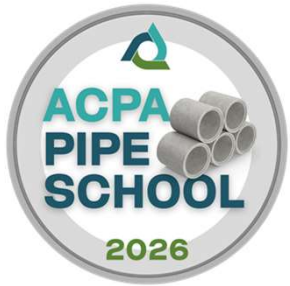
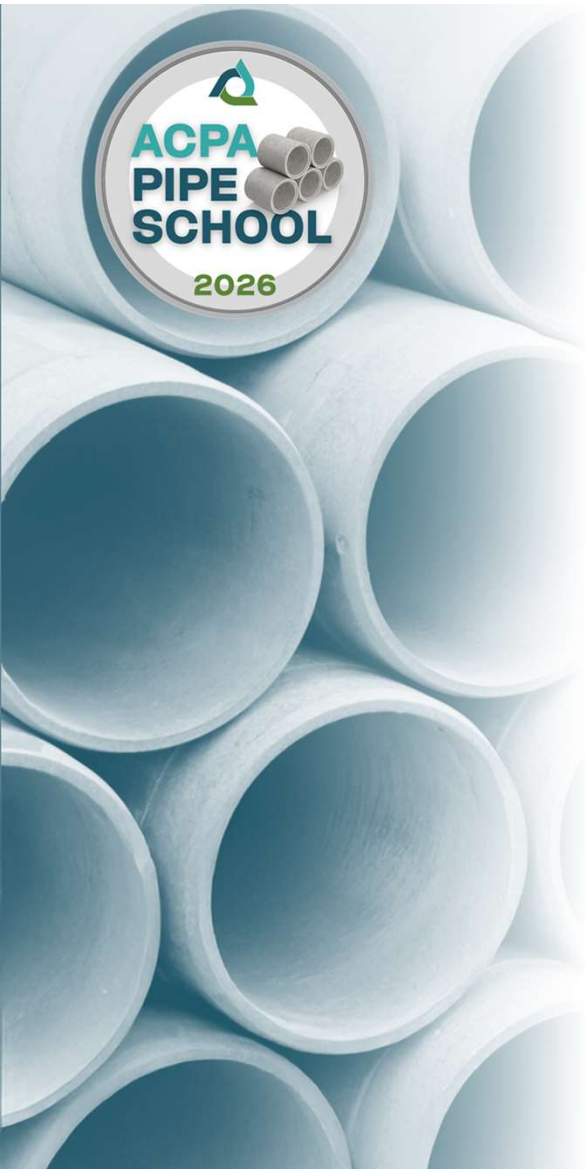


 **ACPA**



Box Culvert Production

Larry Neumann
Mike Lutrick
Jake Jyrkama



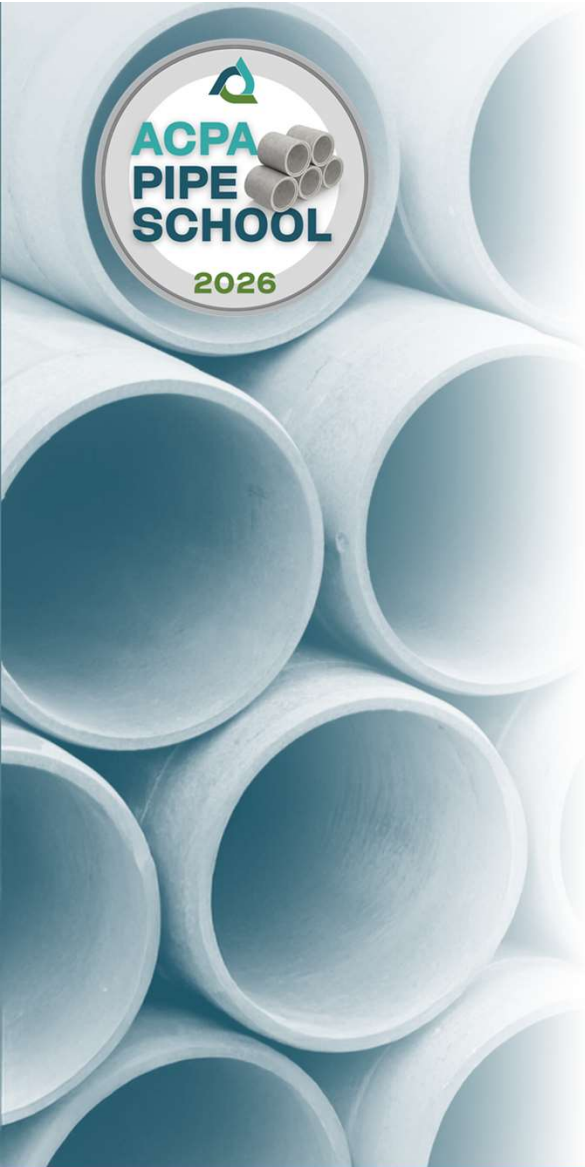
Outline

- Equipment
- Pre-Pour
- Filling and Vibrating
- Curing
- Post-Pour
- Handling
- Shipping



Equipment

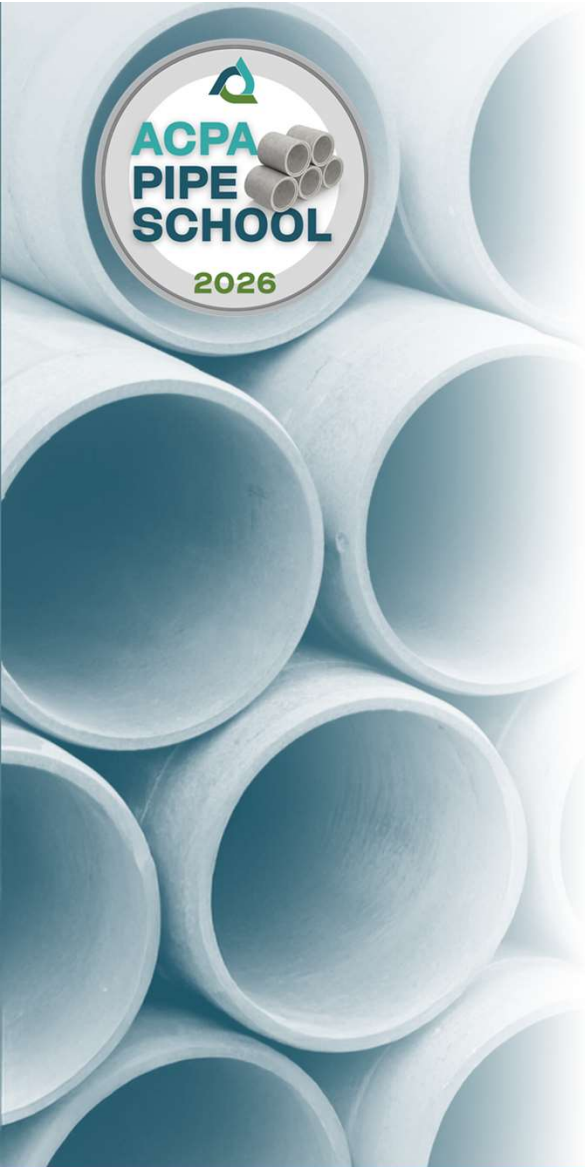




Taking Care of our Equipment is Critical

- For everyone's safety
- Dimensional accuracy of the product
- Ease of assembly
- Service life of the form work
- Formwork is expensive

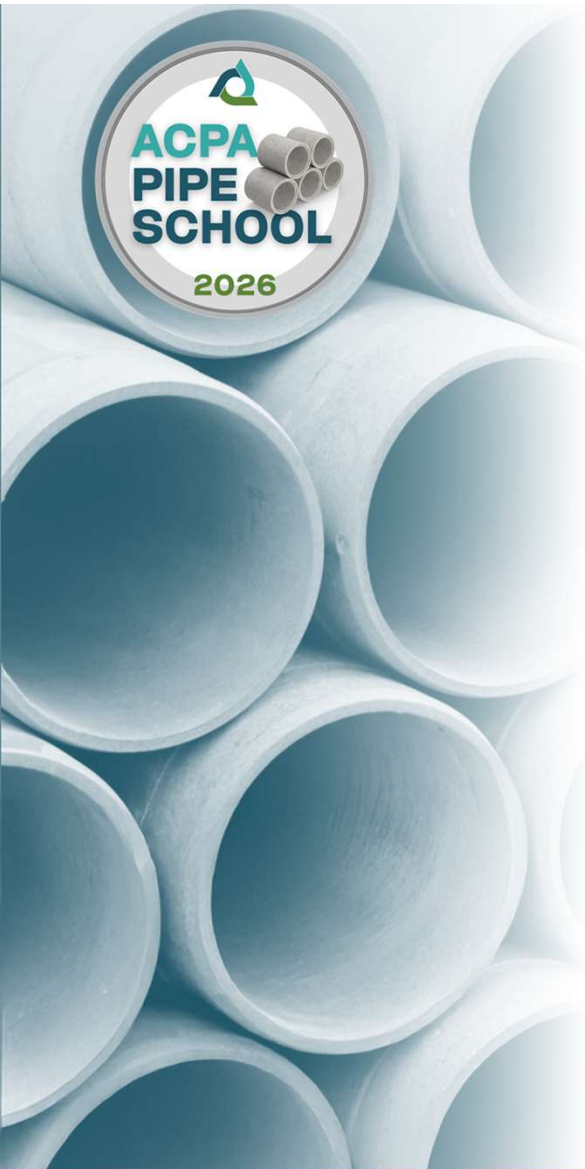




We should first and foremost focus on....

Safety!!!

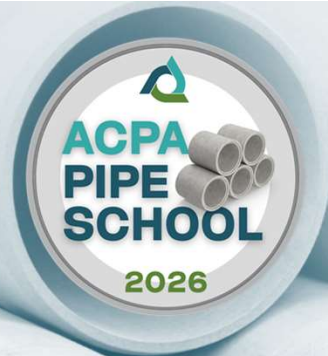




Proper P.P.E.

- Steel Toe **BOOTS!**
- Hard hat
- Safety Glasses
- Gloves
- Hearing protection
- High Visibility clothing
- Grinding shields
- Welding hoods





Safety

Inspect lifting devices, lift holes, rigging and hardware on a regular basis





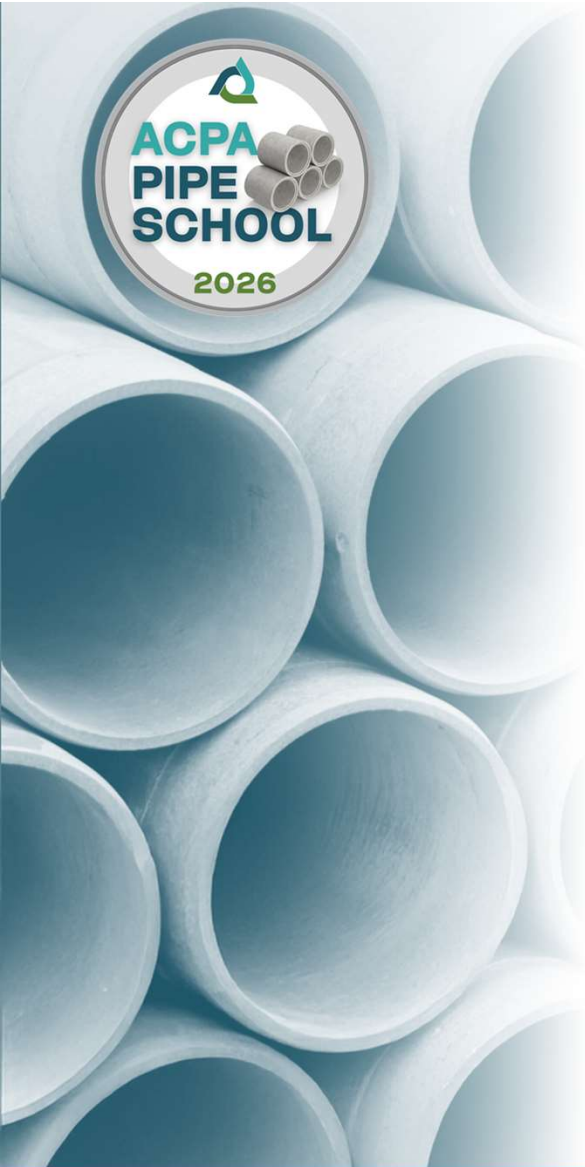
T02
G48100

T05
G49141

T06
G49149
G49160

T08
G49002





Equipment Storage



Storing Box Culvert Form Work

- Neatly stacked
- Stored flat
- Organized
- Use dunnage
- *Stored smooth side up*
- **Put away clean**
- Maintenance done before storing

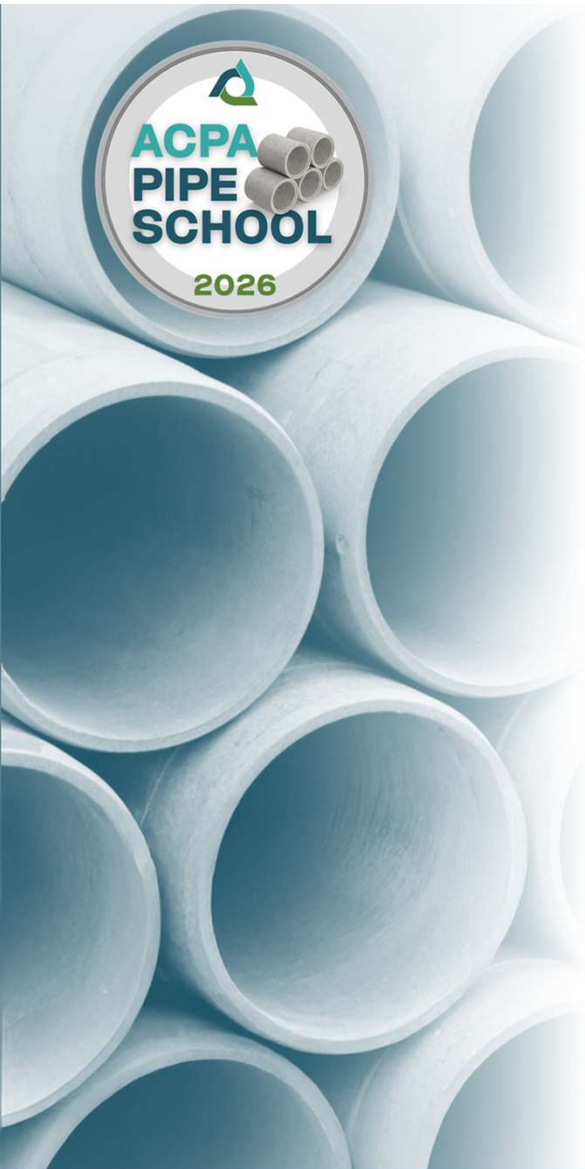






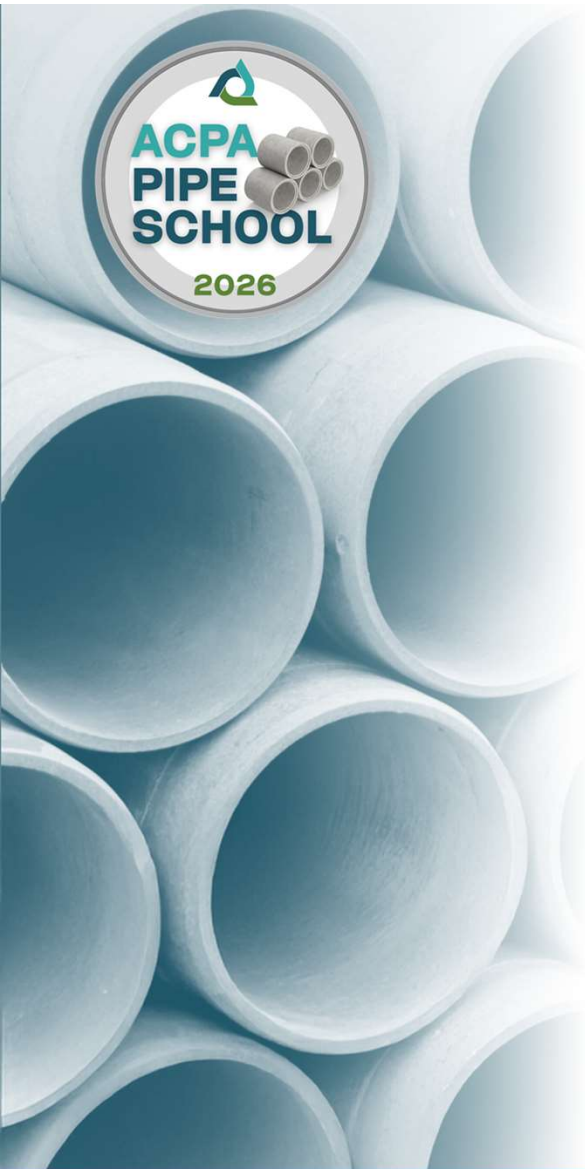




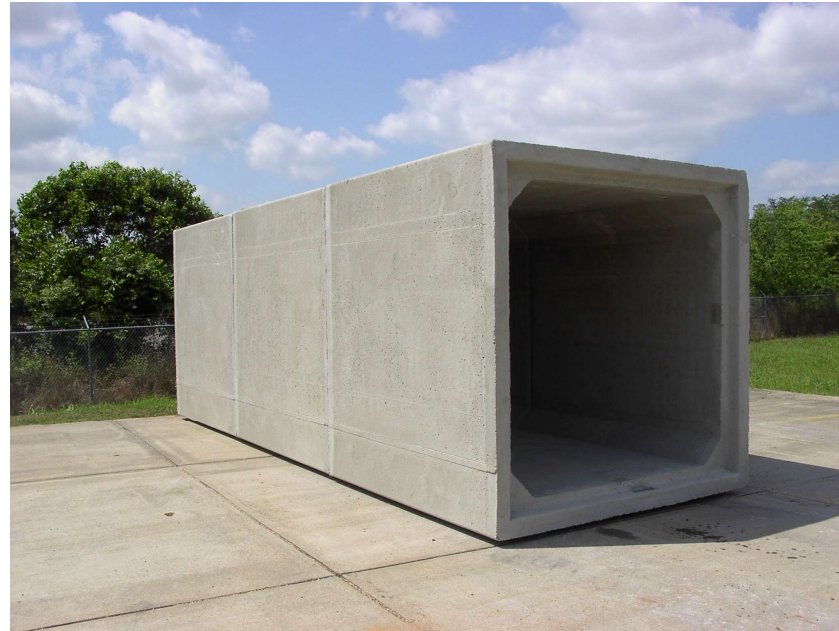


What Is The Most Important Thing We Can Do To Keep Our Forms Maintained?

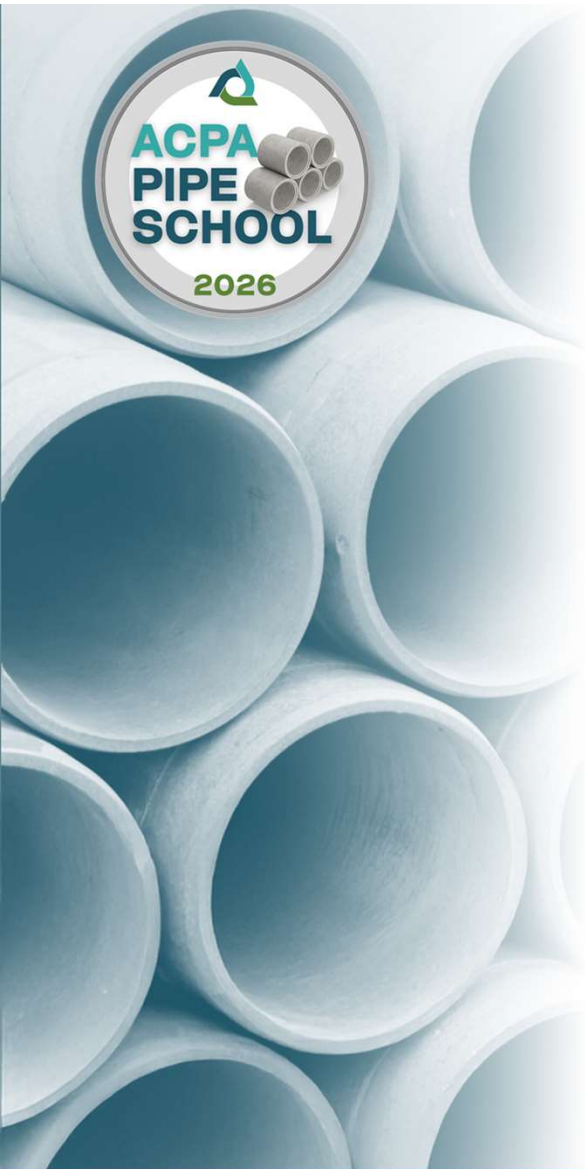
Keep them clean!!!



Picture the end result!



What you see on the form work, is what you will see in the structure



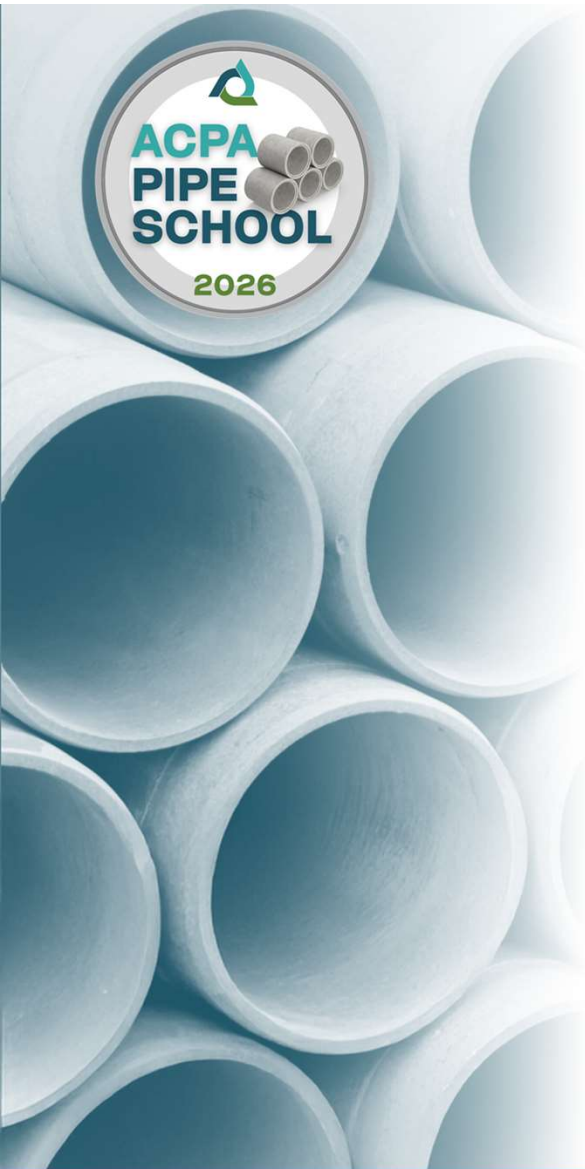
Cleanliness

- Cleanliness is one of the most important things we can do to ensure a quality product
- Clean forms ensure a good mating of form work
- Check for:
 - Concrete build up
 - Build up of old form oil
 - Any rough spots on form work, it should be smooth

The logo for ACPA Pipe School 2026 is circular, featuring a stylized water drop icon at the top, the text 'ACPA PIPE SCHOOL' in the center, and '2026' at the bottom. The background of the slide is a stack of white pipes.

