Interim Guidelines for the Use of Self-Consolidating Concrete in PCI Member Plants

Prepared by
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In early 2002, a request was made by the PCI Plant Certification Committee to the Technical Activities Committee (TAC) to provide more guidance to precast/prestressed concrete producers on the use of Self-Consolidating Concrete (SCC). The result of that request was that TAC formed a FAST Team to address this subject and charged the Team to develop guidelines on SCC for industry use. The result of that effort is this committee report.

The Interim Guidelines for the Use of Self-Consolidating Concrete (SCC) in Precast/Prestressed Concrete Institute Member Plants is now available from PCI Headquarters. In addition, one hard copy of these guidelines has been sent to the primary contact person in each Producer Member plant.

The FAST Team that was charged with the development of these guidelines included volunteer representatives of admixture suppliers currently active in the provision of admix-
industry standards setting groups are at least several years
precast concrete producer representatives that have direct
assist the precast/prestressed concrete industry in moving
experience in the development of SCC mixes and the use of
forward to responsibly incorporate the use of SCC in the
SCC in precast product manufacture, and representatives of
industry consulting engineering firms.
If SCC is being used in a plant or its use is being consid-
ered, the committee urges involved producers to obtain
copies of the SCC Guidelines, to study them and make them
available to plant personnel. SCC can bring important ad-
be superseded by industry consen-
sensus standards as they are published in the near future.

The guidelines address the use of SCC in PCI precast/pre-
stressed concrete manufacturing plant settings and reference
PCI plant quality manuals MNL-116-99, Manual for Quality
Control for Plants and Production of Structural Precast Con-
crete Products, and MNL-117-96, Manual for Quality Con-
trol for Plants and Production of Architectural Precast Con-
crete Products. Construction site use of SCC is not
addressed in these guidelines.

The goal of this document is to present the best available
information on SCC as it applies to current North American
practice. It is recognized that SCC practice is currently
evolving as experience with the material is gained in differ-
ing circumstances and for different purposes.

These guidelines have been additionally reviewed and
commented upon on an expedited basis by selected mem-
ers of the PCI Technical Activities Committee and the PCI
High Performance Concrete Committee.

The body of the SCC Guidelines consists of 93 pages sup-
plemented by 60 pages of appendices for a total of 153
pages.

The following are excerpts from the SCC Guidelines:

**DIVISION 1 – INTRODUCTION AND
GUIDELINES FOR SCC APPLICABILITY**

In the last several years, SCC has gained considerable at-
tention in the concrete industry. Some important questions
have been raised regarding this material:

- Is this a new building material or an extension of our ex-
isting concrete technology?
- What are the economics and advantages to the precast/prestressed producer? Is SCC for every producer?
- What levels of technology and skill are required to pro-
duce consistent quality SCC?
- What is Self-Consolidating Concrete (SCC)?

One definition of SCC is given below:

“A highly flowable, yet stable concrete that can spread
readily into place and fill the formwork without any consoli-
dation and without undergoing significant separation.”

[Khayat, Hu and Montyl]

In 1983, finding sufficiently skilled workers in Japan who
could construct durable concrete structures became an indus-
try-wide problem. One solution proposed was to develop
cement concrete that would consolidate under its own weight
require additional vibration or skilled workers to fully
consolidate the plastic concrete. Professor Hajime Okamura (University of Tokyo, now Kochi Institute of Technology)
originally advocated SCC in February 1986 and the first
success with the material was in 1988.

The ability of concrete to flow around and through rein-
forcement under only the energy of its own weight (without

- Filling ability (confined flowability) – The ability of
SCC to flow under its own weight (without vibration) into
and fill completely all spaces within intricate formwork,
containing obstacles, such as reinforcement.
- Passing ability – The ability of SCC to flow through
openings approaching the size of the mix coarse aggregate,
such as the spaces between steel reinforcing bars, without
segregation or aggregate blocking. (This property is of con-
cern only in those applications that involve placement in
complex shapes or sections with closely spaced reinforce-
ment.)
- Stability (segregation resistance) – The ability of SCC to
remain homogeneous during transportation, placing, and
after placement.

A concrete mix is classified as SCC if the requirements
for all three of the above characteristics are fulfilled. In in-
stances where passing ability is not a concern, this parameter
need not be addressed.

SCC has properties that differ significantly from conven-
tional high performance concrete. Thus, some auxiliary
tools, such as new characterization and quality control tests
and procedures that are adapted to the special properties of
the material, are needed.

It is recognized that currently, there are committees
within the American Concrete Institute (ACI), the American
Society for Testing and Materials (ASTM), and possibly
other organizations in North America that are working on
definitive consensus standards for this material. It is also
noted that the finalization of standards from the traditional

- Stability (segregation resistance) – The ability of SCC to
remain homogeneous during transportation, placing, and
after placement.
vibration) without creating blockage is referred to as the passing ability of the mix. This capability, in conjunction with the absence of the noise associated with vibration within a precast/prestressed concrete plant, creates new production opportunities.

