State of the Art in Grout Mixes

Presented By:

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BALANCED STABLE GROUTS

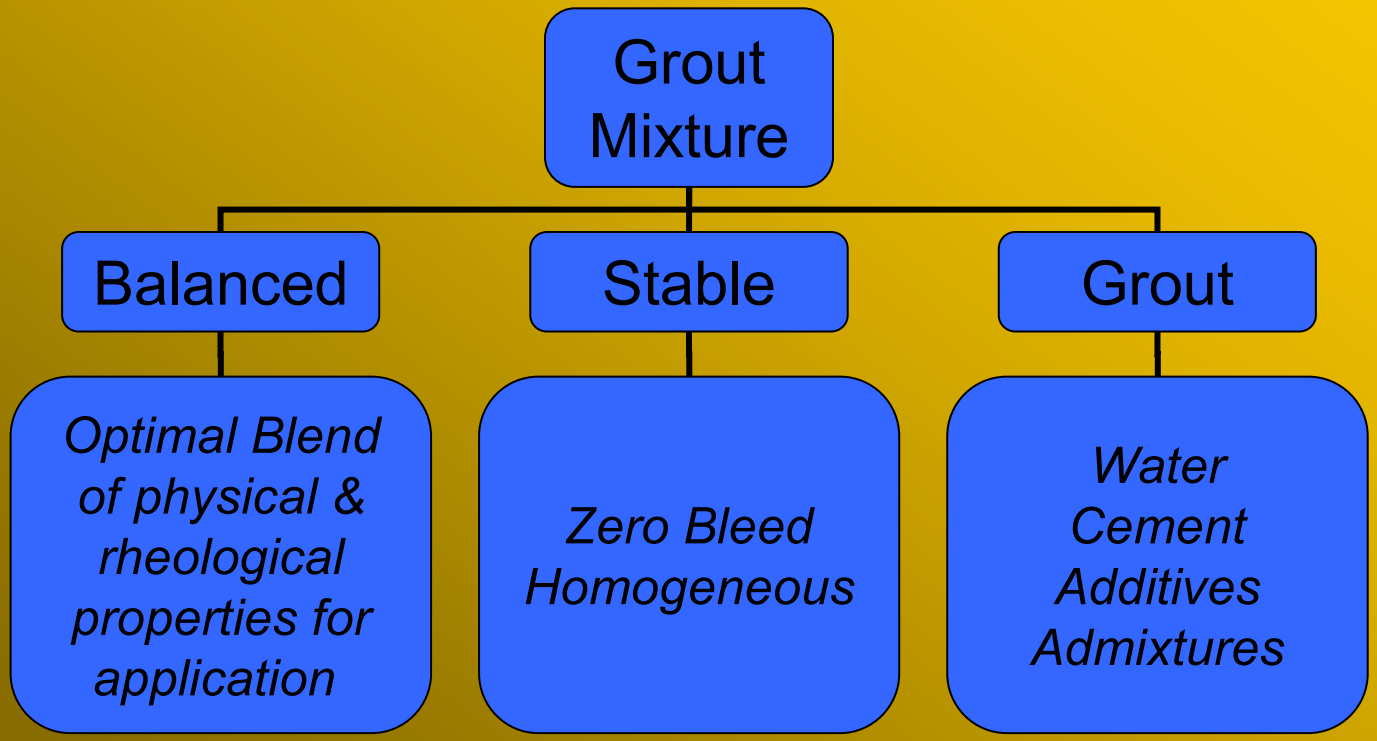
- Definitions
- Theory
- Materials
- Testing

Definition

Balanced Stable Cement Grout

A homogenous balanced blend of water and cement combined with selected additives and admixtures producing a product with zero bleed, low cohesion and good resistance to pressure filtration.