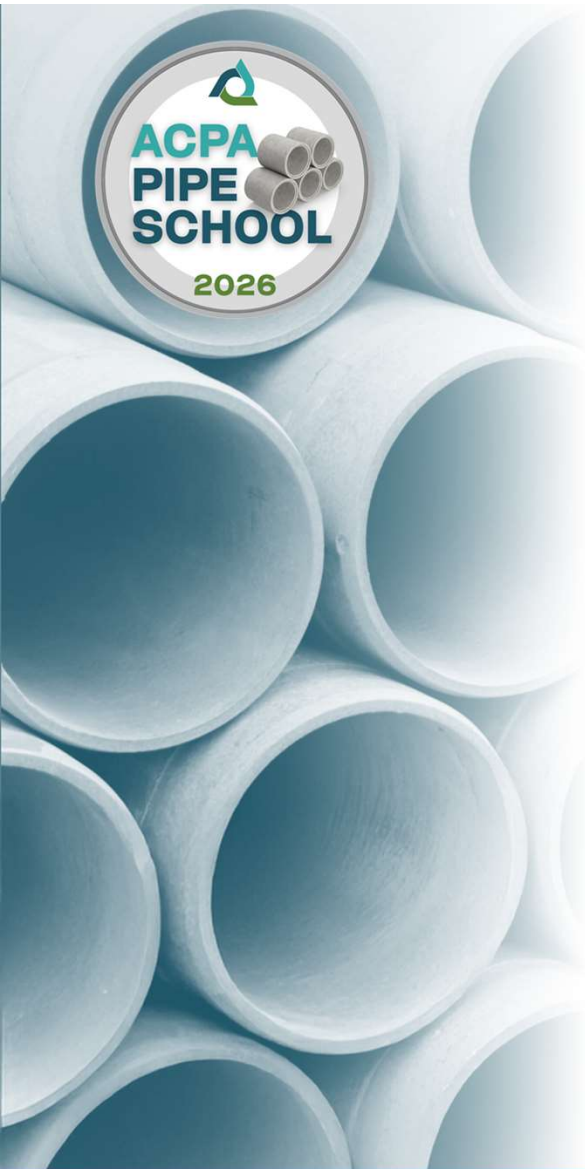
Issues caused by Poor Cleanliness

- Form work seams won't fit together properly
- Gaps in formwork can cause bleeding and honeycombing in the product
- Old concrete may fall into the form work during production
- Bell former and spigot former may not fit properly
- The mating of core/jacket to the spigot former/bell former won't be tight
- Core may not open all the way
- Jacket may not fit snug to the pallet



Impact of Poor Cleanliness on Products

- Impact on post production
 - Thick walls
 - Thin walls
 - Short span and rise
 - Long laylengths
 - Joints won't fit together as designed
 - Discoloration on product from old form oil build up
 - Rough or uneven surfaces



When Should Form Work Be Cleaned

- After each use
- Whenever there is a build up of concrete
- Before any maintenance is done
- Before set up for the next use
- Form work should be clean at all times

The logo for ACPA Pipe School 2026 is circular, featuring a stylized water drop icon above the text 'ACPA PIPE SCHOOL' and the year '2026' below it. The background of the logo shows a stack of pipes.

Joint Formers

- Must be kept clean
- All bolts **MUST** be torqued per manufacturers instructions
- No gaps between sections
- No damage to the joint forming surface

Gasketed Joint Formers

- Very tight tolerances
- Joints must not only be watertight, but also be able to pass a pressure test
- Annular space between bell and spigot is critical to gasket and joint performance

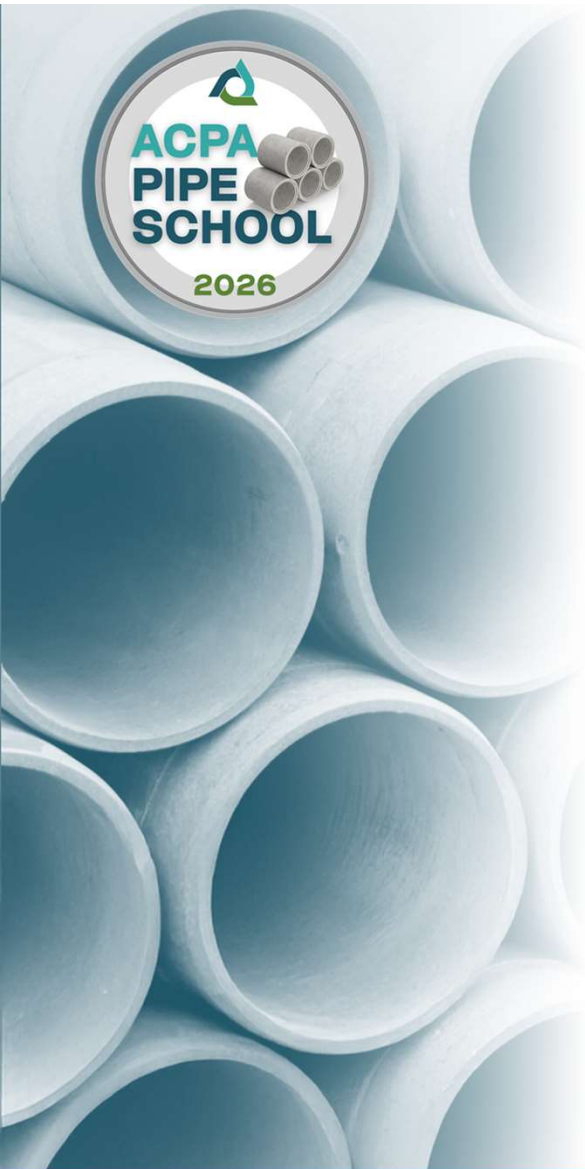












Bent Tongue or Groove Former

Can be caused by...

- storage
- Being ran over
- Lifting devices not placed properly

Possible fixes...

- Replace hardware (nuts, bolts, etc.)
- Remove plates and replace
- Place an "I" beam on top and clamp pieces to it to ensure straightness



 **NORTHERN CONCRETE PIPE**



Chairmans Quality Award

Joint Former Adjustment Tool

Quality Control Innovation Category





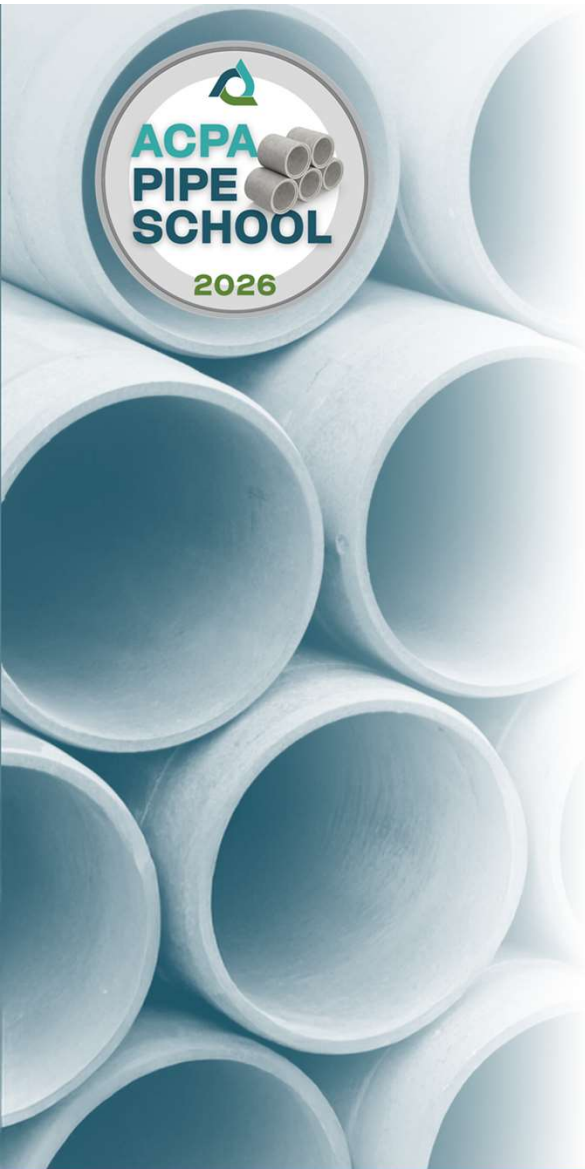


The logo for ACPA Pipe School 2026 is circular, featuring a stylized water drop icon above the text "ACPA PIPE SCHOOL" and the year "2026" below it. The background of the logo is a stack of white pipes.

Core and Jacket

- Cores and jackets are often assembled by using various sized panels
- We combine various sized panels to achieve the dimensions we need
- Building the form work is the same process for any size box, if it's a 4x3 or a 22x12
- Using segmented forms brings with it a unique set of challenges

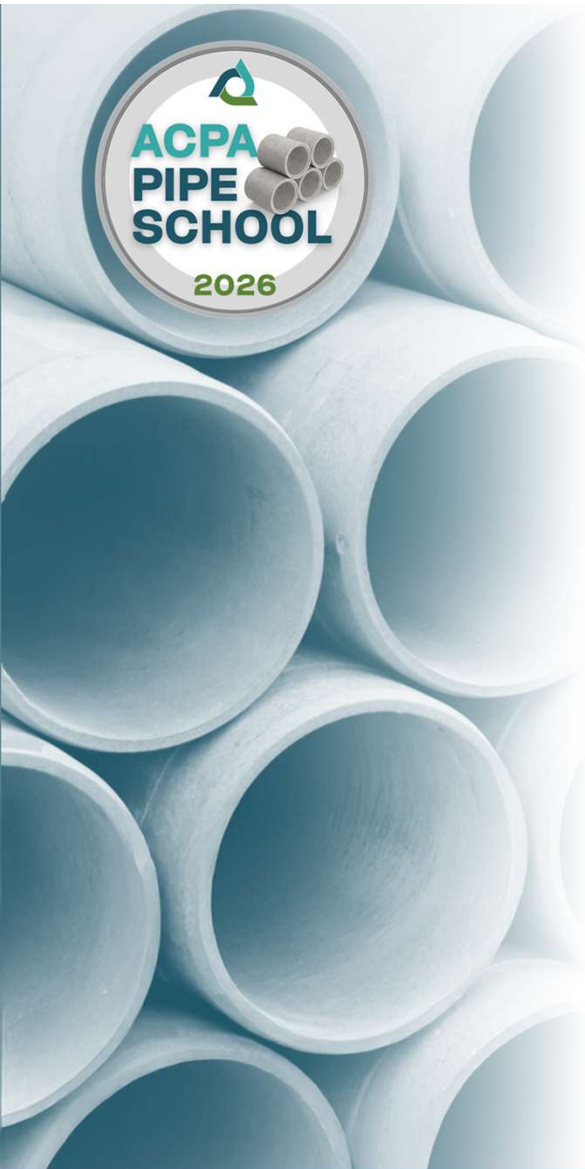




Challenges of using Segmented Forms

- It's important to keep the seams clean
- Gaps in sections can add up and cause bigger issues
- Gaps can cause concrete bleed and honeycombing



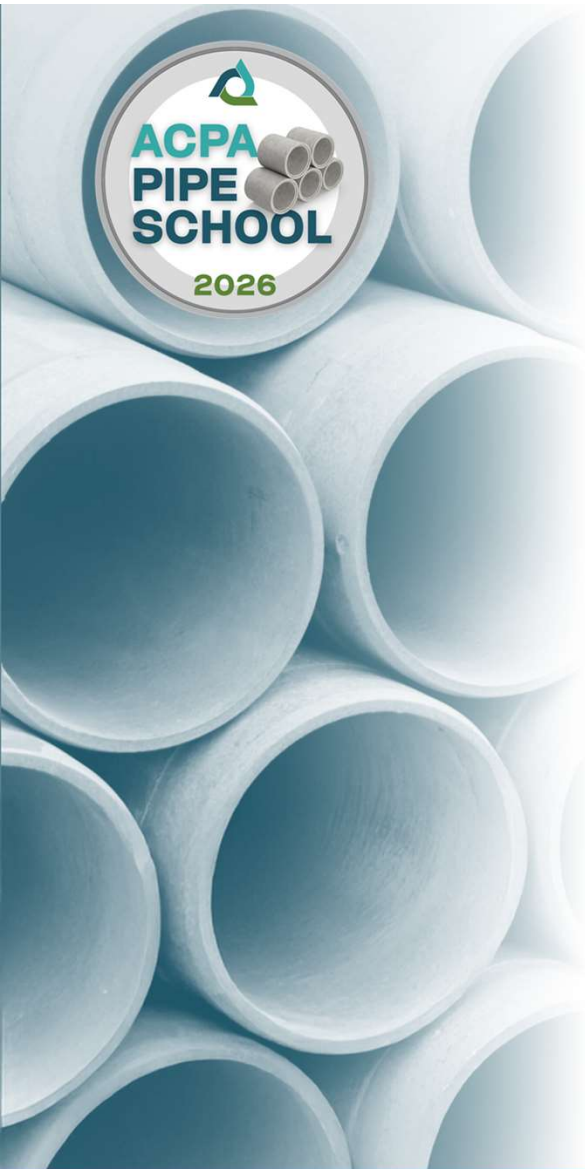


Cores

- Keep the base of the core clean
- Too much build-up will cause the core to lean
- Vibrator cords in good condition
- Bolts torqued correctly (contact manufacturer)
- Core panels are flush with each other
- Gaskets in good condition
- Pallet locks (P-locks) in good condition and functioning



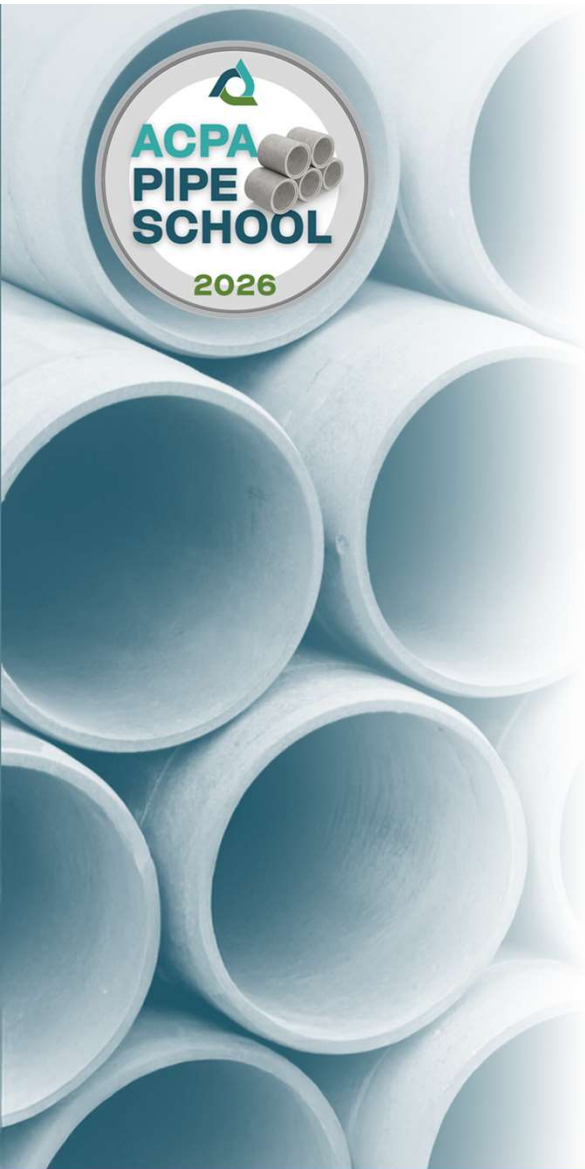




Hydraulic Cores

- Important to keep clean and functioning properly
- Designed to push the corner not the wall
- Check grease fittings regularly

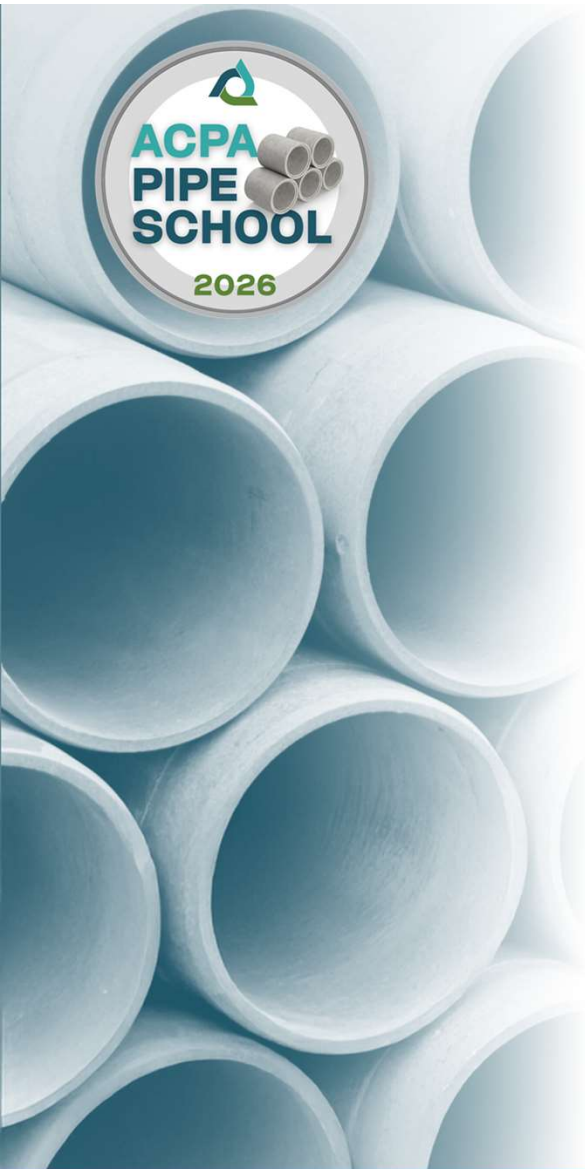




Hydraulic Cores

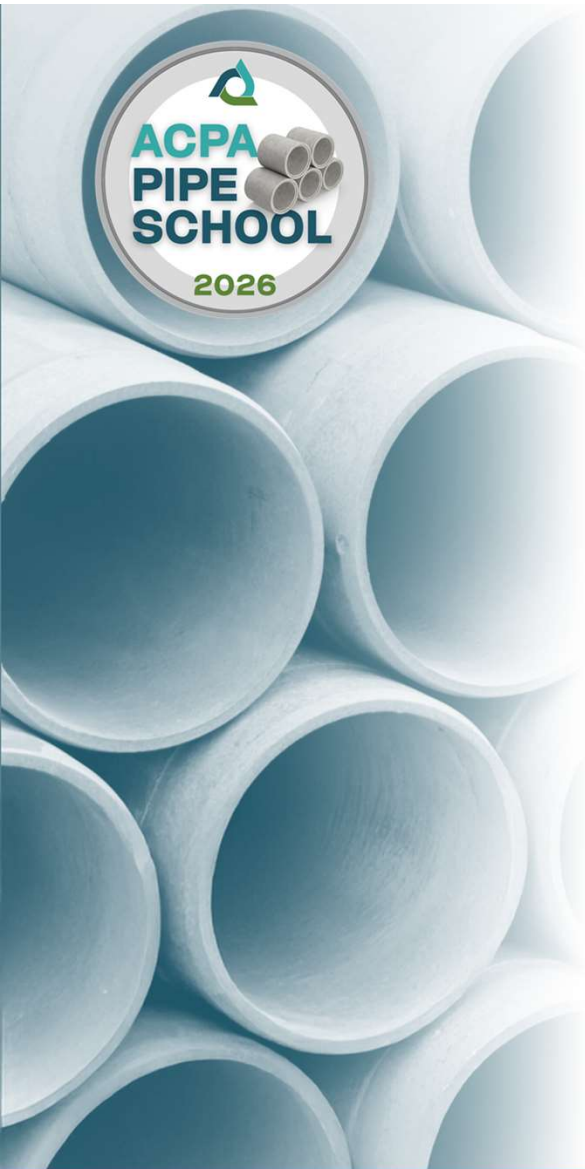
- Hydraulic lines are in good working order
- Hydraulic pump has enough fluid
- Hose fittings are not damaged
- Must be greased daily





When using Hydraulic Cores

- Put hydraulic wall panels as close to the corner as you can
- Always grease the gears
- Keep gears and moving parts clean
- If they do not function properly, they may not expand all the way
- Not taking care of hydraulic forms could result in costly repairs and or lost production



Jackets

- Panels are flush with each other
- Bolts torqued correctly
- Gaskets in good condition
- Pallet locks (P-locks) in good condition and functioning
- Vibrator cords in good condition









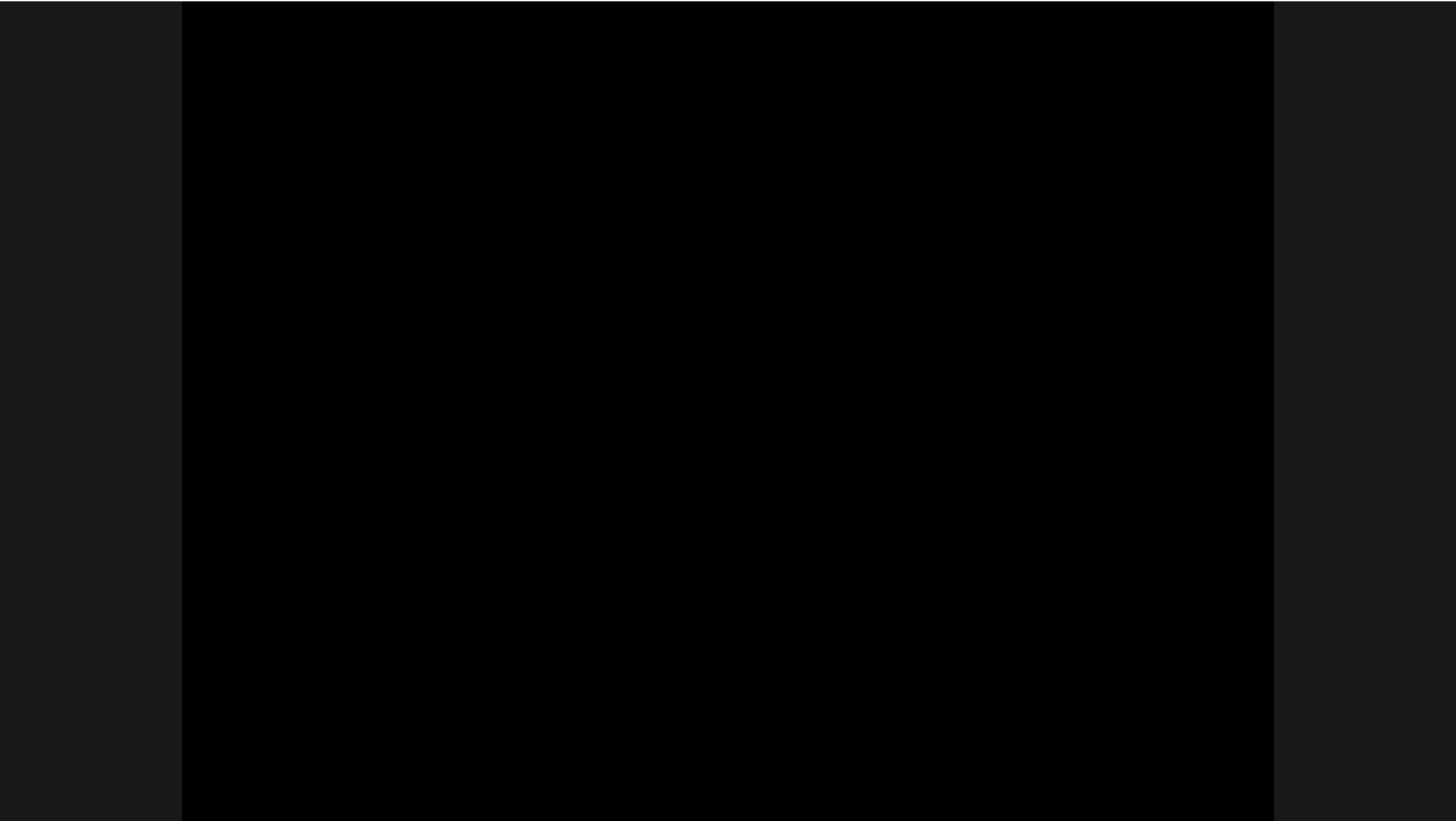




External Vibrators

- Keep vibrators clean from concrete buildup
- Inspect the chord and plug condition
- Check the vibrator settings and rotation

