CP ROAD MAP

shaping the future of **concrete pavement**

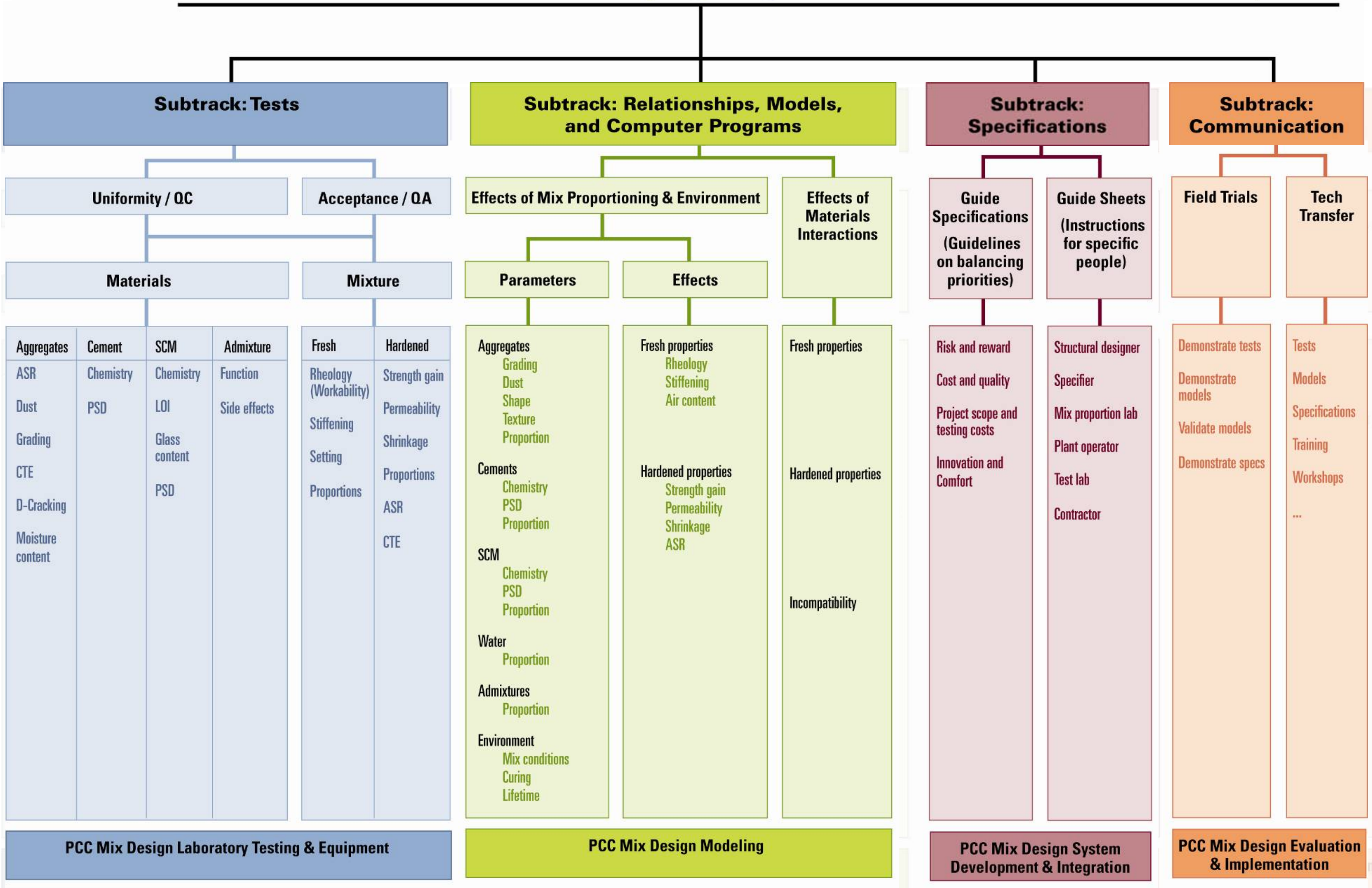
Mix Design and Analysis Track Pooled Fund

I-2015

Mixtures that are consistently long-lasting, constructible, and cost efficient

Track 1. Mix Design Analysis

Goal: Mixtures that are sustainable (consistently long-lasting, constructible, cost-efficient, and environmentally sound)



