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Field Measurements of Form Pressure Exerted by Self-Consolidating Concrete

ACI Spring 2013 Convention
April 14 - 16, Minneapolis, MN

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Field Measurements of Form Pressure Exerted by Self Consolidating Concrete

presented by
Eric Peterson, Sr. Superintendent, Webeor Builders

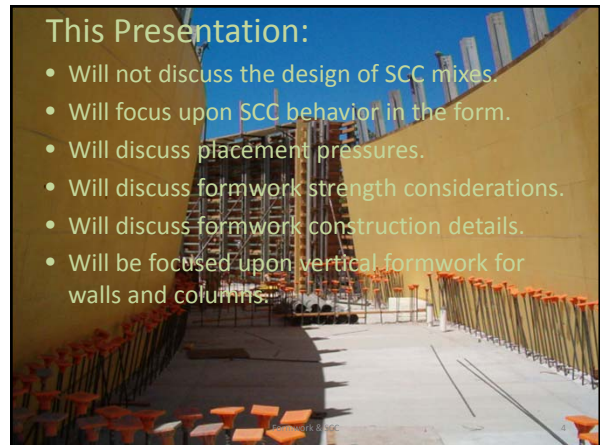
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Field Measurements of Form Pressure Exerted by Self Consolidating Concrete
Sponsored by Committees 237, 238 & 347
April 14, 2013 – ACI Spring, 2013 Convention

SCC Formwork Considerations and Precautions at the Job Site
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Adapted & Presented by
Eric Peterson, Sr. Superintendent, Webeor Builders

Formwork & SCC



This Presentation:

- Will not discuss the design of SCC mixes.
- Will focus upon SCC behavior in the form.
- Will discuss placement pressures.
- Will discuss formwork strength considerations.
- Will discuss formwork construction details.
- Will be focused upon vertical formwork for walls and columns.

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What is Self-Consolidating Concrete?

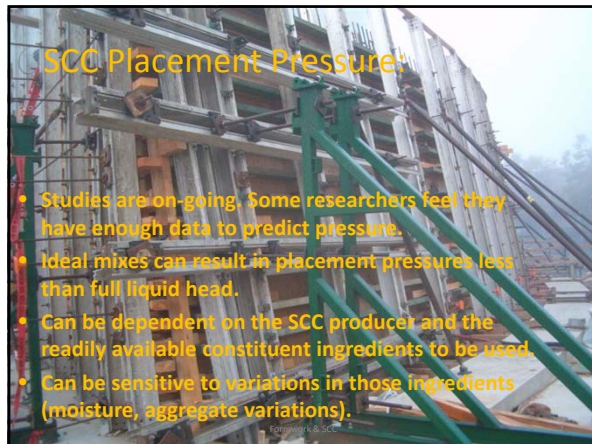
- A very fluid concrete mix. Flows into place in the form with no additional assistance.
- A mix with paste properties such that the aggregate neither sinks or floats to the top.
- Develops an internal molecular structure that can inhibit an increase in form pressure as the height of concrete in the form increases.
- If agitated, can return to a highly fluid state.

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Desirable Properties of SCC from a formwork perspective:

- Rapid internal structure build-up.
- Robustness, i.e. consistent behavior load-to-load and day-to-day.
- Remains consistent from truck to point of placement.
- Not adversely affected by placement method, or is predictably consistent at the point of placement.

Formwork & SCC 6

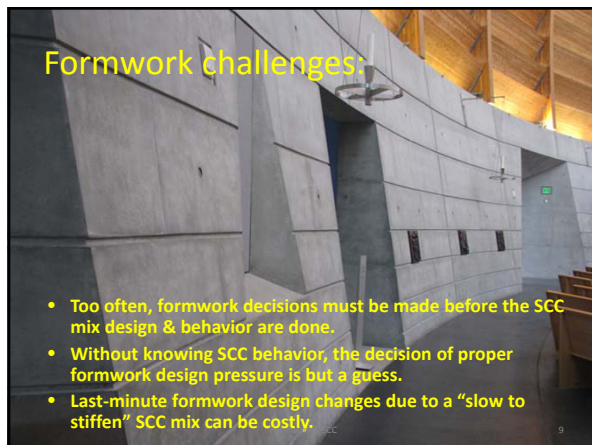


SCC Placement Pressure:

- With an unknown mix behavior, the design placement pressure should be full liquid head.
- Mix design & testing should be done well in advance of a major application of SCC (see formwork challenges).
- Can be indirectly monitored on-site with simple instrumentation. Desirable with an unknown mix.

