Understanding the basics of concrete mixture chemistry

EVERYONE INVOLVED in constructing concrete pavements—roadway designers, mixture designers, building contractors and supervisors, technicians, materials suppliers, and road workers—should have a basic understanding of today's complex mixture designs.

A relatively recent challenge

For nearly a century, concrete pavements have been constructed with the same basic materials: aggregate (gravel or crushed rock and sand), portland cement, and water. The cement and water make a paste that hardens and holds the aggregate together, forming a strong, durable pavement. See ***Equation 1*** below.

In the mid-1950s, Iowa's concrete paving industry began to use more crushed stone than gravel because of its availability. And additives were introduced into mixtures to improve air entrainment in finished concrete, which improves its durability.

Then in the 1980s, prompted primarily by new environmental requirements and cost-reduction efforts, the industry began supplementing portland cement with recycled products that have cementitious properties, like fly ash, ground granulated blast furnace slag, and silica fume. The industry also began to use a variety of chemical admixtures in addition to air entraining admixtures. Today, mineral and chemical additives are used to fine-tune mixtures according to variations in aggregate, construction and weather conditions, and desired characteristics of the finished pavement. See ***Equation 2*** below.

This complexity can cause new challenges. Sometimes aggregates and admixtures are incompatible. Various additives can affect the amount of water needed for hydration, the quality of the bond between aggregate and paste, the uniformity and workability of the mix, the rate of hydration, the timing of initial set and final set, and many other characteristics of the plastic mixture and, eventually, the hardened concrete.

A new resource

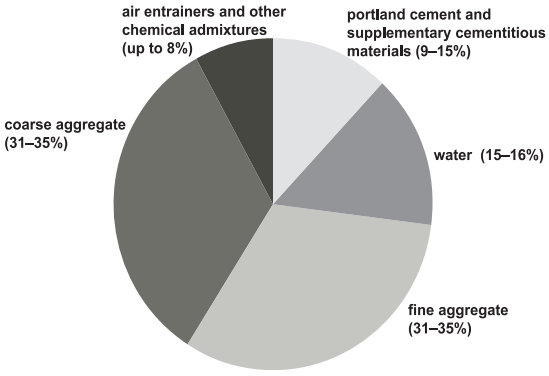
A new publication, *Formation and Characteristics of Portland Cement Concrete for Pavements: The Basics*, can help. This technical brief provides a clear, concise overview of the interactions among aggregate, portland cement, supplementary cementitious materials, chemical admixtures, and water and how those interactions can affect the art of constructing durable concrete pavements.

It was developed by ISU's Center for Portland Cement Concrete Pavement Technology, which is sponsored by the Iowa Concrete Paving Association and the Iowa DOT.

The technical note is being distributed by the American Concrete Pavement Association. Several ACPA chapters, including those in Iowa, Wisconsin, and Michigan, are using it for training purposes.

For more information

To review a copy, contact Jim Hogan, LTAP library coordinator, 515-294-9481, hoganj@iastate.edu. For your own copies, call 1-800-868-6733, or use the online order form, www.pavement.com/. Refer to product code SP486P. •



Chemical admixtures and supplementary cementitious materials make up a small percentage of concrete mixtures but seriously complicate mixture chemistry. (Percentages shown are by volume.)

Equation 1

$$\text{portland cement} + \text{water} + \text{basic aggregate} = \text{concrete}$$

Equation 2

$$\text{portland cement} + \text{water} + \underbrace{\text{supplementary cementitious materials (mineral additives)}}_{\bullet\ \text{slag},\ \bullet\ \text{pozzolans}} + \underbrace{\text{chemical additives}}_{\bullet\ \text{air entrainers},\ \bullet\ \text{water reducers},\ \bullet\ \text{etc.}} + \text{aggregate} = \text{today's concrete}$$