Concrete Rehabilitation

Kleinschmidt

Concrete Deterioration

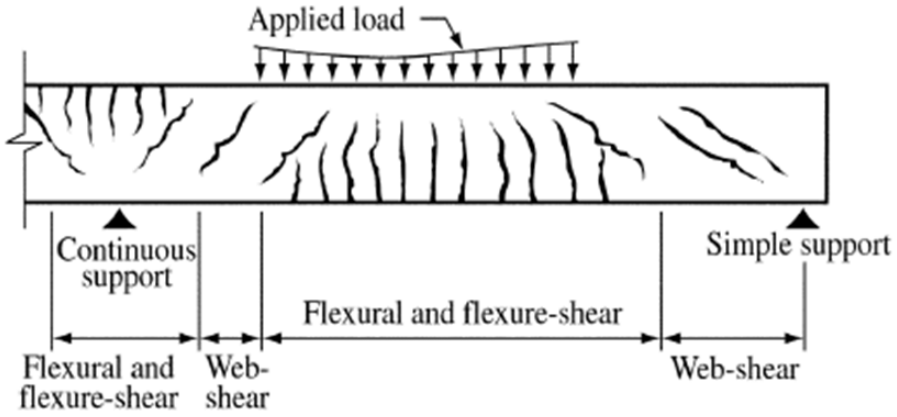
- CRACKS
  - Structural Stress Cracks
  - Shrinkage Cracks (Thermal and Plastic)
  - Settlement/Movement Cracks
  - AAR (Alkali Aggregate Reaction)

- Surface Deterioration
  - Freeze-Thaw related spalling
  - Wear from water flow (debris and sediment)
  - Efflorescence
  - AAR

Concrete Deterioration

CRACKS

- Structural Stress Cracks



Concrete Deterioration

CRACKS

- Shrinkage Cracks (Thermal Cracking, Plastic Shrinkage Cracking)
  - Plastic shrinkage cracking almost always occurs because the surface dries too quickly before it has time to strengthen
  - Thermal contraction cracking is caused by restraint to contraction of cooling concrete, or by differential temperatures in thick concrete placements
- Powerhouse cracking can often be caused by differential temperatures in blocks of concrete of different volumes and different exposures

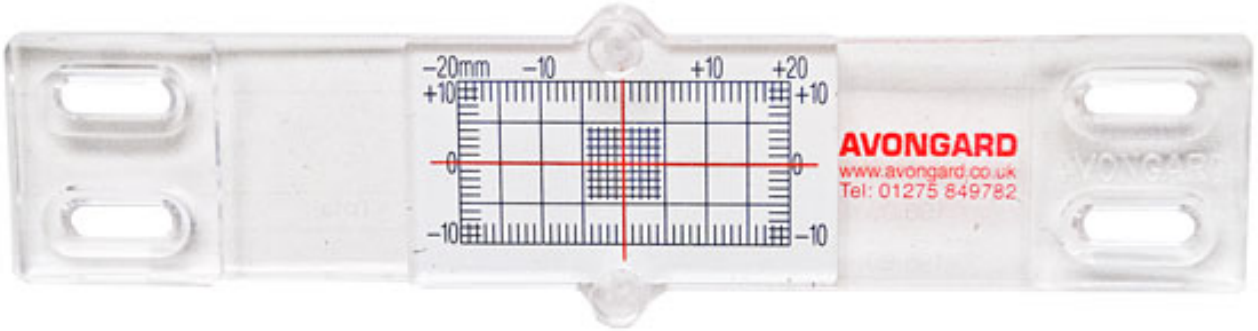
Settlement/Movement Cracks

AAR Related Cracking

- Relative rate of growth between different size blocks of concrete
- Same as movement/settlement cracks – Concrete growth results in differential movement of the concrete parts

