CHEMICAL GROUTING – PAST, PRESENT, FUTURE

ICRI Fall Convention 2015

Fort Worth, TX

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TPCCI

Outline

- The Past – Where did we come from.
- The Present – Where are we now.
- The Future – Where are we going.
- ICRI's role in the future.

What Are Chemical Grouts ?

"Chemical grouts are injected into voids as solutions, in contrast to cementitous grouts which are suspensions of particles in a fluid medium and react after a predetermined time to form a solid, semisolid, or gel."

U.S. Army Corps of Engineers

Engineering and Design

Chemical Grout

1995

TYPES OF CHEMICAL GROUT

- Silicates
- Acrylics (includes acrylamides and acrylates)
- Lignins
- Urethanes
- Resins

U.S. Army Corps of Engineers
Engineering and Design
Chemical Grout
1995

The Past

- Silicates (1886)- soil stabilization during excavation
- Acrylamides (1950's)– municipal applications and soil stabilization
- Acrylates (1980)– municipal applications and soil stabilization
- Lignins (1950's)– used mainly in Europe
- Asphalt – hot and cold mix
- Resins – epoxy, polyester, vinyl ester, etc.

Past Limitations

- Silicates – low strength, brittle, permeability
- Acrylamides – low strength, toxicity issues
- Lignins – difficult to install (heated equipment), aged poorly, toxicity issues
- Asphalt – dangerous and difficult to install, aged poorly
- Urethanes – high viscosity, flammability, shrinkage
- Resins – difficult to install, rigid, brittle, aged poorly

Pioneers of the Industry

- Will Jacques – Avanti International
- David McGill – Avanti International
- Herman Deneef – Deneef Construction Chemicals
- Bert Kriekemans – De Neef Construction Chemicals
- Dave Barton – Barton Southern/Prime Resins
- James Warner – Consulting Engineer

The Present

- Silicates - soil stabilization (temporary)
- Acrylamides - municipal applications, soil stabilization
- Acrylates - municipal applications and soil stabilization
- Acrylics– crack and joint sealing, curtain wall grouting
- Urethanes (single comp.) – crack and joint sealing, curtain wall grouting, void filling, soil stabilization
- Urethanes (plural comp.) – sealing high flow leaks, void filling, curtain wall grouting, slab jacking

CONCRETE REPAIR

The Most Useful Chemical Grouts to the Concrete Repair Industry are :

- Polyurethanes
- Acrylics

WHAT ARE POLYURETHANES?

"Polyurethanes are formed by reacting a polyol … with a diisocyanate or polymeric isocyanate in the presence of suitable catalysts and additives."

-Alliance of The Polyurethane Industry

Polyurethanes

- Foams - Crack, and joint sealing, void filling, curtain wall grouting
- Gels – Joint sealing, curtain wall grouting

HOW DO POLYURETHANE GROUTS EXPAND?

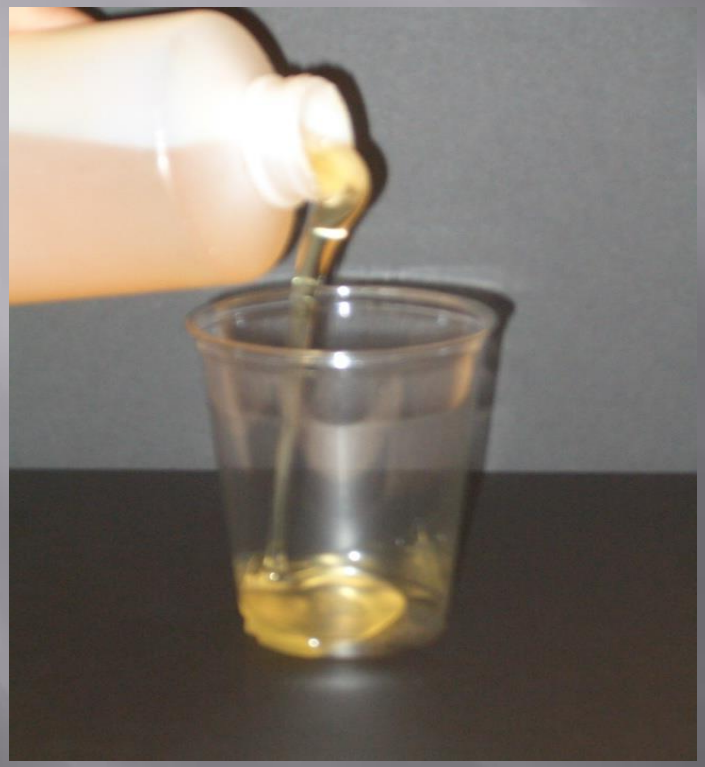
The polyurethane reaction gives off CO_2 gas. By adding a surfactant to the mixture we trap the gas bubbles in the grout matrix.

CLASSIFYING POLYURETHANE GROUTS

Hydrophilic: (water loving)

- Can react with a large excess of water
- Uses no catalyst
- Exhibit post reaction swell
- Contain water in the cured material (25% +/-)
- Will shrink after cure if dry out