Balanced Stable Grout



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Unstable Grout Mixtures

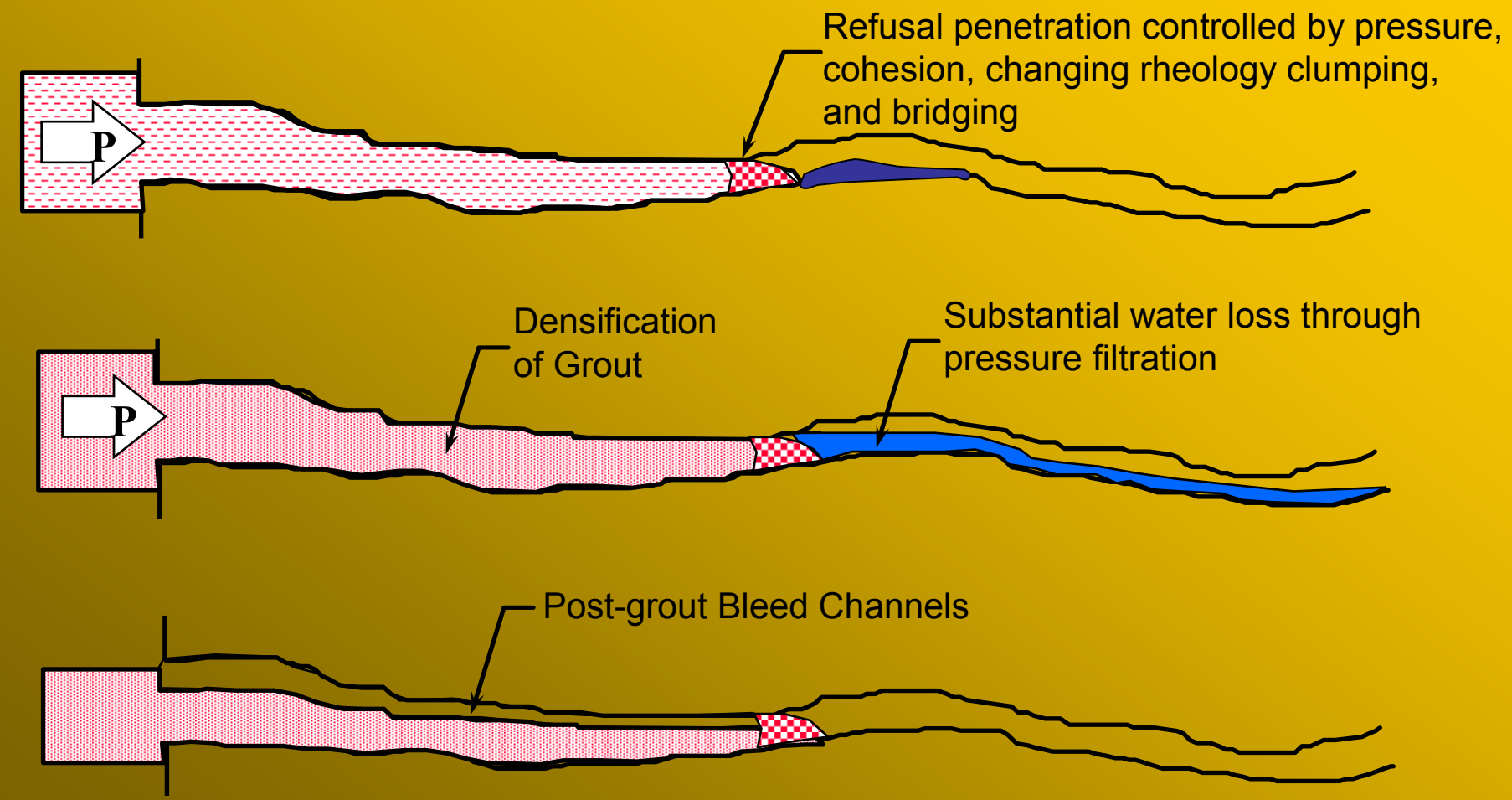
- Variable Rheology
- Poor Particle Orientation
- High Segregation & Sedimentation
- High Pressure Filtration Coefficient
- Unpredictable Behavior
- Unstable During Injection
- Marginal Durability
- High Bleed Potential

Theory

What are the desired properties of a cement based suspension grout?