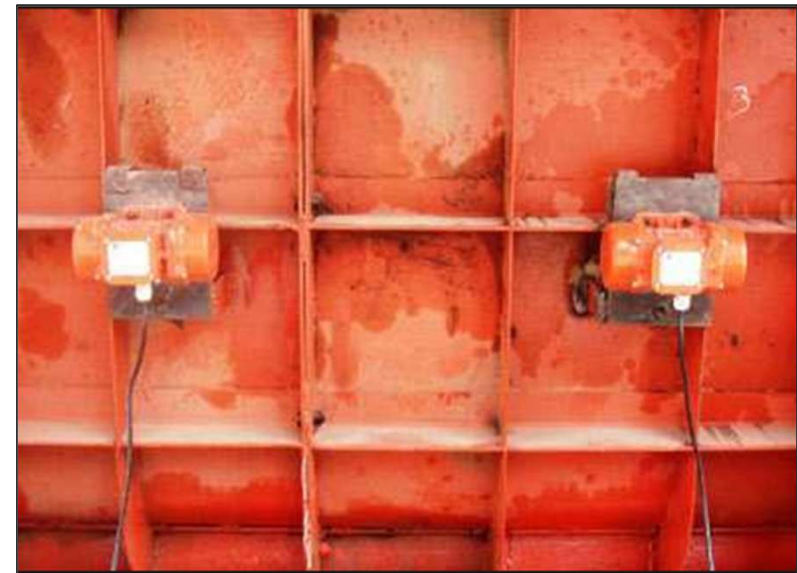


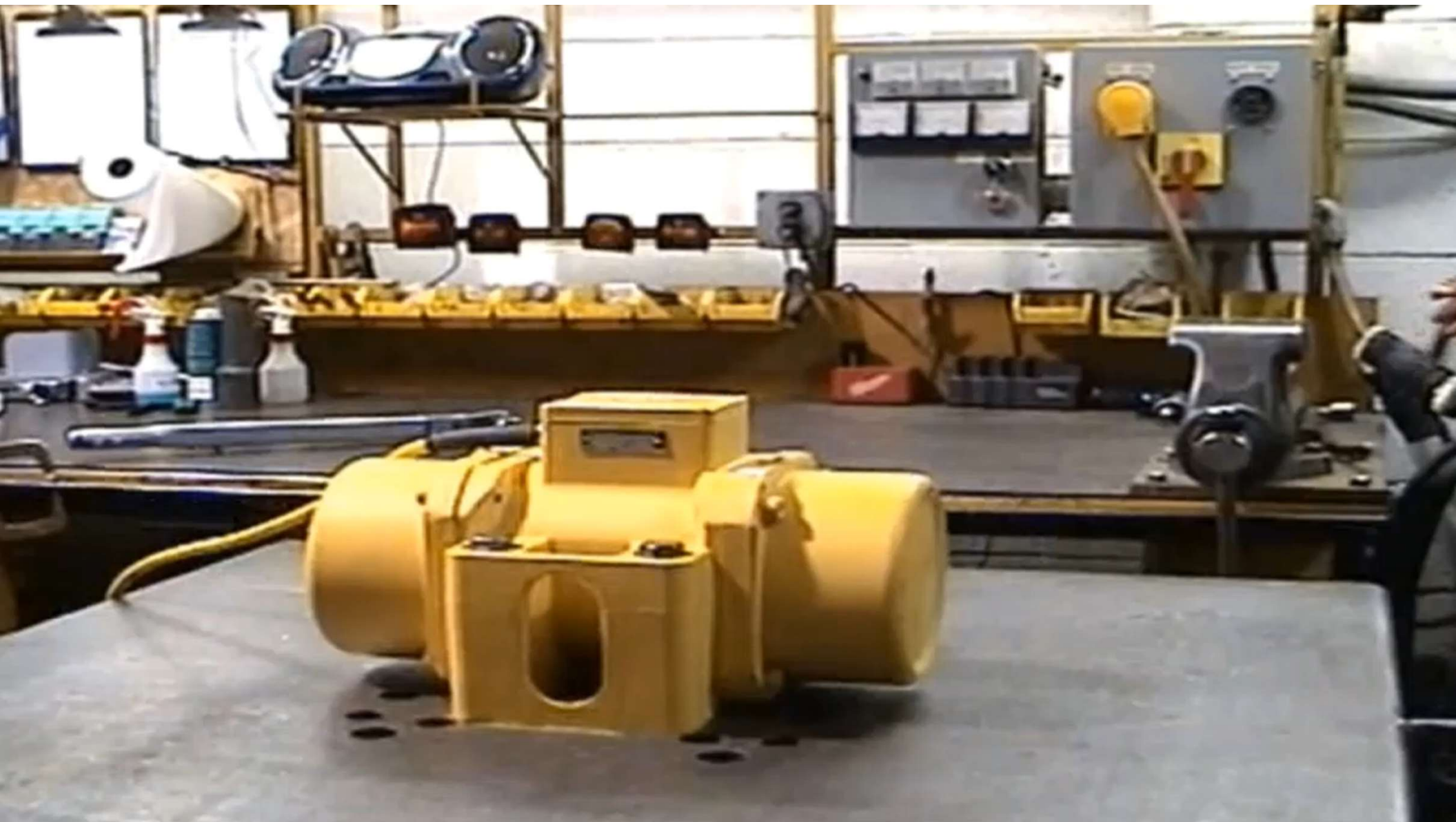




External Vibrators and Mounts

- Rigidly mounted
- Check Welds
- Mounting plate stitch welded, not solid
- No cracks in welds
- Bolts are torqued to manufacturers specifications
- If not done correctly vibrators will not perform as intended





Use The Right Tool For The Job

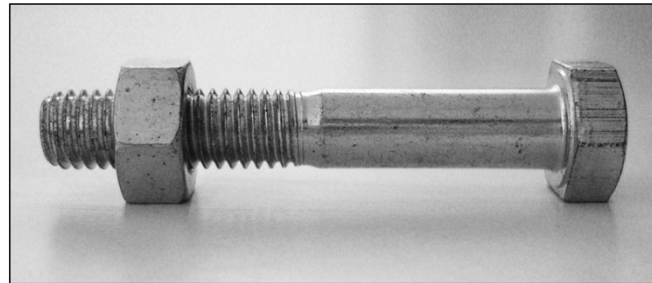
- Use the correct grade bolts
- Torque wrenches
- Dead blow hammers vs steel hammers
- Correct size wrenches
- Welding rods
- Its not always the best idea to give it two more...Ugga Duggas!

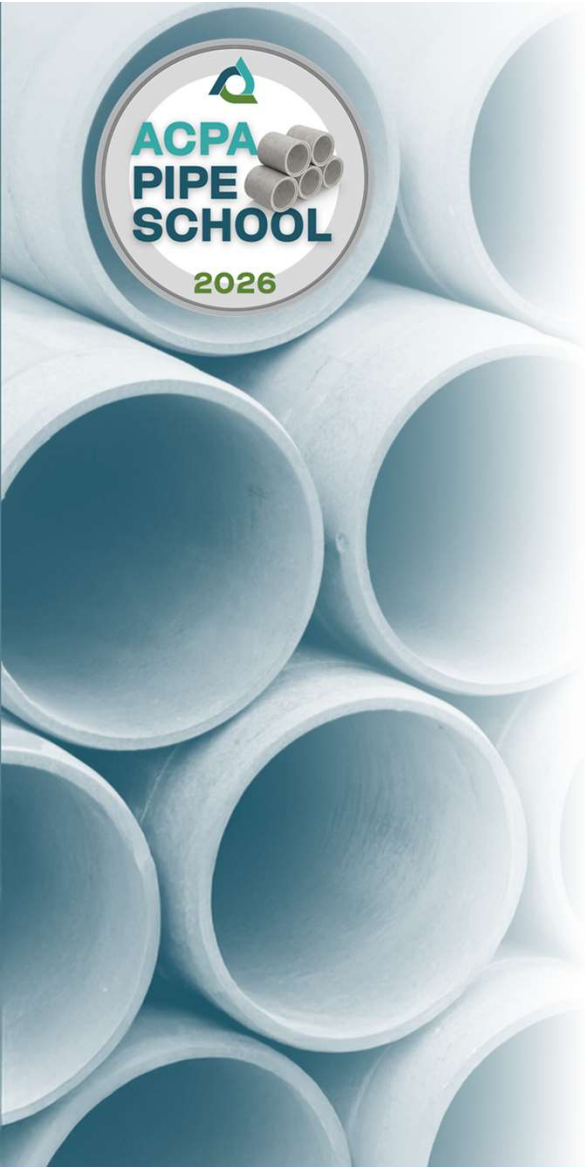


Typical Bolt Grades

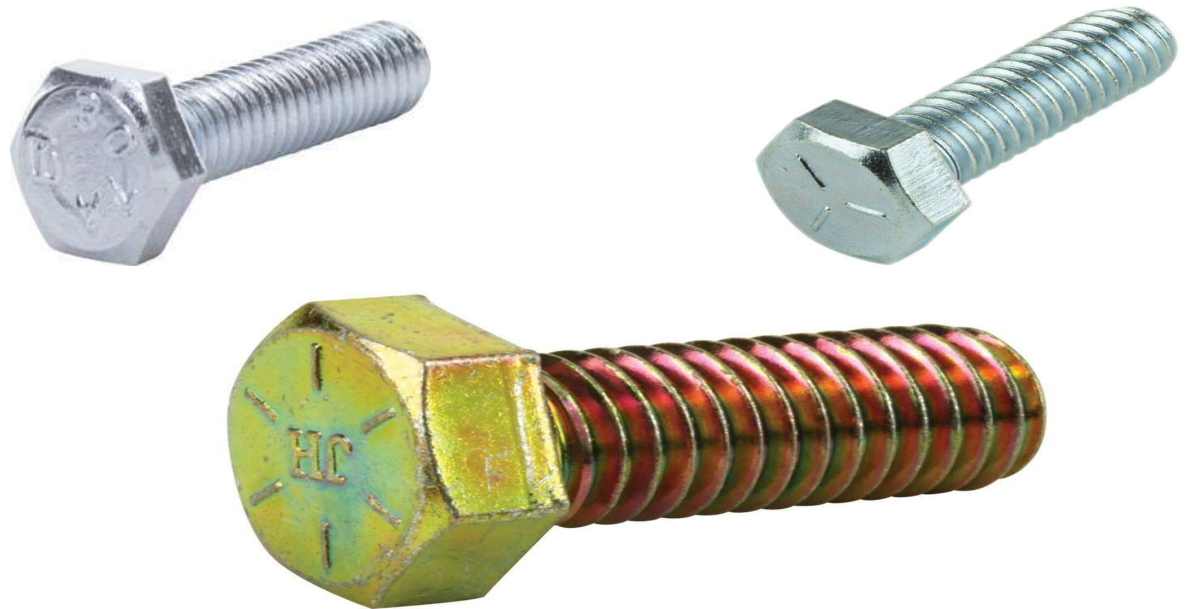
Important to use the right grade of bolt. The typical bolt grades in the U.S. Are:

- Grade 2: Low or medium carbon steel
 - Grade 5: Medium carbon steel. Quenched and tempered
 - Grade 8: Medium carbon alloy steel. Quenched and tempered
- I would suggest at least a grade 5 bolt for wetcast & 8 for drycast





How To Tell What Grade Your Bolts Are



The logo for ACPA Pipe School 2026 is circular, featuring a stylized water drop icon in blue and green at the top. Below the icon, the text "ACPA PIPE SCHOOL" is written in a bold, sans-serif font, with "ACPA" in blue and "PIPE SCHOOL" in green. At the bottom of the logo, the year "2026" is written in a smaller, green font. The logo is set against a background of several white PVC pipes stacked together.

Importance of proper torque on bolts

Over Torque

- May snap the bolt head off
- Will stretch the bolt and weaken it
- Damage the threads
- May damage form work
- An over torqued bolt will break

Under Torque

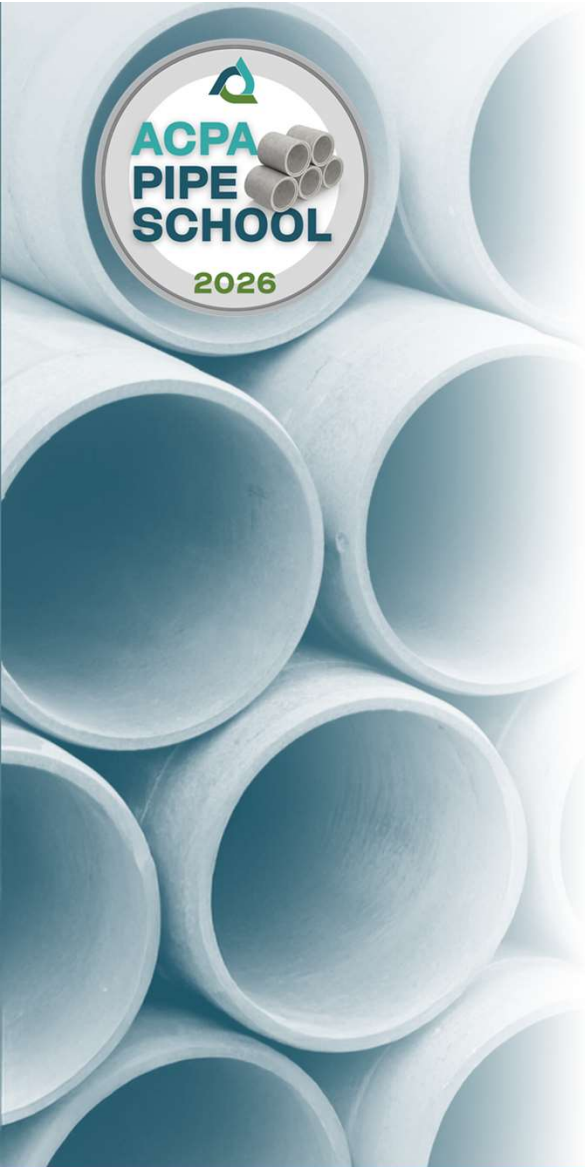
- Bolts will loosen
- Form work will flex
- Form work may come apart while moving
- Bolt will deform and will not provide the clamping force that is needed

The logo for ACPA Pipe School 2026 is circular, featuring a stylized water drop icon above the text "ACPA PIPE SCHOOL" and the year "2026" below it. The background of the slide is a stack of white pipes.

Things You Should Never Do

- Do not hit the form work with a steel hammer
- Don't use grinding disk, use a wire wheel to clean
- Don't use chipping guns, needle guns, or jack hammers on the smooth part of the form work
- A steel hammer will cause the form work to go out of shape
- Grinding disks will tear away at the form work
- Using these tools will cause damage to the form work, causing divots and chips

What you see in the form work, you will see in the structure

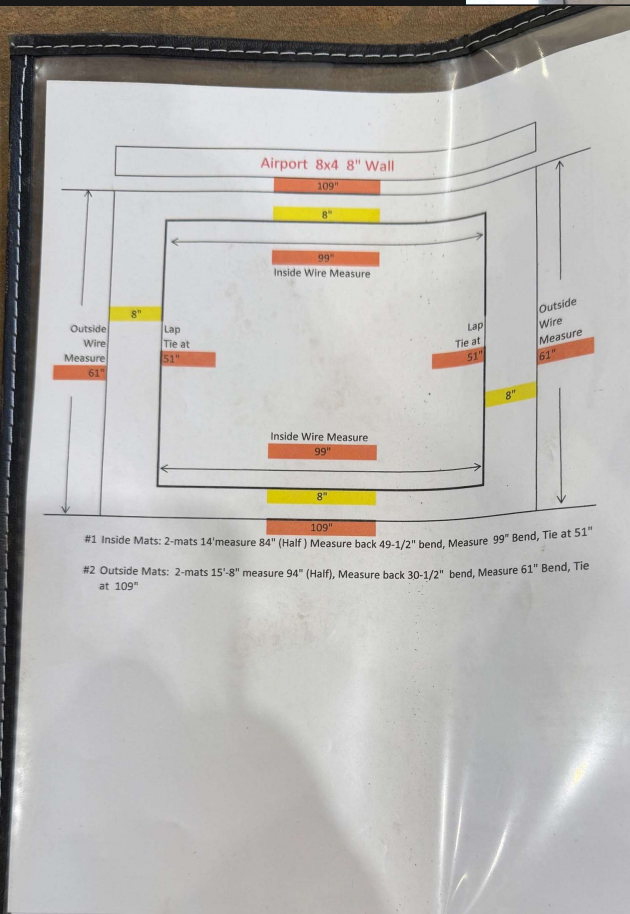


Questions?



Pre-Pour





Airport 8x4

Groove X Groove
9" from bottom
of inside cage

Inside can't be
top of tie

outside

Haunch Bar
Every
12"

25 1/2" Center

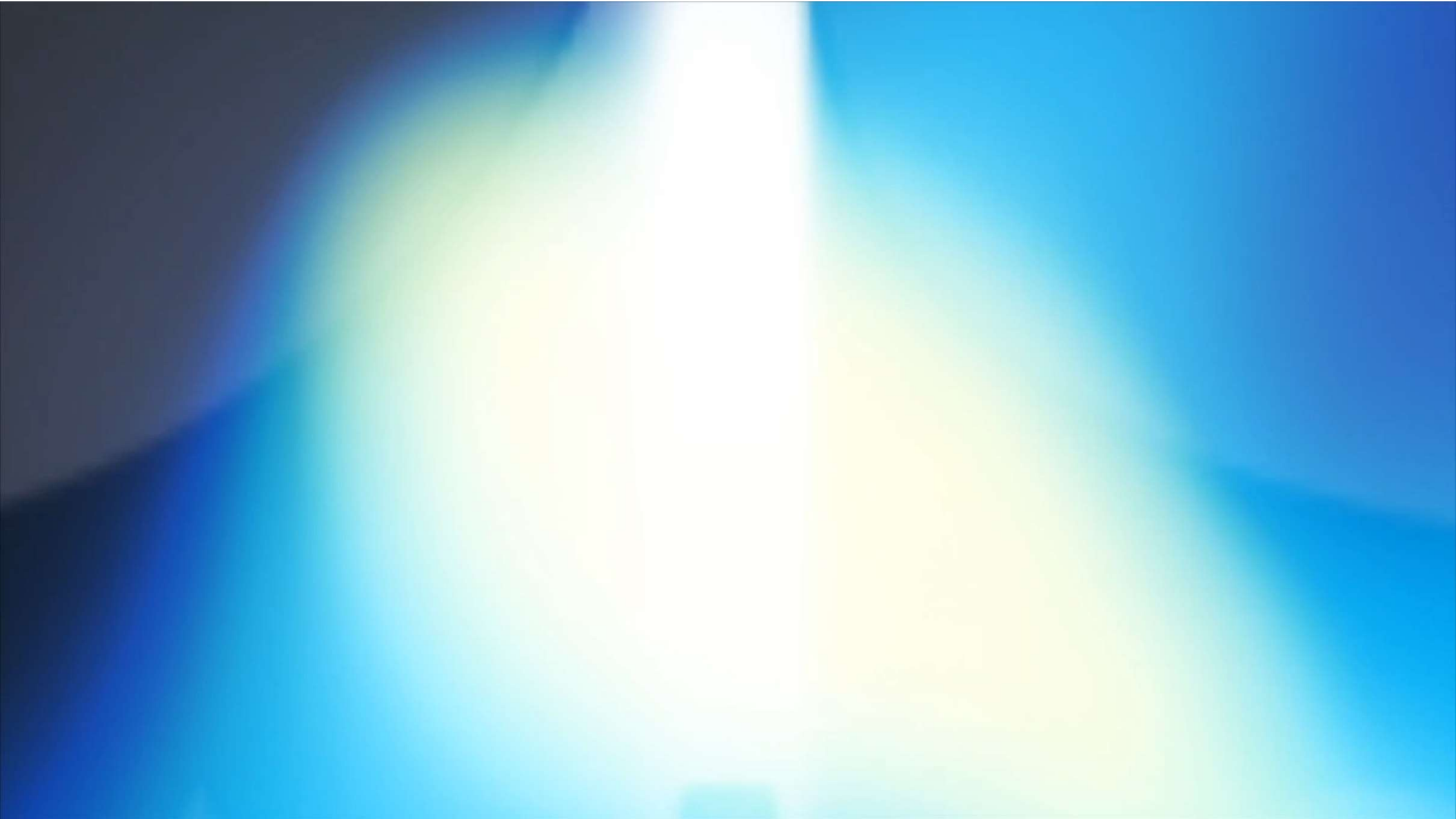
Lift holes

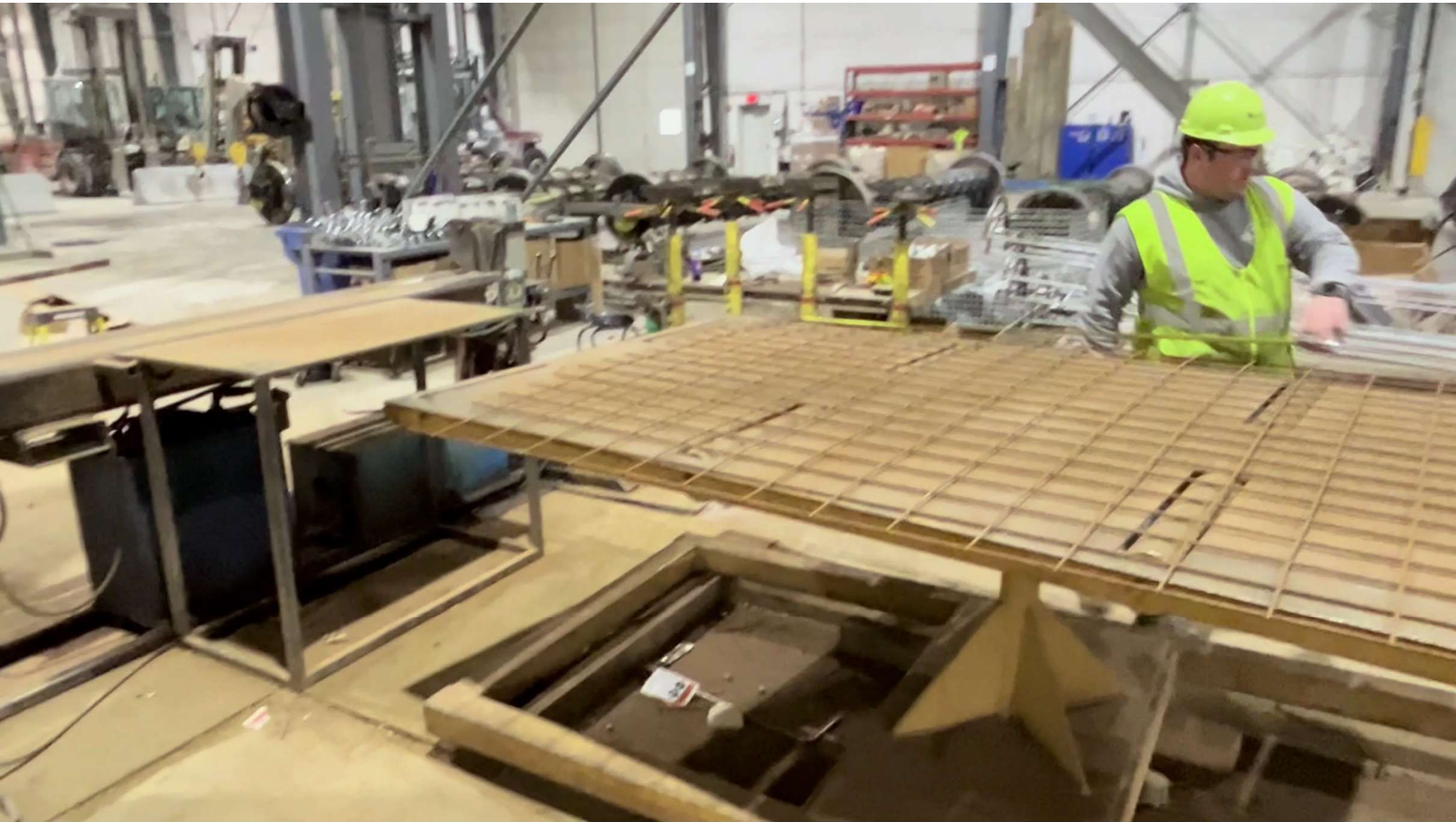
↓ 12-19
↔ 22x29

TOP

Bottom

ULINE

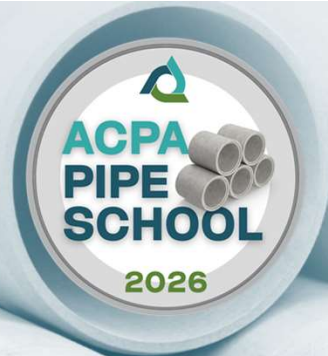






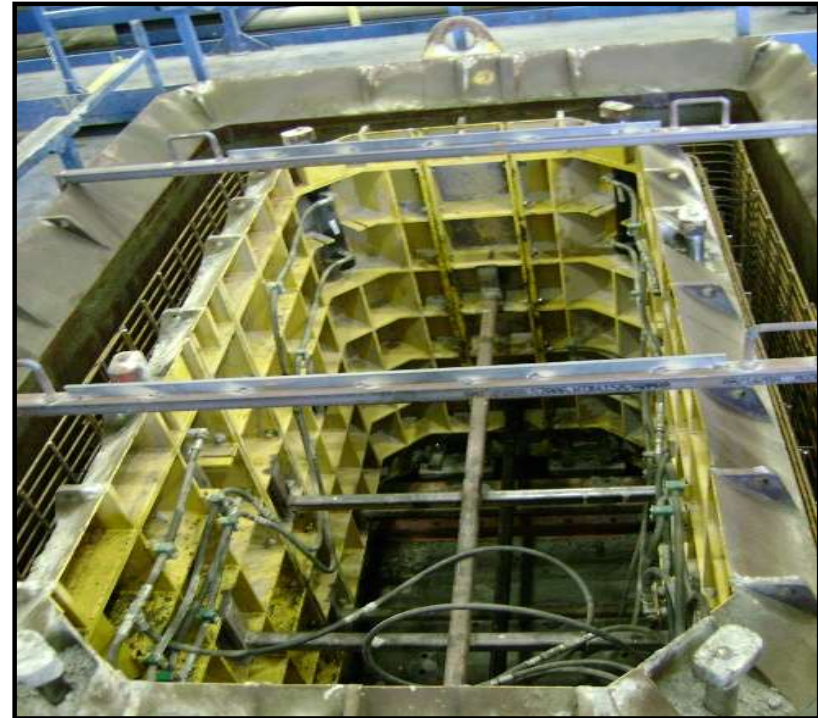


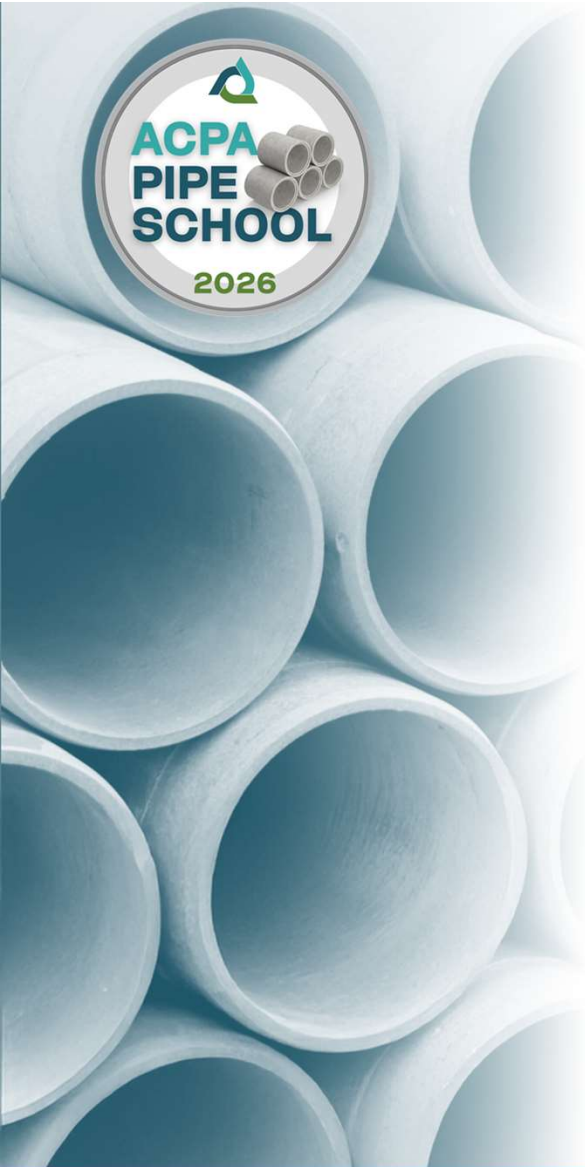




Pre-Pour Inspection

- Verify proper application of form oil
- Ensure form work is square
- Measure wall thickness
- Make sure all accessories are in the proper place
- Check steel cover
- Measure lay lengths
- Check form release
- Check that rods are tight, correctly spaced, and the correct amount

