PCI Plant Quality Talk Series 1
Quality Enhancement Committee

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PLANT TOOLBOX TALKS – SERIES 1

Over the course of producing quality precast concrete members throughout the year, it is necessary to take a moment to reflect on the right ways of doing things. Taking time on a regular basis to consider some quality-control-related topics and production best practices will help continually improve the culture of quality at a production facility.

Use the following Toolbox Talks at least once a month to discuss quality with your production teams. All of the topics included here may not directly relate to your production practices. You are not limited to the topics herein; feel free to use this format to generate toolbox talks that may relate more directly to your needs.

Be sure to keep a record of this training.

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SERIES 1, ISSUE 1 – ACCELERATED CURING

Accelerated curing is advantageous when early strength gain is important or when additional heat is required to sustain the hydration reaction. Accelerated curing may reduce costs and save time to better meet precast concrete production demands and finished product quality. The best way to implement accelerated curing is by adding heat to the precast concrete component while reducing water evaporation through the use of steam, mist, or product tarps.

Common Issues

- If the precast concrete members are not fully covered during accelerated curing, there will be uneven heat distribution and therefore uneven strength gain.
- If the concrete heats up too fast, it may not gain the intended 28-day compressive strength.
- If heated too fast or at a very high temperature, the long-term durability of the concrete will suffer (see information on delayed ettringite formation).

Best Practices

- Fully cover production beds.
- Store compressive strength test cylinders with the pieces.
- Do not exceed 104°F before the concrete has achieved initial set (see QC for initial set time of each mixture).
- After initial set, the internal concrete temperature may ramp up 34°F per hour.
- The maximum internal concrete temperature should be 158°F for straight cement mixtures and 180°F with the proper use of SCMs (Supplementary Cementitious Materials).
- Cool-down should not be more than 50°F per day or 5°F per hour.

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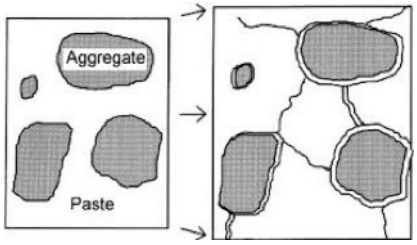
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SERIES 1, ISSUE 2 – DELAYED ETTRINGITE FORMATION

Delayed Ettringite Formation (DEF). Sulfate compounds react with calcium aluminate in cement to form ettringite within the first few hours after mixing with water. If concrete is exposed to high temperatures during curing, the ettringite can dissolve and later reform when exposed to moisture, creating expansive forces within the concrete.

Common Issues

- Expansion and cracking can occur in concretes of particular chemical makeup when they have achieved high temperatures soon after placement (about 160 to 210°F).
- This delayed expansion is characterized by expanding paste that becomes detached from various components of the mixture, creating gaps at the paste-aggregate interface. The gap can then be filled with larger ettringite crystals.



Best Practices

- Use sound (proven) aggregate.
- Cure below 158°F for straight cement mixtures and below 170°F for SCM (Supplementary Cementitious Material) mixtures, after initial set (104°F max. during initial set).
- Use SCMs to mitigate the reformation of ettringite.

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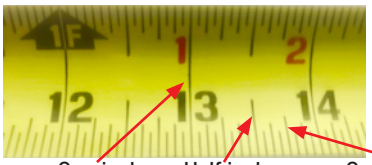
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SERIES 1, ISSUE 3 – HOW TO USE A TAPE MEASURE

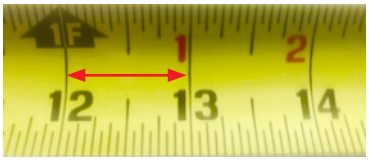
How to Read a Tape Measure

A tape measure is a type of flexible ruler that can be made from a variety of materials including steel, plastic, and cloth. Tape measures come in both imperial units (inches and feet) and metric (centimeters and meters), and have unit breakdowns for further accuracy. The following guides showing how to read a tape measure assume imperial units.

On a standard tape measure, the biggest marking is the inch mark. As the increments get smaller, so does the length of the mark. For example, ½ in. has a bigger mark than ¼ in., which has a bigger mark than ⅛ in., and so on.



The space from the largest mark to the next one is one inch.



Reading one-half inch is the same as reading one inch, only the space between the second-biggest mark and the biggest mark is read. Think of a half-inch mark as halfway between a full inch.