SCC is a high performance concrete in the plastic state. It takes less energy to move the material (lower shear stress) (viscosity) and should not separate or segregate. A material that takes less energy to move will require fewer workers or finishers to produce a quality precast/prestressed concrete unit. SCC has the potential to allow reallocation of manpower and increased production with existing resources.

When SCC is placed in a form, its motion may be a creeping movement or a rapid flow. Because of this style of flow, the surface finish between the form and the concrete can be exceptionally smooth, creating a much-improved form finish over conventional concrete. To take advantage of the properties of SCC, new production considerations come into play. For example, an important factor in capturing the finish advantages is the type of form oil used, as this can significantly affect the surface finish.

Demanding form configurations, irregular shapes, thin sections, and heavily reinforced elements can be produced with confidence using SCC. Producing concrete without vibration results in a greatly improved work environment in the plant. Safety hazards are also reduced in the plant, as use of SCC minimizes the need for workers to walk on the top of the form, and eliminates the cords and hoses associated with concrete vibrators. It has been reported that worker absenteeism and accidents have both seen significant reductions when SCC has been introduced into precast production activities.

Concrete forms also benefit from lack of vibration with increased life cycle. Typically, form vibration is one of the elements that lead to form damage, associated repair requirements, and ultimately to form replacement.

1.2 Product Applicability

What is the applicability of SCC? Where can it be used?

Technically, SCC has many advantages over normal production concrete used in precast/prestressed concrete plants. It is well suited for producing both vertical and horizontal components with block-outs and crowded reinforcement. SCC is applicable for production of architectural and textured surfaces. Some precast plants are reporting using SCC in nearly 100 percent of their production and expect further opportunities for SCC with the industry acceptance of an SCC specification.

SCC will require a higher level of quality control, a greater awareness of aggregate gradation, mix water control, and the use of highly advanced high-range water-reducing admixtures and/or viscosity modifiers.

When looking at SCC costs and benefits versus those of conventional concrete, economic analysis should not be restricted to the material cost of the mix alone. The benefits of SCC will filter throughout a plant with savings in production labor, greater form life, fewer bug holes, less patching, improved work environment and the opportunity of changing production methods by eliminating vibration.

Using SCC in plant production provides the opportunity for improved, more efficient operational procedures. An economic study of SCC use for a specific plant needs to span six months to a year to completely analyze the beneficial impact of SCC production, as modified production methods associated with the use of the material, will continue to evolve over time.

1.3 Changing Production Methods to Take Advantage of SCC Properties

It is expected that significant additional advantages will result from SCC usage as individual producers rethink their production methods in the context of the characteristics of SCC. For example, can the current methods of concrete transportation within the plant be changed to take advantage of the ease of placing SCC? Can the methods of forming and securing internal reinforcement and hardware be revised because they do not have to withstand the forces associated with the vibration/consolidation process?

Can the time associated with concrete placement be reduced, thus allowing more time in the daily cycle for other things? Can more time be made available for curing during the daily production cycle, thus reducing the need for accelerated curing? Are there elements of the current plant layout that the use of SCC will allow to be made more efficient? Can labor be allocated from placement activities to other important activities allowing improvements in efficiency and quality?

1.4 Potential New Product Applications for Elements Cast from SCC

An important aspect of the design of many current precast elements is the ability to place and consolidate concrete within the form and around the internal reinforcement, prestressing strand, and hardware that are incorporated within the element. In some cases, this includes providing space for the insertion of internal vibrators and assurance that there is sufficient space to allow concrete flow. Can the increased flowability of SCC ease any of these constructibility requirements and can element shapes be changed to advantage (made more efficient) as a result?

Can smaller diameter reinforcement on a smaller grid spacing be used to advantage to develop thinner sections that still provide adequate strength and serviceability? Can high strength composite materials be used in combination with thinner sections to produce high value products that are now produced by other segments of industry? SCC may allow the development of new manufacturing processes that can be used to produce new classes of precast concrete elements.

A wide variety of architectural finishes can be accomplished with SCC. As with any new concrete mix, the procedures to attain desired finishes must be developed for new SCC mixes.

If surface finish quality were to be dramatically improved through use of SCC, what new high value products could the precast industry produce? Some examples might be
The first level is that associated with laboratory testing of the mix to determine the initial mix characteristics and confirm the hardened properties of the basic mix design.

The second level of testing is the qualification testing necessary to qualify the mix in the production environment. This level includes qualification of the batching process, the mixing process, the transportation and placement process, and finally the finishing and curing process.

Finally, the third level of testing is that associated with the quality control of the fresh SCC and the confirmation testing to confirm the hardened properties of the SCC.

These levels of testing are schematically shown in Fig. 3.1.1.

**CONCLUDING REMARKS**

SCC appears to have significant potential for its use in the precast/prestressed concrete industry. As with any new material, there are material properties differences and production process differences that must be understood and appropriately addressed in both design and production activities.

The development and distribution of the PCI SCC Guidelines is one step in furthering the understanding of this material that will allow its appropriate use in the production of high quality precast/prestressed concrete products that meet all of the needs of the industry’s many and varied customers.