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8

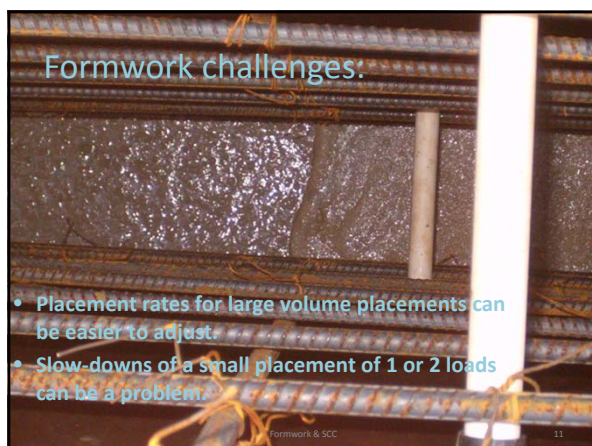


Formwork challenges:

- If an SCC mix is slow to develop its internal structure (or to "stiffen"), placement rates must be reduced to keep below the design placement pressure.
- This can impact the supply "train", reducing the frequency of delivery or possibly causing concrete to remain in the truck too long.
- Placement size (volume) can help or hinder.

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10

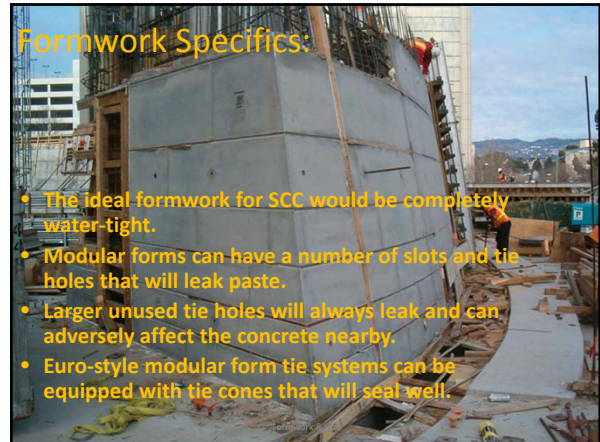
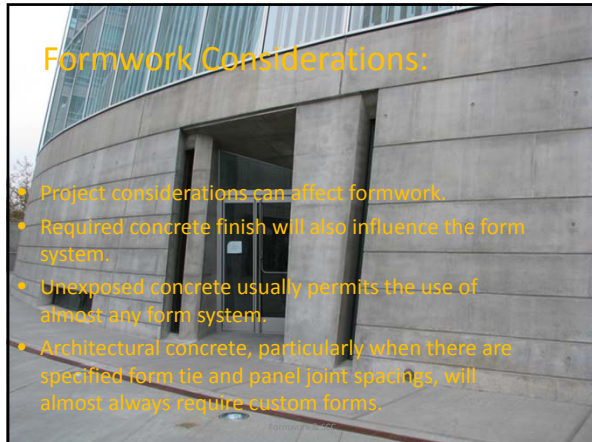


Formwork Considerations:

- Design placement pressure has an effect on the economics of the form system.
- Modular forms from rental stock have a "standard" rated safe placement pressure.
- Pressure ratings vary from 1,000 pound per square foot (PSF) to 1,500 PSF.
- Forms with higher safe placement pressure exist but are not always readily available.

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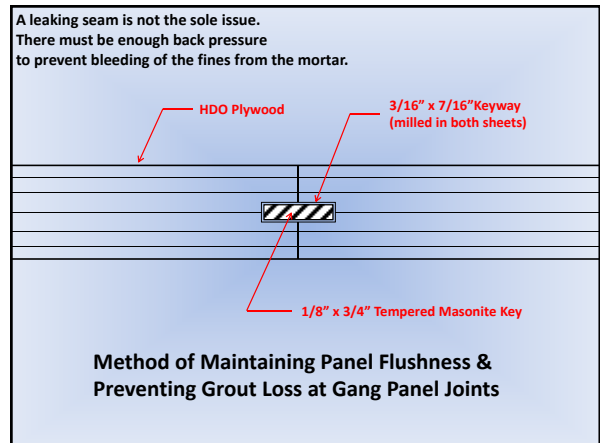
12



Formwork Specifics (panels):

- Modular forms' panel-to-panel joints can leak paste, depending on the style of form.
- Earlier U.S. style panels (Moduform, Steel-Ply, etc.) have a number of tie and hardware slots that will leak paste.
- Installing gaskets between these form panels is possible, but very labor intensive.

