. Calcium chloride-based and other salt brines are now sprayed onto the road surface prior to snow events with 100% surface contact, so that ice has little chance of forming. These salts soak into the dry pavements and as we now understand, they can chemically react causing a reduction in the life of the concrete.

We needed to make a better concrete, one that will resist this deicing attack. Industry; MDOT; Michigan Universities; National Concrete Consortium (NCC) – 32 States, FHWA, and Academia; Leading national experts; have all worked on the solution.

A better concrete mix:

1. **Densify the cement paste: Supplementary cementitious materials (SCM's)** like fly ash and slag cement extend the chemical reaction and make a denser, less permeable paste.

   Cement + Water = Glue (CSH) + Chalk (CH)

   Chalk (CH) + SCM = Glue (CSH)

   The more CSH we have, the denser the paste and less room for anything else.

   The deicing salts react with CH, so when use up more of the CH there is less material for the salt to react with.

2. **Well graded aggregate mixes:** Concrete is made up of rock, sand, and glue. The glue is used to hold the rock and sand together and to fill the small spaces between them. By using more intermediate size rocks, we can fill more of the gaps with rock rather than glue. We don't need as much glue.

   Reduced cost - The cement is the most expensive part of the mix and now we use less.
   Increased durability – The paste is what is attacked, so we now have a smaller target.

Reduced CO2 footprint – environmentally friendly.

3. **Increased aggregate testing:** A few local fine aggregate sources (sands) may react with the cement, creating a gel called ASR which can take on water and expand and crack the concrete. We are now testing and eliminating aggregate sources with this ASR potential.

4. **Other new materials:** There is a constant stream of new products being promoted. Some may have potential while others have not done well in initial testing. The industry as well as MDOT is interested in new innovative products, but testing and small demonstration sections needed to be successfully completed before wide scale implementation.

Better base support:

5. **Pavement Drainage:** Over time, pavement soaks up water, and damage will start to occur when a fully saturated pavement goes through a freeze thaw cycle. By providing a clear path for water to drain away, we are able slow and even stop this process.

6. **Stabilized Base:** Pavement engineers determine the strength of the natural ground and then design the pavement section to protect the ground from the traffic that is anticipated to use the road. Water seeps into the pavement structure over time even when we provide a drainage path. Water eventually reaches the surface of the natural ground and over many years may soften and reduce its original strength. The loss of strength will allow for differential movement of the pavement, causing cracking and further water intrusion. We have stabilized the base on several demonstration sections of pavement. The goal of this stabilization is to provide a waterproof layer of protection that should extend the life of the pavement.

New Testing Procedures:

7. **Super Air Meter:** We build a matrix of tiny air bubbles so water will not crack the concrete when it freezes. Historically, we have used a standard air content test to measure the total volume of these air bubbles prior to placement. The standard air content test, however, is unable to determine the quality of the air system. This test has been reliable, but on a few projects, it failed to assure good concrete performance. We are now demonstrating a new Super Air Meter (SAM) which reportedly will provide both total air content and a measure of the air quality. MDOT and industry are currently running field trials of this device.

8. **Resistivity Meter:** As concrete gains strength and densifies over time, the resistance to electrical current flow changes. We are currently demonstrating a test that uses this to measure the density of the concrete.

9. **Accelerated durability testing:** We are working on testing that will allow us to see within a few weeks how concrete will perform over the long term.

Other items of interest:

10. **Plastic and steel fibers:** Fibers mixed into the concrete provide reinforcement, making it tougher and holding it together when cracks form.

11. **New epoxy coatings for dowels:** Green epoxy coatings have been typically applied to rebar and dowels. The green epoxy is designed with some flexibility so the rebar could be bent. The new epoxy coatings are designed for dowels which need more scratch resistance rather than flexibility.

12. **Geotextile fabrics:** Provide positive drainage paths and help hold the panels in alignment.

13. **New Design procedures:** A move from slide rule based to computer based design procedures.

14. **Stringless Grade Controls:** All grading and paving equipment is now controlled with survey instruments. Significant time savings and elimination of potential survey error.

Industry wide efforts:

15. **Workforce Development:** We have established an industry wide workforce development effort. Individual contractors looking for 2 to 20 workers cannot compete with the large industries looking for 500 to 1000 people. The Michigan Construction Foundation (MCF) provides a vehicle for many companies in the construction industry to speak with one large voice. In addition, there are many training programs and entry points for individuals to start a construction career, but they can be difficult to find. MCF provides a single place for all known entry points as well as direct links to companies that are searching for people. You can check us out at www.Michiganconstruction.com

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