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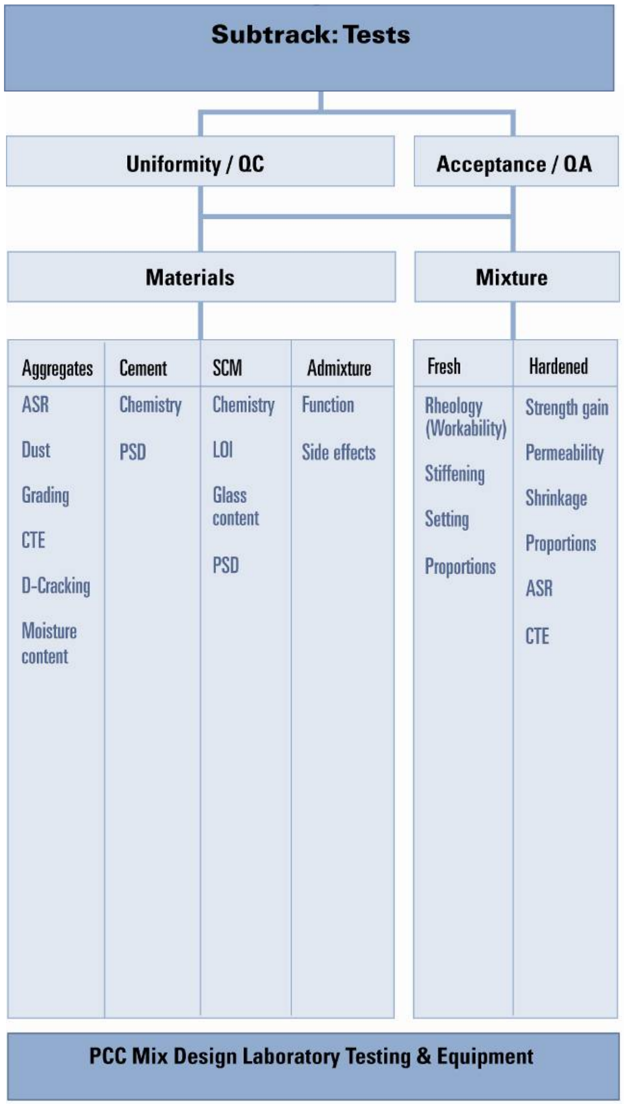

- CTE
- AVA
- Field Temperature Monitoring
- Foam Index
    - Permeability
    - Torrent
- Boiled water test
- Micro-Deval abrasion test
- Foam Drainage
- Rheology test for pavement mixtures
- Mix proportions

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- Field Temperature Monitoring
  - A tool to assess uniformity
  - Indicates setting times
  - Indicates potential incompatibility
  - A formal method statement needs to be developed for submission to AASHTO and ASTM.