- Low cohesion
- Viscosity consistent with acceptable penetration rate
- Minimal to zero bleed
- Constant rheology during application
- Dispersed particles
- High durability

Grouting Theory - Neat Cement Grouts



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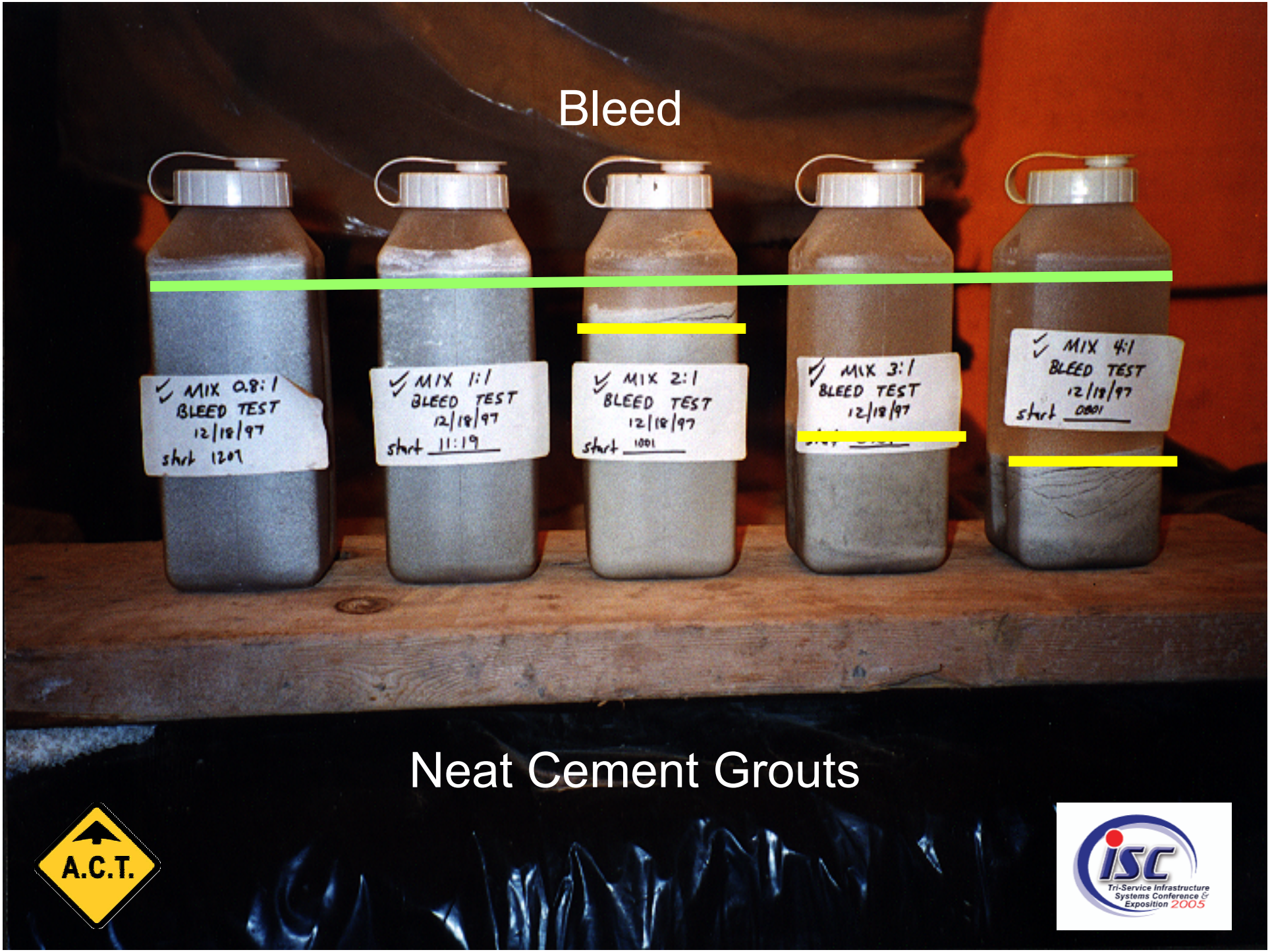
Bleed
MIX 0.8:1
