



# SHOTCRETE FOR REPAIR, REHABILITATION AND REPURPOSING


MAY 21, 2026 - CONCRETEFIX WEBINAR  
CONCRETE SOCIETY OF SOUTHERN AFRICA





Charles Hanskat, PE (FL), F.ACI, F.ASCE  
Executive/Technical Director  
American Shotcrete Association



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# THE ORIGINAL 3-D PRINTING



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## Shotcrete - Definition



*Concrete placed by a high velocity pneumatic projection from a nozzle.*

As defined in ACI CT-25 *Concrete Terminology*

High Velocity = 60 to 80 mph



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Shotcrete is not a product...

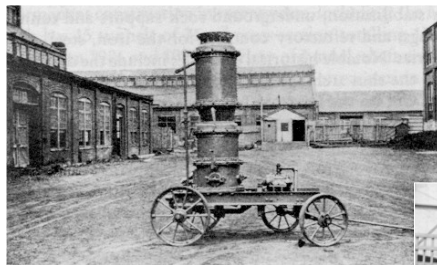


...It is simply a method of placing concrete



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## History of Shotcrete



Carl Akeley  
Original Shotcrete Gun  
1907

Dry-Mix Shotcrete  
1920's



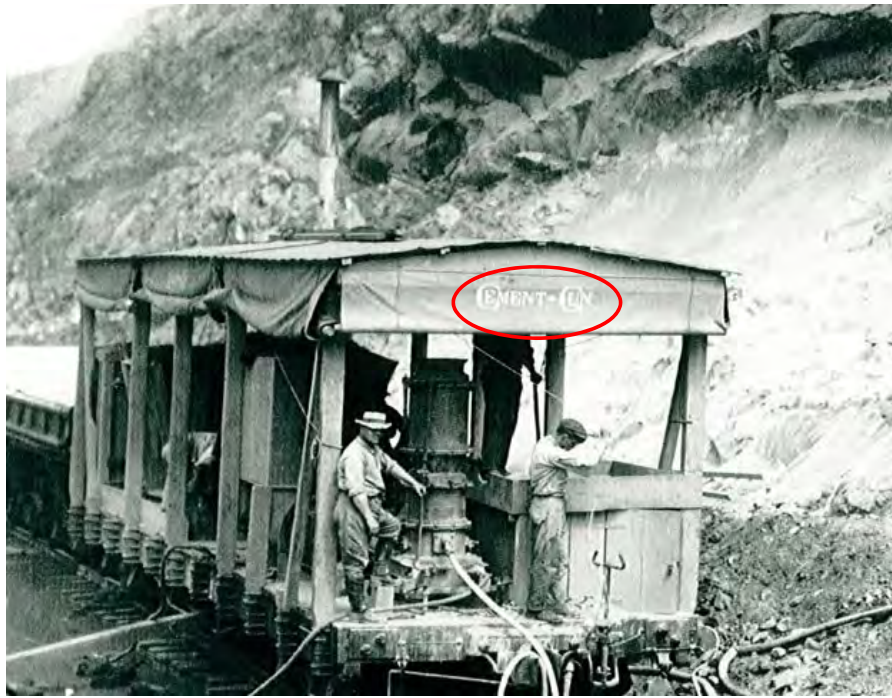
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# History of Shotcrete



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## History of Shotcrete



Dual chamber  
Shotcrete gun 1922

Dry-mix shotcrete  
1922



regon City Bridge  
"Shooting and Screeding Gunite on Top of Arch Rib. Oct. 27, 1922"

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## History of Shotcrete Wet-Mix Process



Wet-mix Process  
1959

1951 – ACI adopted the term “shotcrete”

1966 - ACI adopted “wet-mix” and “dry-mix” shotcrete

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## History of Shotcrete



Dry-mix shotcrete  
Today



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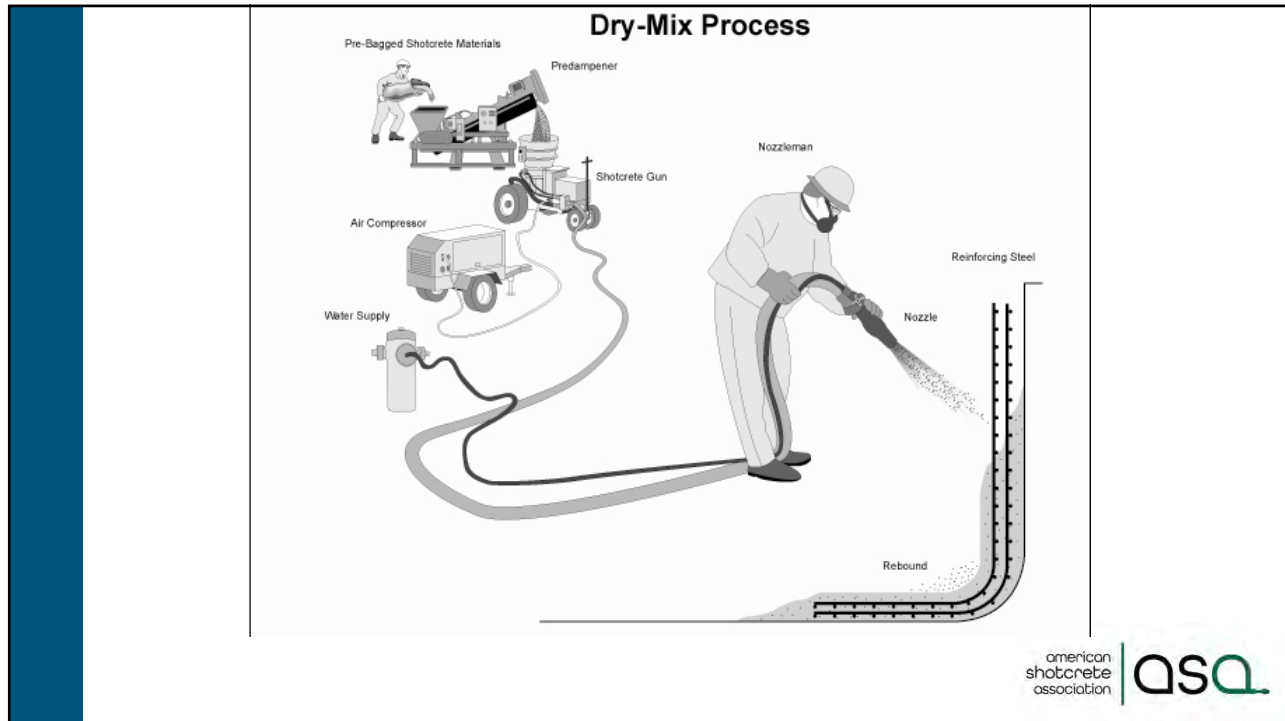
## History of Shotcrete