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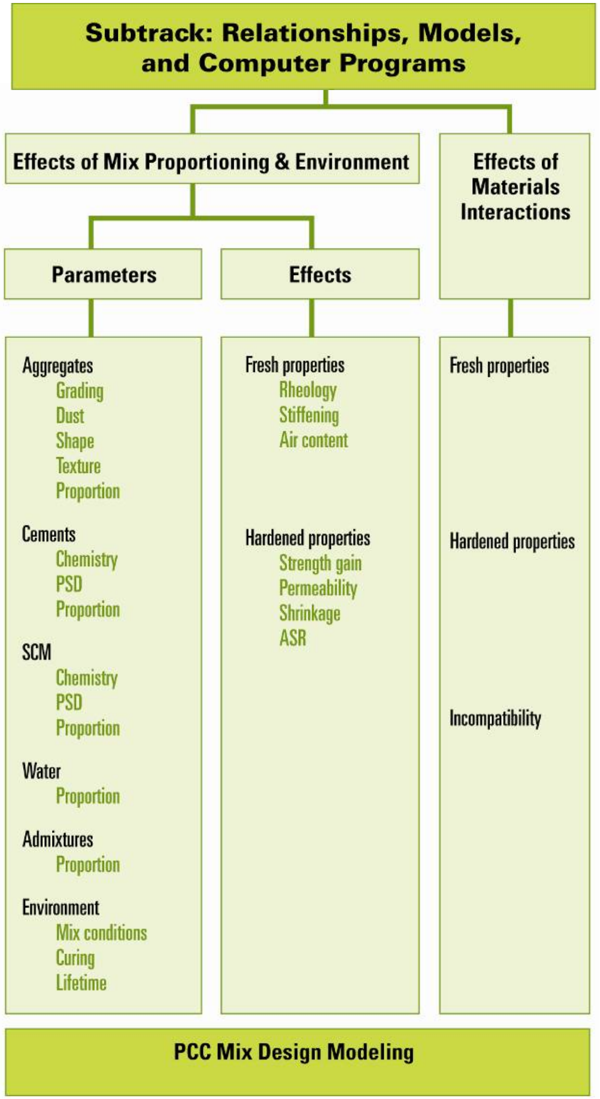
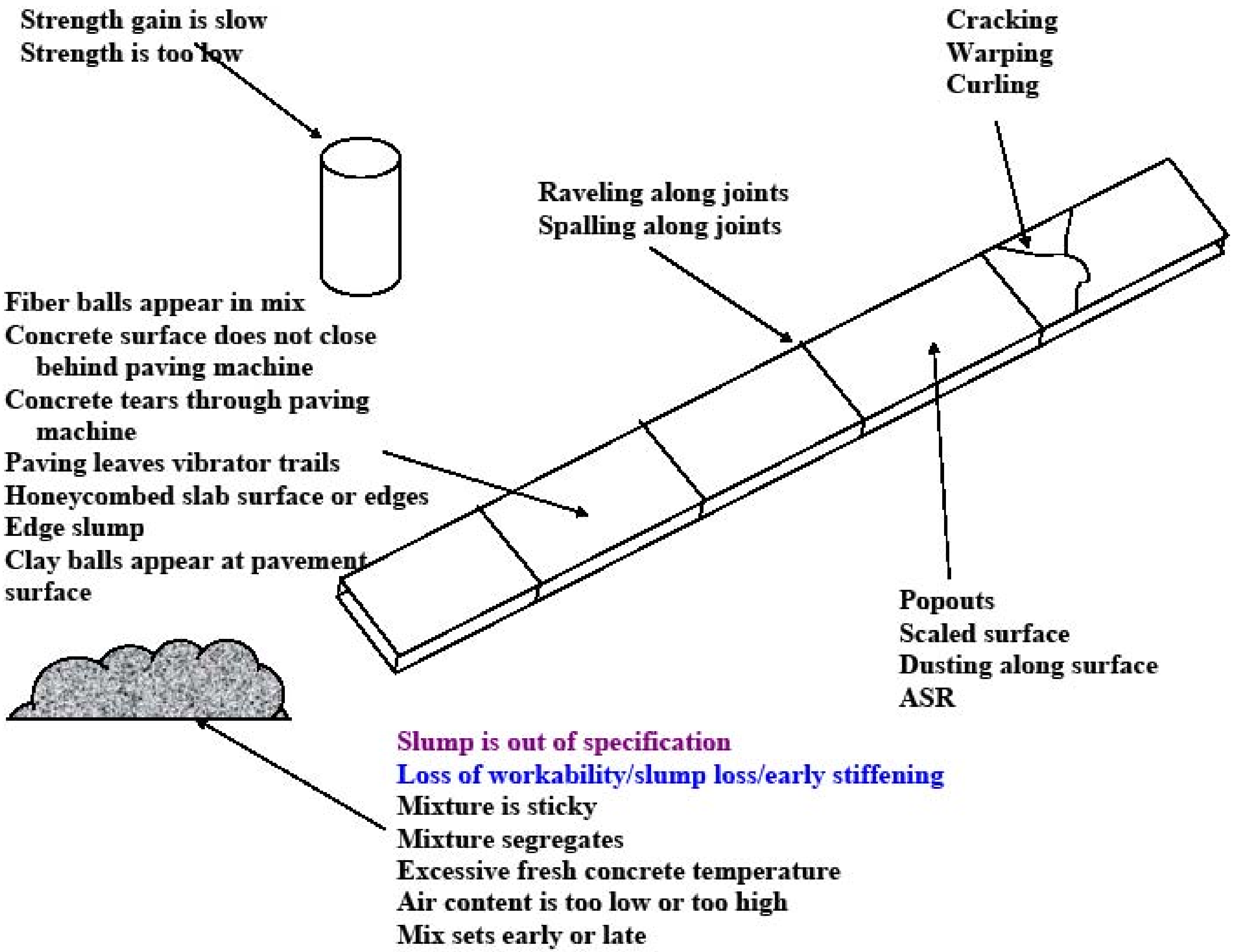