CJ Requiring Repair

Crack Monitoring

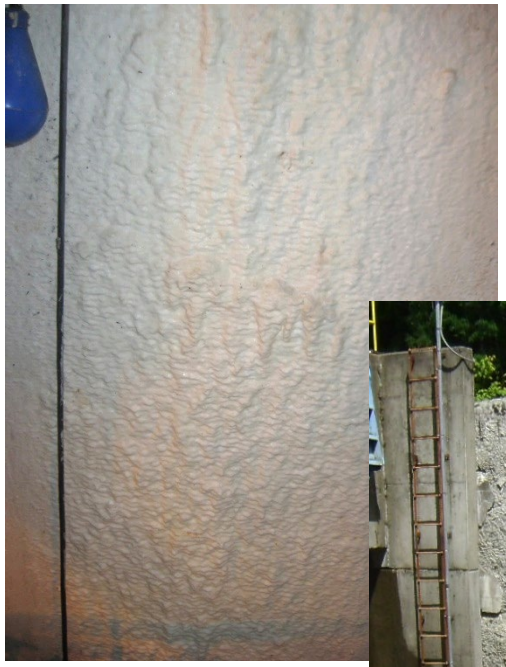


Surface Deterioration

- Freeze-Thaw related spalling
- Wear from water flow (debris and sediment)
- Efflorescence ("to flower out" in French)
  - Crystalline deposit of salts (or any soluble material) often seen on the surface of concrete
  - Calcium hydroxide combines with carbon dioxide in the air to form calcium carbonate. Calcium hydroxide is much more soluble in water at cold temperatures
  - Mostly harmless but **the cause, water migration, is the concern**

AAR Related Surface Deterioration

Aesthetic – Repair?



Surface Deterioration Requiring Repair

Concrete Repairs

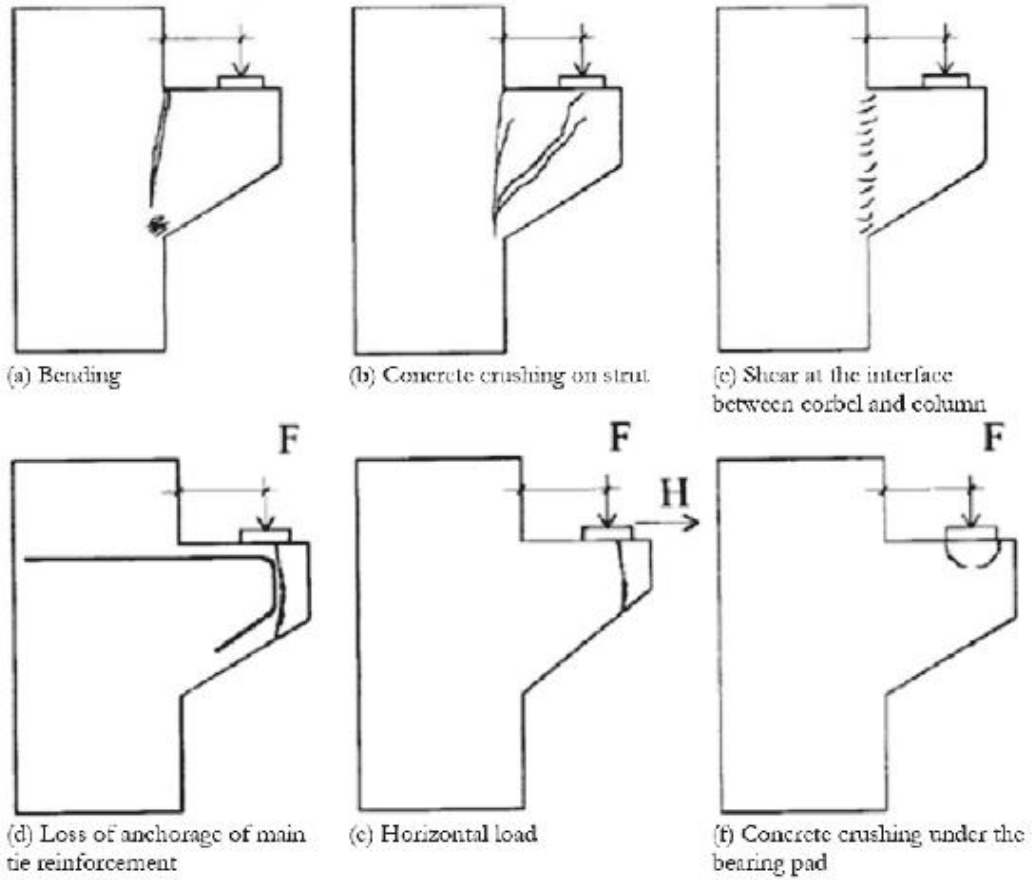
Determining a repair starts with determining the cause