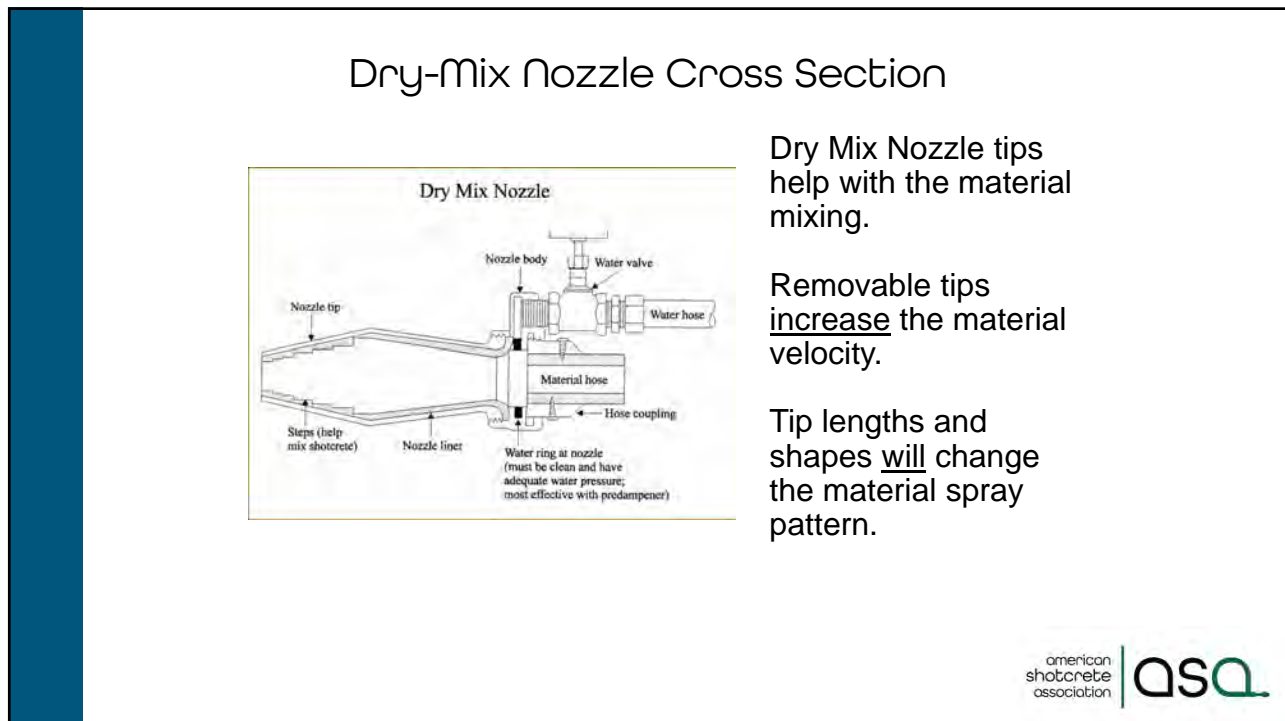
Wet-mix shotcrete  
Today



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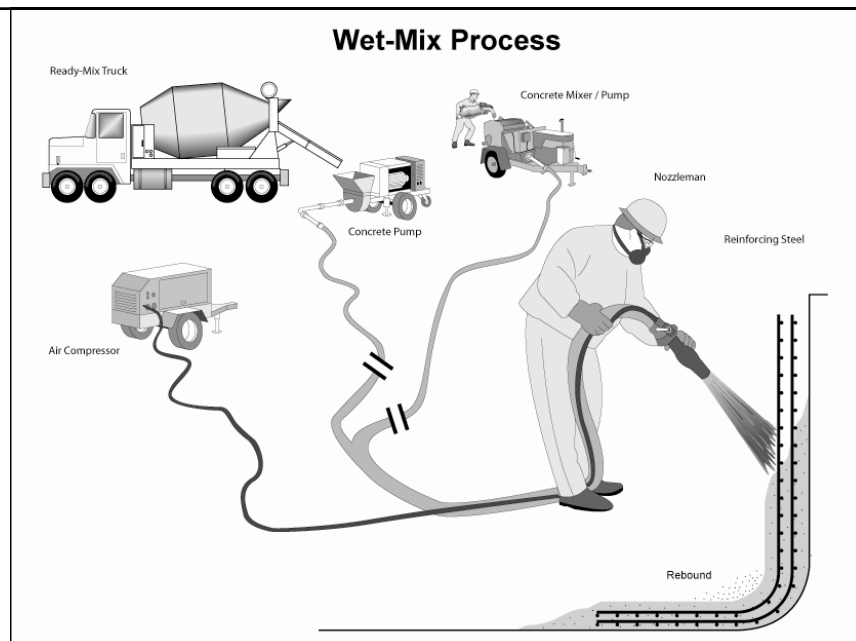