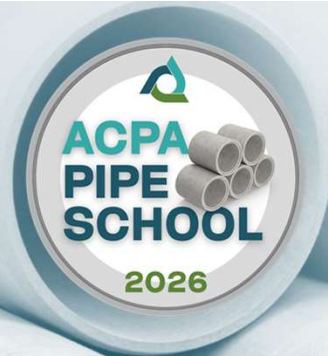




Pre-Pour Inspection

- Visually inspect form work for cleanliness
- Look for any gaps between form work
- Make sure bell former is seated properly on the core





Pre-Pour Inspection

- Check and all insets and blockouts for both location and dimensional accuracy
- Keyways
- Threaded insets
- Hole formers
- Lifting hole formers
- Inserts are well secured
- This is where you check everything before the jacket goes on
- Inserts and blockouts should be considered as form work







Top And Bottom Rods

- Top and bottom rods are designed to hold everything together
- The rods are how we are going to control the wall thickness
- Not having rods correct will affect everything else

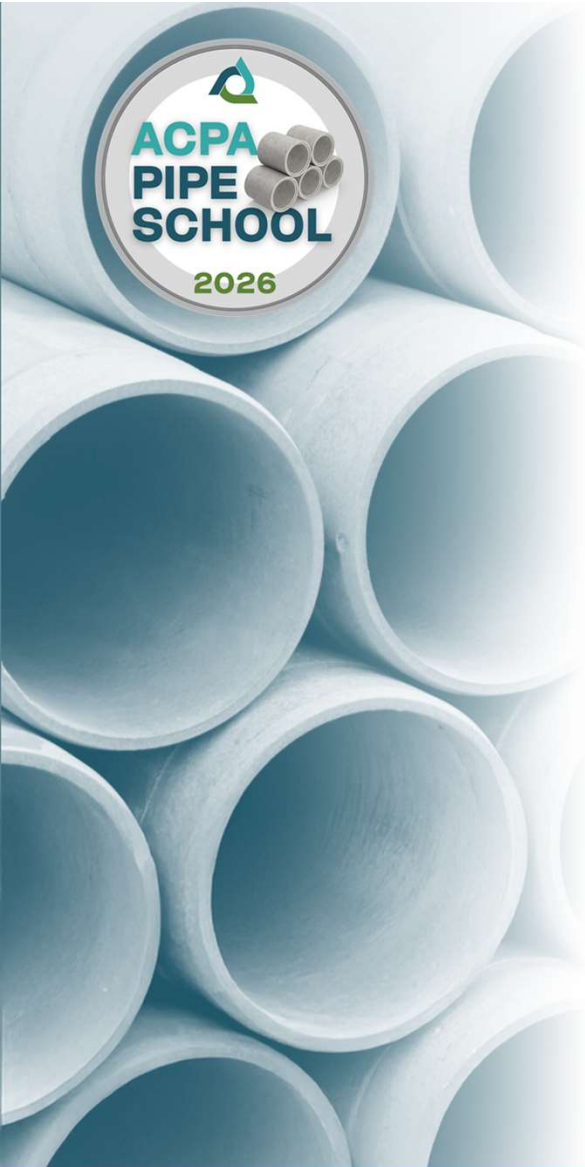




Top Plates

- Hold the groove former to the core
- Ensures the core won't be displaced when concrete is added
- Stops the groove former from pushing up when concrete is added



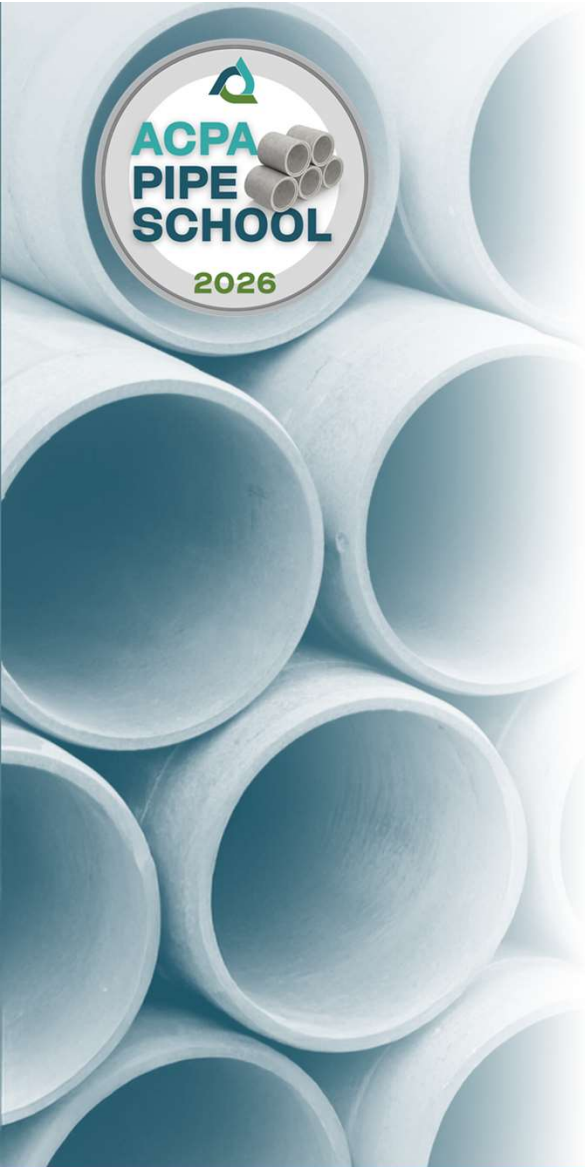


Questions?



Filling and Vibrating

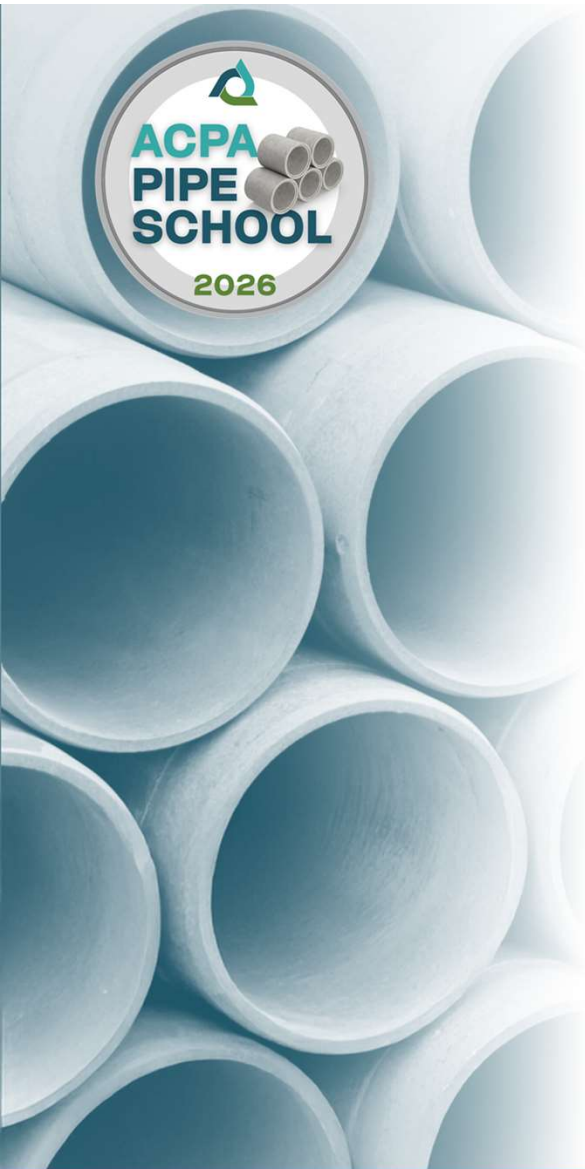




What about our supply of
concrete?



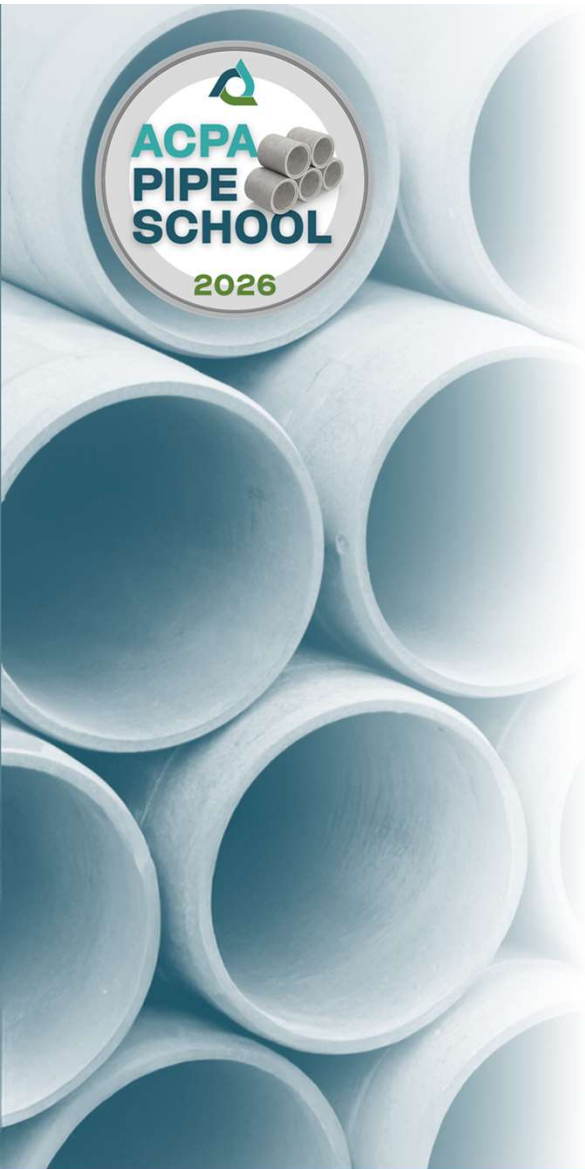




What's left in the mixer, on the belt or in the hopper?





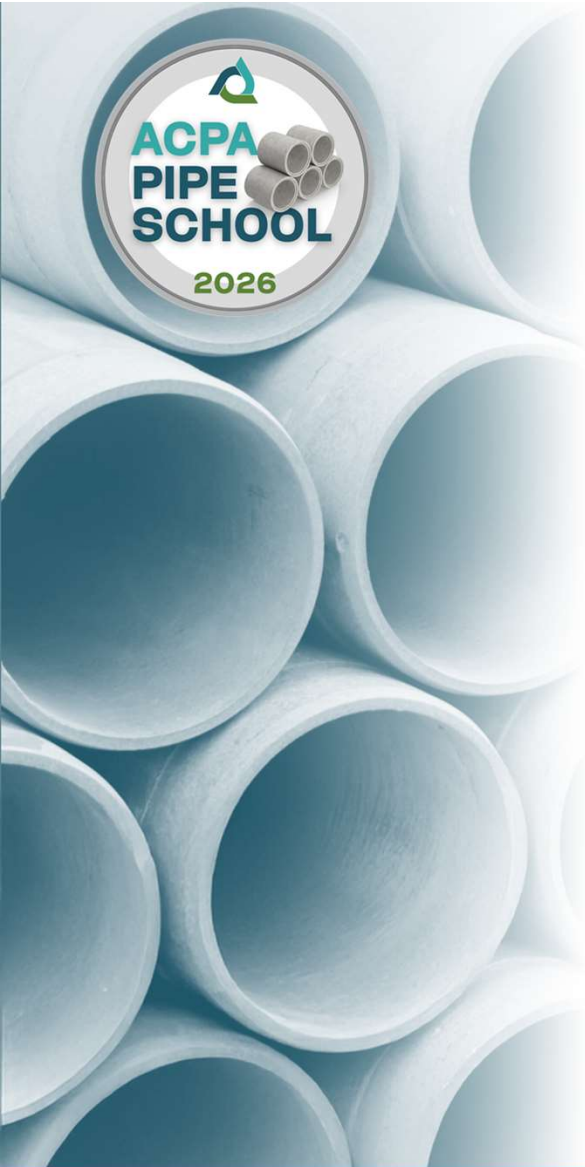


Effects of Dry Concrete

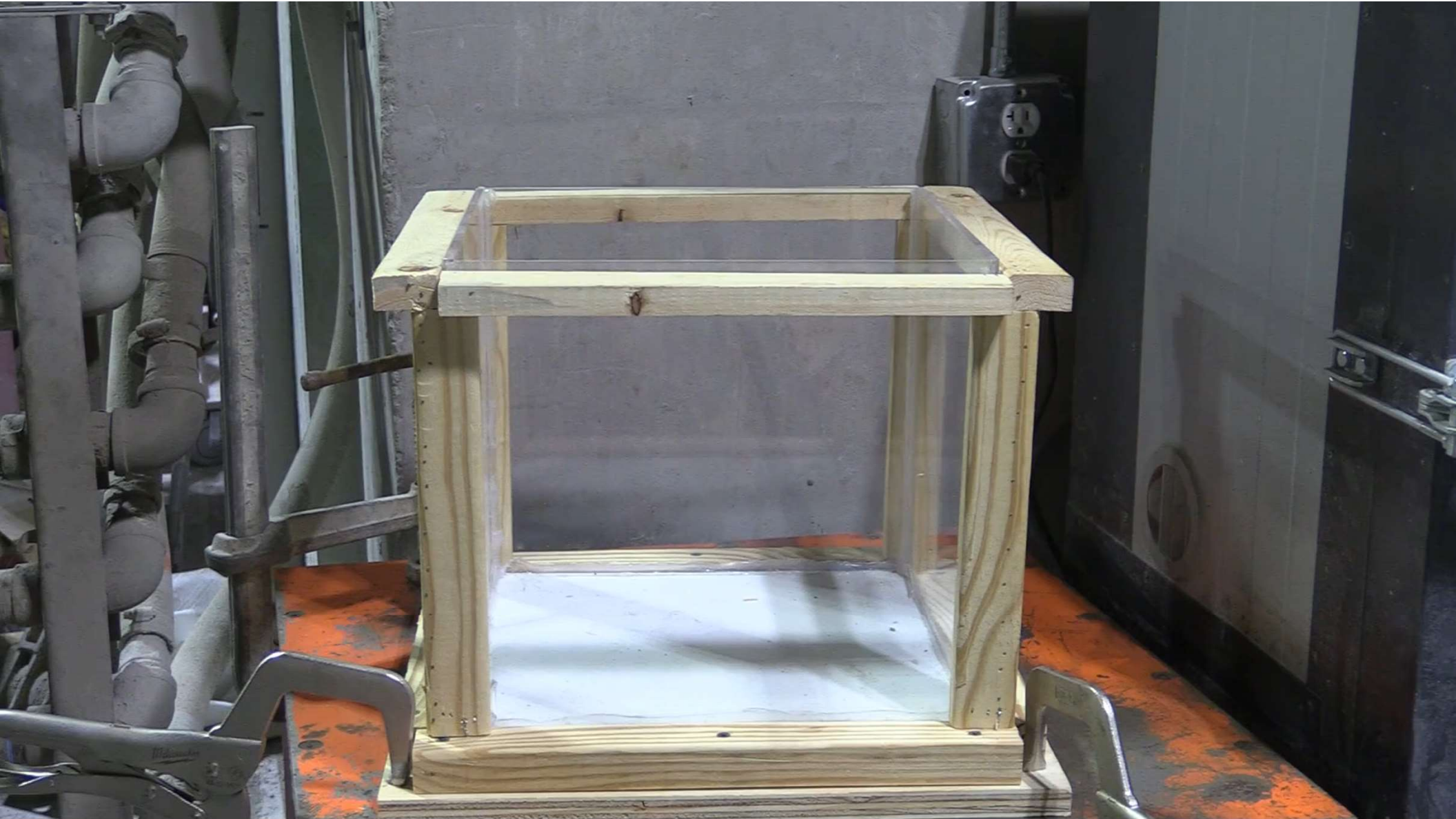
This can have serious detrimental effects

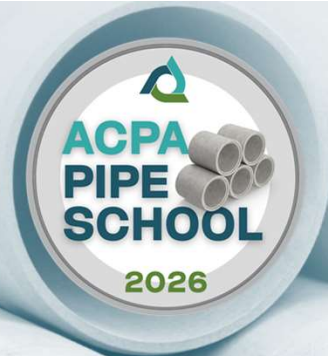
- You can vibrate all you want but if the concrete can't flow it will be very difficult to make it compact or consolidate
- This adds critical minutes to vibrating time that adversely affects production time and often results in a rejected piece of product





Filling Boxes - Drycast





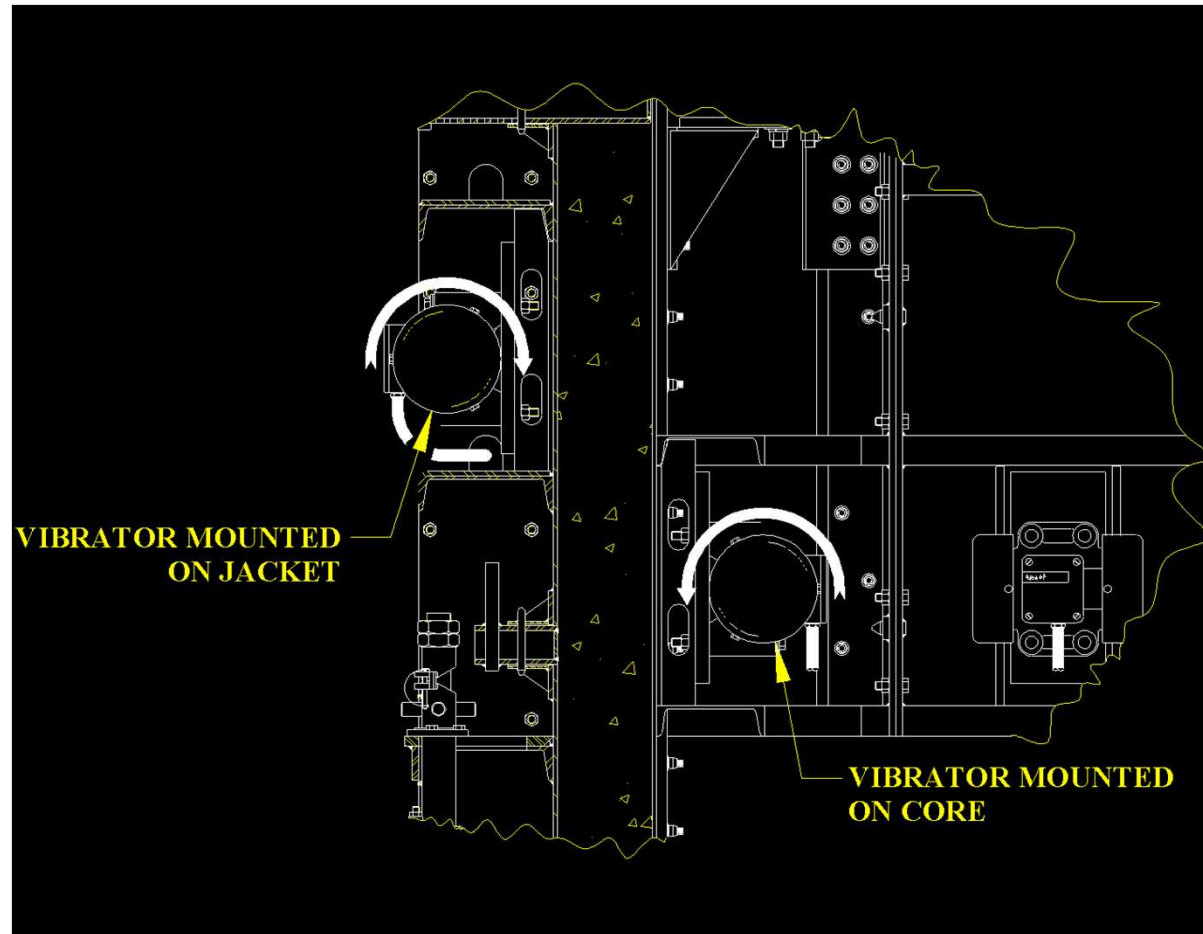
Filling Boxes - Drycast

- Don't feel you have to run all vibrators at the same time
- Start the vibration with 12-18" in the bottom of the form
- When filling is near the next row of vibrators turn them on
- Fill in 4-6" lifts
- Slow down in the haunches to allow consolidation
- Ensure consolidation by seeing the sheen near the core and jacket