- Structural Cracks – Why did it Crack? Overloaded? Design? Construction?

Corbel Cracks

Cause?

- Miss-placed Rebar or no Rebar
- Under sized Rebar
- Poor Anchorage
- Load Exceeded Design (heavy crane lift)

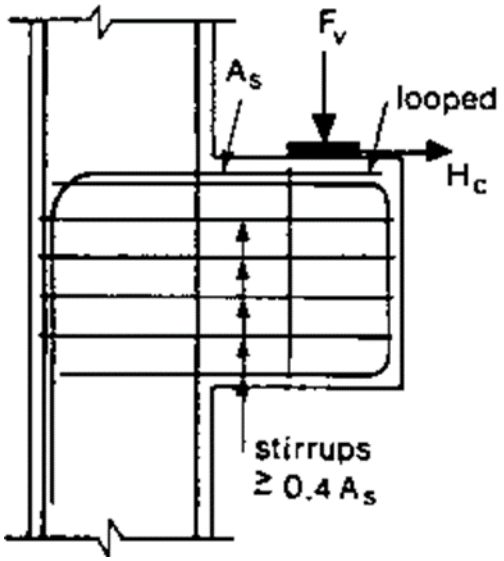


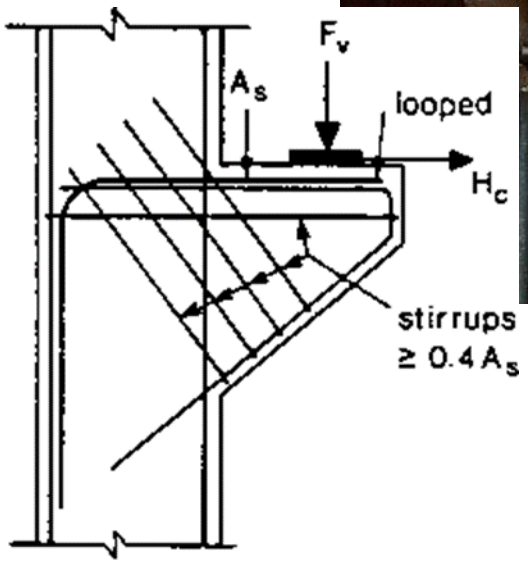
(a) Bending (b) Concrete crushing on strut (c) Shear at the interface between corbel and column

(d) Loss of anchorage of main tie reinforcement (e) Horizontal load (f) Concrete crushing under the bearing pad

