


WJE SOLUTIONS FOR THE BUILT WORLD

**Thin SCC Grout
Vertical Repair**
Tainter Gate Side Seals
Auxiliary Spillway
Folsom, CA



www.wje.com
WJE
Who, What, Where, How, Why, Inc.

Todd Nelson and Stephen Schmitt, Jr.

Outline

- Project Background
- Description of a Tainter Gate/Terminology
- Problems with Original Side Seal Grout Construction
- WJE's Role
- Repair Design and Procedures
- Implementation
- Lessons Learned

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Project Background

- Auxiliary spillway compliments the existing Folsom Dam
- Provides protection for a 200 year flood
- Approximately \$900 million dollar project, started in 2008
- US Army Corp of Engineers and Bureau of Reclamation (DOI)
- Spillway consists of a 3,000 foot channel with a control structure consisting of six submerged, tainter gates

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Project Background

- Allows water flow into American River
- Protects Sacramento
- Folsom Lake
- Full completion October of 2017
- Control structure operational – winter 2016



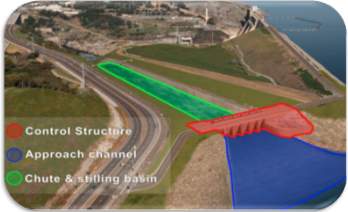
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Project Background

- 1100 foot approach channel
- 3,000 foot chute and stilling basin
- Control structure will be able to release 312,000 cubic feet of water per second!



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Construction



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Construction

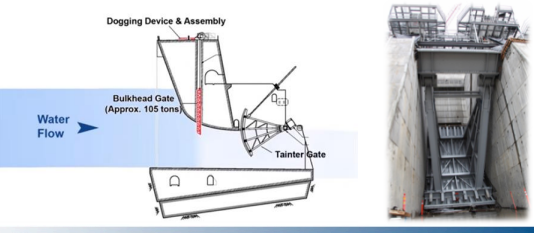


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What is a Tainter Gate?



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What is a Tainter Gate?

- Also known as a radial gate
- Skin Plate
- Radial Trusses
- Trunnions/pin
- Rubber seals
- Little force to open/close
- Efficient opening/closing



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Tainter Gate Side Seals

- Seal plate
- Gates ride along seals
- Bumper plate
- Swipe
- Secondary placement
- 5 foot lifts



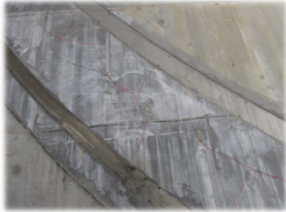
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Original Grout Issues

- Significant random cracking
 - Appeared soon after original grout placement
- Debonded from substrate concrete
- Consistent problems on each bay



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Original Grout Issues

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Original Grout Issues




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Original Grout Issues

- Significant random cracking and debonding from substrate
- Original mock-up repair efforts were not successful – epoxy injection
- COE concerned about grout spalling
- Repairs solutions needed!



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WJE's Involvement

- Assist COE and contractor with grout repair design and procedures
 - Original grout removal, surface preparation, new steel and anchor design, new grout materials, placement techniques, etc.
- Full time, on site consulting and construction observations/ monitoring
- WJE and COE approval at each step in the repair process


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Repair Design

- Preserve steel embeds – side and bumper seals - \$
- Removal and replacement of all grout in swipe and upstream
- COE, contractor, and WJE jointly worked on appropriate repair design and procedures
- A few iterations of reinforcing steel and anchor designs were needed to jointly agree
- Each step of repair process was to be inspected, documented, and approved by both COE and WJE

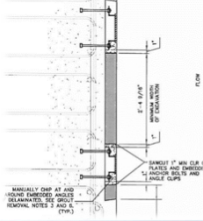
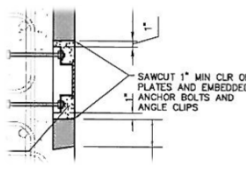


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Repair Design





SAWCUT 1" MIN CLR. OF PLATES AND EMBEDDED ANCHOR BOLTS AND ANGLE CLIPS



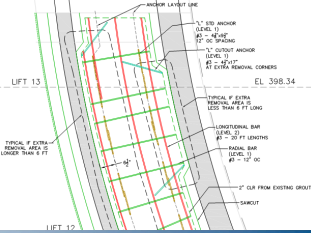
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Reinforcement and Anchor Design


- Anchors
 - "L" shaped, No. 3 epoxy coated anchors spaced at 12 inches o.c.
- Longitudinal bars
 - Three, No #3 epoxy coated longitudinal bars
- Radial bars
 - Radial No. 3 at 12 inches o.c.
- Additional Reinforcing steel
 - in extra grout removal areas