BLEED TEST
12/18/97
start 1207
MIX 1:1
BLEED TEST
12/18/97
start 11:19
MIX 2:1
BLEED TEST
12/18/97
start 1001
MIX 3:1
BLEED TEST
12/18/97
MIX 4:1
BLEED TEST
12/18/97
start 0801
Neat Cement Grouts
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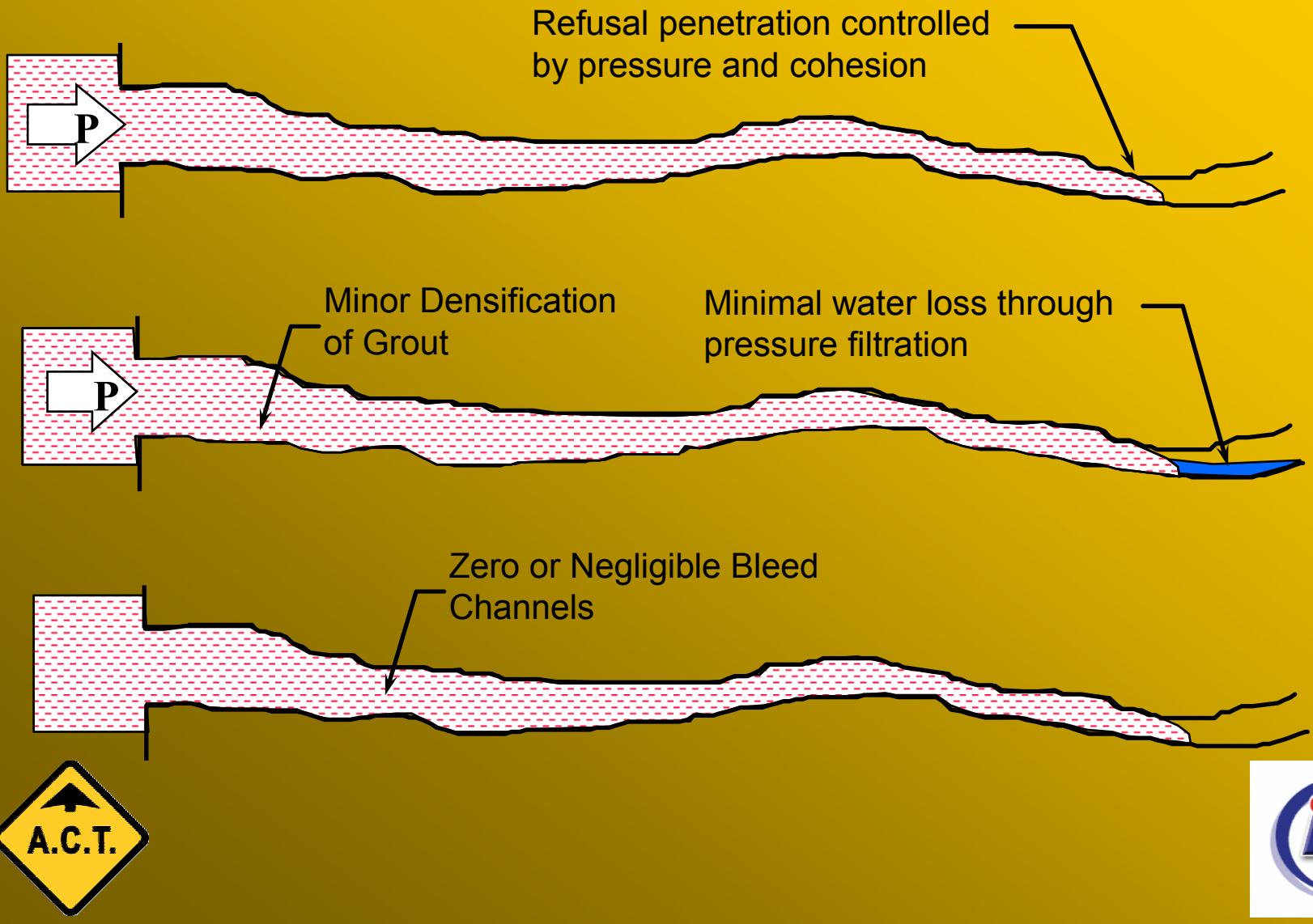
Grouting Theory - Balanced, Stable Grouts




