Structural Repairs using Preplaced Aggregate Concrete

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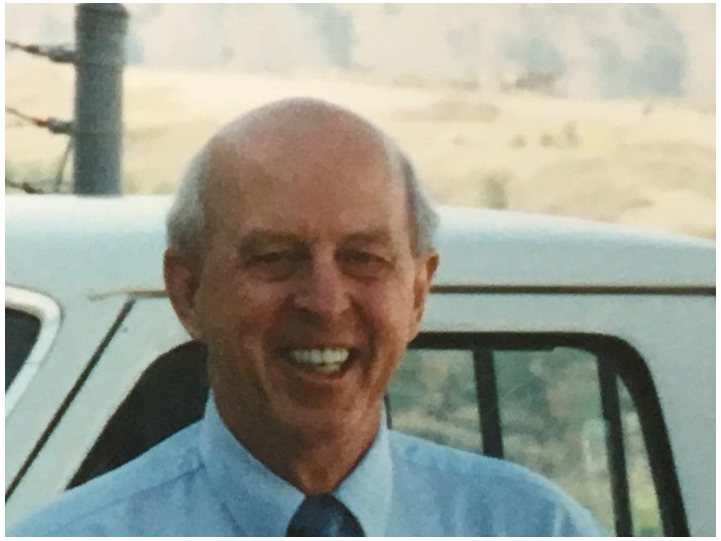
Presentation in Honor of Tony Murray

Tony Murray was Chairman of ACI 546 – Repair of Concrete from 1993 to 1999 and Chairman of ACI 563 – Repair Specifications from 2007 to 2011

Joined ACI in 1968, and became a Fellow of the Institute in 1991

He was owner of Restruction Corporation, based in Sedalia, Colorado from 1975 until his retirement in 2008



What is Preplaced Aggregate Concrete?

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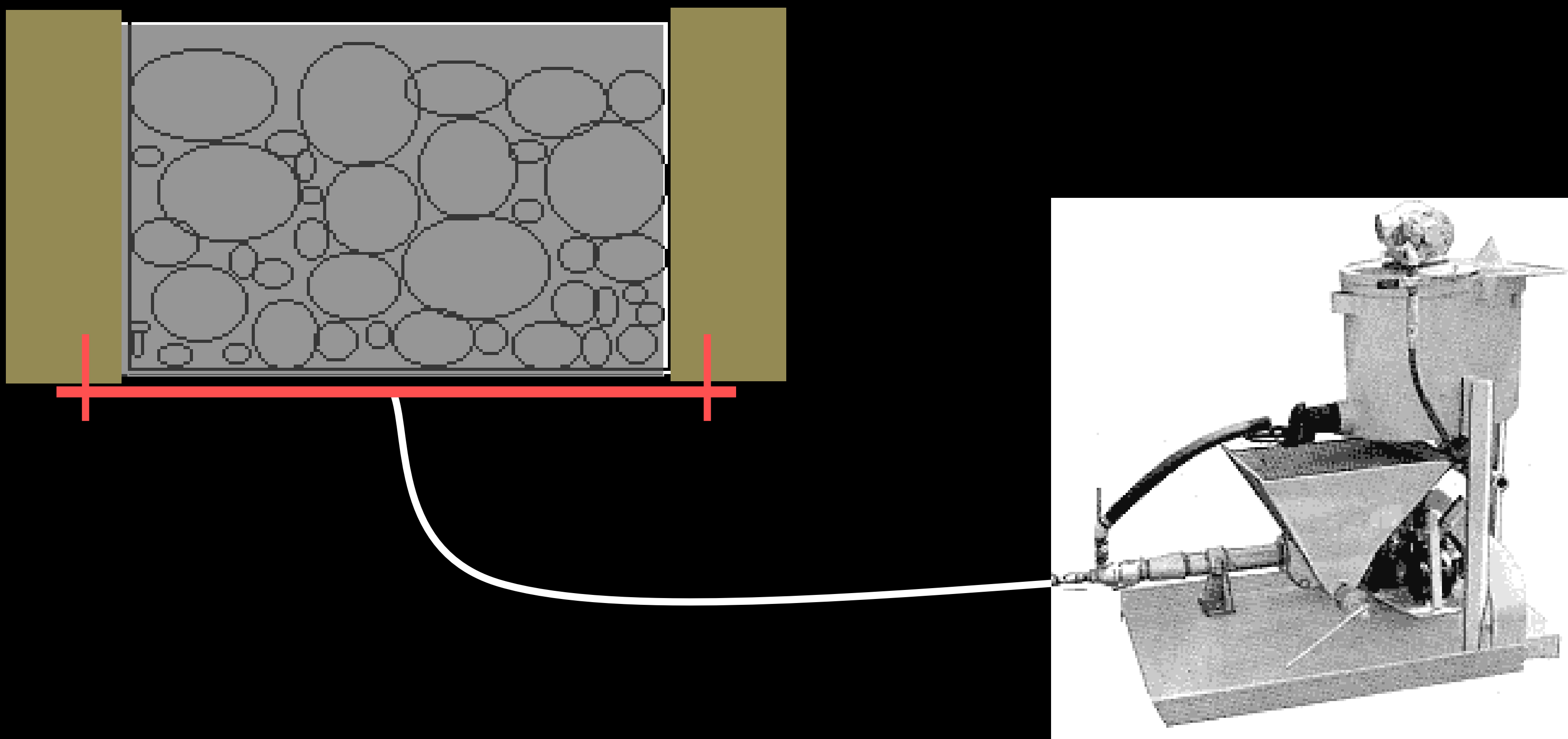
I’m not really sure I know what Preplaced Aggregate Concrete really is, and I don’t think I would ever use it even if I did…