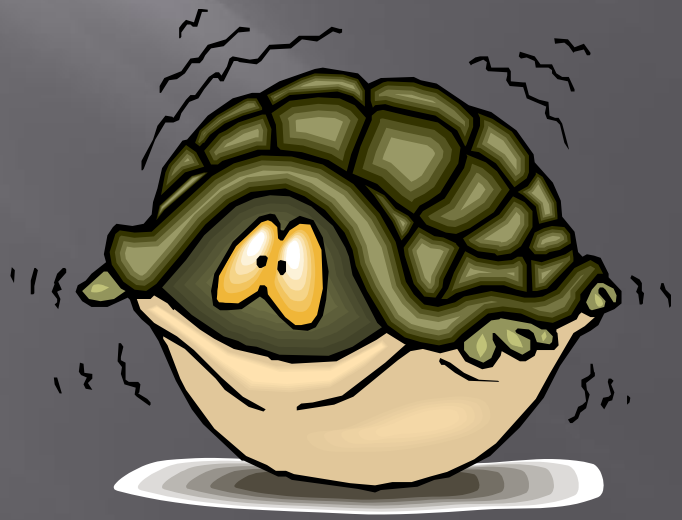
Hydrophilic Urethane



CLASSIFYING POLYURETHANE GROUTS

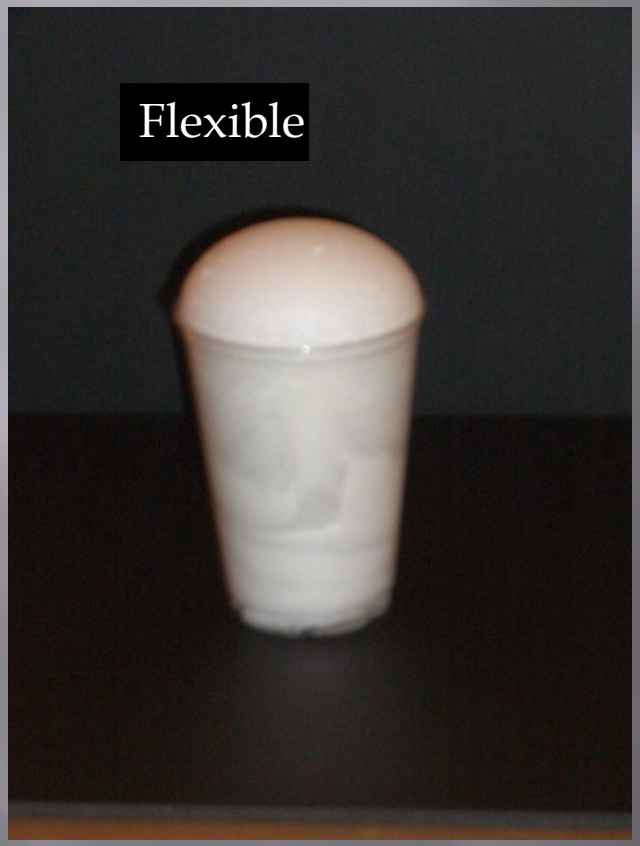
Hydrophobic: (water fearing)

- Uses very little water in its reaction (5-7%)
- Requires a catalyst (allows for control of the reaction time.)
- No post reaction swelling.
- Will not shrink after cure



Hydrophobic Urethane (Pre reaction)

HYDROPHOBIC URETHANES (POST REACTION)



CLASSIFYING POLYURETHANE GROUTS

Single component:

Can be pumped through a single component pump.

Plural component:

Requires a plural component pump.

CLASSIFYING POLYURETHANE GROUTS

Viscosity:

Measure of resistance to flow.

Measured in centipoises. (cps)

Water = 1 cps.

High:	> 1000 cps
Moderate:	750 – 1000 cps
Low:	500 – 750 cps
Very low:	250 - 500 cps
Ultra low:	< 250 cps

POLYURETHANE FEATURES

- Widely available
- Available in single component formulation
- Foams economical due to expansion
- Gels economical due to mixture with water
- Foams can be used in high flow situations
- Two component materials can be used to stop high pressure leaks
- MDI based materials exhibit low toxicity

WHAT ARE ACRYLICS?

- Based upon the acrylic resin molecule
- Two component products combined at a 1 to 1 ratio at the mixing head of the pump.
- The set times can be controlled by varying the amounts of catalyst on the resin side (Triethanolamine) and salt on the water side (Sodium or Ammonium Persulfate)
- Reinforcing agent can be added to the water side.

Chemistry Cont'd.

- Unlike single component urethanes which react with water and expand these acrylic components react together to form a gel.

- After curing they form a hydrophilic gel that will swell upon contact with water.

Part A & B

Gelled Acrylic Resin

Viscosity Comparison

Flexible hydrophobic Foam	450-850 cps
Flexible Hydrophilic Foam	250-350 cps
Low Viscosity Hydrophobic Foam	150-250 cps
Soil Grout	25-35 cps
Methacrylic Resin	6-8 cps*
Acrylate	1-3 cps*

* Mixed viscosity

VISCOSITIES OF COMMON MATERIALS (70˚F)

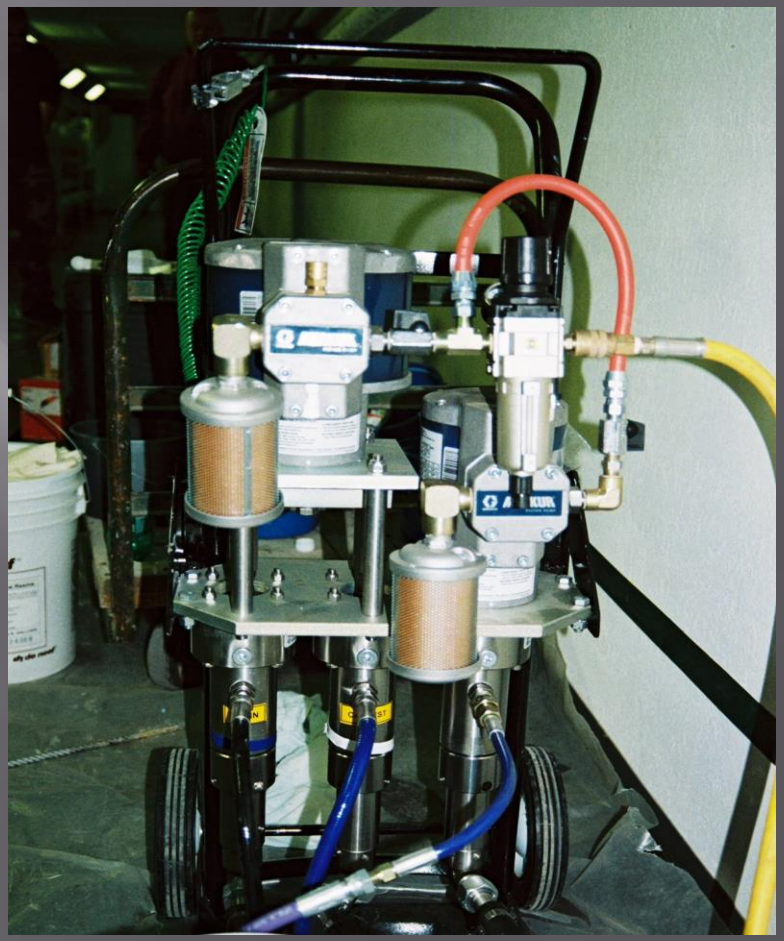
Material	Viscosity in Centipoise (cps)
Water	1 cps
Milk	3 cps
SAE 10 Motor Oil	85-140 cps
SAE 40 Motor Oil	650-900 cps
Castor Oil	1,000 cps
Corn Syrup	5,000 cps

Pumping Acrylics

- Since the reaction between catalyzed resin and salt water begins as soon as the two components touch, pumping acrylics requires a plural component pump.

- In addition acrylic resins are very sensitive to iron and the salt water is highly corrosive. These characteristics requires that all components of the pump that come in contact with the injection materials be made of stainless steel.