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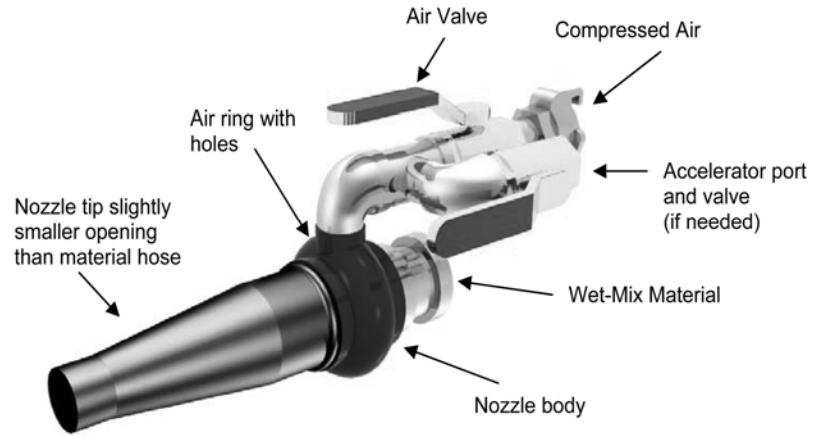
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## Wet-Mix Shotcrete Nozzle



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## Dry vs Wet Process?

Specifications should be performance based  
and left  
to the choice of the contractor

## Comparison of Shotcrete Processes

Dry-mix process	Wet-mix process
<b>1. Instantaneous control over mixing water and consistency of mixture at nozzle to meet variable field conditions</b>	<b>1. Mixing water is controlled at mixing equipment</b>
<b>2. Well suited for placing in applications that often have to start and stop</b>	<b>2. Less dust and cementitious materials lost during shooting operation</b>
<b>3. Delivery hoses are lighter and easier to manipulate</b>	<b>3. Normally has lower rebound, resulting in less waste</b>
<b>4. Lower volume per hose size</b>	<b>4. Higher volume per hose size</b>

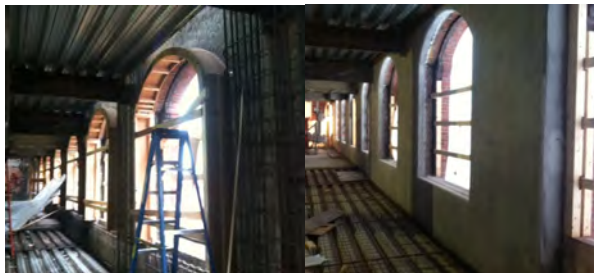
## Parking Garage



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## Building Retrofits



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## Bridge Retrofits



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## Canals and Aqueducts



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## Marine Structures



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## Dams



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## Remotely Manipulated Nozzle



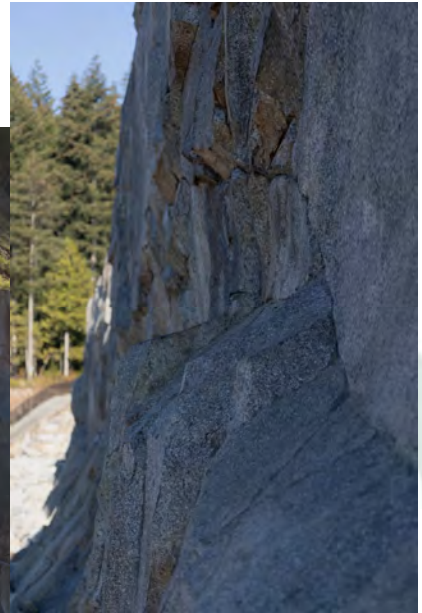
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## Soil Nail



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# Soil Nail Walls



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# Foundation - Basement Walls



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## Structural Walls



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## Architectural



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# Architectural



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# Pools



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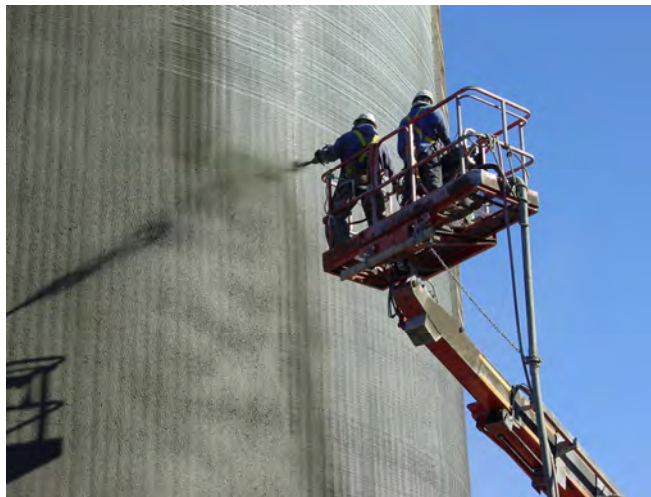
# Pools



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# Prestressed Tanks



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# Storage Domes



# Bobsled Run



# Skate Parks



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# Zoo Exhibit – Simulated Rock



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# Example Repair Projects

- Highway
- Tunnel
- Marine

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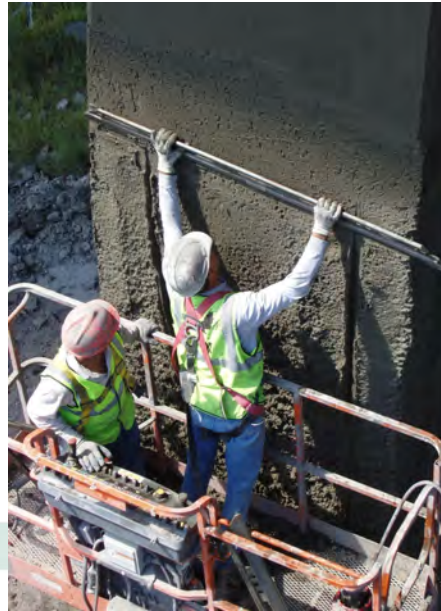
**50 ft by 6 ft (15 m by 1.8 m)  
Platforms weighing more than  
6,000 lbs (2700 kg)**