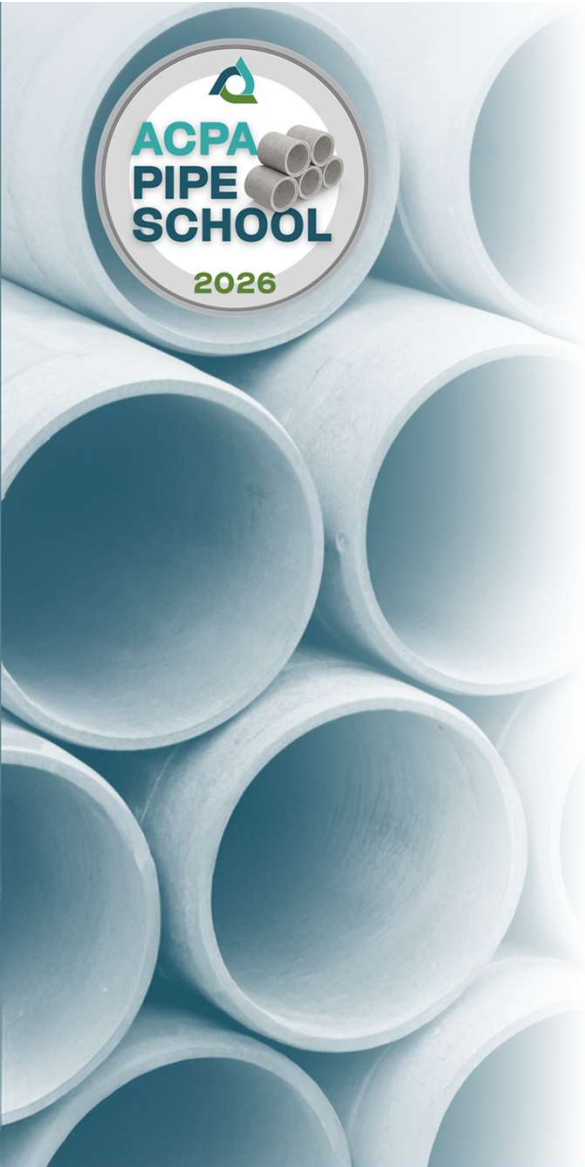




Filling Boxes - Drycast



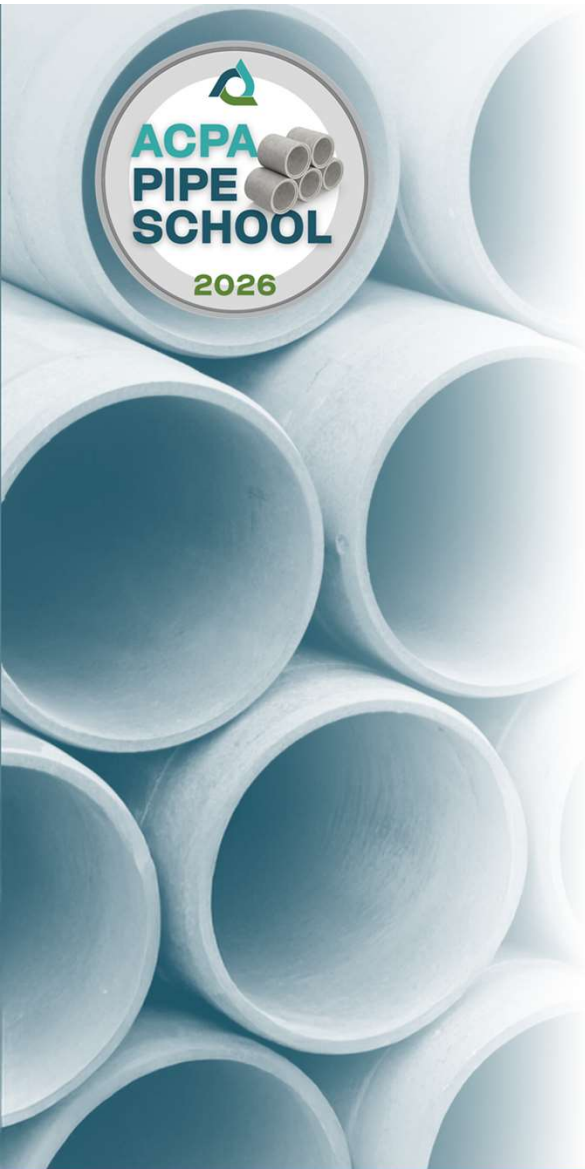




Filling Haunches - Drycast





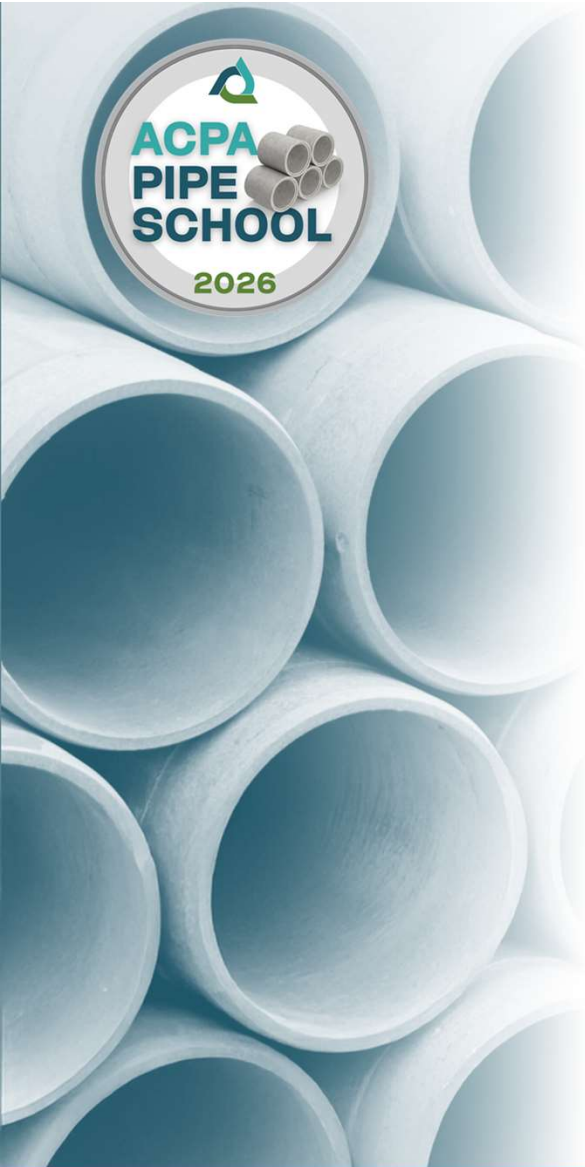


Correct fill rates ensure
correct and complete
consolidation



Understand what fill rate means to the product !!

The amount of concrete put in per pass is critical to consolidation and that rate **MUST** be controlled if you are to achieve good, watertight concrete



Filling Boxes - Wetcast





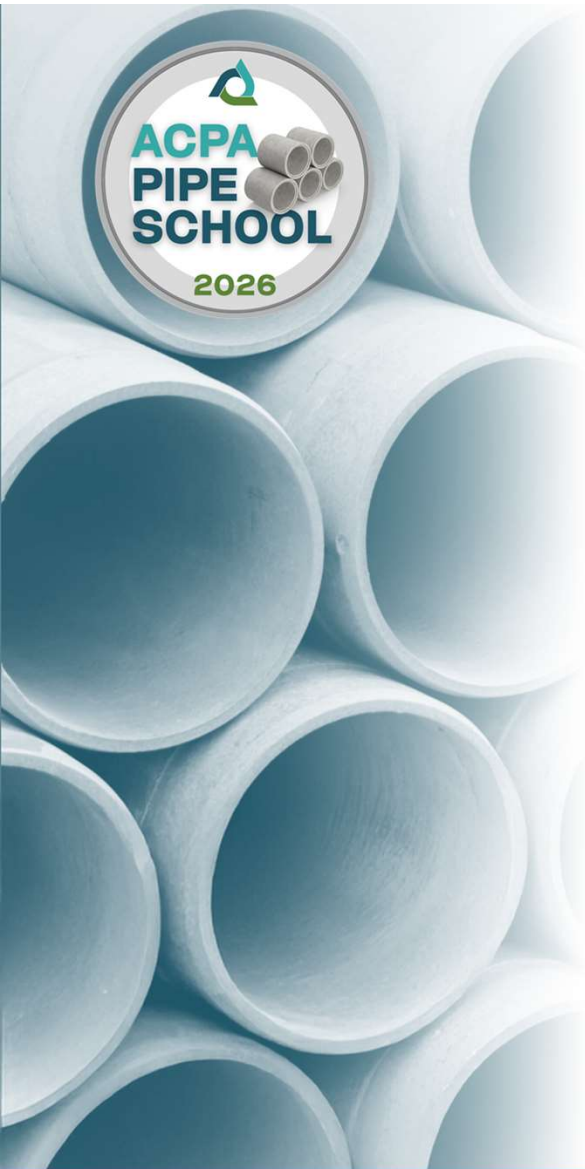


Effects of not Overlapping Fields of Action

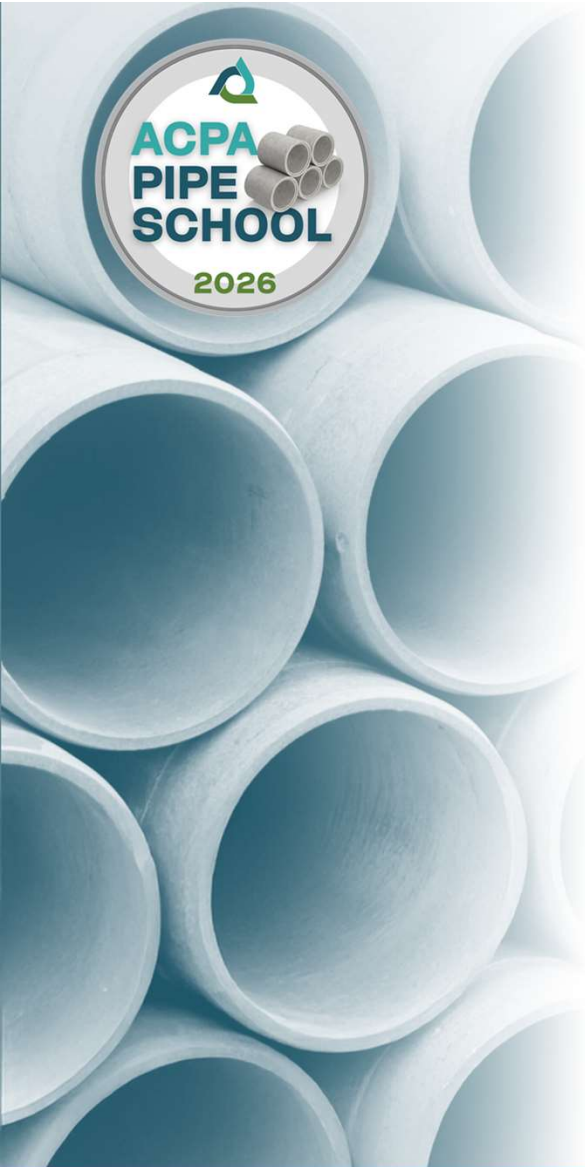
Reduced strength and durability because of:

- Voids
- Honeycombing
- Entrapped air
- Reinforcement not covered



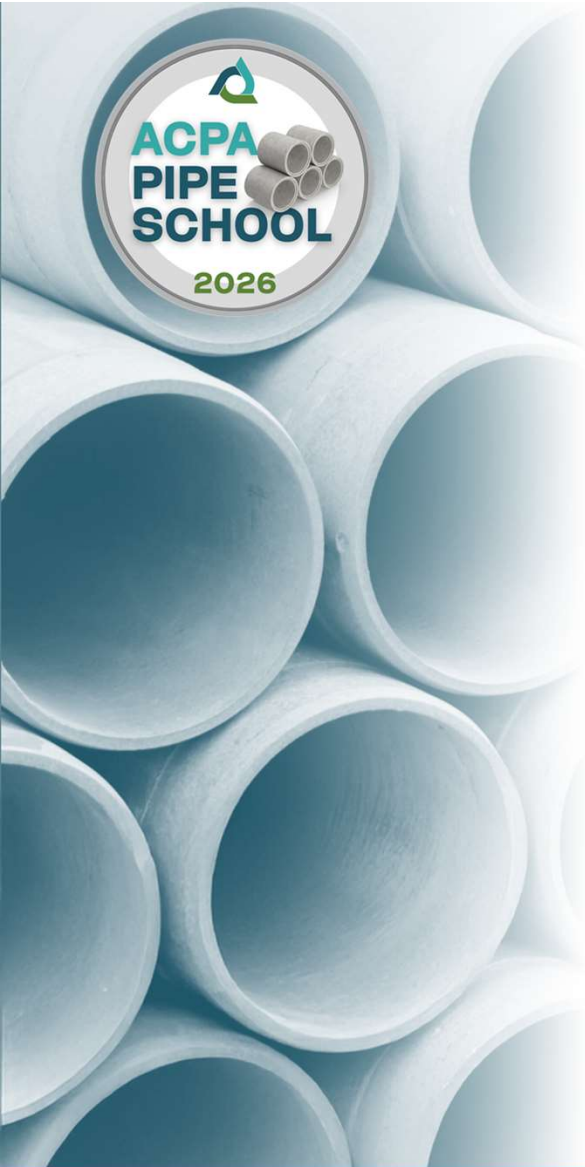


Consolidation Compaction Vibration



Consolidation

Is the process of inducing a closer arrangement of the solid particles in freshly mixed concrete during placement by the reduction of voids, usually by vibration, rodding or tamping



Compaction

Is the process which expels entrapped air from freshly placed concrete and packs the aggregate particles together to increase the density of the concrete

The logo for ACPA Pipe School 2026 is circular, featuring a stylized water drop icon at the top, the text 'ACPA PIPE SCHOOL' in the center, and '2026' at the bottom. The background of the slide is a stack of white pipes.

Consolidation and Compaction

Two Stages

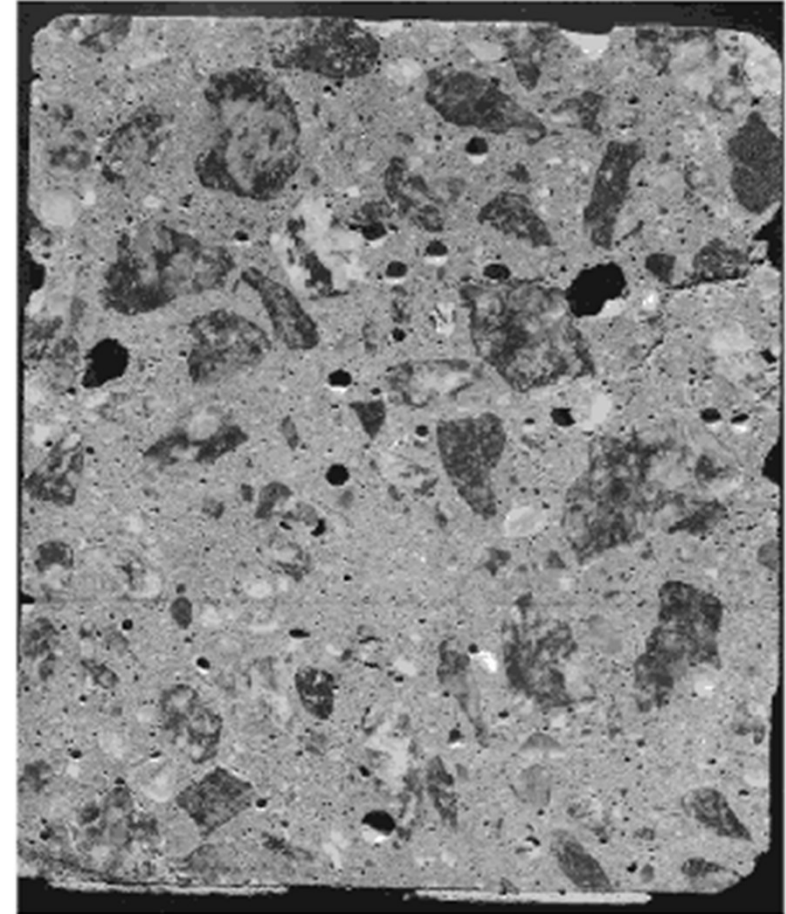
- The aggregate particles are set in motion and “slump” to fill in the form giving a level top surface
- Entrapped air is expelled

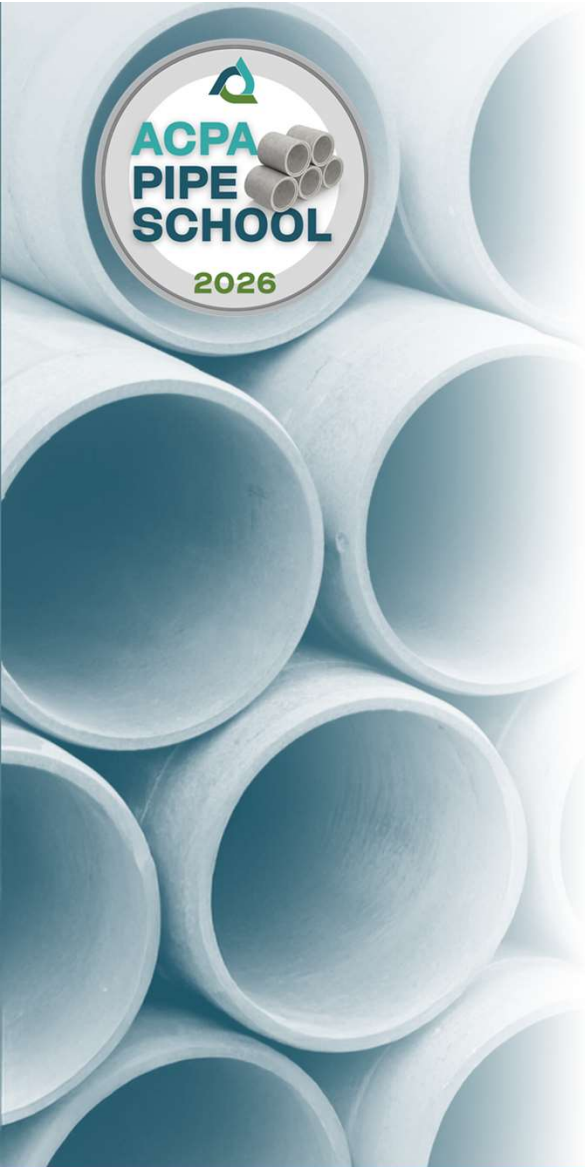
With vibration, initial consolidation of the concrete can often be achieved relatively quickly. Compaction must be prolonged until no more large air bubbles appear on the surface

The logo for ACPA Pipe School 2026 is circular, featuring a stylized water drop icon at the top, the text 'ACPA PIPE SCHOOL' in the center, and '2026' at the bottom. The background of the logo shows several white pipes.

Proper Vibration Should

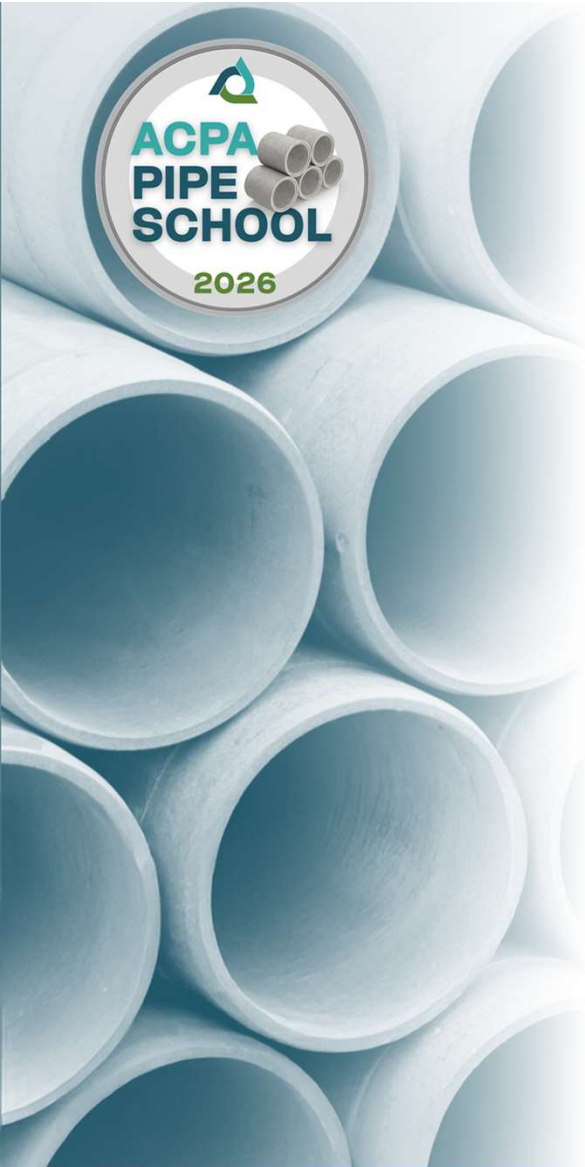
- Eliminate voids and honeycombs by forcing the concrete to consolidate
- Release entrapped air as the compaction stage starts
- Fully encase reinforcement, embedded items, and blockouts with fresh concrete



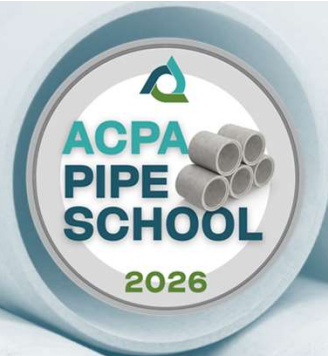


However...