Pumps



ACRYLIC FEATURES

- Low viscosity allows injection into very fine cracks
- Low pressure injection
- Inject multiple ports at one time
- Wide range of reaction time
- Low toxicity

Ways To Use Chemical Grout

- *Crack Injection*-A hole is drilled on a 45 degree angle to intersect the crack. This allows the grout to penetrate throughout the repair area.

- *Curtain Wall Grouting*-Holes are drilled through the wall and into the soil which allows placement of chemical grout on the exterior side of the structure..

- *Probe Grouting*- Injection probes are driven down into the soil which allows placement of chemical grout on the exterior side of the structure.

Grout Placement

Effective chemical grout placement requires getting the grout to the required location and holding it there long enough for it to react.

Crack Injection

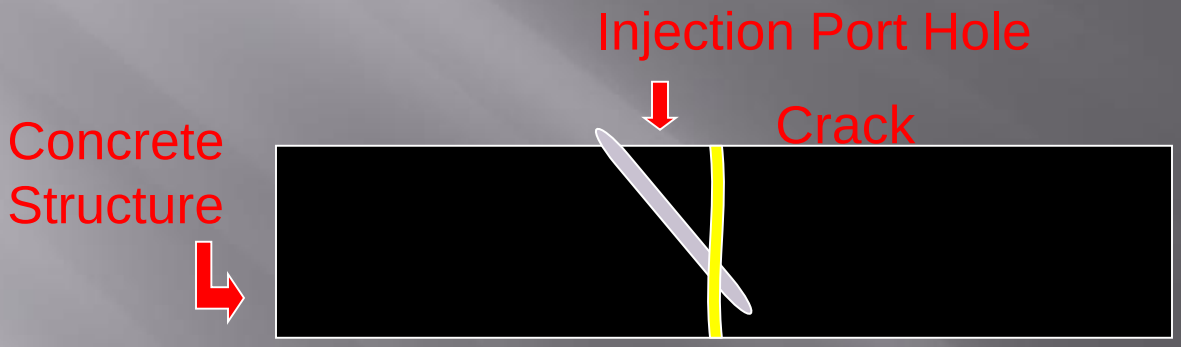
An entry point is created into the repair area to allow pressurized grout to be injected.

- The most common grouting method
- Allows for grouting into very small cracks and spaces
- Allows for grout to be pushed from the negative side to the positive side of a structure

Grout Selection Criteria

- Cause of cracking
- Are cracks static or dynamic
- Will there be wet / dry cycling
- Rate of leakage through the crack
- Width of cracks
- Temperature of water and substrate

Calculating The Port Hole Distance From The Crack

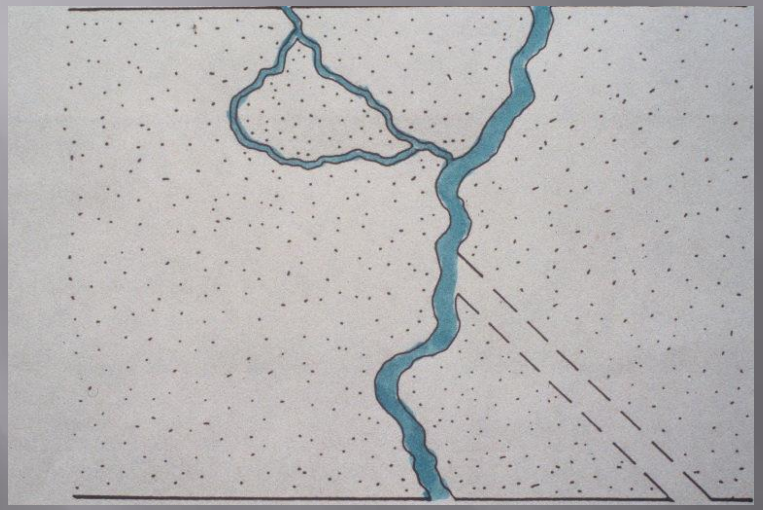


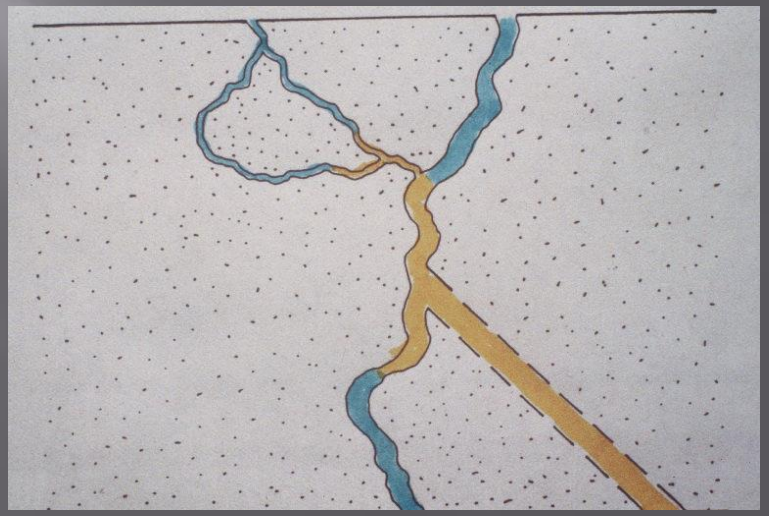
To drill at a 45° angle drill distance must be ½ the thickness of the wall.

Example: 12” thick wall = drill holes 6“ from crack.