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Wet cured with wet cotton mats for a minimum of 7 days



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15,000 ft<sup>3</sup> (425 m<sup>3</sup>) of removal and replacement



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Over 15,000 lb (6800 kg) of supplemental reinforcement



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Water cured with wet cotton mats for 7 days



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## The Deterioration of Piers



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## Pier Hammerhead



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## Drainage problems led to the corrosion



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## Preparation of Repair Areas



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# Overhead placement



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# Prepackaged Materials



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## Supporting the bridge during concrete removal and shotcrete placement



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## Completed Shotcrete Piers



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## Tunnel Project – Liberty Tunnel, Pittsburgh



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## Tunnel Project



Additional reinforcement

Hydro-demolition



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## Mobile equipment



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Finished patch on ceiling with white to clear curing agent.

Prepared substrate ready for application of flashcoat.



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# Finished tunnel



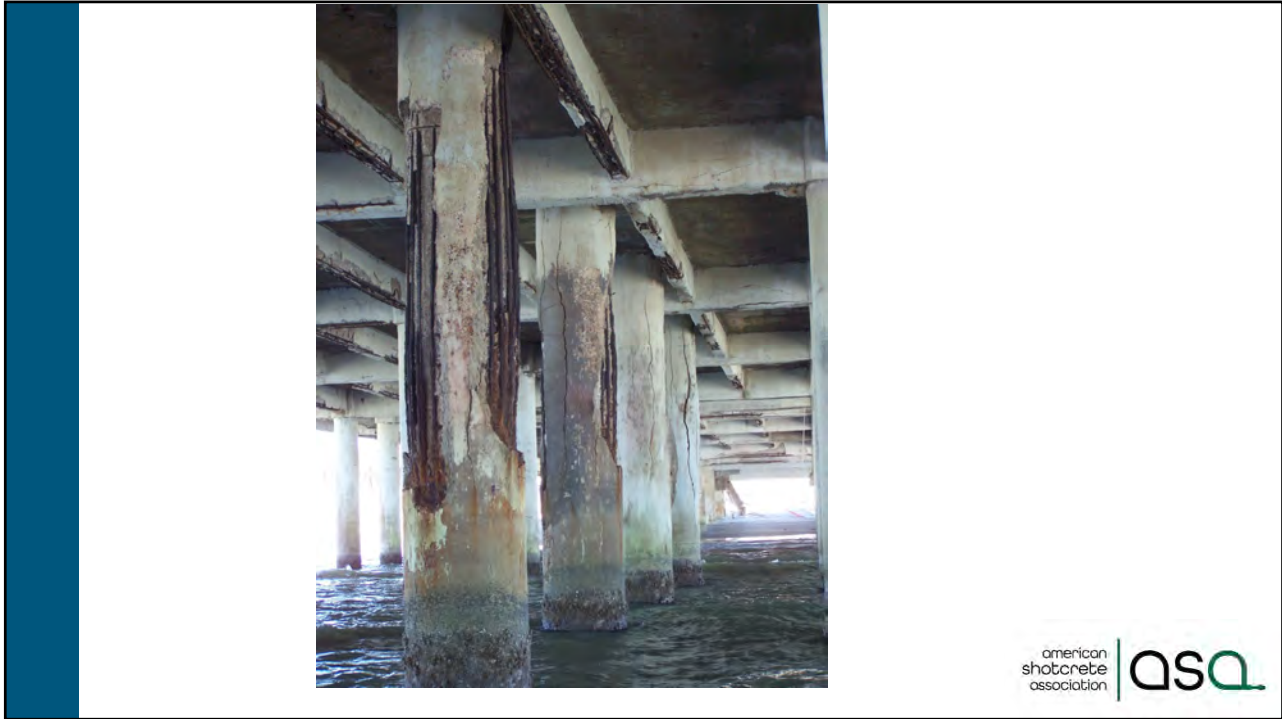
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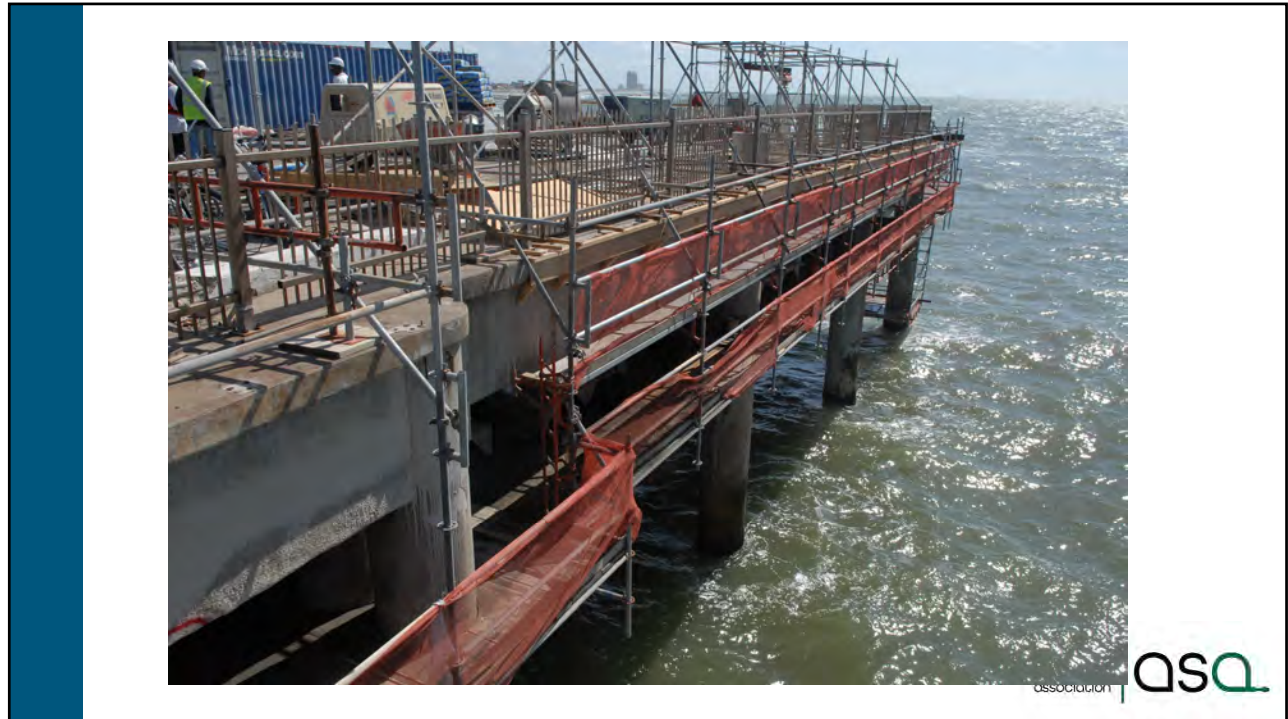
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## Environmental Conditions