- Interaction Hyperdoc


Strength gain is slow
Strength is too low
Cracking
Warping
Curling
Raveling along joints
Spalling along joints
Fiber balls appear in mix
Concrete surface does not close behind paving machine
Concrete tears through paving machine
Paving leaves vibrator trails
Honeycombed slab surface or edges
Edge slump
Clay balls appear at pavement surface
Popouts
Scaled surface
Dusting along surface
ASR
Slump is out of specification
Loss of workability/slump loss/early stiffening
Mixture is sticky
Mixture segregates
Excessive fresh concrete temperature
Air content is too low or too high
Mix sets early or late

Loss of workability/slump loss/early stiffening

Action	**Side Effect**
Use a mix design that includes slag or Class F fly ash	Will change many concrete mixture properties
Reduce Class C fly ash dosage	Will change many concrete mixture properties
Use a water reducer or retarder	Will change setting time
Change the type of water reducer	May change other mix properties
Check the air content/air entrainer dosage	May change strength
Chill the mix water or use ice instead	
Use an agitator rather than dump trucks	
Verify that aggregate gradations are correct…	

these materials, which may not fall under categories covered by other specifications.

Effects of Supplementary Cementitious Materials in Concrete

SCMs in concrete affect a wide range of fresh and hardened concrete properties. Some of the effects may be considered desirable and are the reason why the materials are used. Other side effects may be less desirable and have to be accommodated. An understanding of all the potential effects is essential to prevent surprises.

The effects of SCMs on properties of fresh and hardened concrete are briefly discussed in the following sections and summarized in tables 3-7 and 3-8, respectively (see chapter 5, page 105, for a complete discussion of concrete properties).

In most cases, the extent of change in concrete behavior will depend on the particular material used, the amount used, and the properties of other ingredients in the concrete mixture.

Trial batching with unfamiliar material combinations is essential to provide assurance of critical concrete properties.

Fresh Properties. In fresh concrete, SCMs can affect workability and setting times in the following ways:

- Workability is always changed by SCMs. Fly ash will generally increase workability, as will GGBF slag to a lesser extent. Silica fume may significantly reduce workability at dosages above five percent.
- The rate of slump loss (stiffening) may be increased if there are chemical incompatibilities (see Potential Materials Incompatibilities in chapter 4, page 97).
- Setting times may be delayed and early strength gain slowed if GGBF slag and fly ash are included. However, this effect will depend on the product used.

All of these factors can have a significant effect on the timing of finishing and saw cutting in pavements, making it important that the performance of the cementitious system being selected for a project be tested in trial batches well before the project starts. Trial batches need to be tested at the temperatures expected when the paving operation will be conducted.

Durability/Permeability. SCMs generally improve potential concrete durability by reducing permeability. Almost all durability-related failure mechanisms involve the movement of fluids through the concrete. Tests show that the permeability of concrete decreases as the quantity of hydrated cementitious materials increases and the water-cementitious materials ratio decreases.

With adequate curing, fly ash, GGBF slag, and natural pozzolans generally reduce the permeability and absorption of concrete. GGBF slag and fly ash can result in very low chloride penetration test results at later ages. Silica fume and metakaolin are especially effective and can provide concrete with very low chloride penetration (Barger et al. 1997).

In order for SCMs to improve durability, they must be of adequate quality and used in appropriate amounts, and finishing and curing practices must be appropriate.

Alkali-Silica Reactivity Resistance. Alkali-silica reactivity (ASR) of most reactive aggregates (see Aggregate Durability later in this chapter, page 47) can be controlled with the use of certain SCMs. Low-calcium Class F fly ashes have reduced reactivity expansion up to 70 percent or more in some cases. At optimum dosage, some Class C fly ashes can also reduce reactivity, but at a low dosage a high-calcium Class C fly ash can exacerbate ASR.

SCMs reduce ASR (Bhatty 1985, Bhatty and Greening 1978) by (1) providing additional calcium silicate hydrates (C-S-H) that chemically tie up the alkalies in the concrete, (2) diluting the alkali content of the system, and (3) reducing permeability, thus slowing the ingress of water.