Learning Objectives

- Gain a better understanding of what preplaced aggregate concrete is and how it is installed
- Understand how preplaced aggregate concrete can be used for concrete repairs, including its advantages and disadvantages when compared to more conventional repair techniques
- Know the typical applications for preplaced aggregate concrete repairs

Preplaced Aggregate Concrete is **“concrete that is produced by placing coarse aggregate in a form and later injecting a Portland cement-sand grout, usually with admixtures, to fill the voids”.** (ACI 116R)

Preplaced Aggregate Construction



A Brief History of Preplaced Aggregate Concrete

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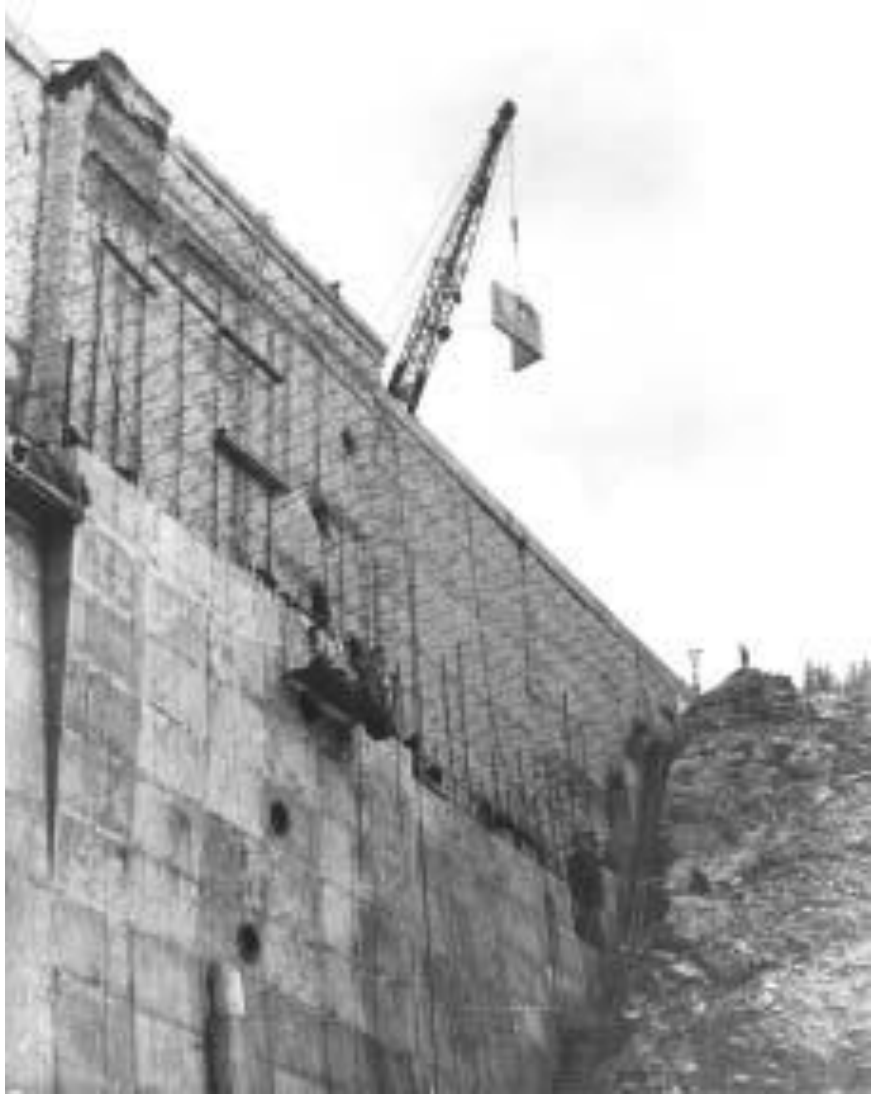
- First application was for a repair of a Santa Fe Railroad tunnel near Martinez, California in 1937.
- Research on the method was performed between 1937 and 1940, and patents were issued for the method – trade named "Prepaki".
- Most early work with Preplaced Aggregate Concrete was for dams, bridges and tunnel linings.

Hoover Dam Spillway
Repair – Early 1940's
Replaced eroded area
approximately 112 feet long
by 33 feet wide and as
much as 36 feet deep



Barker Dam – 1947
Resurfacing of the 170 foot high dam by using Preplaced Aggregate behind the 6 foot high precast concrete panels. Aggregate was grouted in one continuous operation over a period of 10 days

Applications for Preplaced Aggregate Concrete in Repair

- **Where low volume change repair concrete is required**
  - Shrinkage is reduced by 50% to 100% compared to typical cast-in-place concrete

Applications for Preplaced Aggregate Concrete in Repair

- Where low volume change repair concrete is required
- **Where the repair concrete is to participate in stress distribution**
  - Point to point contact of large aggregate, combined with low shrinkage distributes stresses more uniformly between existing concrete and repair material.
  - Modulus of Elasticity is typically slightly higher than conventional concrete

Applications for Preplaced Aggregate Concrete in Repair

- Where low volume change repair concrete is required
- Where the repair concrete is to participate in stress distribution
- **Where high-density concrete is required (Nuclear)**
  - Heavyweight coarse aggregate can be preplaced without the concern of segregation, as is the case with conventional cast-in-place concrete. Heavyweight fine aggregate can also be used in the grout.

Applications for Preplaced Aggregate Concrete in Repair

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- Where the repair concrete is to participate in stress distribution
- Where high-density concrete is required (Nuclear)
- **Placement in areas with closely-spaced reinforcement**
  - Preplaced aggregate concrete can be used in areas where reinforcement is too closely spaced to permit the use of vibrators. Aggregate can be placed as forms are erected around the reinforcement while access is still possible.