Cold weather – (ACI 306R *Cold Weather Concreting*)

- 40°F (5°C) and falling unless protective measures taken
- Do not apply shotcrete on frozen surfaces
- Mix temperature above 50°F (10°C)
- Protect from freezing until it has reached at least 500 psi (4 MPa) in compressive strength

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## Environmental Conditions

Hot weather (ACI 305R *Hot Weather Concreting*)

- Keep mix temperature as low as possible
- **Do not apply shotcrete when ambient temperature above 100°F (38°C) unless precautions taken**
- Cool water
- Sun shades where possible
- Fogging / misting

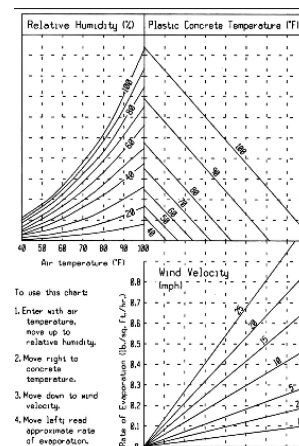
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## Environmental Conditions

### Wind

- Avoid applying shotcrete during high wind conditions
- Provide protective barriers
- Causes separation of fines in nozzle stream
- **Causes high rates of evaporation**
- Can cause plastic shrinkage cracking



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## Environmental Conditions

### Rain

- Heavy rain
- Ponded or running water
- Protection possible

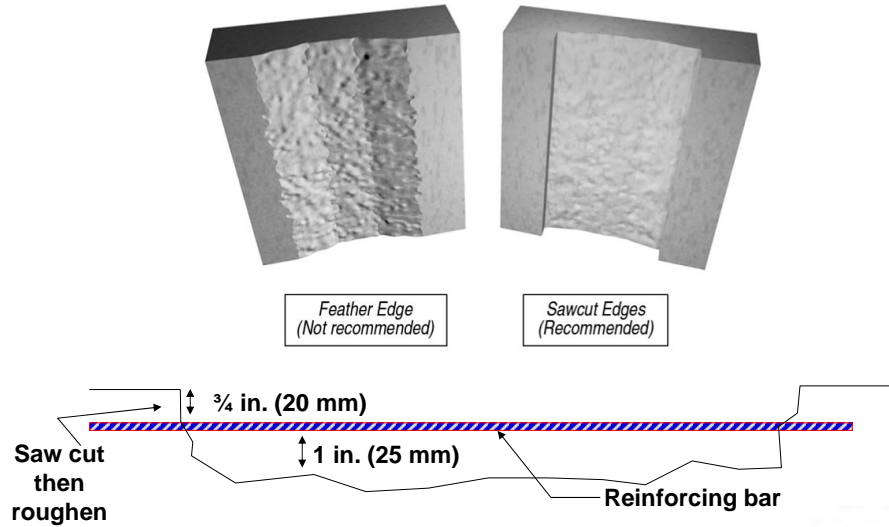


## Preparation of Existing Structure

1. Back to sound substrate
2. Rough
3. Clean
4. Wetted to saturated, surface dry condition (SSD)



## Preparation of Existing Structure



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## Preparation of Existing Structure

- Bonding agents are **never** recommended for wet or dry mix shotcrete applications
- The shotcrete process inherently ensures excellent bond to properly prepared SSD substrate
- Bonding agents **will** create a “bond breaker” at the interface between the shotcrete and the substrate and **will** lead to bond failure

## What about Cold Joints?



“Cold joint—a joint or discontinuity resulting from a delay in placement of sufficient duration to preclude intermingling and bonding of the material, or where mortar or plaster rejoin or meet.”

*ACI CT-22 Concrete Terminology*

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“Cold joint—a joint or discontinuity resulting from a delay in placement of sufficient duration to preclude intermingling and bonding of the material, or where mortar or plaster rejoin or meet.”

