# SELF CONSOLIDATING CONCRETE

Serge Ter-Arakelov, P.E.

PENNDOT – Bureau of Construction & Materials
Structural Materials Section

January 2007

## What is Self Consolidating Concrete? ( SCC )

- "A highly flowable, yet stable concrete that can spread readily into place and fill the formwork without any consolidation and without undergoing significant separation"

## How do you produce SCC?

- Higher dosages of High Range Water Reducers than traditionally used
- Optimize aggregate gradations and quantities
- Increase fines
- Use viscosity-modifying-admixtures (VMA's), if necessary, for stability.

## So what does that all mean?

- SCC can "flow" to fill areas around dense reinforcement and through narrow openings under its own weight with minimal formation of voids, segregation or bleeding (PCI 2003)

## Brief History of SCC

- Evolved in Japan in the 1980's due to a shortage of skilled labor.
- Several European countries adopted it in the early 1990's.
- In the US, SCC's primary use has been in the precast industry for the construction of structural items.

## Present SCC usage, by other MidAtlantic States

- New Jersey -
  - Recently developed a specification for **precast** use.
- New York –
  - Used for **precast** last 2 years – must pass freeze thaw testing
  - Used for **prestressed** beams – must meet stringent HPC criteria
- Virginia
  - Used on two research projects (**prestressed** beams)
- Maryland
  - **Precast** concrete only this time. No formal specification.
- West Virginia
  - **Precast** concrete only at this time. No formal specification

*** Presently we are participating within PCEF QA subcommittee in developing SCC specification for all MidAtlantic States DOTs.**

## PENNDOT's Initial Use

New Enterprise Stone & Lime (2001)

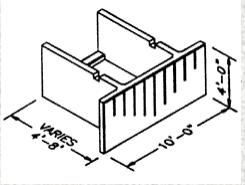
Pedestrian Bridge: Double T, P-T.

**PENNDOT Research project 2001-06**

- Significant qualification testing of mix design
  - Durability testing showed SCC would meet present criteria and provide long term durability.
- No formal ASTM or AASHTO test methods for slump, air etc. at that time.

## PENNDOT's Initial Use

- Schuylkill Products, Inc. (2003)
  - Evergreen Wall – Precast Wall System
  - District 5-0 approved use for this thin wall precast earth retaining system.




## PENNDOT's Initial Use

- Schuylkill Products Inc. – (2005)
  - Pennsylvania Infrastructure Alliance (PITA) & Lehigh University – ATLSS research center
  - Two PCEF Bulb Tee Girders- One SCC, One traditional
  - Beam properties and concrete analyzed, evaluated and compared.
    - **SCC performed as well as or better than the control beam produced with conventional concrete**
    - **The project developed a simple pull out test to confirm strand bond properties for SCC concrete.**

## PENNDOT Pilot program

- In November 2005, the Department initiated a pilot program permitting use of SCC for precast and prestressed concrete products.
- Only traditional ACI 211 and Bulletin 5 mixtures used – ie no high fine to total aggregate ratio designs
  - This decision was made to limit shrinkage, creep and elastic shortening, particularly for prestressed use.

## SCC Pilot Program

- Unlimited use for precast concrete
- Initially limited use for prestressed beams to four (4) projects
- Extensive Mix qualification testing required prior to use.

## 'Application' Requirements for SCC producers

- Interested producers were required to submit:

1. Producer's experience & use of SCC
2. Experience of QC staff in developing SCC mixes
3. Modified QC plan to address:
   a. Placement & finishing techniques (including vibration, if applicable)
   b. Condition of formwork
   c. Set time & application of cure
   d. Sampling & Testing

## Mix Qualification Testing

**Precast and Prestressed Concrete:**

- Compressive Strength
- Air Content – Pressure Method
- Slump Flow (w/VSI) & J-Ring (2" max difference)
- Concrete Temperature
- Static Column Segregation
- Freeze/Thaw Resistance – (Min. Durability factor of 80)
- Hardened Air Analysis – ( info only - 3.5% entrained air)

**Prestressed Concrete and/or Box Culverts**

1. Rapid Chloride Permeability – (≤ 2000 coulombs)
2. Strand Bond Analysis- (Lehigh University test method)

## Production Tests

1. Compressive Strength
2. Air Content – Pressure Method
   - Pilot Specification: 7 ± 2%
     - Lower limit and range increased based on research
3. Slump Flow (w/VSI) and J-Ring
   - Pilot Specification: 20-30"
     - Below 20", high slump concrete
     - Above 30" usually not stable
   - J-Ring within 2" of slump flow
     - > 2" indicates blocking potential
4. Concrete Temperature

## Strength and Plastic Air tests

- Cylinders are made the same , except they are filled in one lift and NO rodding or vibrating is allowed.
- The base of the air meter as well is filled in ONE layer instead of three. NO rodding or vibration

## Slump Flow (w/ VSI)

- Slump cone can be used either in the "normal" position or it can be "inverted."
- Slump Cone is filled in ONE lift.
- Wait for concrete to stop flowing; measure the largest diameter of resulting circular spread.
- Measure a second diameter of the spread at an approximate perpendicular angle to the original measured diameter. Slump Flow = $(d_1 + d_2)/2$; reported to nearest ½ in.

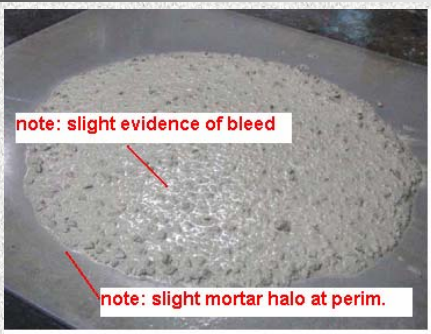
## Visual Stability Index Values

Specification has pictures and descriptions –
VSI= 0, 1, 2 or 3. Pilot Specification: VSI= 1 (max)


VSI = 0; Highly Stable

No evidence of segregation or bleeding in the slump flow spread

## Visual Stability Index Values




VSI = 1; Stable

No evidence of segregation. Slight bleeding observed as a sheen on slump flow spread

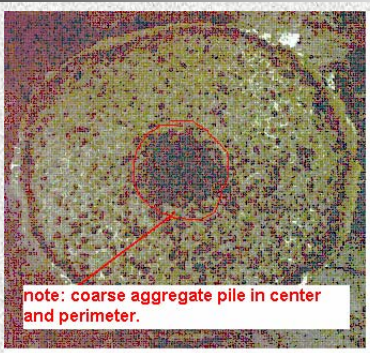
# Visual Stability Index Values


VSI = 2; Unstable

A slight mortar halo ≤ 0.5 in. and/or aggregate pile in the slump flow spread

# Visual Stability Index Values

Spec – VSI 0 to 1 Max.




VSI = 3; Highly Unstable

Clearly segregated by evidence of a large mortar halo > 0.5 in. and/or a large aggregate pile in center of the slump flow spread

## J-Ring

- Determines the "passing" ability of SCC Mixes.
- Conducted same way as Slump Flow Test except the cone is placed inside the "J-Ring."
- J-Ring Flow = $(d_1 + d_2)/2$; reported to nearest ½ in.
- Spec: – within 2" of slump flow


## Future Actions –

- Meet with industry producers who used SCC and other business partners to develop final specifications and test methods.
  - PTM's may be required until ASTM and AASHTO specifications are available.
- Pilot period will be extended until final specifications are developed
  - Anticipated March 2007
  - Provide continuity via Standard Special Provision until Pub. 408 changes are effective.

## .....now on the Industries perspective

- Please hold your questions until the conclusion of this two part presentation.