Repair

- Post-Tension Ties

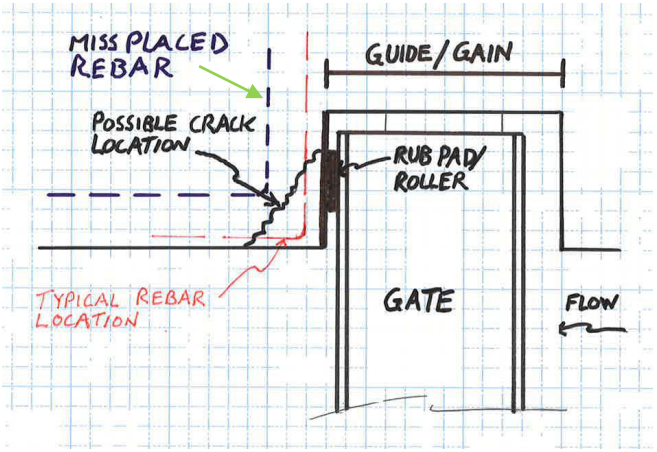


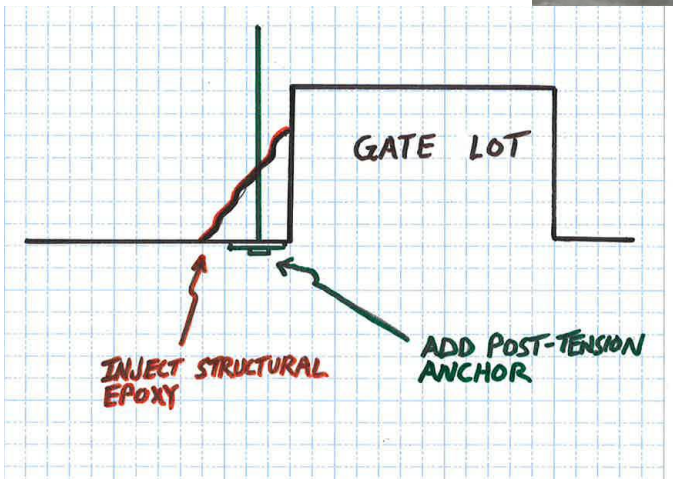


Gate Guide Cracks Can Be Concerning

Cause?

- Miss-placed Rebar or no Rebar
- Under sized Rebar
- Load exceeded Design (Ice, Earthquake, Flood)





Spot the Real Issue

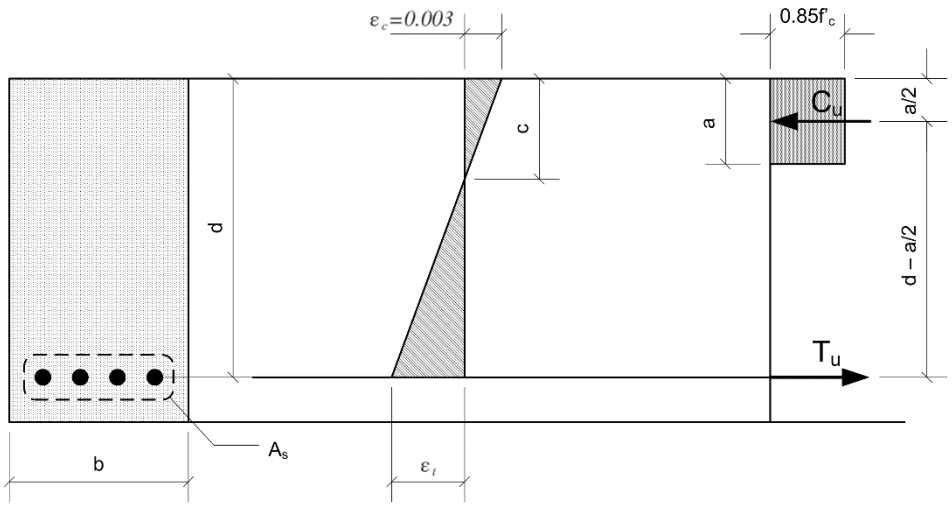
Surface Deterioration – Is Repair Required?