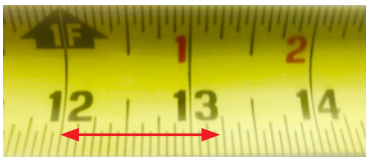


The remaining markings follow a similar pattern: ¼ in. is half of ½ in.; ⅛ in. is half of ¼ in. Most tape measure markings go as small as 1/16 in.

How to Measure Using a Tape Measure

Measure a length by putting the end of the measure at one end of the length you want to measure and keep the tape measure tight, with no sagging. Then take a reading on the tape measure.

To determine the accurate length, read the length in feet and/or inches and add any remaining fractions of an inch. For example, to determine the length shown in the image below, you would add 1 in. + ¼ in. to get 1¼ in., or "one and a quarter inches."



As another example, the image below shows a length that goes from the inch mark to one of the smallest markings, which are sixteenths—there are 16 of these increments per inch. To measure this length, count all the sixteenth markings or larger to get 13/16 in.



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Note to instructor: Try measuring the following lines with your crew to get a sense of their grasp of the subject.

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SERIES 1, ISSUE 4 – STRESSING OPERATIONS (SINGLE STRAND)

Stressing strand is of great importance to the production of prestressed concrete members. It is important to be accurate in every part of the stressing operation.

It is necessary to record the strand elongation and force for each pull. During stressing, the jack must be level with the strand and chucks must be clean. Chucks can only be used once before cleaning. Never hit a chuck with a steel hammer. If casting indoors and the strand is stored outside, when ambient temperatures drop more than 25°F below the anticipated fresh concrete temperature, the coil packs need to be brought in at least 24 hours before use, or a temperature correction should be made to the calculations if using an abutment bed (no correction is required for self-stressing forms). When using forms with abutment jacking systems (not self-stressing systems), a force and elongation adjustment must be made when the strand and concrete temperatures differ by 25°F or more (PCI MNL116 and 117, 5.3.11-5).

Common Issues

- Data for force not documented for each pull
- Data for elongation not documented for each pull
- Stressing jack not level when pulling
- Defective chucks

Best Practices

All employees should be trained in operation procedures for the following:

- Coil pack usage and storage
- Data recording for all stressing operations
- Chuck cleaning and inspection process
- Proper operation of stress jacks and rams

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SERIES 1, ISSUE 5 – STRAPPING DOWN LOADS

One of the most important jobs during loadout is making sure the proper strapping of products is in place.

Proper strapping of products ensures not only the safe travel of the product but also protects the product from sustaining damage during transit. Spalling at strapping locations is one of the most common complaints of contractors when products arrive at the jobsite.

Best Practices

All employees should be trained in operation procedures for the following:

- Always be aware of your surroundings.
- It is the driver's responsibility to ensure that the load is strapped down correctly.
- Always use chain guards. Refer to the following images of incorrect and correct use of chain guards on a precast concrete member.



Incorrect strapping without chain guards



Correct strapping with chain guards



Incorrect—chain guard is loose



Correct—chain guards are firmly in place

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SERIES 1, ISSUE 6 – CEMENT BALLING IN CONCRETE MIXTURES

When batching concrete mixtures, sometimes some of the constituent materials do not get mixed in homogenously. Often this results in "cement balls": dry material that forms clumps during batching. These balls will result in a weakened concrete product and should be removed from the concrete if spotted. It is imperative to address the issue immediately.

Potential cause: Improper batching
Actions:

- Ensure proper material discharge timing.
- Ensure proper sequencing of materials:
  - Cement should ribbon in with aggregate.
  - Avoid putting all the water in up front.
  - Do not add high-range water-reducing admixture before the cement is wetted out.
- Increase mixing time.

Potential cause: Mixer condition
Actions:

- Clean any buildup in the mixer and on the mixing blades.
- Ensure all materials are introduced into the mixer at an even rate, not all at once.

Potential cause: Fiber
Actions:

- Make sure the timing of the fiber addition and mixing of fibers is per the manufacturer's recommendation.
- Consider placing the fibers on the aggregate belt for introduction to the mixer.
- Reduce rate of introduction.

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SERIES 1, ISSUE 7 – MAKING AND TESTING 4 × 8 CYLINDER SPECIMENS

The correct preparation and storage of cylindrical test specimens as per ASTM C31 and PCI requirements is an imperative step in the production of quality precast concrete members. The proper testing of cylinders and recording of compressive strengths as per ASTM C39 and PCI requirements is important as well. Cylinders are needed to determine when concrete has the required compressive strength to strip forms, and safety is of the greatest importance. If required, cylinders are used to determine 7-day strengths. They are also used to determine the 28-day compressive strength as per engineering design requirements.