*ACI CT-22 Concrete Terminology*

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Bond quality of shotcrete is derived from the very high energy placement and abrasion at the surface



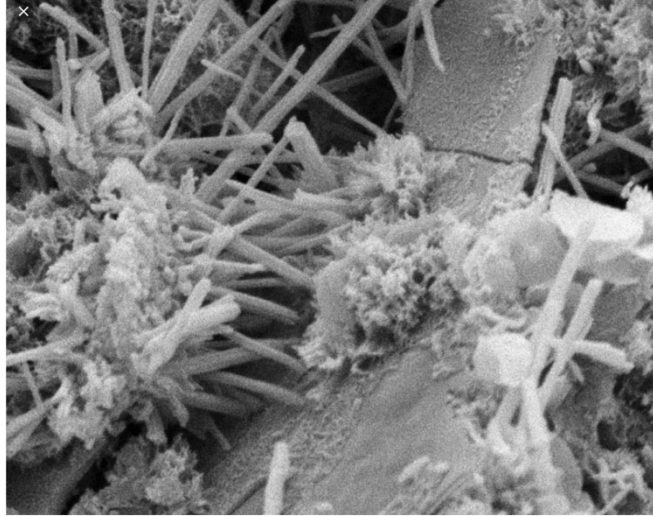
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Thin layer comprised of compacted cement paste



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## Cement hydrates in the pores of the substrate



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Shotcrete applied to a properly prepared concrete substrate can form a bond that is stronger than the cohesive strength of the underlying layer



Close up of repair shotcrete bond (right)  
to an existing concrete substrate (left)

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## The Application

### FORM AND POUR



### SHOTCRETE



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## Formwork

- One-sided forms
  - *Lighter*
  - *More than 50% less materials*
  - *No need for carrying high pressure*
- Many projects need no forms
- Curved & tapered sections easily produced

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## Reinforcement

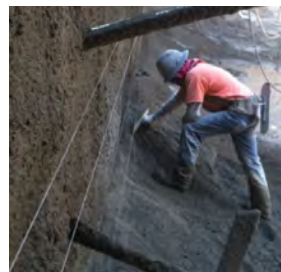


- Same concrete design
- Non-contact lap splices
- Multiple layers

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## Alignment Control

- Use alignment control devices to establish line and grade. Devices include:
  - Ground wires (*piano wire*)
  - Pencil rods for curved profiles
  - Depth gages
  - Guide strips/formwork
  - Templates



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## Construction Joints to an Angle



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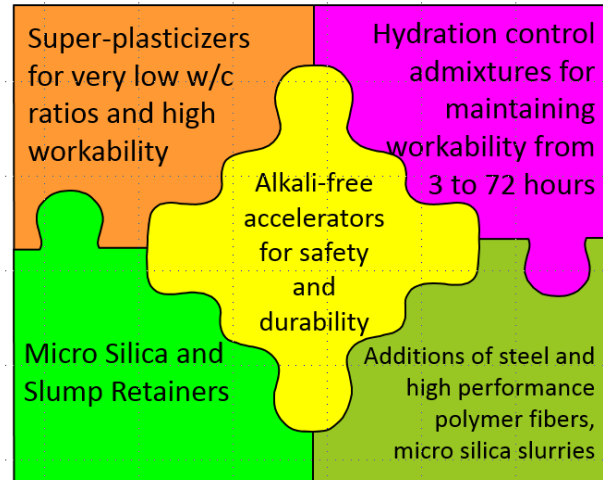
## Sustainability of Shotcrete

- Reduced formwork
- Most efficient sections
- Reduced equipment needs
- Flexible access and schedule
- Time savings
- Better bonding, more durable
- Creative shapes done economically

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## Modern Admixture Technology



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## Typical Shotcrete Mixture

- Cement (Type I, II, III, IL or V) 17 - 20%
  - *Silica Fume* 2 - 8%
  - *Fly Ash or Slag* 15% to 50%
- Water Reducing Admixtures Wet mix only
- Blended Aggregates 75 – 80%
- Air-entraining admixture\*
- Synthetic Fibers\* 1.7-3.4 lbs/yd<sup>3</sup> (1-2 kg/m<sup>3</sup>)
- Steel Fibers\* 65-115 lbs/yd<sup>3</sup> (39- 68 kg/m<sup>3</sup>)
- w/cm **0.30 – 0.45**

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# Portland Cement

Type I, II, III, IV, and V  
GU, LH, HE, MS, HS (Canada)



*Type I and Type II make up ~90% of cement in the United States but PLC (IL and GUL) is coming*

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## Supplemental Cementitious Materials Silica Fume, Fly Ash, Slag

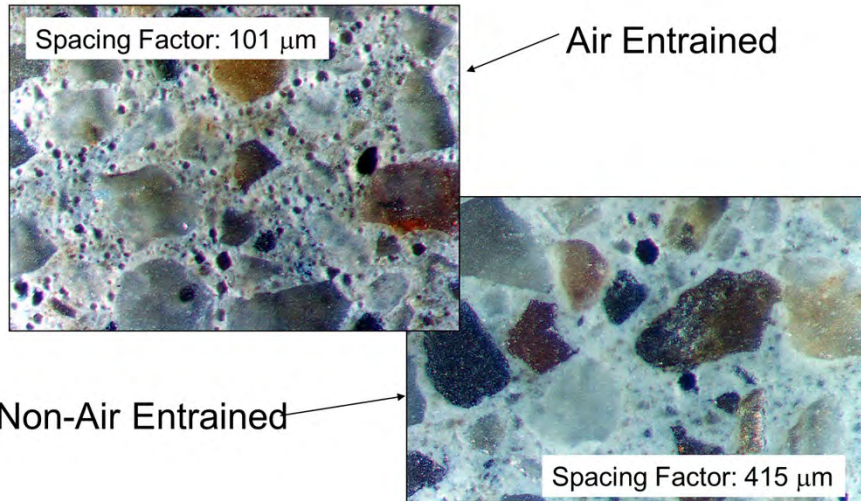
- Higher compressive & flexural strengths
- Silica fume has better adhesion and cohesion
- Reduced permeability - Improves durability
- Improves resistance to sulfate, chemical attack and chloride ion penetration
- Class-F fly ash improves resistance against ASR

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## Air Entraining Admixtures

Dry-Mix Shotcrete



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## Rapid Set Accelerators

- Thicker applications in a single pass
- Reduces set time and develops higher, early age compressive strength
- Accelerator dosage must be carefully controlled