45 Degree Angle Drilling Method

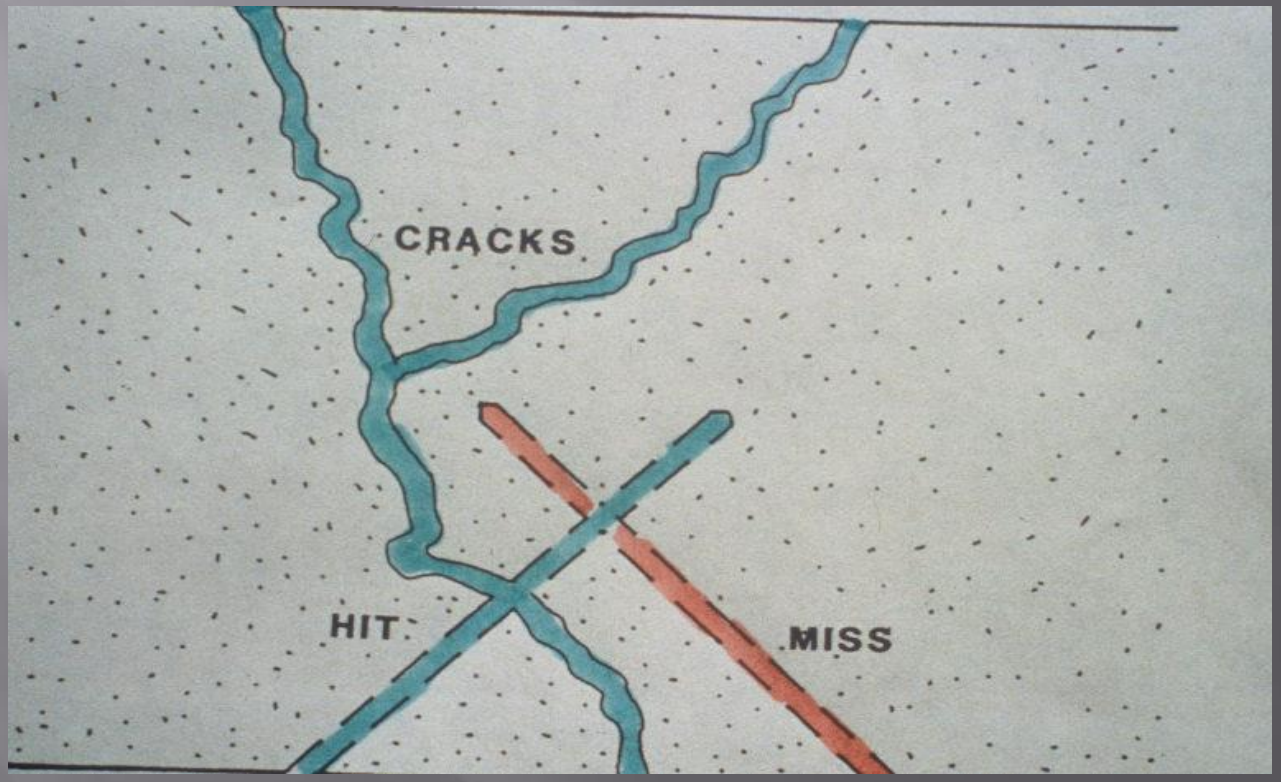
- Allows material to intersect crack at midpoint and flow both forward and back.





Alternate Side Drilling

- Increases the odds of intersecting a crack, which may deflect inside wall.



Step One

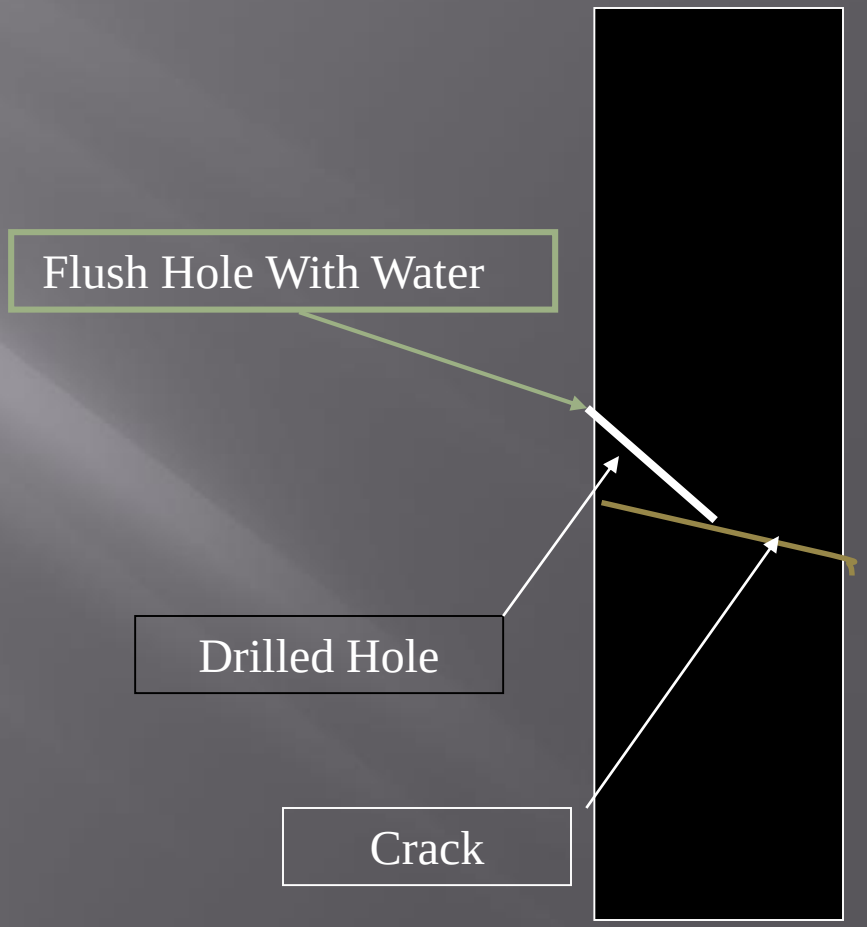
- Clean the surface
  - helps to identify the crack
  - Removes dirt and mineral deposits to open crack

Step Two

- **Drill Port Holes**
- **45° angles**
- **Alternate sides**

Step Three

- **Flush Holes With Water**
- **Removes drilling dust**



Step Four

- Install packers
  - Mechanical Packe
  - HP Packers
  - Plastic Bang-Ins
  - Zerk Fittings
  - Button Heads