Best Practices

Making 4 × 8 inch test specimens:

- Equipment needed: cylinder molds, scoop, $\frac{3}{8}$ in. diameter steel rod with hemispherical tip, flat level surface.
- Plastic single use molds can be reused a limited number of times; discard plastic molds if they lose their shape.
- Cylinder molds are to be lightly oiled so that the specimen can easily be removed from the mold.
- Take the concrete needed for the cylinders from the middle of the load after all water has been added. The minimum sample size is 1 ft^3.
- Put the concrete in the cylinder mold in two layers of equal volume.
- Each layer must be rodded 25 times, with the rod penetrating about 1 in. into the layer below.
- Each specimen is to be tapped 10 to 15 times with a rubber mallet or an open hand after rodding each layer.
- For self-consolidating concrete, fill the entire mold with concrete at one time with no lifts. Do not rod the concrete or tap the molds.
- Strike off the top of the cylinder.
- Finish the top of the cylinder to smooth the surface with a mag float or a steel trowel.

Storing specimens:

- Move the cylinders to their storage place immediately after finishing, keeping movement to a minimum.
- Once the cylinders have been placed in their curing spot, they are not to be moved until it's time to remove them from the molds.
- Store the cylinders in or on the form where the concrete they represent is being poured.
- Cover the cylinders in the same way that the concrete is covered.
- Handling of hardened cylinders is to be done with care to avoid chipping, breaking, or cracking.
- Remove the cylinder from the mold using air pressure applied to a small hole on the bottom of the mold, or remove the cylinder from the mold using a mold splitter.
- All cylinders must be marked with: job number, product type, mixture design number, cast date, 28-day test date, casting location.

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Compression testing of cylinder specimens:

- Turn on the compression machine.
- Check the condition of the neoprene pads. If they are in bad condition, immediately bring this to the attention of the lab technician to obtain new pads. Place the cylinder in the caps.
- Place the cylinder in the compression machine and center the cylinder in the compression machine with the top and bottom platens.
- Ensure the spherically-seated top platen is free to rotate and that the cylinder is perpendicular to the bottom platen.
- Run at full advance until the numbers on the display begin to climb; at this point turn the machine setting to metered advance.
- Continue to load the cylinder at metered advance until failure.
- The load on the cylinder is to be added at a rate of 28 to 42 psi per second.
- Read the number on the display. This number is in pounds of force and needs to be converted to pounds per square inch (psi).
- To convert the display reading to compressive strength in psi, the math is as follows:

$$\frac{\text{load}}{\text{area}} = \text{compressive strength in psi}$$

Example: Load reading = 48,500/area for a 4×8 in. cylinder = 12.57 in.^{2} (Area = πr^2)

$$\frac{48{,}500}{12.57} = 3858 \text{ psi}$$

- When the conversion is made, record the compressive strength in psi and the age of the concrete.
- For the release strength, break a second cylinder using the same procedure as the first, record the psi, and average the two tests. For the 28-day test, an average of three cylinders is necessary.
- If the compressive strengths are within the required range, the corresponding piece is safe to strip from the form. If the compressive strengths are not within required range, then a Quality Control Inspector is to be contacted and made aware of this critical situation right away.

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SERIES 1, ISSUE 8 – HANDLING EPOXY-COATED REINFORCING BAR

One method of preventing steel reinforcement corrosion in precast/prestressed concrete members is the use of fusion-bonded epoxy-coated reinforcing bar. There are some special considerations to take into account when working with epoxy-coated reinforcing bar.

Common Issues

- Epoxy coating gets scratched or chipped off of the reinforcing bar, creating a place for corrosion to begin.
- Epoxy-coated reinforcing bar is cut and the ends are not recoated, allowing corrosion to begin.
- Steel chains are used to lift epoxy-coated reinforcing bar, damaging the coating.

Best Practices

- When handling epoxy-coated reinforcing bar, take special care not to damage the coating.
- Use nylon strapping to ensure the coating is not damaged by cables or chains.
- Use multiple lift points so that bars are not allowed to sag and rub during handling.
- Epoxy-coated reinforcing bar needs to be stored separately from non-epoxy-coated reinforcing bar.
- Take measures to protect bars, such as storage on wood, plastic, or rubber-coated racks.
- Bars with damaged coatings need to be repaired using an approved repair material before being used.
- If stored outside, epoxy-coated reinforcing bar needs to be protected from direct sunlight. Ultraviolet light degrades the epoxy coating over time.
- When assembling reinforcing bar cages using epoxy-coated reinforcing bar, take care not to damage the epoxy coating.
- When tying cages, use PVC-coated tie wire (4.8.5 of referenced article).