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Formwork Specifics (panels):

- Euro-style modular forms' panel-to-panel joints may minimally leak paste.
- Most all Euro-style form panels have tie locations away from the edges of a panel.
- In most applications of Euro-style panels all tie holes are used. Plug any unused tie holes. Use tie cones that seal well against the form face.

Formwork & SCC 17





Formwork Specifics (all styles):

- Forms should be set against or on sills (or kicker) that have been sealed to the underlying footing or slab.
- Seals (foam tape or caulk) should be applied to the sills immediately before setting forms.
- Ideally, the forms for the exposed wall face should be set first to provide access to both sides of the formwork.

Formwork & SCC 20

Formwork Specifics (all styles):

- SCC will mirror every imperfection in the form face.
- Do not permit nails to be used to locate & space reinforcing bars, as the holes will be reflected in the concrete when the panel is next used.
- Consider the attachment methods to be used for any required embeds. Ideally, they should be fastened from the back side of the form.

Formwork & SCC 21



Tips for Preventing Bleeding at Bottoms of Forms & Panel Seams

- Put 2"x4" down boards around wall or column forms flat on surface of concrete – don't lap at corners – 2"x4"s should extend full length of form.
- Hold bottom of column or wall form studs up just enough to clear bottom down-board;
- For Architectural work, stay away from spray foam; → Foam is no substitute for sloppy carpentry
- Assure straightness and parallel of panel edges during fabrication;
- Use of foam tape must be accompanied by adequate pressure to maintain position and seal;
- Use of down-boards, with gasket material beneath them, fastened to the floor, is a good method of blocking leakage from gaps beneath vertical formwork:

- During architectural placements keep what is needed to stop leaks close at hand;
- Use a form tie which seals the drilled hole around the tie;
- Back-up gang to gang seams;

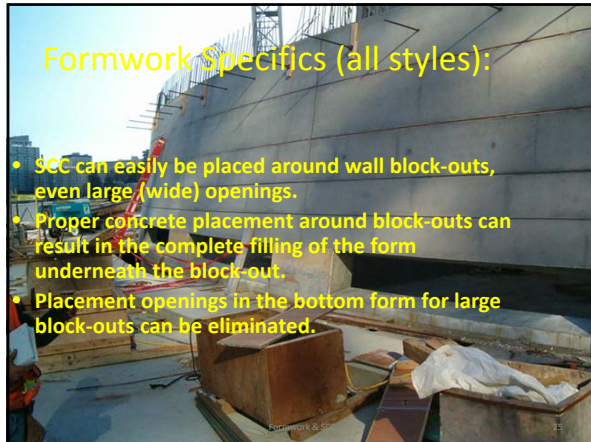
Formwork Specifics (all styles):

- Reveals, recesses and openings can be problematic when sharp, crisp corners are expected.
- These items can accumulate form release agents in the corners which can weaken the surface of the concrete.
- Forms must be carefully separated from the concrete to avoid chips & spalls on sharp corners.

24

Formwork Specifics (all styles):

- SCC can easily be placed around wall block-outs, even large (wide) openings.
- Proper concrete placement around block-outs can result in the complete filling of the form underneath the block-out.
- Placement openings in the bottom form for large block-outs can be eliminated.