NONE of this will be possible without a
QUALITY MIX DESIGN
That's
WORKABLE



External Vibrators



Power Sources for Vibrators

- Pneumatic



- Hydraulic



- Electric



External Vibrators



Electric 3600 RPM

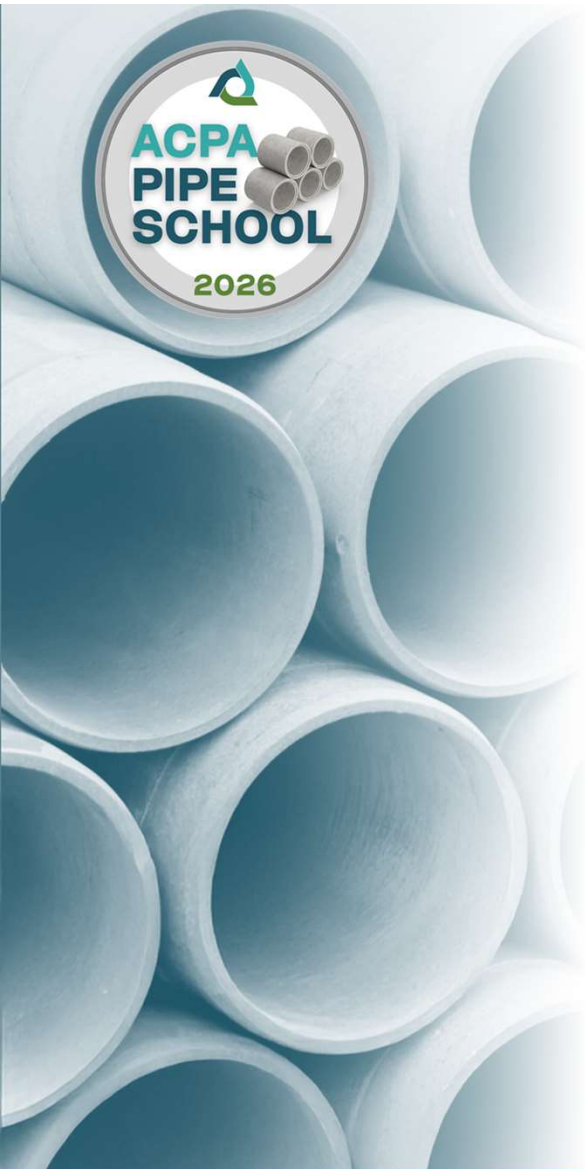


Electric 7200 RPM



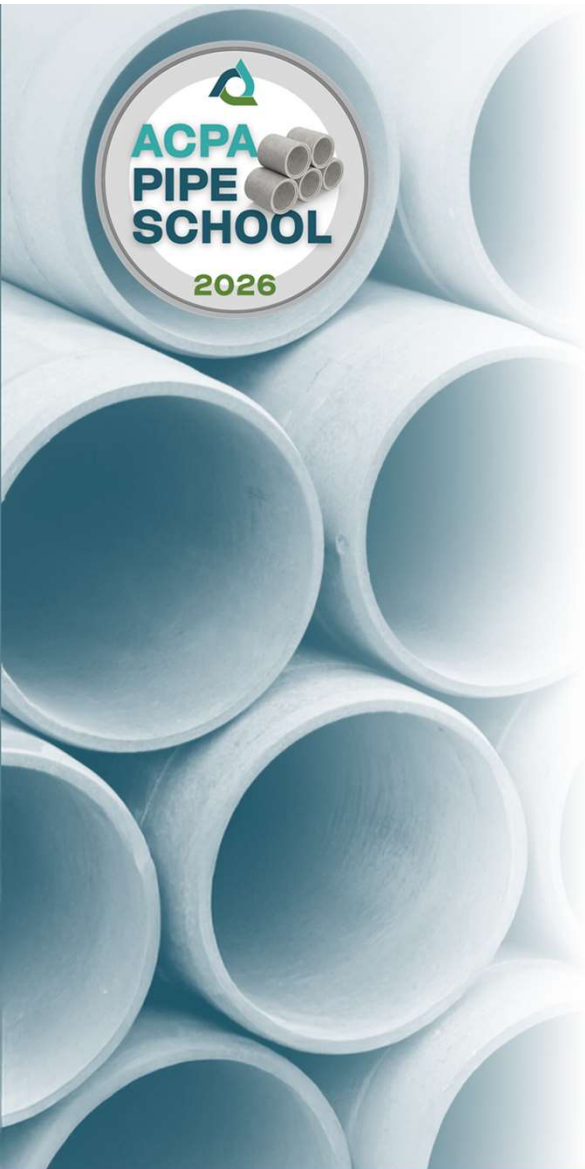
Pneumatic 6600 RPM





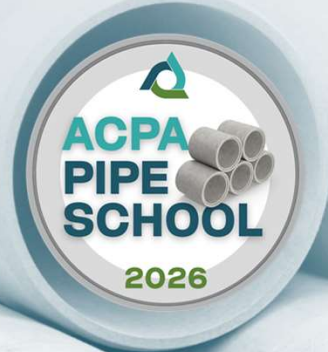
Vibration

Regardless of the power source, some principles of vibration are common to all types



Vibration – The Theory

- MASS
- FREQUENCY
- AMPLITUDE
- ACCELERATION
- FORCE
- RESONANCE



Mass = Weights



Pneumatic ball vibrator

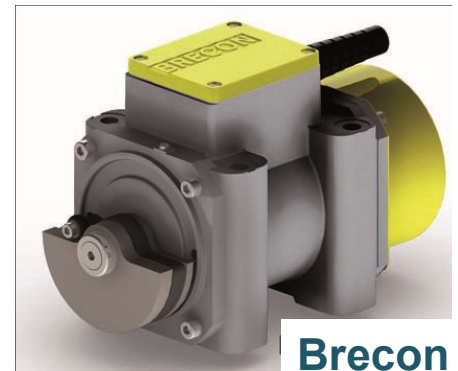
COUGAR D-SERIES



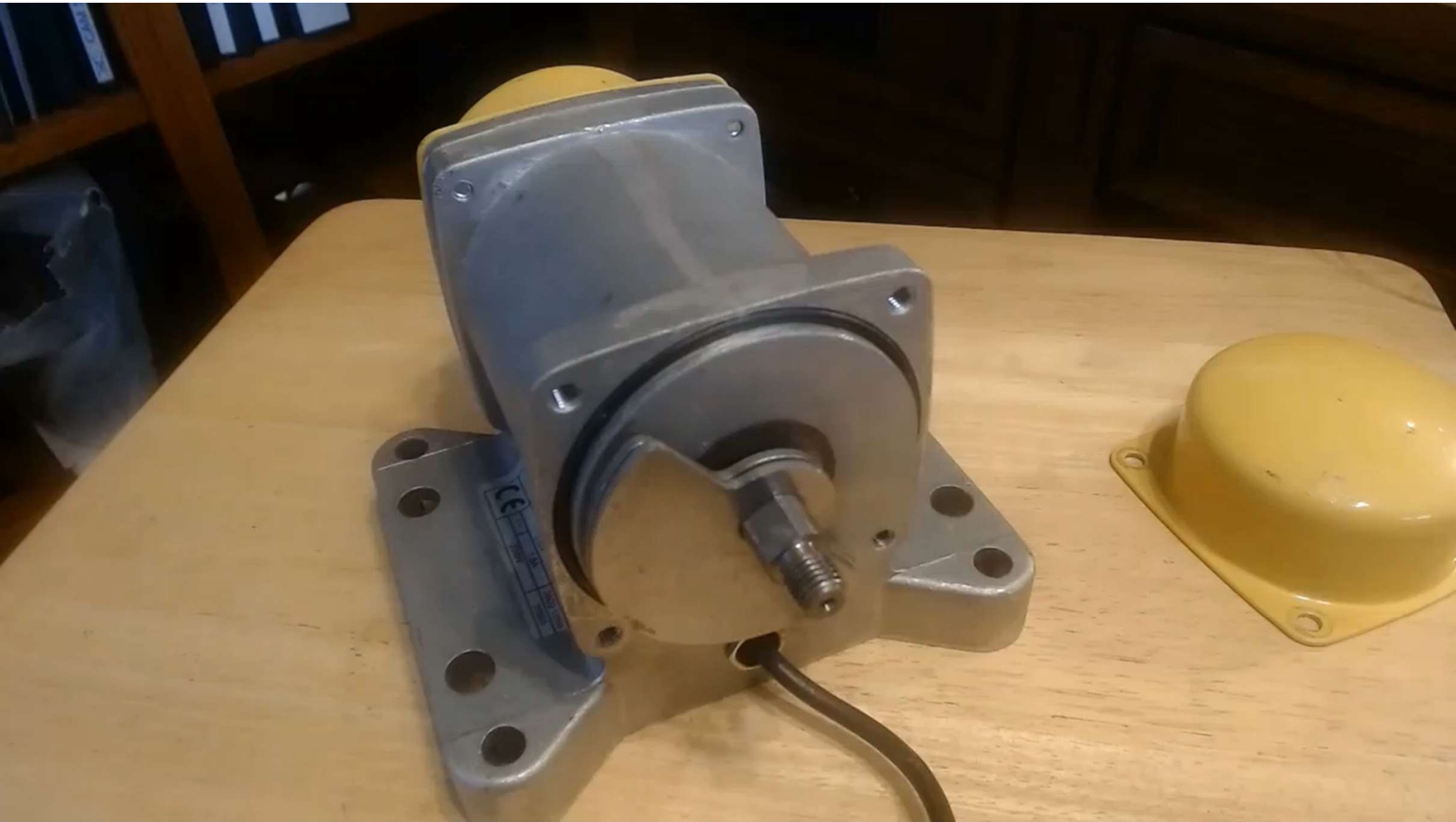
ISKCO HKM75LFS

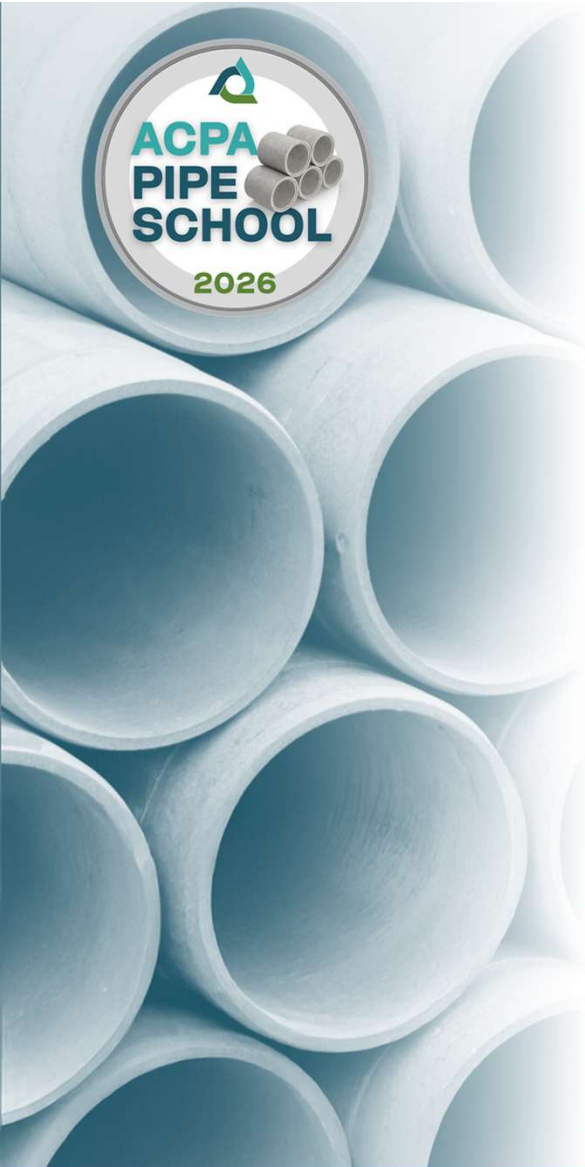


OLI 5100

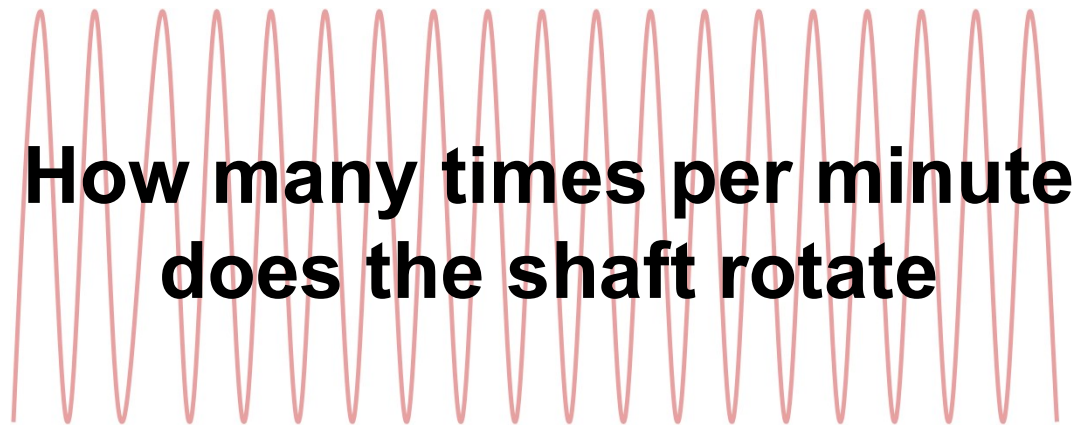


Brecon





Frequency



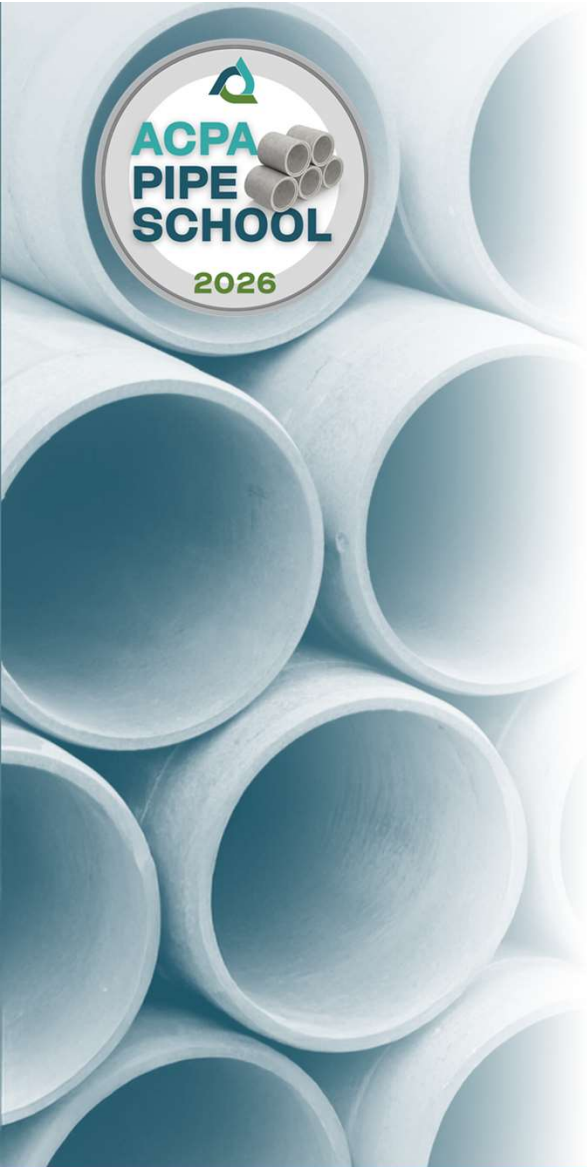
**How many times per minute
does the shaft rotate**

3450

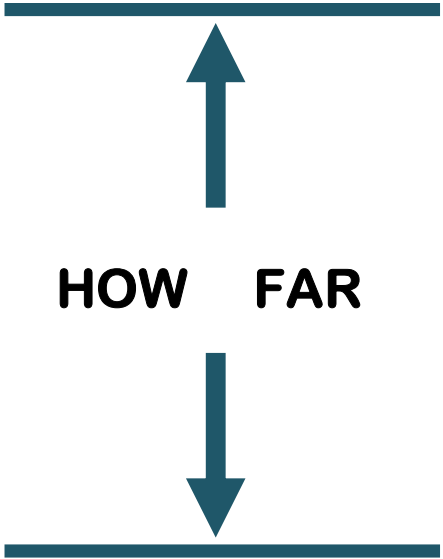
3600

6000

10-15,000



Amplitude



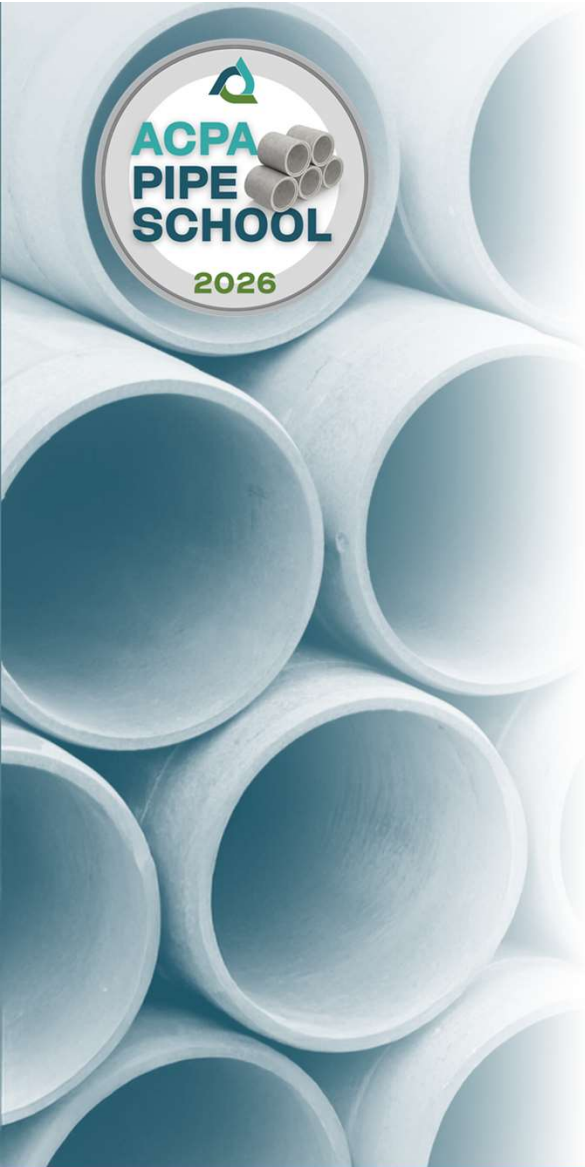
The logo for ACPA PIPE SCHOOL 2026 is circular, featuring a stylized water drop icon at the top, the text 'ACPA PIPE SCHOOL' in the center, and '2026' at the bottom. The background of the slide is a stack of white pipes.

Amplitude

It is affected by frequency....

The higher the frequency the lower the amplitude

The lower the frequency the higher the amplitude



Amplitude/Frequency Demo

The logo for ACPA Pipe School 2026 is circular, featuring a stylized water drop icon in blue and green at the top. Below the icon, the text "ACPA PIPE SCHOOL" is written in a bold, sans-serif font, with "ACPA" in blue and "PIPE SCHOOL" in black. At the bottom of the logo, the year "2026" is written in a smaller, green font. The logo is set against a background of stacked white pipes.

Amplitude & Frequency of Vibration

Amplitude

- Effects heavier mass
- Moves the aggregate
- Determines the radius of action

Frequency

- Effects lighter mass
- Moves the paste
- Governs liquefaction

The logo for ACPA Pipe School 2026 is circular, featuring a stylized water drop icon at the top, the text 'ACPA PIPE SCHOOL' in the center, and '2026' at the bottom. The background of the slide is a stack of white pipes.

Vibration Force

Take the MASS

Determine the FREQUENCY

Which affects the AMPLITUDE

Which is also affected by the ACCELERATION (CENTRIPETAL)

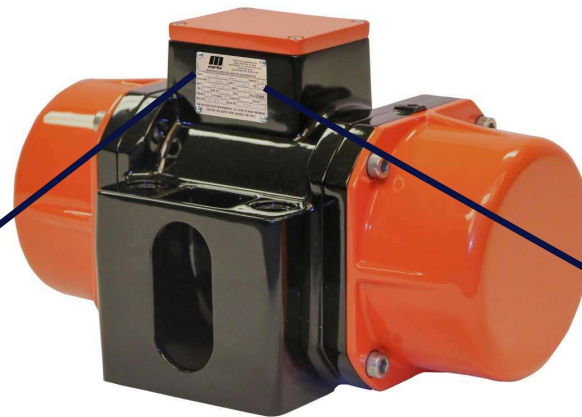
And you come up with the **FORCE**

FORCE IS WHAT IS ACTUALLY

DOING THE WORK OF CONSOLIDATION

Vibration Force

Martin MB36
3000



PERFORMANCE DATA								
Part Number	Model	RPM at 60Hz	Unbalance In. Lbs 60Hz	Cenrifugal Force	Power Output	Amps		Weight
				460V 60Hz lbs (kg)	460V 60Hz hp (kW in)	230V 60Hz	460V 60Hz	460V 60Hz lbs (kg)
MB35C02	MB36-3000	3600	8.94	3000 (1361)	1.30 (1.00)	3.80	1.90	66.8 (30.3)

The logo for ACPA Pipe School 2026 is located in the top left corner. It features a circular emblem with a stylized water drop icon at the top, the text 'ACPA PIPE SCHOOL' in the center, and '2026' at the bottom. The background of the slide is a stack of white pipes.

Form Vibration

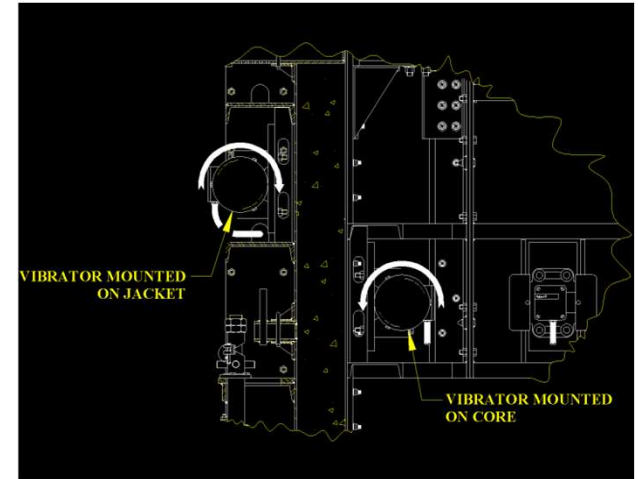
The formula for typical vibration pounds of force requirements:

$$\text{Force Needed} = \left(\text{Weight of the form} + \text{Weight of the concrete} \right) \times 1.5 - 2.0$$



Example

8x6x6 Box Culvert



$$\left(6,500 + 19,200 \right) \times 1.5 = 38,550 \text{ lbs}$$

10 – Brecon 18126, 3950 lb @ 65% = 39,500 lbs

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Form Vibrator Sizing

- The harsher the mix = more Force
- The stiffer the form = more Force
- More flowability = less Force

*Take away: it all varies by plant, forms, size, raw materials, mix design, etc.

Work with your suppliers on sizing



Stinger Vibrators

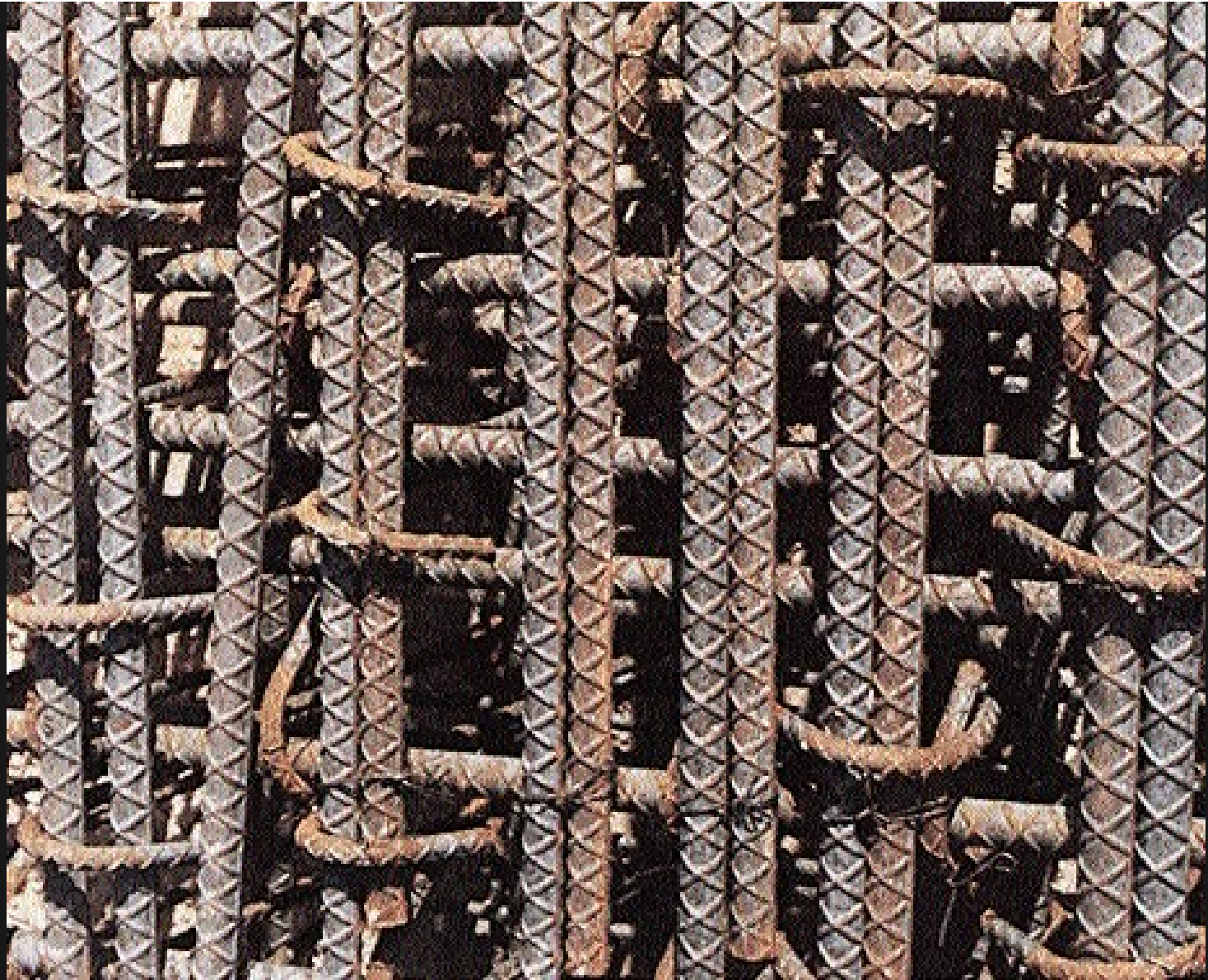
Rule of Thumb

The Head Diameter should be approximately:

$$\frac{\text{Wall Thickness}}{4}$$

It's important to assess your common cage configurations





The logo for ACPA PIPE SCHOOL 2026 is circular, featuring a stylized green and blue water drop icon at the top. Below the icon, the text "ACPA PIPE SCHOOL" is written in a bold, sans-serif font, with "ACPA" in green and "PIPE SCHOOL" in blue. At the bottom of the circle, the year "2026" is written in green. The logo is set against a background of stacked white pipes.