Step Five

- Pump Water
  - Flushes debris
  - Provides water for Grout

Step Six

- Prepare Material
- Mix Grout
- Add CAT
- Cup Test

Step Seven

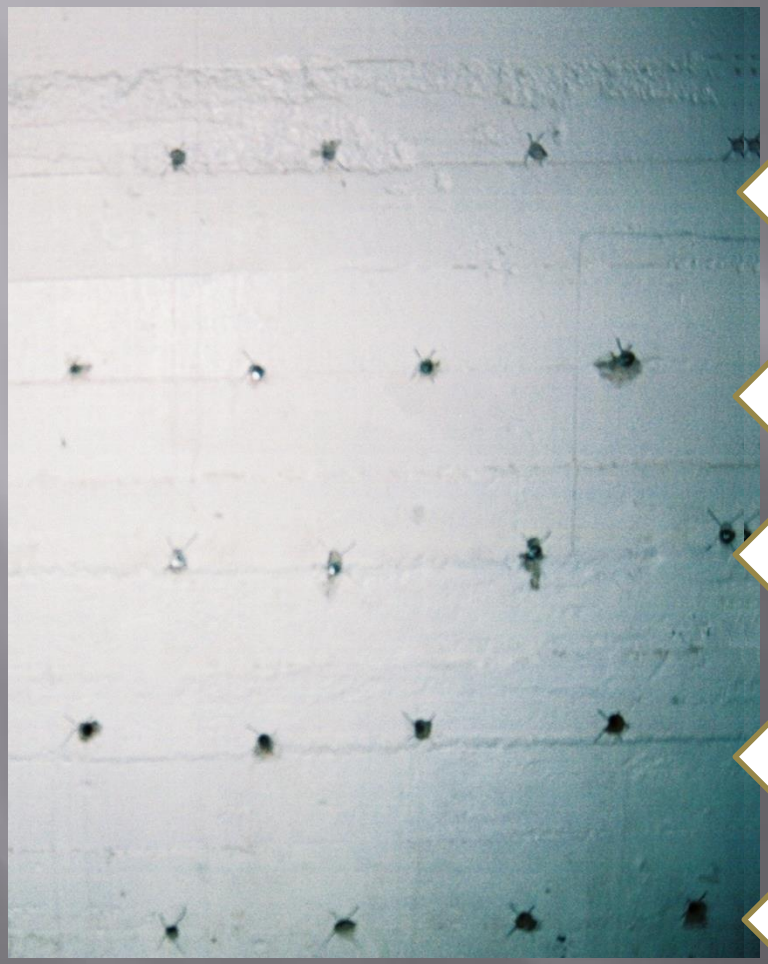
- Inject Grout

CURTAIN WALLS

Why perform curtain wall grouting?

- Masonry, stone, or CMU walls do not crack inject well.
- When cracks cannot be identified.
- Previous crack injection has failed.