- Where
- Rate of Deterioration
- Exposed Rebar

Beam Equation

Design Moment Capacity

$$\phi_b M_n = \phi_b A_s \times f_y \times \left(d - \frac{a}{2} \right)$$



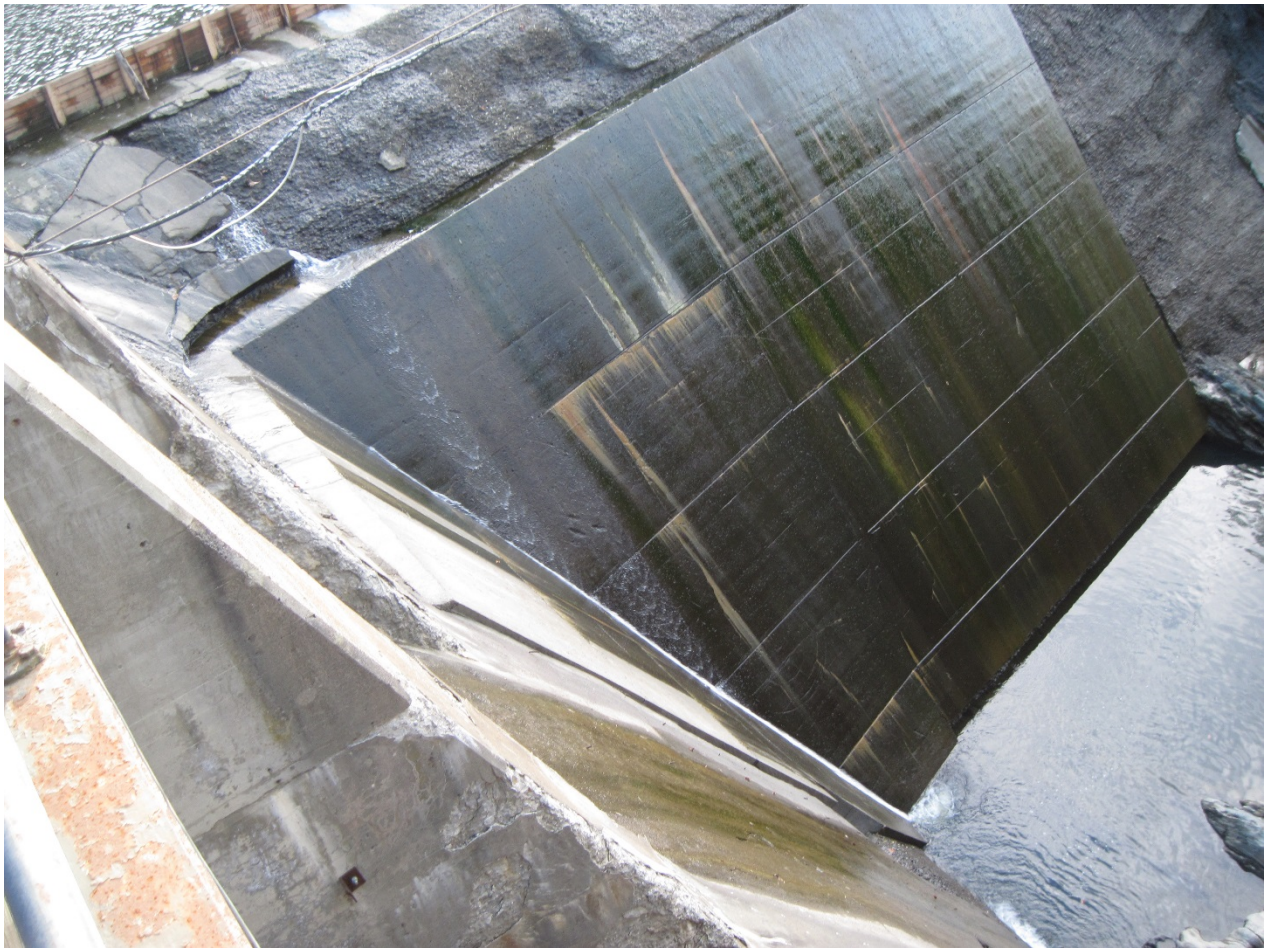
Rectangular Beam Cross Section

Strain Distribution

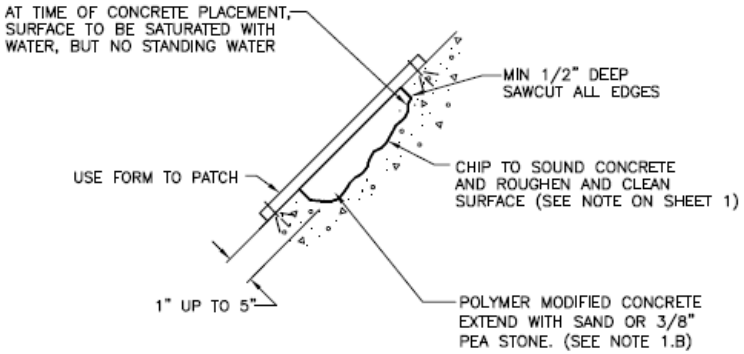