Applications for Preplaced Aggregate Concrete in Repair

- Where low volume change repair concrete is required
- Where the repair concrete is to participate in stress distribution
- Where high-density concrete is required (Nuclear)
- Placement in areas with closely-spaced reinforcement
- Placement in areas where overhead contact is required
- **High-lift monolithic placements**
  - The only limits to the height of the monolithic placement is the strength of the forms and the need to mix and pump the grout continuously from start to finish

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- High-lift monolithic placements
- **Underwater concrete placements (ACI 546.2R)**
  - Preplaced Aggregate repairs are particularly applicable for underwater applications as the grout (with anti-washout admixtures) will displace the water as it is being pumped

Installation Procedures

Check surface of repair for contamination. Often the surface of the repair is saturated with water to prevent excess absorption of water from the grout. Surfaces should be allowed to dry prior to pumping grout.

The goal is to achieve a Saturated, Surface Dry Condition.

Installation Procedures

Aggregate is often saturated with water prior to placing in forms. Aggregate must be gap-graded per ACI 304.1R

For most common applications, no more than 10% should pass a 3/4” sieve and no more than 2% should pass a 1/2” sieve

Installation Procedures

Forms must be grout-tight. Grout is usually pumped at about 10psi pressure. Seal against existing concrete with thick mortar, caulking rope, or strong compressible material.

Do not use caulk. Caulk can yield under the head pressure from the grout.

Installation Procedures

Typical mixing equipment is a two tub mixer with a water meter. Keep at least one backup pump on hand.

Installation Procedures

Test the consistency of the grout. Flow of 10 to 30 seconds is typical for site mixed grout using a standard flow cone test.

Installation Procedures

Start pumping at bottom of placement. Grout inlets can be placed vertically on the sides of the forms, or grout tubes may be used to distribute the grout to different elevations.

Installation Procedures

Finish the repair as needed on any exposed surfaces (top of repair). Curing is same as conventional concrete.

Other Considerations when using Preplaced Aggregate Concrete

- Strength of Preplaced Aggregate concrete is easily comparable to, or can exceed that of conventional concrete.
  - Strengths of 13,000psi at 1 year have been reported

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- Preplaced Aggregate Concrete has demonstrated excellent durability
  - This is likely due to the placement method and the air entrainment that naturally occurs due to the admixures used

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- Preplaced Aggregate Concrete has demonstrated excellent durability
- Heat of Hydration can be readily controlled using Preplaced Aggregate techniques
  - Forms, aggregate and grout can be cooled prior to placement.
  - Initial temperatures of 40 to 45 degrees F are easily obtained

Other Considerations when using Preplaced Aggregate Concrete

- Grout Fluidifiers are commonly used
  - Contains a water-reducing admixture, a suspending agent, and aluminum powder
  - Offsets the effect of bleed water
  - Reduces the w/cm ratio
  - Retards set time
  - Aluminum powder generates hydrogen gas, which causes slight expansion of the grout and adds small bubbles to the hardened grout – increasing freeze-thaw durability

Other Considerations when using Preplaced Aggregate Concrete

- Grout Fluidifiers are commonly used
- Epoxy can be used in place of the cementious grout
  - Provides high early strength
  - Improves bond strength
  - Epoxy does produce a large amount of heat, so it is best used in thinner applications (about 2” or so)
  - Aggregate must be completely dry to prevent steam formation

Common Applications
Bridge Repairs

West 6th Street Viaduct, Erie, Pennsylvania prior to repair

And 26 years later…

Common Applications Nuclear Facilities

Hand-Placing High Density Aggregate (Barite) for Biological Containment Structure at Materials Testing Reactor in Arco, Idaho

Equipment Hatch in Nuclear Containment Structure

How do I know if Preplaced Aggregate Repairs are Right for my Project?

- Cost is definitely higher than conventional repairs because formwork must be tighter and the operation is more labor-intensive
- Advantages outweigh the cost in some situations, particularly when low shrinkage is desired and/or rebar or embedded items make vibrating conventional concrete impossible.

Thank You!

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