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SCC Repair Procedure

- Grout Removal
- Surface Preparation
- Supplemental Reinforcement
- **Mock-Up Panel**
- Surface Conditioning
- Formwork Construction
- **Structure Mock-Up**
- **Form Vibration Tests**
- Batching and Mixing
- Placement and Curing
- Tensile Pull-Off Testing



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Grout Removal



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Surface Preparation



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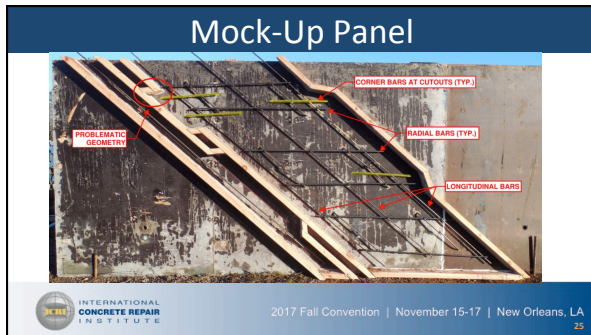
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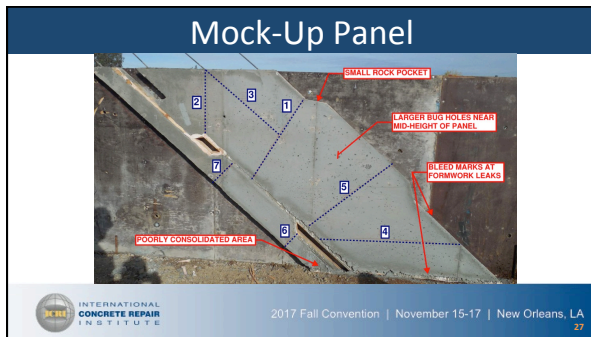


















Structure Mock-Up



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Structure Mock-Up



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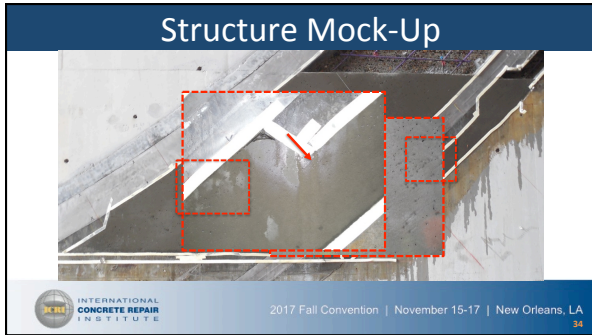
Structure Mock-Up



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Form Vibration Tests

- Evaluate effect of various external vibration methods on consolidation and surface finish

| ID | Description |
|----|---|
| A | Hand-held (stinger) vibrator applied externally once form was filled |
| B | Stinger vibrator applied externally plus rodding once form was filled |
| C | Distributed bush-hammering applied once the form was 1/2 full and filled |
| D | Externally mounted pneumatic form vibrator activated once form was filled |

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Vibration Test (Bush Hammer)



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Vibration Test (Form Vibrator)



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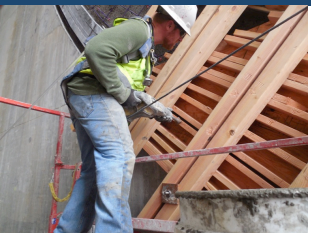
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Vibration Test Results

| ID | Description |
|----|---|
| A | Hand-held (stinger) vibrator applied externally once form was filled |
| B | Stinger vibrator applied externally plus rodding once form was filled |
| C | Distributed bush-hammering applied once the form was 1/2 full and filled |
| D | Externally mounted pneumatic form vibrator activated once form was filled |

Distributed bush-hammering at 1 ft lifts!



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Tensile Pull-Off Testing

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Tensile Pull-Off Testing

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Tensile Pull-Off Testing

| Test No. | Ult. Tensile Stress (psi) | Failure Mode |
|----------|---------------------------|---|
| 1 | 174 | |
| 2 | 226 | Cohesive failure at near-surface of SCC repair mortar; therefore bond strength > test results |
| 3 | 312 | |
| 4 | 185 | |

- Average ultimate tensile stress = 224 psi
- Sample standard deviation = 63 psi

COE specifications required 150 psi min!

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Lessons Learned

- Importance of communication:
 - Owner, Engineer, contractor, sub-contractors, and consultants
 - Ensures repair performance, acceptability, and constructability
- Importance of mock-ups:
 - Acceptability to owner and constructability to contractor
- Awareness of variability of pre-bagged materials

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Questions?



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