Stress Distribution

Concrete Resurfacing

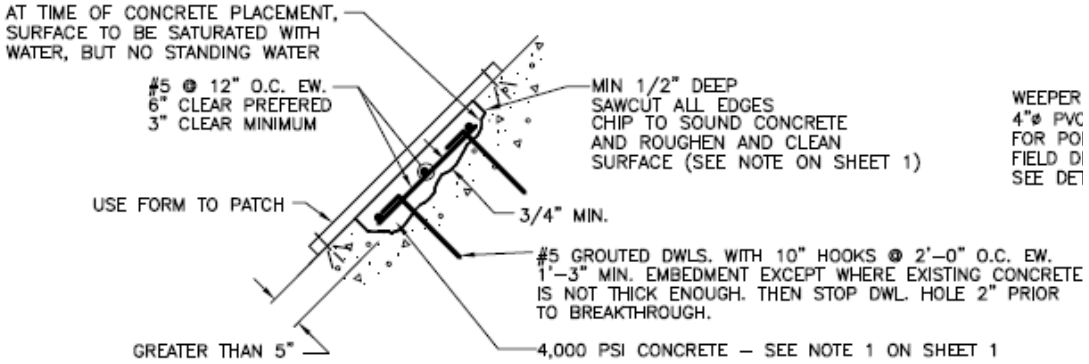
Concrete Resurfacing



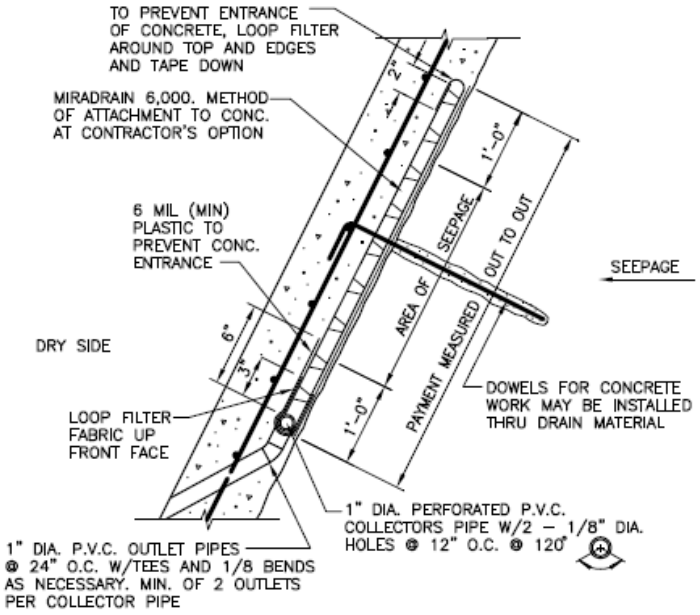
Standard Repair Details



1" UP TO 5" DEEP
PATCH REPAIR DETAIL
N.T.S.



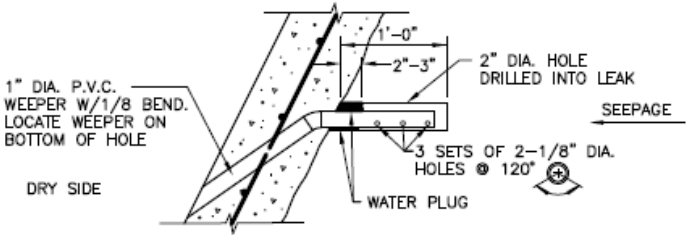
DEEPER THAN 5"
PATCH REPAIR DETAIL
N.T.S.