Injection Sequence



5th injection row

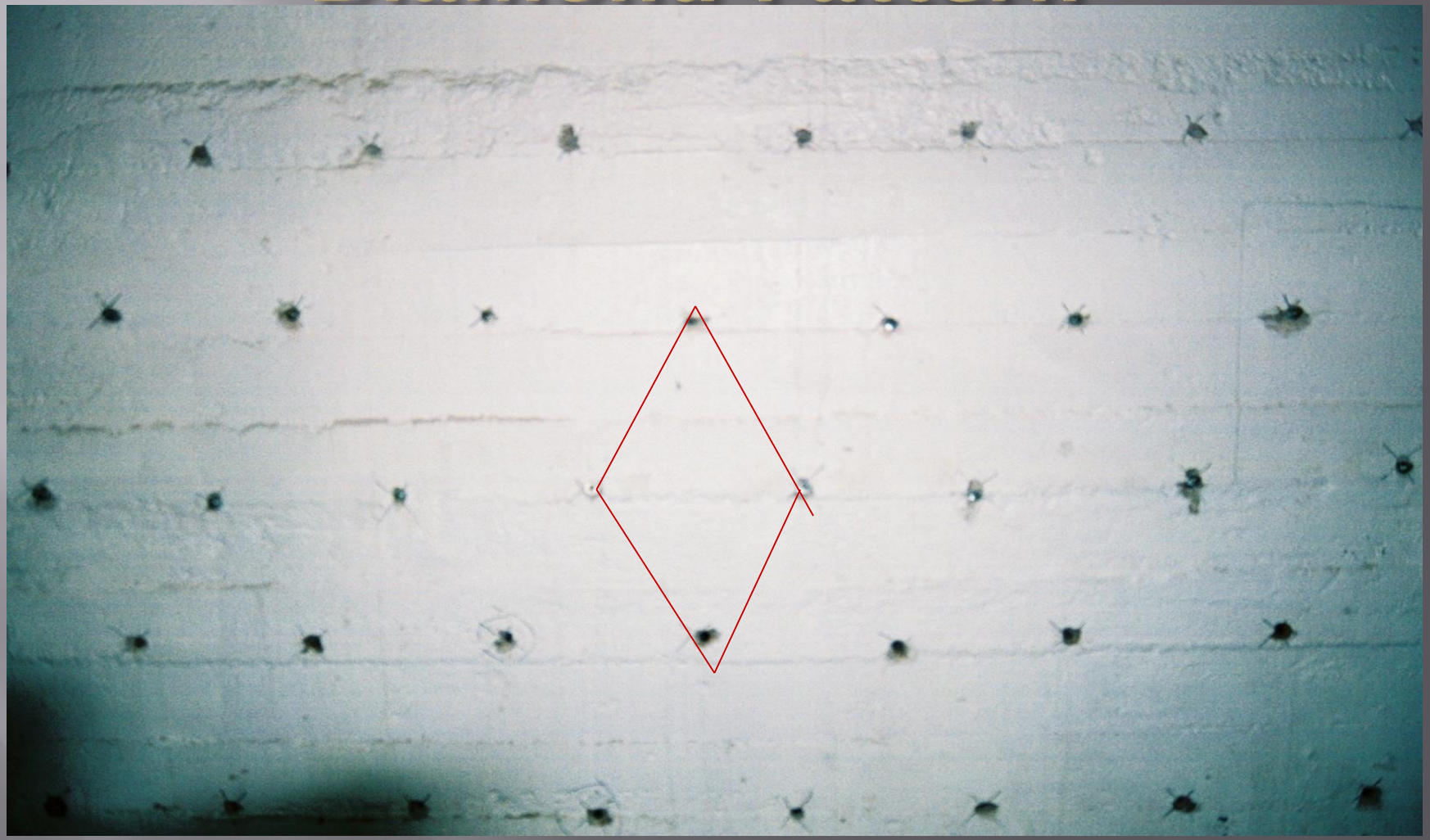
4rd injection row

3rd injection row

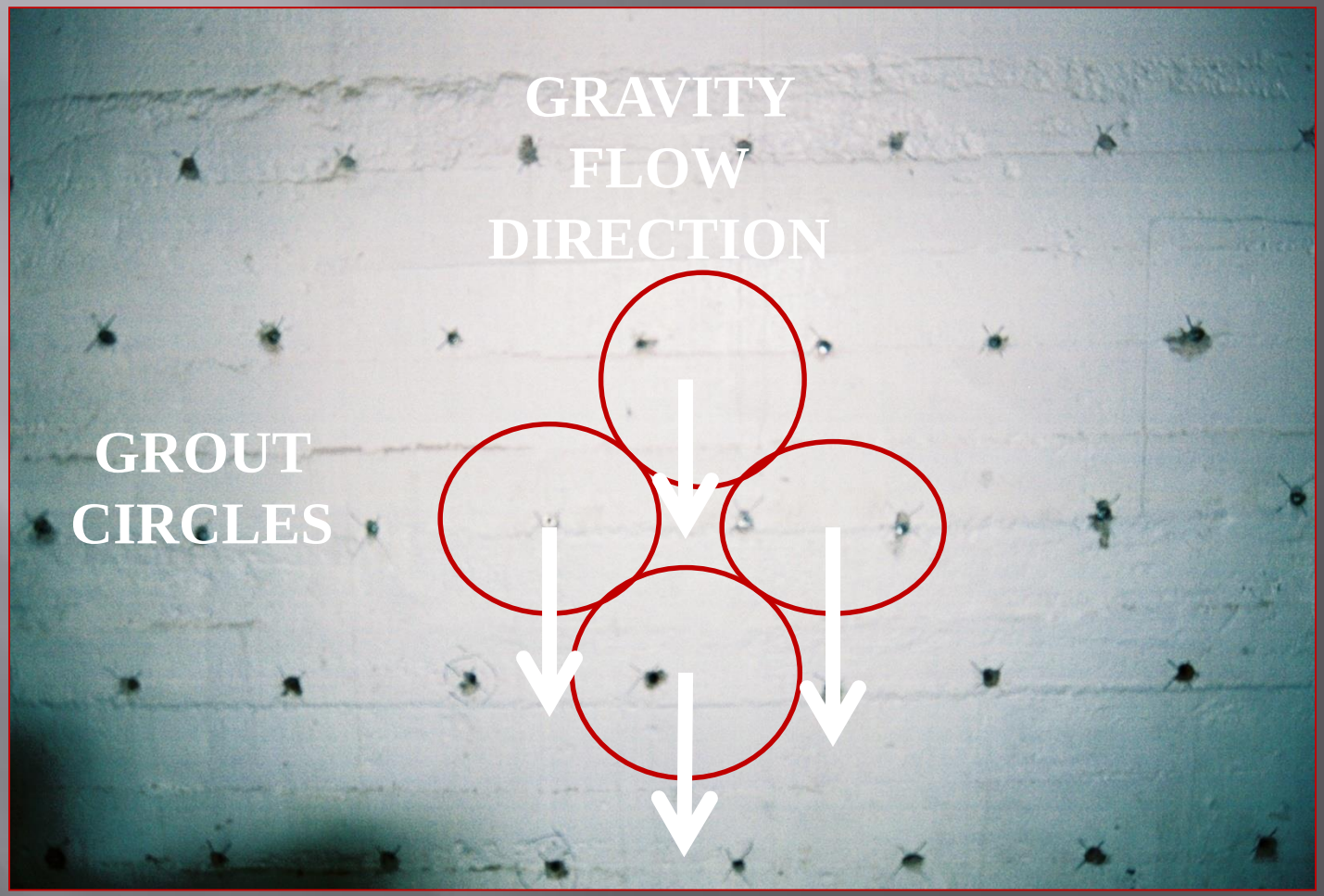
2nd injection row

1st injection row

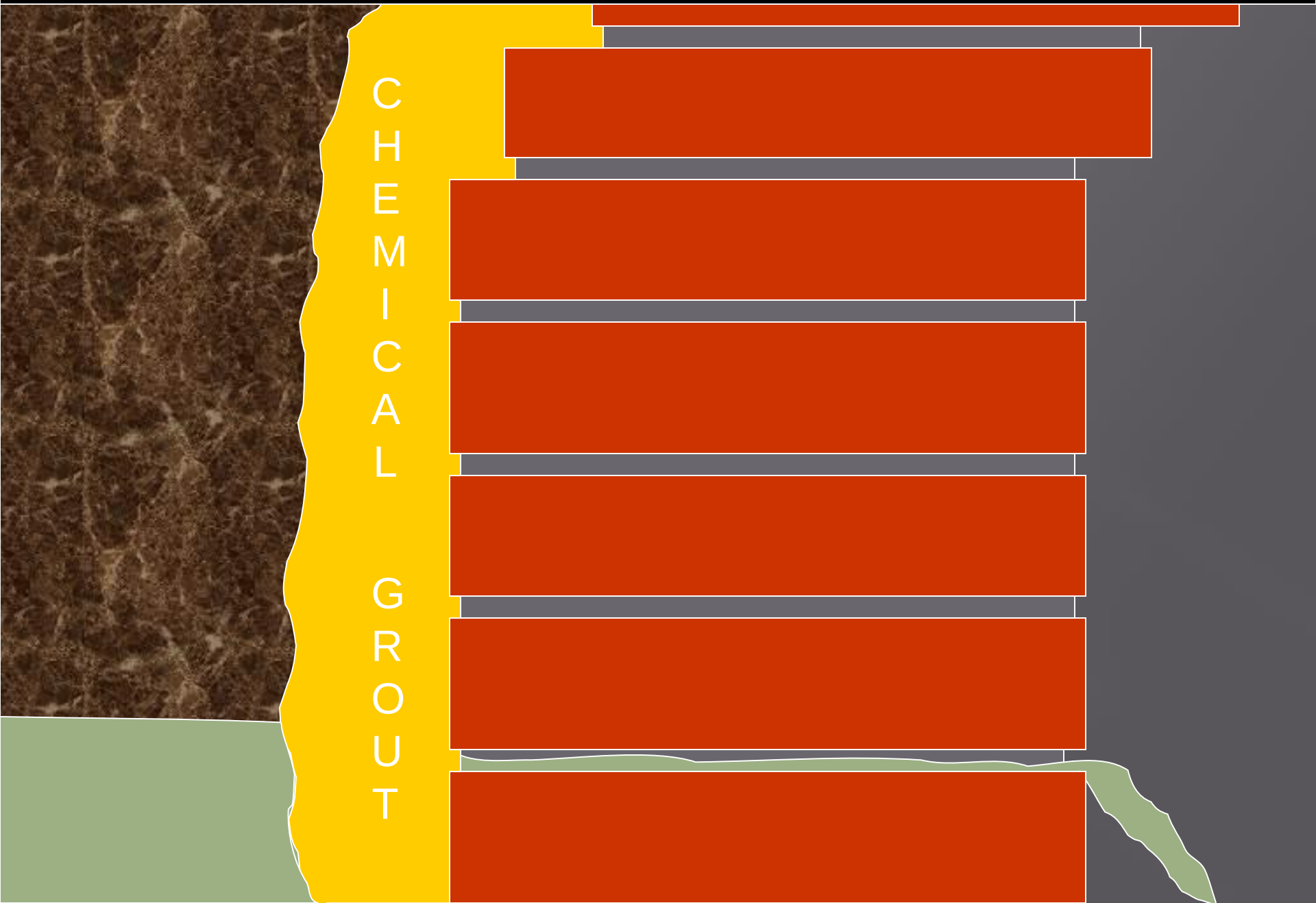
Diamond Pattern



Diamond Pattern Gravity Flow



CURTAIN GROUTING



Probe Grouting

SOIL INJECTION BASICS

Probe Grouting Cont'd.