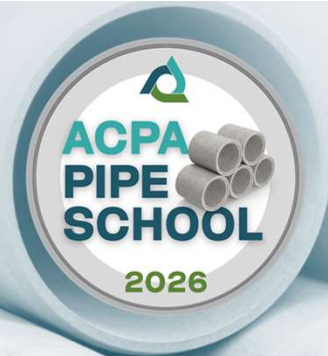
Stinger Vibrators

Stinger vibrators are usually VERY HIGH VPM

10,000-17,000 VPM

(however, they typically loose 20% when inserted in concrete unless the motor is in the head of the stinger)

Be careful when using an air entrainment additive as it may significantly reduce the air if over vibrated



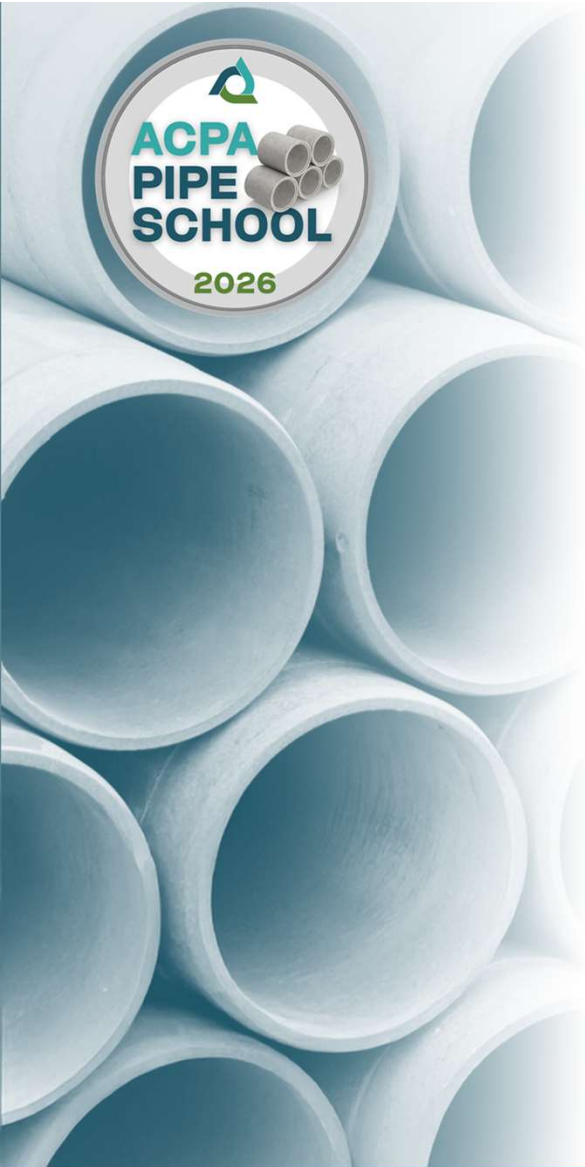
Important Note:

Dry-cast vibration is very different from wet-cast vibration

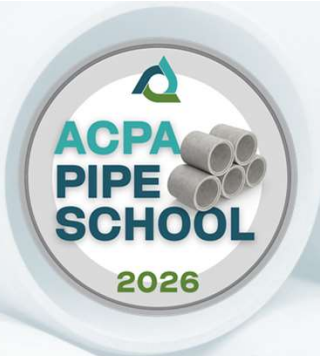
Dry-cast forms are designed for specific vibration system

Don't mix & match dry and wet-cast systems!



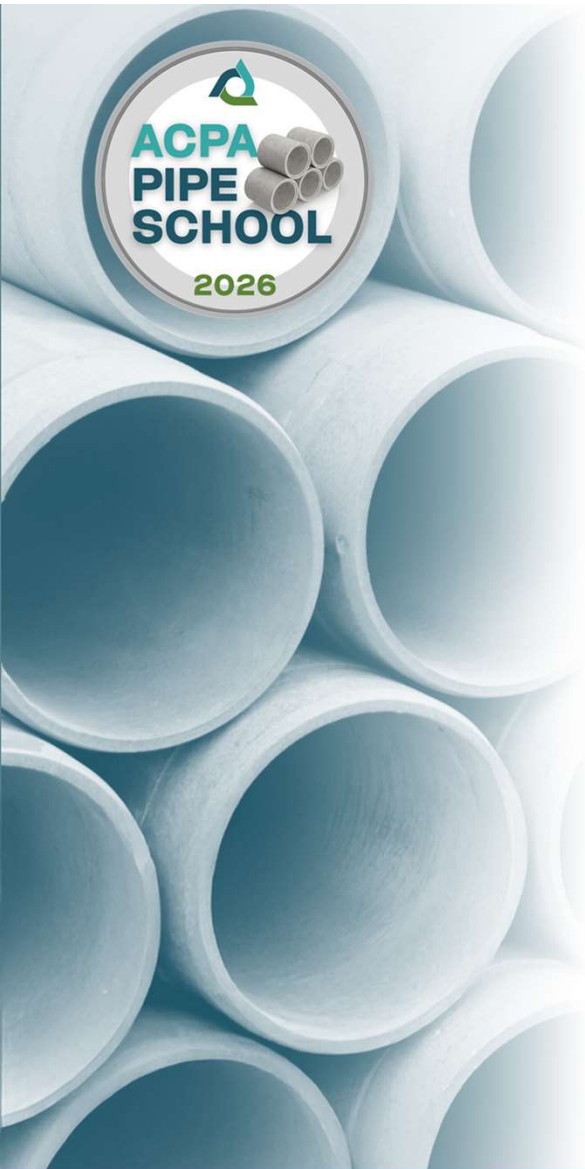


Questions?



Curing





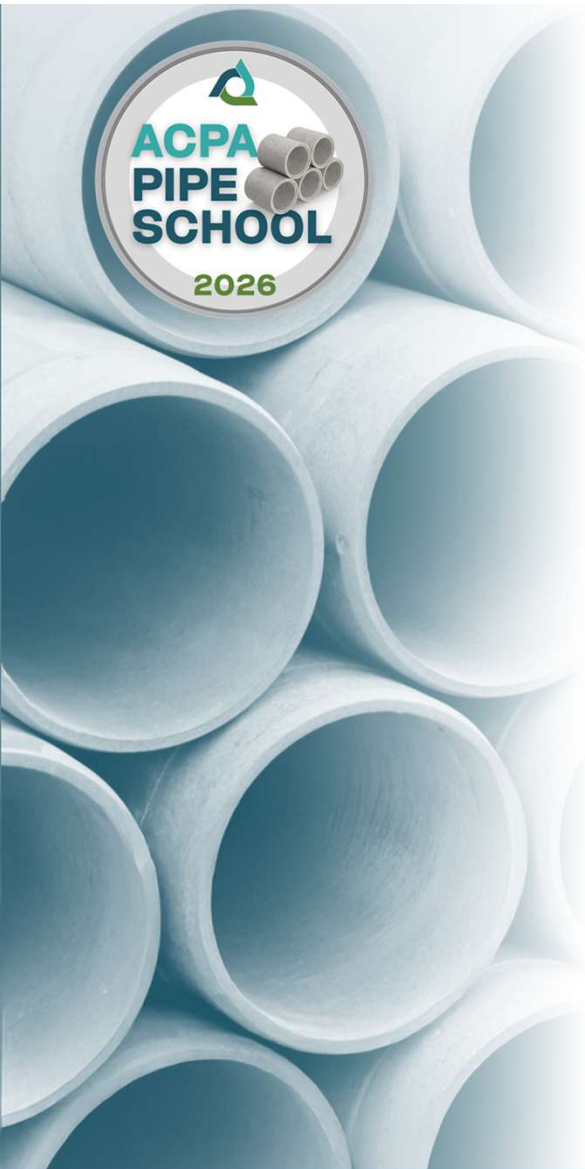
How Does Curing Work? - Hydration

It's a chemical reaction between the water and cementitious material which makes the

CSH gel

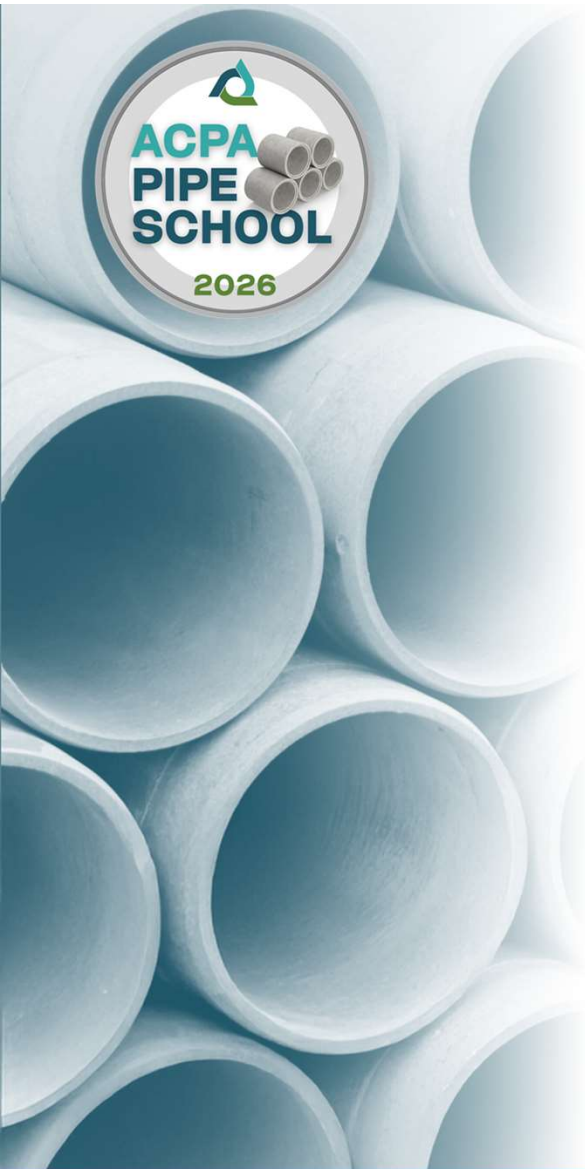
(Calcium silicate hydrate)

CSH is the "Glue" that holds the concrete together



What Conditions MUST BE MET FOR CONCRETE TO CURE PROPERLY?

To properly cure concrete, it is important to provide a **humid environment** and a **warm temperature**



Accelerated Curing Cycle

- Preset – initial set
- Ramp – 20 to 40 degrees per hour
- Hold – Curing temp for 4 to 6 hours
- Cool Down – allow concrete temperature to gradually cool down

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Accelerated Curing Cycle

Initial Set

- Initial setting time of concrete is the time period between addition of water to cement till the time the concrete paste reaches 500 psi

Ramp Rate

- Must stay below 40°F/hr to avoid thermal shock

Hold

- Holding period at higher temperature, usually 4 – 6 hours, Must stay below **160°F per specifications**

Cool Down

- Allow concrete to cool down at a similar rate to the ramp rate to avoid thermal shock

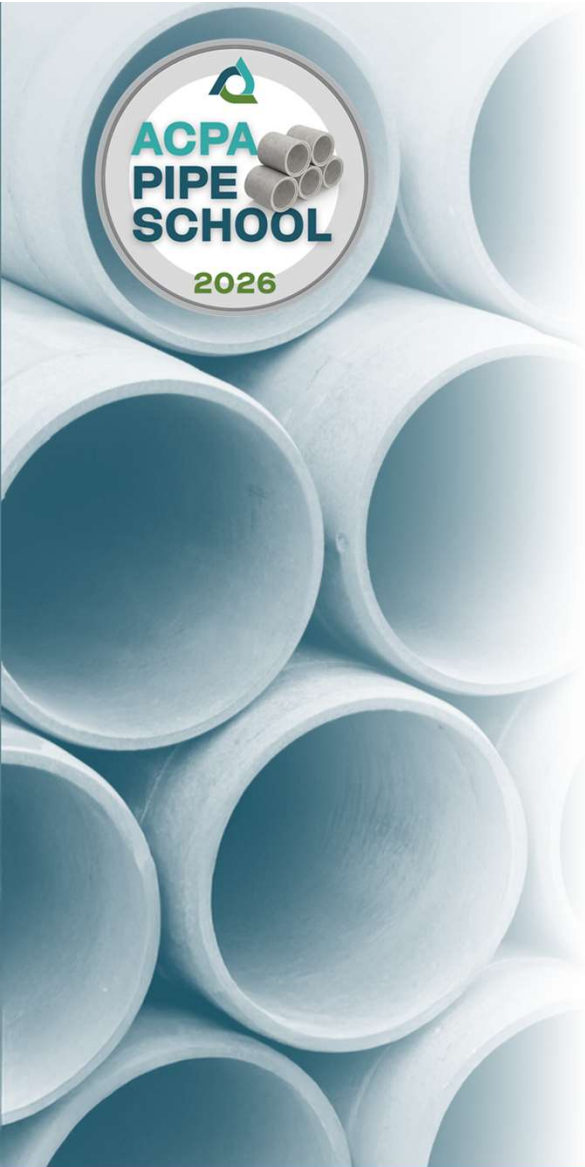




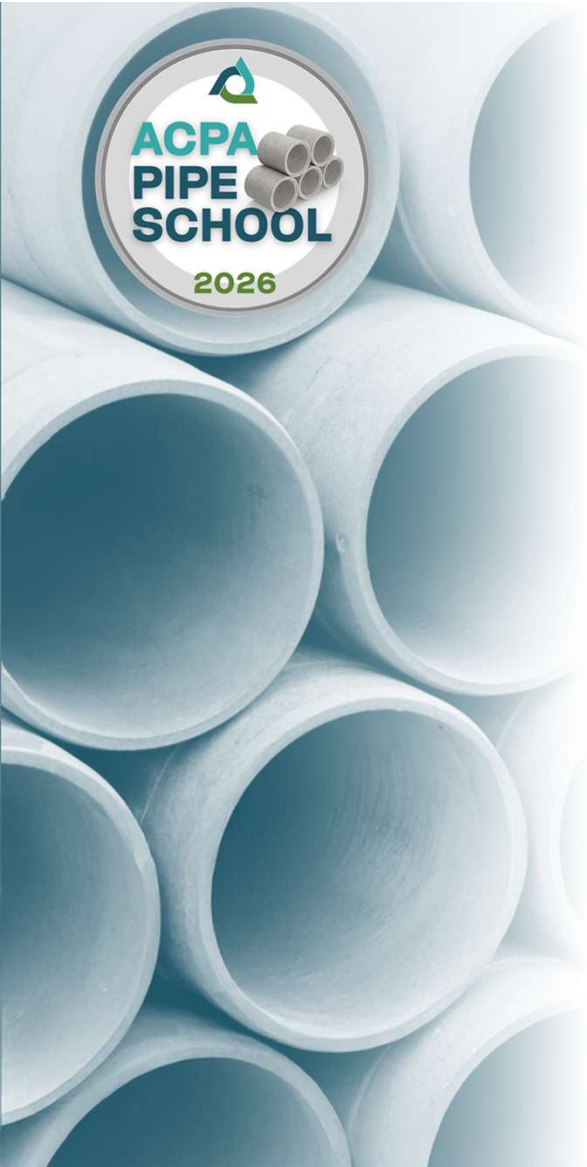








**It Is Very Important To
Monitor Your Curing Cycle**



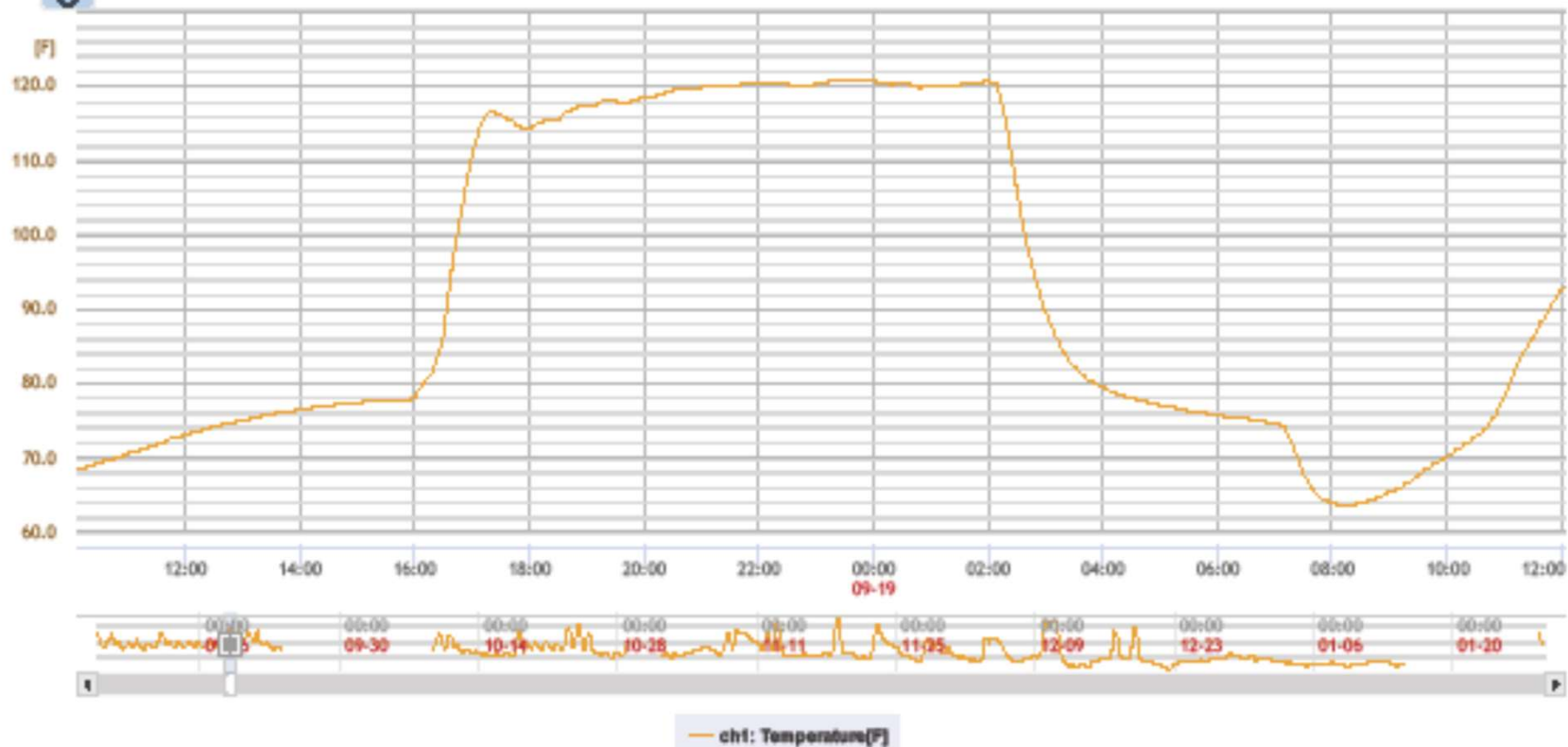
2/3/25, 8:46 AM

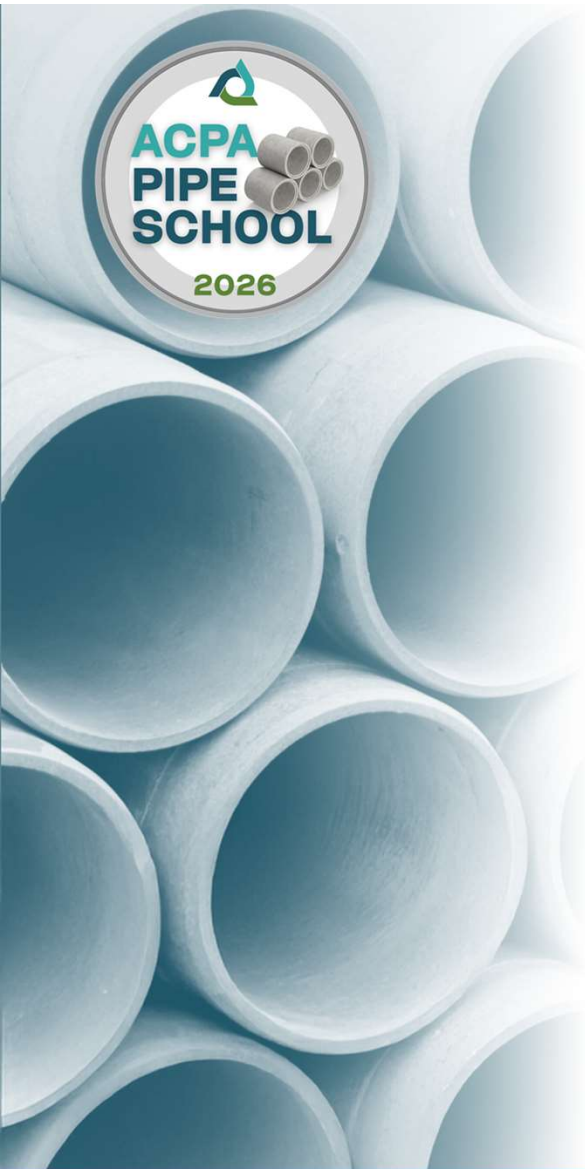
Device Name : Specials 2 - MDOT

Device Name: Specials 2 - MDOT

Model: RTR501B , Serial Number: 328000EB , Number of Readings: 16000

Zoom **1H** 6H 12H 1day 1w 1M All

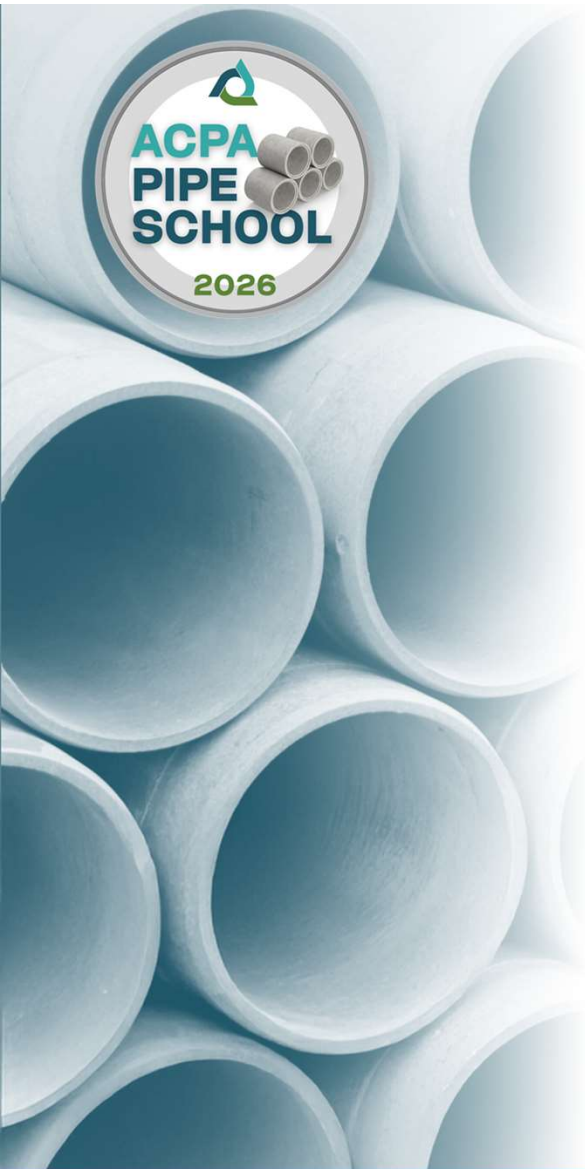




If We Did Everything Right But We Didn't Cure Correctly

What Are Some Of The Signs Of Under Cured Product?

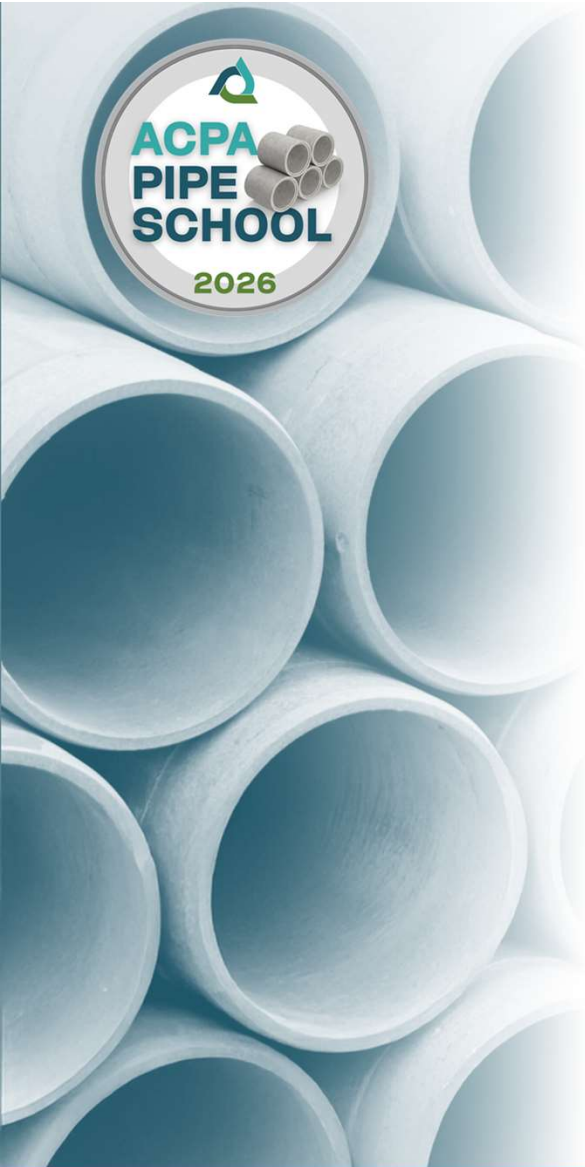
What Are Some Of The Signs Of Over Cured Product?