Reference

CRSI product guide, *Specialty & Corrosion-Resistant Steel Reinforcement*.

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SERIES 1, ISSUE 9 – YARDING AND DUNNAGE

The use of dunnage and related storage practices are important to precast concrete. Proper dunnage and yard storage are needed to ensure the quality of precast concrete members. Failure to store products properly can lead to damage or can cause considerable amounts of field repairs. A proper storage plan and dunnage method are necessary to help maintain quality requirements.

Common Issues

- Improperly placed dunnage
- Using the wrong size dunnage
- Precast concrete member stacked incorrectly; dunnage not aligned
- Unlevel or soft ground for storage
- Lack of space
- Dirty dunnage, sap leaking, staining by water runoff from dunnage
- Cracks from poor-quality dunnage



Uneven stacking; dunnage not aligned



Misaligned stacking, tilted stack, and soft ground

Best Practices

- Two dunnage points, unless more are required by design
- Level bearing
- Clean dunnage, non-transfer dunnage materials (i.e. - products that do not leave marks on precast members)
- Adequate storage space
- Flat ground that is paved or graveled
- Grading the yard as required due to traffic or weather conditions
- Quality yard checks for compliance, conducted by Quality Systems Management Team

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SERIES 1, ISSUE 10 – EMBED PLACEMENT

Placing embeds is a vital part of the precast concrete production process. The location of each required embed is significant for the installation/connection of each precast concrete piece. Proper placement will help field crews maintain the erection schedule and contributes to the overall quality of the project. These connections are very important to the success of each project. Embed issues can create significant costs for the field when redesign and/or rework is required, and can cause delays.

Common Issues

- Embeds not in the proper location
- Embeds sunk into the concrete or moved off during casting
- Incorrect shop drawings, causing mislocated embeds
- Lack of consolidation around embeds (voids)
- Embeds missing
- Embed not level
- Lack of training of importance of embed location

Best Practices

- Use standard plates specific to certain product types.
- Shop drawings should provide special embed details with a dimensioned detail.
- Provide a drawing that contains all embeds needed for each piece.
- Have a quality system in place with pre- and post-pour checks for proper embed placement.
- Plant should provide standard work instructions for proper embed placement (refer to PCI MNL 135 for standard imbed tolerances per production type).
- Develop a standard practice to ensure there are no voids beneath the embed as it is being cast.
- Premount embeds whenever possible.
- Avoid placing embeds into concrete that has already begun to set.



Embed not flush with concrete surface



Embed not level

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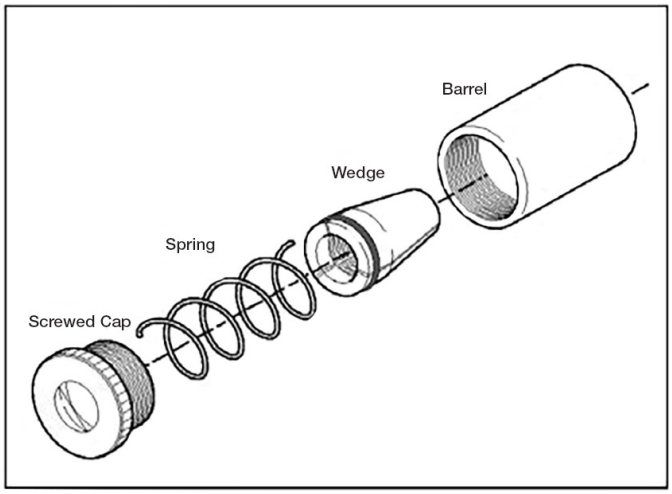
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SERIES 1, ISSUE 11 – CHUCK MAINTENANCE

Chucks are placed over both ends of the strands once they have been passed through the locating holes in the stressing heads/abutments. Used in combination they lock to grip the strand, holding the force on the strand throughout the rest of the production process. A dirty, cracked, or worn chuck can fail by allowing the strand to slip out of the anchor under load, with potentially catastrophic consequences.