Formwork Specifics (form ties):

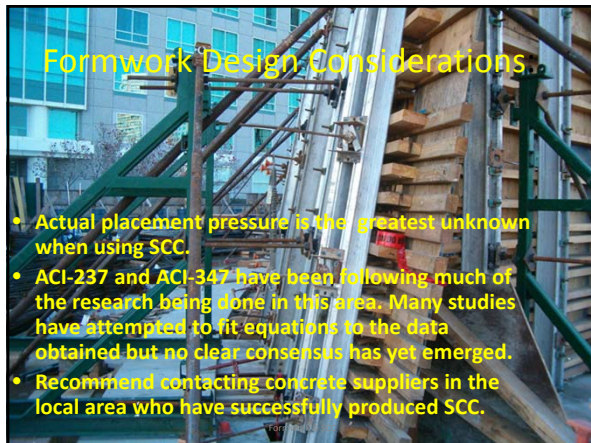
- Standard cone type rod ties for older U.S. style modular panels may leak a bit. Modular panel joints should be gasketed with foam tape.
- Euro-style modular panels and custom built gang panel can use coil ties with cones or thru rods (coil rod or Dywidag rod).
- Sealing cones with PVC pipe spacers are recommended for thru rods (see LinerCone - www.tsl.ca).

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25

Formwork Design Considerations

- Actual placement pressure is the greatest unknown when using SCC.
- ACI-237 and ACI-347 have been following much of the research being done in this area. Many studies have attempted to fit equations to the data obtained but no clear consensus has yet emerged.
- Recommend contacting concrete suppliers in the local area who have successfully produced SCC.



Formwork Design Considerations:

- Form failures using SCC typically occur because of overloaded ties, poorly constructed job-built fillers, bulkheads or corner conditions.
- Failures (aside from ties) are usually unstoppable leakage of the paste requiring that the placement be halted until the formwork is repaired.
- Job-built items such as bulkheads, fillers, pilasters and non-standard corner condition require careful attention to detail.

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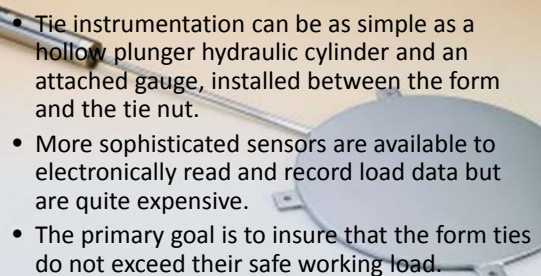
28

Formwork Design Recommendations:

- Establish a reasonable design placement pressure based on the SCC mix history.
- For job- or shop-built gang panels, consider
 - designing the form facing for full liquid head.
 - designing the studs and the strongback/walers for the expected SCC pressure.
- Consider instrumenting some ties to document actual placement pressure.
- Placement rate can be slowed if excessive tie loads are observed.



Formwork Design Recommendations:

- Tie instrumentation can be as simple as a hollow plunger hydraulic cylinder and an attached gauge, installed between the form and the tie nut.
 - More sophisticated sensors are available to electronically read and record load data but are quite expensive.
 - The primary goal is to insure that the form ties do not exceed their safe working load.
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30

Formwork Design Recommendations:

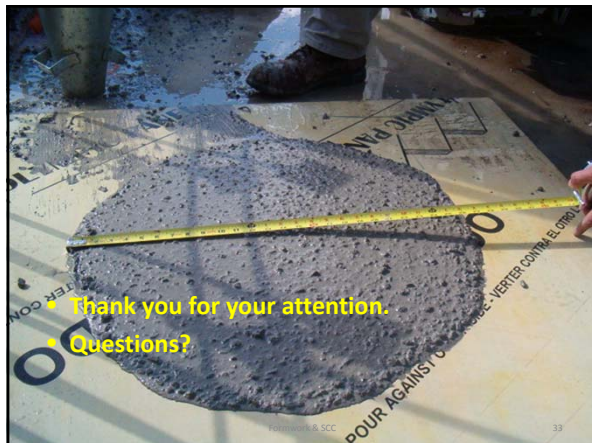
- Column forms are usually filled quite rapidly and very seldom will a placement rate restriction be followed.
- As such, column forms for SCC should be designed for full liquid head.
- Columns with large plan dimensions (see ACI 347 2.2.2.1.3) may be designed for less than full liquid head if an appropriate placement rate can be held.

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31

Formwork Design Recommendations:

- For column forms, consider the following:
 - A readi-mix truck will contain about 8 yards.
 - Most placement methods can empty the truck in an hour.
 - A 24" square column using 8 yards of concrete would be 54 feet tall, for a placement rate of 54 feet per hour.
 - A 72" square column using 8 yards of concrete would be 6 feet tall, for a placement rate of 6 feet per hour.
- The point: column concrete placement rates rarely conform to a specified value.



- Thank you for your attention.
- Questions?

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33