Chemical Grouts may be directly injected into soils to:

Redirect ground water
Stabilize soils
Create a curtain wall around structures

Injection Procedures

- **Injection Probes**
- Injection probes range from steel ,copper and PVC pipes to Tube a Manchette's / sleeve port grout pipes.

- **Inserting Probes**
- Injection probes can be installed in various ways, hammer driven probes with air to keep injection holes open, air driven probes and water driven probes are the three most common methods.
- Care should be take with water driven probes not to create large voids and loss of soil contact with the inserted probe.

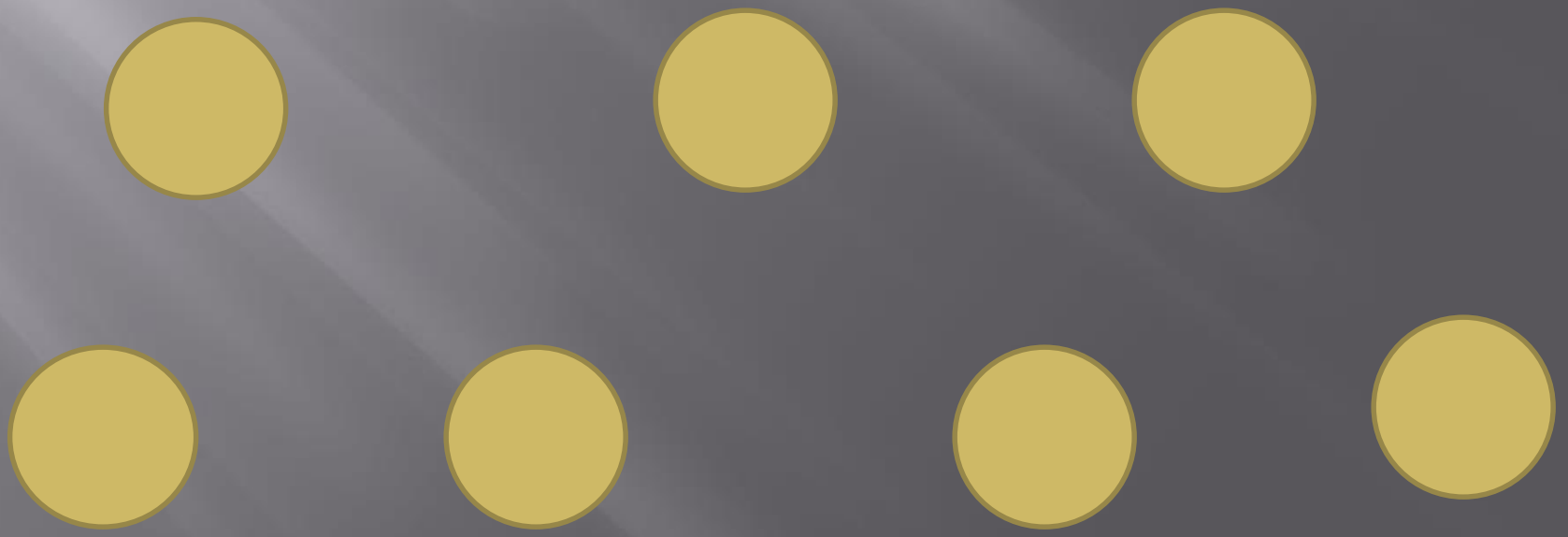
Setting Holes in Roadway

Probe Design

Installing Probes

Injection of Material

- Injection is performed at predetermined increments, pumping the designated volume of material then raising probes up to next area and repeating process.
- Continue pumping probes in sequence until all probes have been injected.
- **Alternating probes method**
- Injecting into probe one then skipping to probe three etc., is common to create a very dense soil mass.



Stabilized Soil Mass

Grouting Pressures

How much pressure should I use?

- Grout at the lowest pressure required to get flow of resin into or beside the structure.
- Raise pressure as required to get continuity from each injection point to the next.
- A slow building of pressures is always preferable to sudden increases.

Refusal Criteria

How long do I pump grout?

- Absolute refusal
- To a specified pressure
- To a specified volume
- To a specified number of passes
- Until the water is stopped

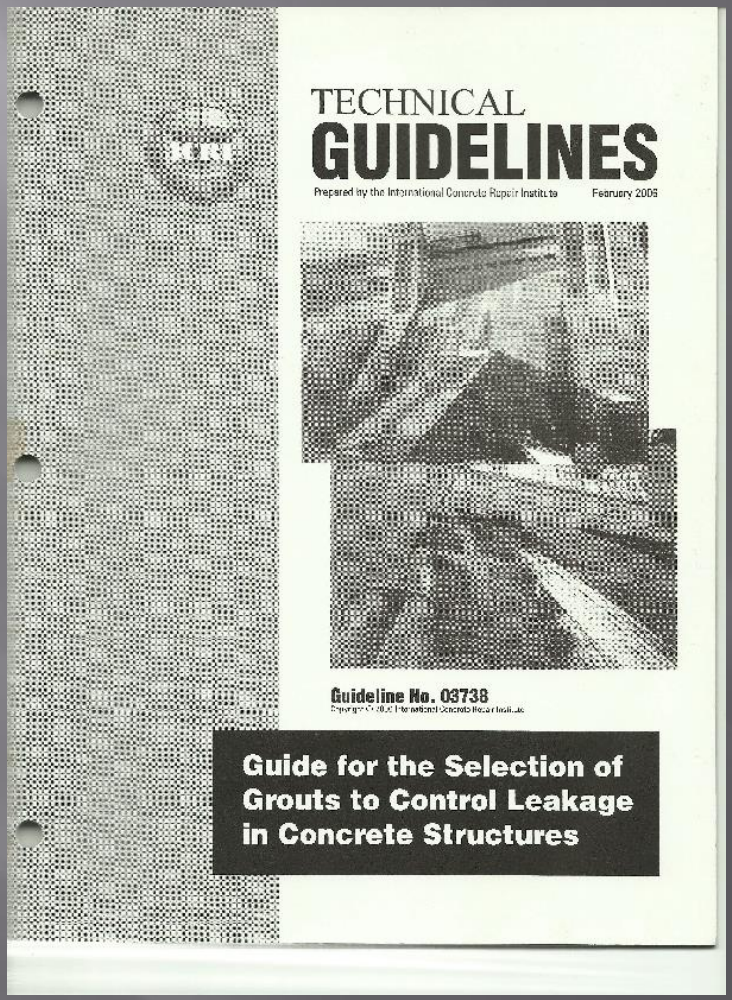
Present Limitations

- Silicates – low strength, brittle, permeability
- Acrylamides – low strength, application equipment, complex mixture, toxicity issues
- Acrylates – low strength, application equipment, complex mixture
- Acrylics – low strength, application equipment, complex mixture
- Urethanes (single comp.) – TDI based
- Urethanes (plural comp.) – TDI based, application equipment