Best Practices

- Wedges should be marked with the manufacturer's name, size, and, where space allows, the batch traceability marking. Barrels should have the manufacturer's name, maximum load rating, and batch traceability markings. The manufacturer's certificate of conformity to their inspection plan and quality management procedures should be available upon request.
- Components for different strand sizes or from different manufacturers must not be mixed; control systems should be in place to ensure that this mixing does not take place.
- The barrels and wedges should be stored in a dry atmosphere, away from moisture. The wear rate on a set of wedges should be equal. Stock rotation should be used to ensure even wear on the wedges.
- Chucks should be cleaned and inspected after every use. A competent employee should ensure that the barrels and wedges are cleaned, inspected, and lubricated using the correct lubricant. When cleaning, care should be taken to remove any dirt from the teeth and on the segment joining faces, as this will affect the performance. Wedges are normally supplied with a rubber O ring to hold the segments together. It is important that these are fitted and in good condition to help align the wedges during use.
- Chuck maintenance should be carried out regularly and consistently in an area away from production to prevent mixing clean chucks with dirty ones. Inspection of the barrels and wedges must be carried out in good light with the aid of a magnifying glass. Rejected items must be removed from production immediately to prevent their reuse.



Enclosed Barrel Wedge

- The chucks should always have a cap and spring. The spring puts equal pressure on the wedge segments while the strand is pulled through. Without the spring, the wedge segments could seat unevenly, potentially resulting in strand slippage or failure. Stressing against a chuck without a cap could damage the chuck body and increase the chances of having misaligned jaws. Some chuck designs do not include a cap and spring. Typically, this type of chuck is only used at the dead end of the bed.
- Never strike a chuck with a hard object such as a steel hammer, reinforcing bar, or chunk of concrete. This will damage the chuck body or cap, making it even harder to get off the strand the next time. This cycle will continue until the chuck is unusable.

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- Tumblers can be used to clean chuck bodies and wedges. If they are used, be sure to never use hard media such as ceramic beads, glass beads, or sand. These will wear the components rapidly. Use natural media instead, such as walnut or pecan shell or ground corn husk. An inspection of the teeth on each jaw should be conducted if tumbled to ensure a good gripping surface.

A more detailed article on strand chuck use and maintenance is given in the appendices of PCI MNL 116 and 117.

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SERIES 1, ISSUE 12 – DETENSIONING

The term "detensioning" refers to the removal of tension in the uncast portions of strand. It occurs once the transfer strength of the concrete has been achieved. The process can be a high-risk activity, so care is necessary and normal stressing precautions need to be taken. Prestressing of concrete members requires cutting or releasing of the tensioned strands outside the ends of the member, which transfers the load in the strand from the anchoring abutments to the concrete.

Best Practices

- Detensioning must not be done until the required minimum compressive strength has been reached.
- Detensioning where the strands are cut with a gas torch or other mechanical cutter should be carried out with care because the unrestrained ends of the strands have a tendency to retract suddenly and splay out in an unpredictable way. Extreme care must be taken when cutting strands; employees should be positioned so that the retracting wires will not strike them upon release.
- The strands should be detensioned in a side-to-side symmetrical pattern about the centerline of the strand pattern.
- The top strand should typically be detensioned first. (Depressed elements may require a special detensioning sequence.)
- The same strand between all panels (full length of the form) should be cut at the same time and manner.
- Detensioning sequences should be listed on the shop drawings or available from QC.
- Cutting is done on each strand simultaneously at both ends of the prestressing bed and preferably at all spaces between the ends of adjacent members. Where spaces between the ends of adjacent members are short, simultaneous cutting at all spaces between members may not be required; however, any cutting must be done according to the approved sequence.
- When detensioning is done with a cutting torch, the flame should initially be applied over several inches of the strand. The strand should be heated in such a manner that the individual wires fail distinctly and independently. If multiple wires fail simultaneously, the strand was heated too quickly.
- Detensioning should take place while the member is still warm and moist. If the concrete is permitted to dry and cool before detensioning, dimensional changes take place that may cause cracking in the concrete due to restraint. This is especially true if hold-downs are used to deflect strands. Therefore, detensioning should be done immediately following the curing period and when test cylinder strengths indicate that the required minimum compressive strength has been obtained.

Multiple Strand Release

- The strands may be released simultaneously by hydraulic jacking.
- The total force is taken from the header by the jack and gradually released.
- Minimal sliding of the members on the bed may occur.
- Structural members stressed by this method are required to be free from all restrictive movement, other than sliding friction on the bed.

Draped Strands

Unless the plans or specification indicate otherwise:

- Release the tension in the strands at the ends of the structural member(s) by heating each strand until failure. The strands are cut using heat in accordance with the approved sequence.
- All hold-down devices for the draped strands are released and the hold-down bolts within the members removed, typically before any detensioning occurs.

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