It is important to determine the optimum dosage for a given set of materials to maximize the reduction in reactivity and to avoid dosages and materials that can aggravate reactivity. Dosage rates should be verified by tests, such as ASTM C 1567 or ASTM C 1293. (Descriptions of aggregate testing and preventive measures to be taken to prevent deleterious alkali-aggregate reaction are discussed later in this chapter under Aggregate Durability, page 47.)

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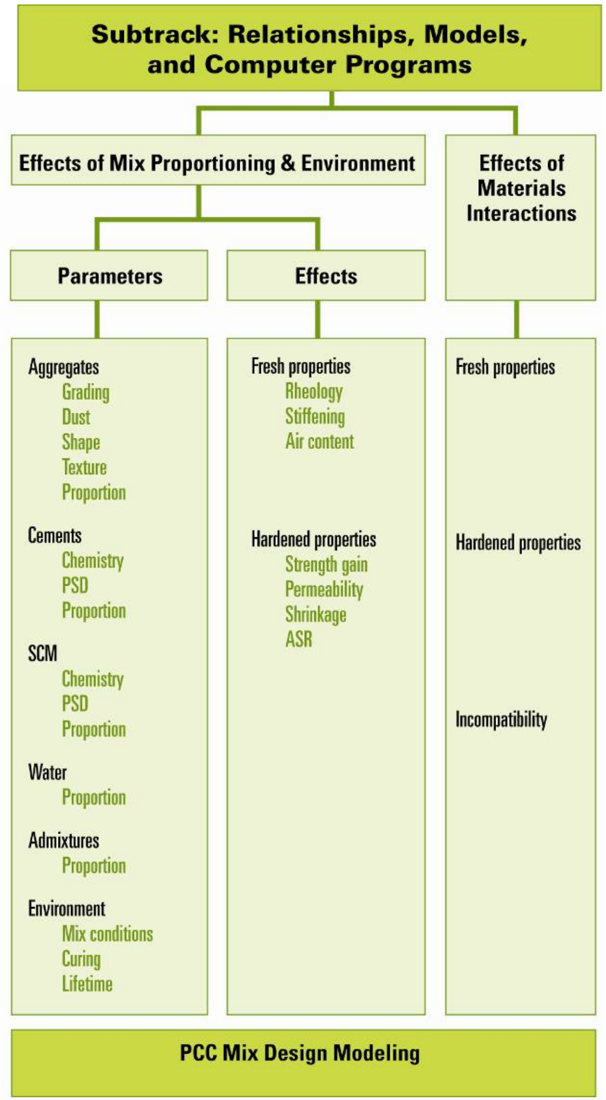

- Interaction Hyperdoc
- Air void system – minimum requirements
- Paste content and shrinkage
- Working temperatures
- Combined gradings
- Long term monitoring

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- Check sheets
- Guide specification
- Generic admixture specification

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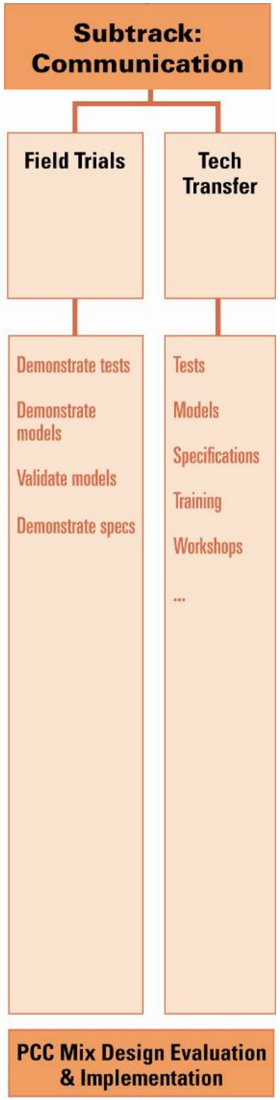

- Field trials - new tests
- Field trials - new models
- Field trials - new specifications
- Training materials

• Budget:	
• Tests	$200,000
• Models	$300,000
• Specifications	$200,000
• Communication	$200,000
• Project oversight	$100,000
• Total	$1,000,000

- Funding
  - Pooled fund $500,000
  - CPTech Center $500,000

Assuming 11 States =
$15,000 per year for 3 years

Which tasks do we want first?

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