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## Fiber Reinforcement

- Steel fibers



- Micro-synthetic fibers
- Macro-synthetic fibers



- Natural hydrophilic fibers



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## Pre-construction Testing

**ACI PRC-506.7-23 Shotcrete**  
*Preconstruction Mockup—*  
*TechNote*



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Cores containing reinforcement should be provided to the A/E for visual examination for acceptance



Cores should have a minimum diameter of 3.75 in. and be the full thickness of the mockup panel

Refer to ACI PRC 506.6-17:  
*Visual Shotcrete Core Quality Evaluation Technote*

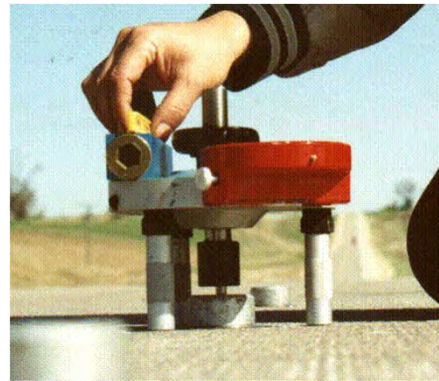
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## Bond Tensile Pulloff Test

Results depend on:

- Surface preparation
- Material quality
- Shotcrete placement

Expect a minimum of 150 to 200 psi (1 to 1.4 MPa)



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## Quality Assurance (QA) Quality Control (QC)

- Shotcrete acceptance/rejection criteria
  - Plastic shotcrete
    - Age, air, temperature and setting time
    - Readily Evident Visually
      - Sags, sloughing, tears
      - Reinforcing encapsulation
      - Line, grade and cover
      - Finish and tolerance

## Quality Assurance (QA) Quality Control (QC)

- Shotcrete acceptance/rejection criteria
  - Hardened shotcrete
    - Compressive strength (cores from panels)
    - Flexural strength (beams)
    - Bond Pulloff (in place) 150 psi
    - Toughness (circular panels)
    - Permeability (RCP, Surface Resistivity, BWA)

## Production Testing

QC testing during production verifies the materials used are as specified



ACI SPEC  
506.2-13(18)  
shoot a test  
panel every  
day or for  
every 50 yd<sup>3</sup>

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## Good Shooting Practices

Corners >  
Edges >  
Middle



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## Impact Velocity vs Reinforcing Bar Encasement



*Proper velocity = Clean bars and proper encasement*

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## Types of Shotcrete Finish

### Examples

- Natural or gun finish
- Cut
- Broom or brush finish
- Sponge finish
- Floated or troweled
- Carved
- Textured
- Exposed aggregate
- Painted & Stained



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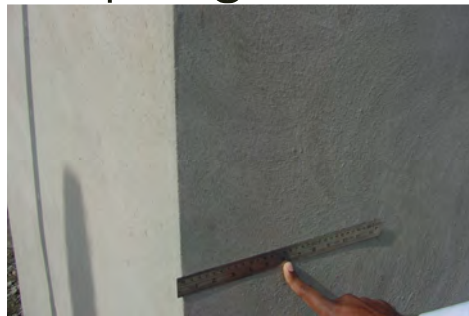
# Rod Finish



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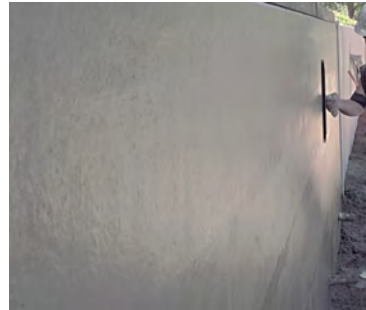
# Sponge



# Float



# Steel Trowel



# Gun



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## Curved Sections – No Problem!



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## Easily Blend to Existing



No formwork  
Same shape and texture  
Color often won't match

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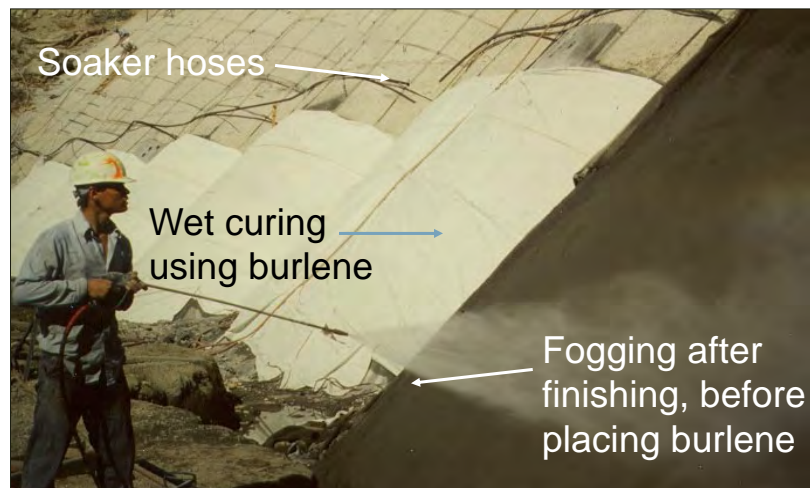
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## Curing Shotcrete

- It's concrete, it needs curing!
- Exposed surface
- Fogging/misting immediately in hot, dry or windy conditions

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## Proper Curing Practices



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## Curing Compounds

- Alternative to wet curing
- Reduce evaporation, but does not add water
- Curing compound is a bond breaker
- Recommend 2 times the rate



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## ACI Shotcreter Certification Program

### Want all the benefits of the Shotcrete process?

Then don't skip any steps.

1. Start with a project-appropriate specification
2. Use only QUALIFIED CONTRACTORS with relevant project experience
3. Verify Nozzlemen are ACI Certified



aci  
American Concrete Institute  
www.concrete.org

www.ACIcertification.org verify  
to confirm that the nozzlemen on  
your job is ACI certified!