REPAIR DETAIL FOR LARGE SEEPAGE AREAS

N.T.S.

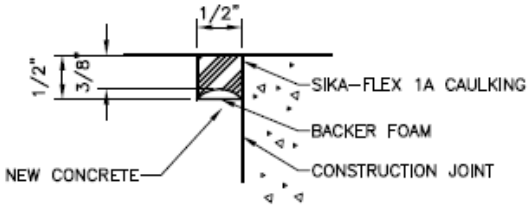
NOTE: PROVIDE SEEPAGE CONTROL AT LOCATIONS HAVING LARGE (>1.0 S.F) SURFACE AREAS AND WHERE INDICATED BY OWNER



REPAIR DETAIL FOR POINT SOURCE SEEPAGE

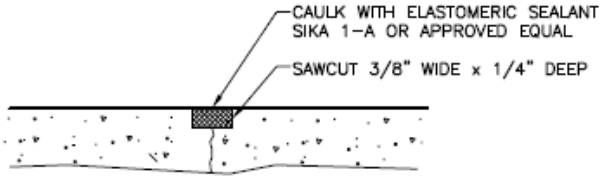
N.T.S.

NOTE: PROVIDE WEEPER PIPES AT LOCATIONS OF POINT SOURCE LEAKAGE AND WHERE INDICATED BY OWNER



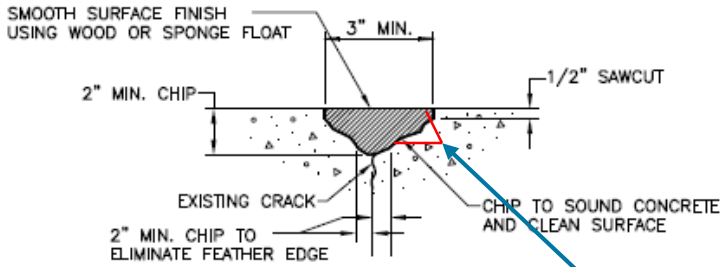
TYPICAL CONSTRUCTION JOINT CAULKING DETAIL

N.T.S.



TYPICAL HAIRLINE CRACK NON-STRUCTURAL REPAIR DETAIL

N.T.S.



TYPICAL LARGE CRACK NON-STRUCTURAL REPAIR DETAIL

N.T.S.

Bevel Undercut is better to key patch in

Gunite versus Shotcrete

- Gunite (trademarked term for "dry-mix" – water added at nozzle)
  - Sand cement mix appears to be denser and less permeable that CIP conc & Shotcrete; tends not to weep, allowing water to build up behind it.
  - Often used for conc repair in 1950s-mid 1970s
  - Based performance observations: good product for upstream side applications, but not so good on Downstream side.
  - Historically applied 1-3" thick over WW mesh with shallow cinch anchors (aka expansion bolts)
  - Pay attention to address active leaks and seepage when applying product
  - Delaminates due to buildup of water behind, freeze thaw jacking, shallow anchors, poor surface prep

Gunite versus Shotcrete

- Shotcrete (Generic term for wet or dry-mix applications)
  - Wet-mix is often application of choice
  - Applied thicker (4”-8”)
  - Normally use rebar anchored to existing conc
  - Should properly address surface prep, leakage & seepage, anchorage.
  - Can use fibers in concrete to reduce micro cracking. Applicators often argue fibers makes material move through piping and hoses easier and also improves screening and finishing of surface.

Strengthening

- Add Concrete – Resurfacing with Structural Concrete
- Add Steel - Rebar, Post-tensioned Anchors, Plate, or Steel Beam
- Add FRP?

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