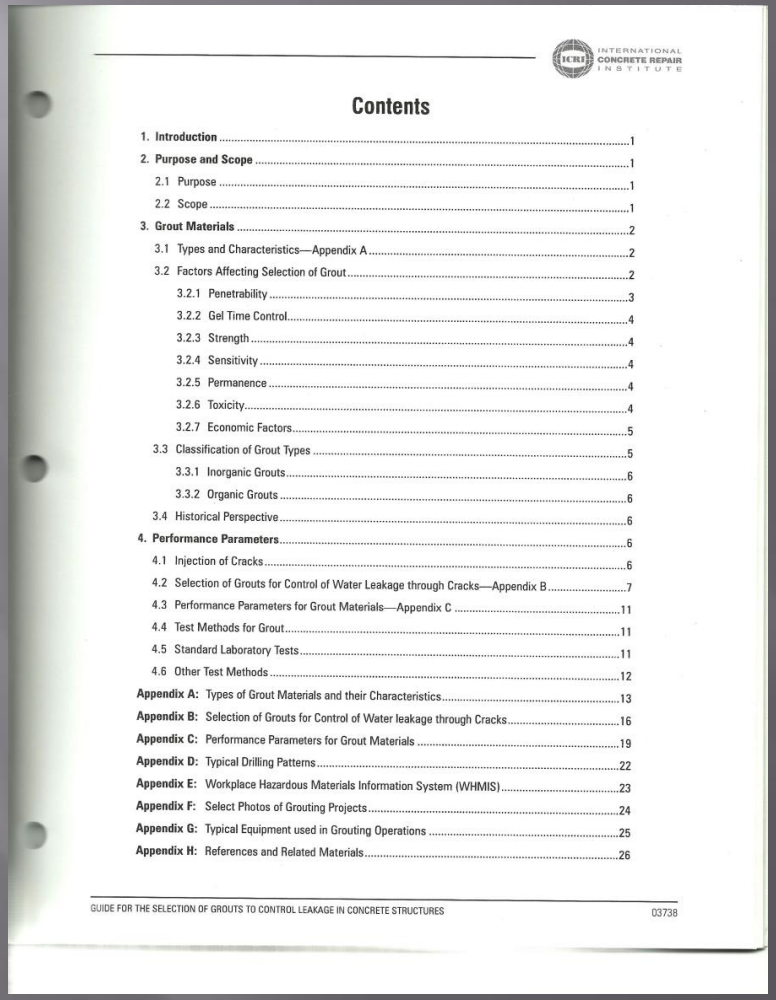
The Future

- Acrylics – crack and joint sealing, curtain wall grouting
- Urethanes (single comp.) – crack and joint sealing, curtain wall grouting, void filling, soil stabilization, TDI Free
- Urethanes (plural comp.) – sealing high flow leaks, void filling, curtain wall grouting, slab jacking, TDI free
- New technologies

ICRI Guideline 03738



ICRI Guideline 03738 Cont'd.



INTERNATIONAL CONCRETE REPAIR INSTITUTE

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ICRI COATINGS & WATERPROOFING COMMITTEE
SUB-COMMMITTEE 710-E – GROUTING GUIDELINE

Mark D. LeMay – JQ Engineers – Chairman
John M. Ziebell - TPCCI
Monica Rourke – Maepi
Scott Anderson - W.R. Grace
James Warner - Independent Consultant
Britt Babcock – Avanti
Kevin Buck – Huntsman
Elena Kessi – Aquafin Bldg. Product systems

ICRI COATINGS & WATERPROOFING COMMITTEE

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Peter Golter – 3M

David F. Dorsch – Dorsch Consulting

Jacob Holland – Summit Sealants

Jim Spiegel – Seal Boss Corp.

Michael Taggart – Jean's Waterproofing, Inc.

340-1 Outline Draft #1

- ICRI COATINGS & WATERPROOFING COMMITTEE
- SUB-COMMMITTEE 710-E – GROUTING GUIDELINE
- 03.22.15
- OUTLINE – DRAFT #1
- I. Introduction
  - A. Intended Audience
- II. Purpose of Document
- III. Scope of Document
- IV. Historical Background
  - A. First use of grout materials
  - B. Previous grout materials used
  - C. Common grout materials used now
    - 1. Types of grouts
- V. Factors Affecting Selection of Grout
  - A. Penetrability
  - B. Gel Time Control
  - C. Flexibility
  - D. Sensitivity
  - E. Durability
  - F. Toxicity
  - G. Economic Factors
    - 1. Material Cost
    - 2. Installation Costs

340-1 Outline Draft #1 Contd.

- VI. Performance Parameters
  - A. Material Selection Checklist
    - 1. Refer to Appendix A
  - B. Selection of Grout Material for Control of Water Leakage
    - 1. Refer to Appendix B
  - C. Performance Parameters for Grout Materials
    - 1. Refer to Appendix C
- VII. Installation Methods
  - A. Equipment and Accessories
    - 1. Pumps
    - 2. Ports
    - 3. Oakum Rope
  - B. Injection of Cracks
    - 1. Typical Drilling Patterns
    - 2. Spacing of ports
  - C. Joints
    - 1. Typical Drilling Patterns
    - 2. Packed Joints (Soaked Oakum)
  - D. Re-Injection
- VIII. Safety
  - A. Material Safety Data Sheets (MSDS)
  - B. Personal Protective Equipment
  - C. Protection of Adjacent Surfaces
- IX. Warranty
- X. References and Related Materials

ICRI Guideline 03738

SUB-COMMMITTEE 710-E – GROUTING GUIDELINE needs your input. If you specify or install chemical grouts please let the committee know what you would like to see in the Guideline. The committee is committed to make this a working guideline by which you can choose or install chemical grouts. An interim revision will be issued to make the Guideline useful while a complete revision is written.

QUESTIONS ?

THANK YOU FOR YOUR ATTENTION !