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www.shotcrete.org

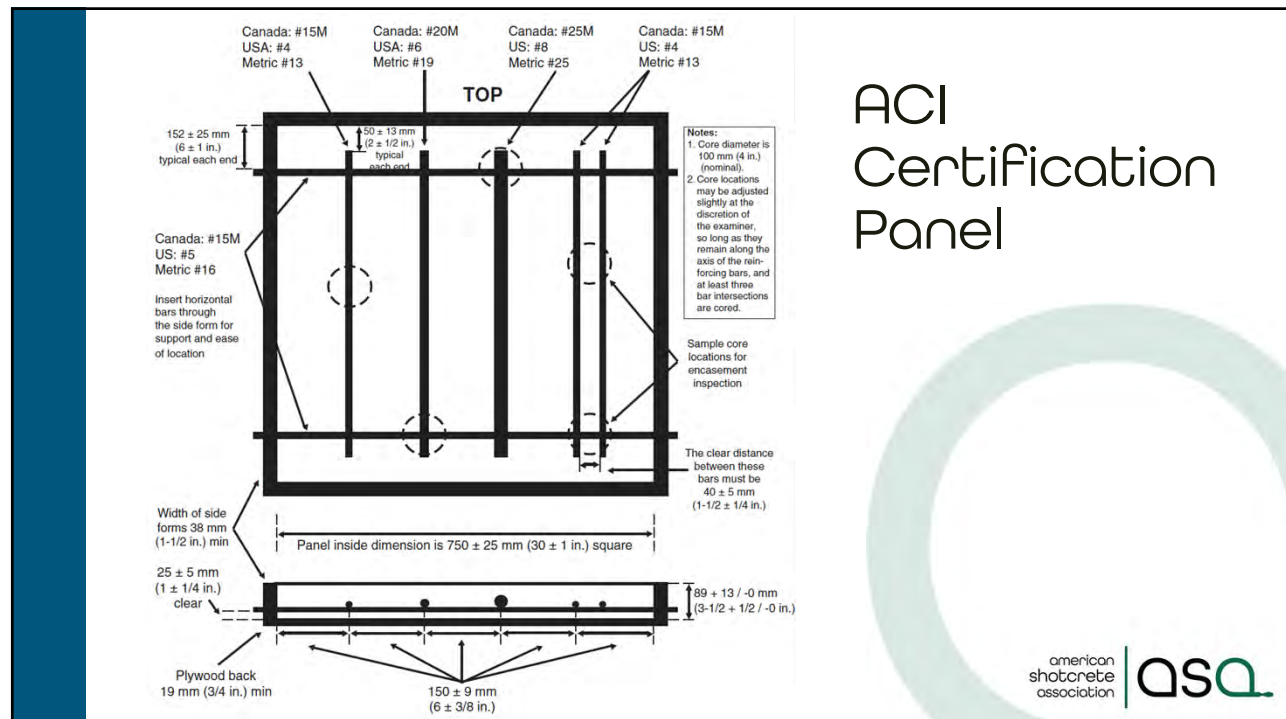
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## Requirements for Shotcreter Certification

- One day of ASA mandatory education
- Requires 500 hours of documented experience that can be verified by the examiner
- Written examination, oral examination, practical examination
- ACI Shotcreter Certification application is processed by ASA

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## Differences in application technique can be dramatic



- Same concrete mix from one truck, sprayed 10 minutes apart
- Sprayed by two different nozzle men one ACI Certified, the other one not

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Shotcrete's growing use in construction and its newly released inclusion in ACI 318-19, "Building Code Requirements for Structural Concrete," necessitates on-site inspectors who are knowledgeable about shotcrete materials, application, and quality. The ASA Shotcrete Inspector Education is an excellent review session for the material tested in ACI's Shotcrete Inspector Certification Program and will count as part of the required work experience on the application. Look for a seminar near you, or request to host one!

**WHO:**

- ACI Certified Construction Inspectors or Field Testing Technicians;
- Testing lab or third-party inspection firms responsible for monitoring shotcrete placement; and
- Building officials, owners, or suppliers desiring a more thorough understanding of the requirements for quality shotcrete placement.

**WHY:**

- Gain insight to materials, equipment, and application techniques for quality shotcrete placement;
- Learn the visual clues essential to evaluate the quality of shotcrete placement; and
- Understand the ACI and ASTM specification requirements for materials, methods, testing, and protection for shotcrete placement.

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## ACI Shotcrete Inspector

- Written Exam
- 3 Years Work Experience in Shotcrete
- Study References from ACI and ASTM Documents
- ASA Full-day Shotcrete Inspector Education equivalent to 1-Year of Experience

## ASA Shotcrete Contractor Qualification



## ASA Shotcrete Contractor Qualification

- Evaluates projects, shotcrete team, and equipment
- Structural Level I (minimum 3 years, 15 projects)
  - *Lightly reinforced, thinner, vertical*
- Structural Level II (minimum 5 years, 15 projects)
  - *Structural sections, thicker, overhead*
- Pool (minimum 3 years, 15 projects)
- Full-day Shotcrete Contractor Education

## Best Practices & Pitfalls

- Proper surface preparation – sound substrate, rough, clean, SSD (ICRI CSP 5+)
- Control of rebound and overspray
- Proper equipment (air compressor size, water booster pump)
- Appropriate concrete materials (slump, cementitious content)
- Lighting (need to see when placing)

## Best Practices & Pitfalls

- ACI-certified shotcreter (process and orientation)
- Knowledgeable inspector (ACI certified or proven experience)
- Qualified shotcrete contractor (ASA or verified experience record)
- Curing (initial and final)
- Careful attention to the rapid-set accelerator
- Proper PPE

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## Questions?

- [Shotcrete.org](https://Shotcrete.org)
- [info@Shotcrete.org](mailto:info@Shotcrete.org)
- ASA Technical Inquiries – 847-682-3676  
[Charles.Hanskat@Shotcrete.org](mailto:Charles.Hanskat@Shotcrete.org)



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