Curing

- Was there enough heat?
- Did it even get heat?
- Was the curing cycle too short?
- Was there flueing in the kiln or tarp?



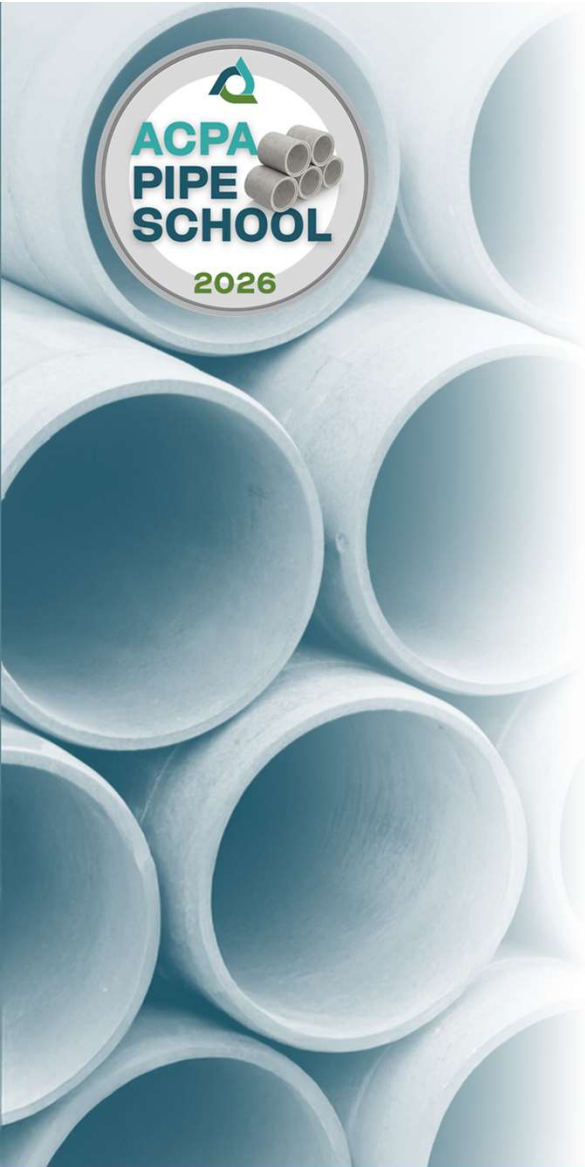


Questions?



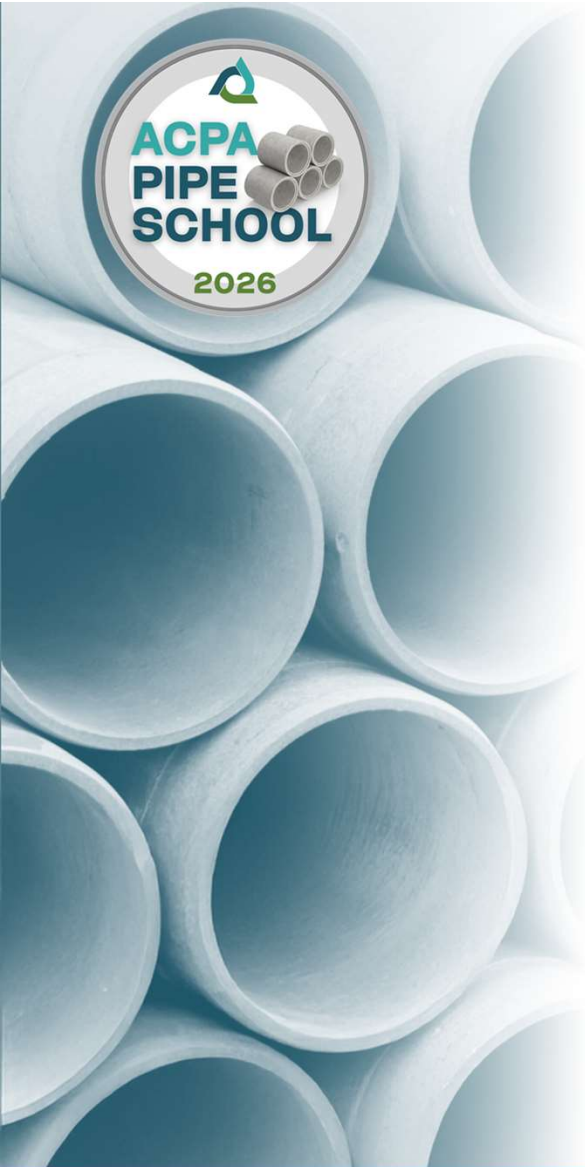
Post Pour





Why Do We Do Post Pours?

To verify the overall quality of the structure and
to have a written record

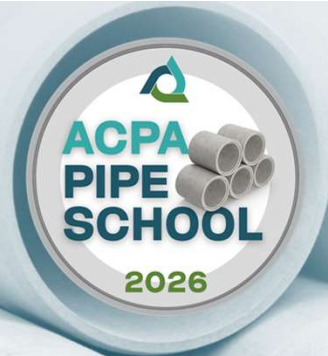


Visually Inspect The Box For

- Cracks
- Voids/Bleeding
- Flashing
- Slumping
- Exposed Steel
- Bugholes
- Spalls and breaks





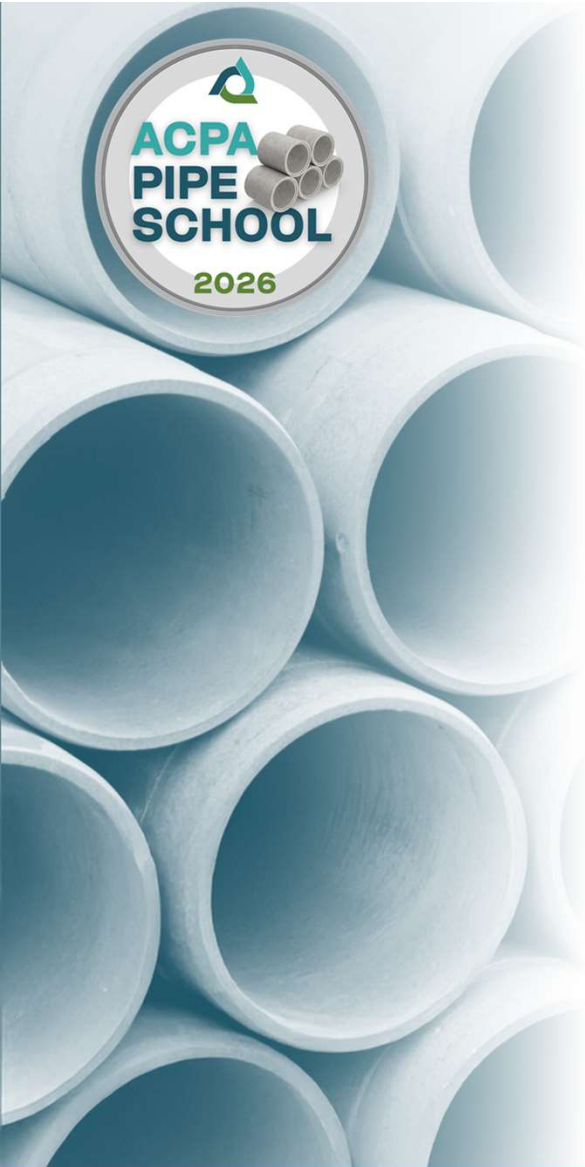


Inserts

- Location of inserts and block-outs
- Size of inserts and block-outs
- Consolidation of concrete around inserts and block-outs
- Removal of block-outs
- Depth of inserts
- Straightness of inserts
- Check for any damage to inserts







Marking





5

4800 X 2400 PORT QUIN
UNIT 5 3050 TON

6138.

FEB. 12, 2025

LOUIS W. BRAY CONSTRUCTION

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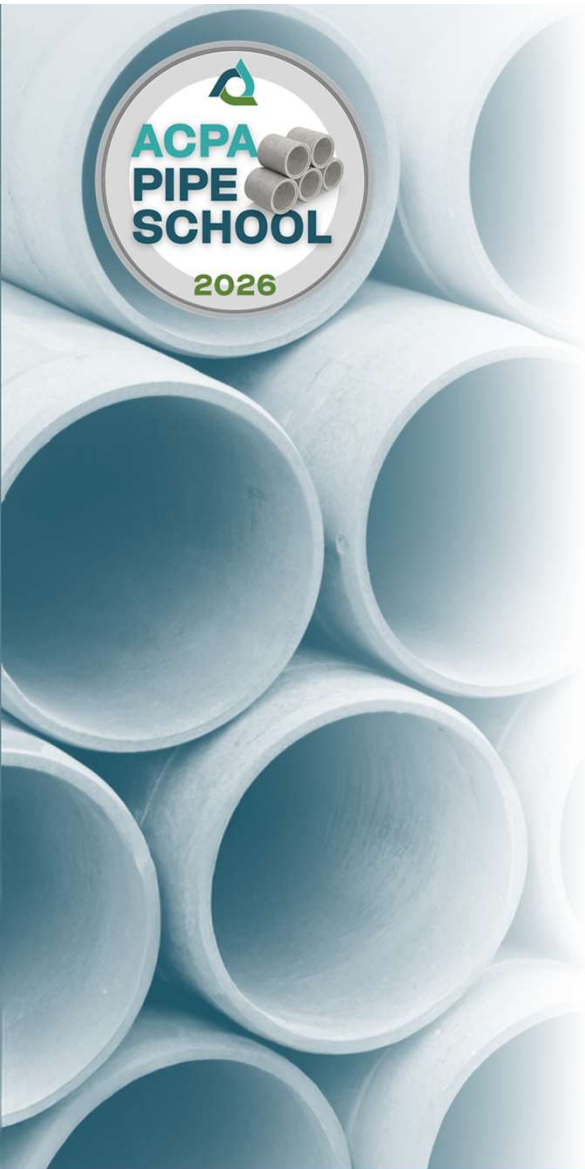
Minor VS. Major Defects

Minor Defects

- Any defect that affects the appearance of the product, but not the structural integrity or performance of the product

Major Defects

- Any Defect the affects the ability of the structure to preform as designed
- Some of these may include structural concerns



Example Of a Minor Defect

- Any chip or spall that doesn't affect the performance of the structure
- Superficial cracks that are allowed by specifications
- Small or shallow bugholes
- Cosmetic defects should always be addressed by patching or working to avoid them to begin with



Types Of Major Defects

- Exposed wire with less than 5/8" of cover
- Voids
- Any break that affects the joint
- Honeycombing
- Cracks greater than .01" that go through the wall









What Do You See?

- A hammer
- Could this have been prevented?
 - Should have been seen on the pre-pour
 - By QC or the person that dropped it in the form work





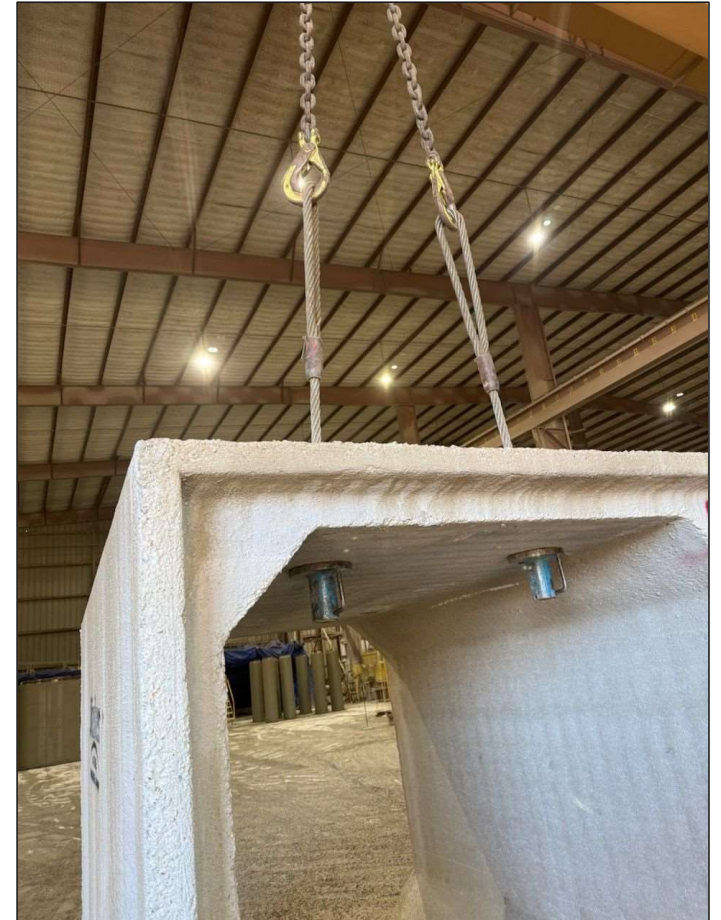
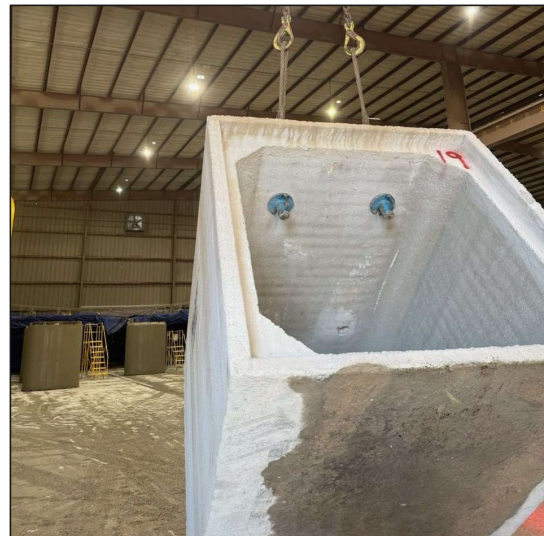
Handling





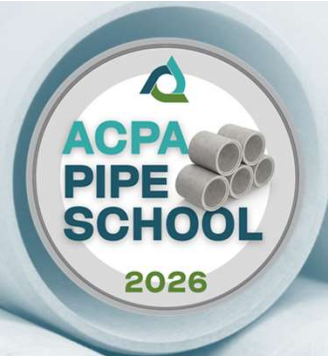
Tipping Boxes

- Tipping table
- Tipping in soft material
- Tipping with cables
- Tipping with fork trucks







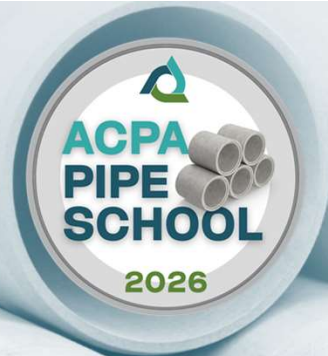


Lifting and Moving Boxes

- Lifting jigs
- Lift holes and pins
- Lift holes, cables, and pods
- Embedded lifting devices
- Fork trucks with protection on forks



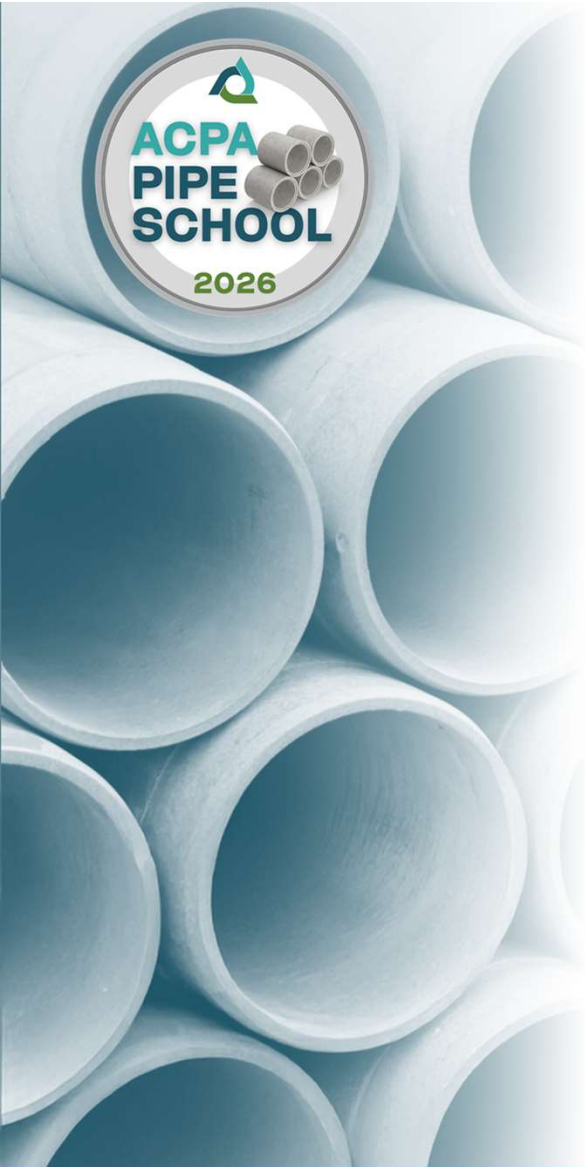




Handling Beams

- A must when lifting with cables or lifting chains
- Educate your contractors!





Storage

- When to yard boxes
- Store box culverts on flat ground or dunnage
- Do repairs while box is still warm
- When stacking, put dunnage between boxes

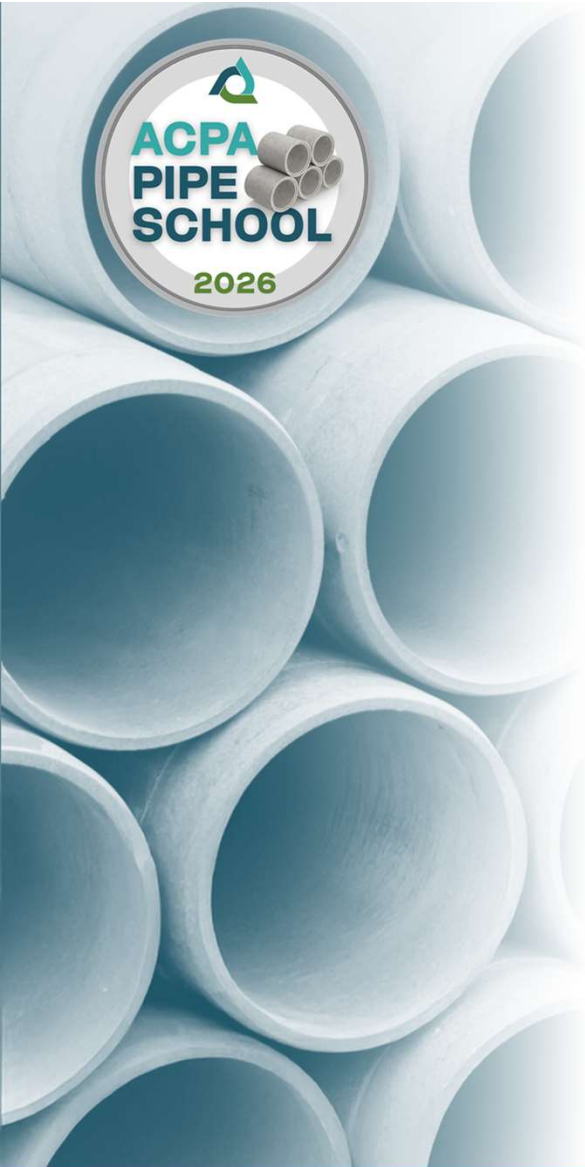






Shipping



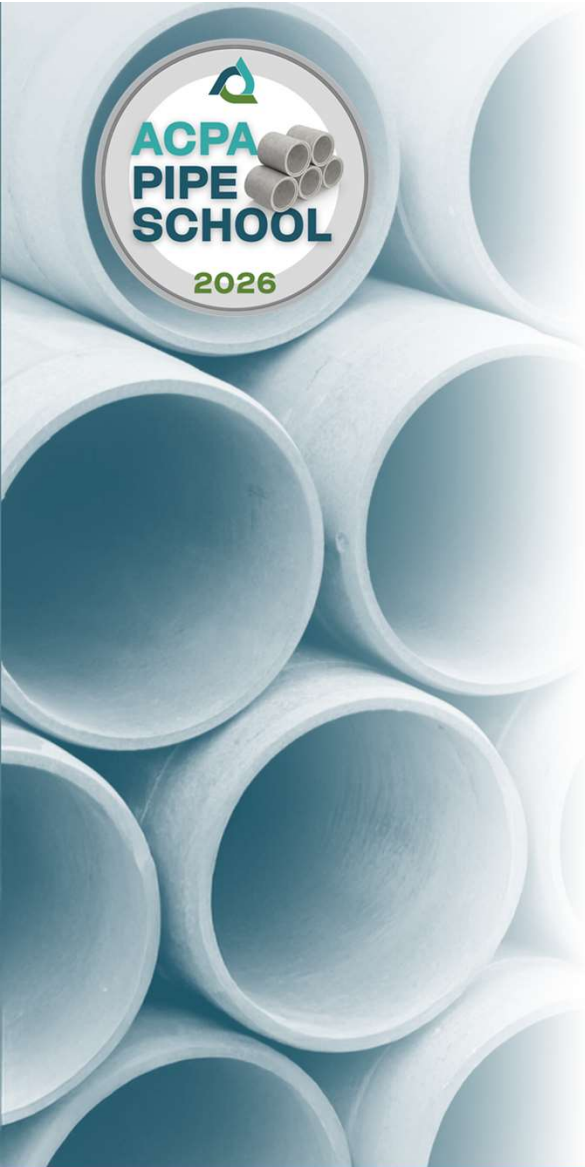


Shipping

- Use edge protectors
- Set boxes on dunnage where steel rails on trailer decks may flex during transit





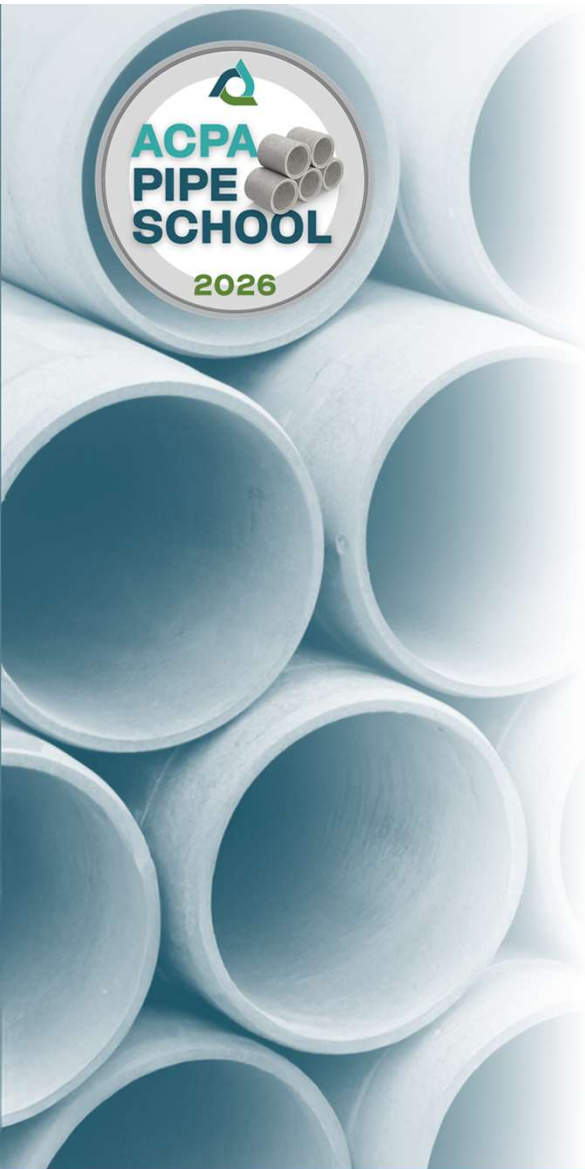


Why Did We Spend So Much Time On Box Culvert Production?









In Conclusion

It is better to be proactive during maintenance and pre-pours, than to be reactive after post pours



Thank You

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