Bleed
MIX A
BLEED TEST
12/18/97
start 0891
MIX D
BLEED TEST
12/18/97
start 1032
MIX F
BLEED TEST
12/18/97
start 1147
MIX G
BLEED TEST
12/18/97
start 1239
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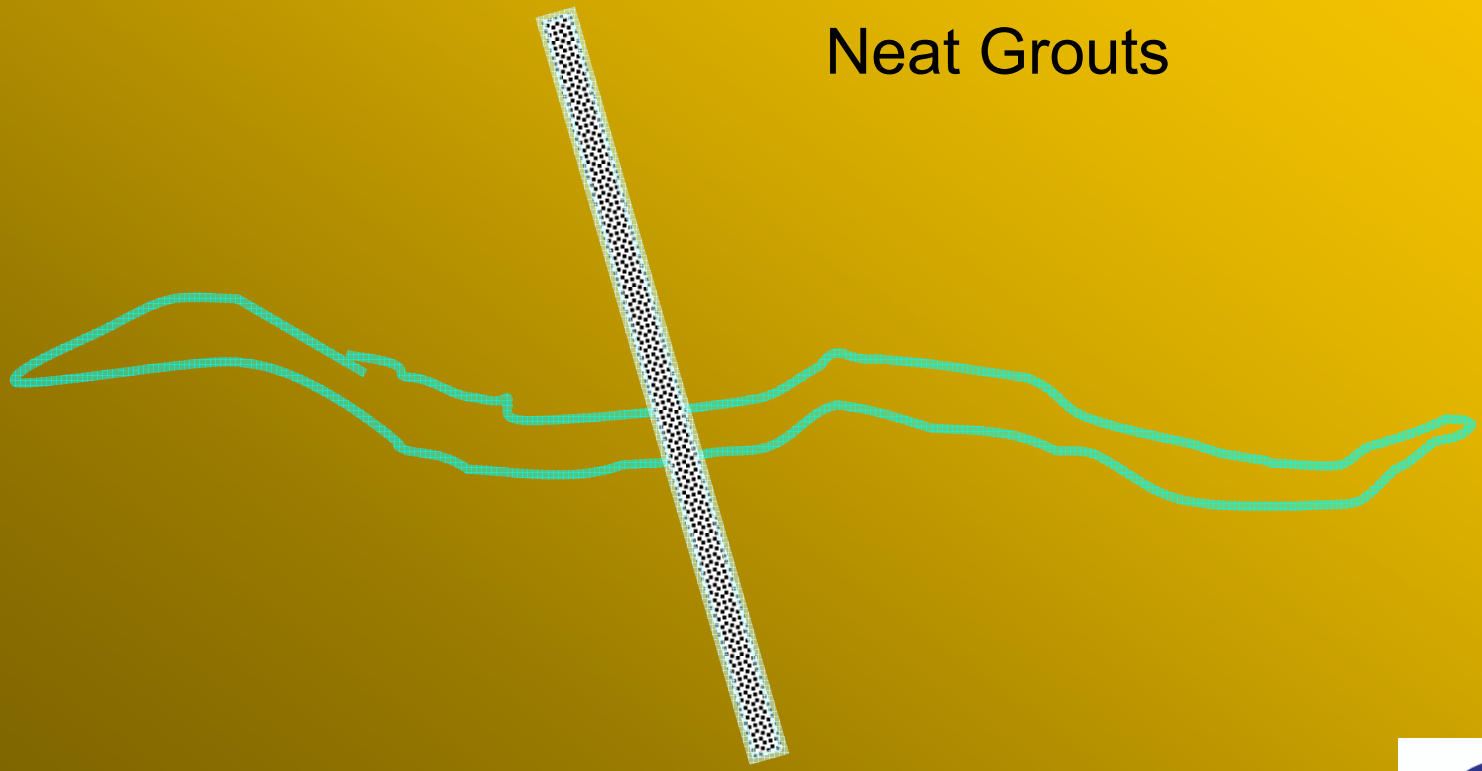
Stabilized vs. Neat Grouts

Grout Injection Theory

Neat Grouts



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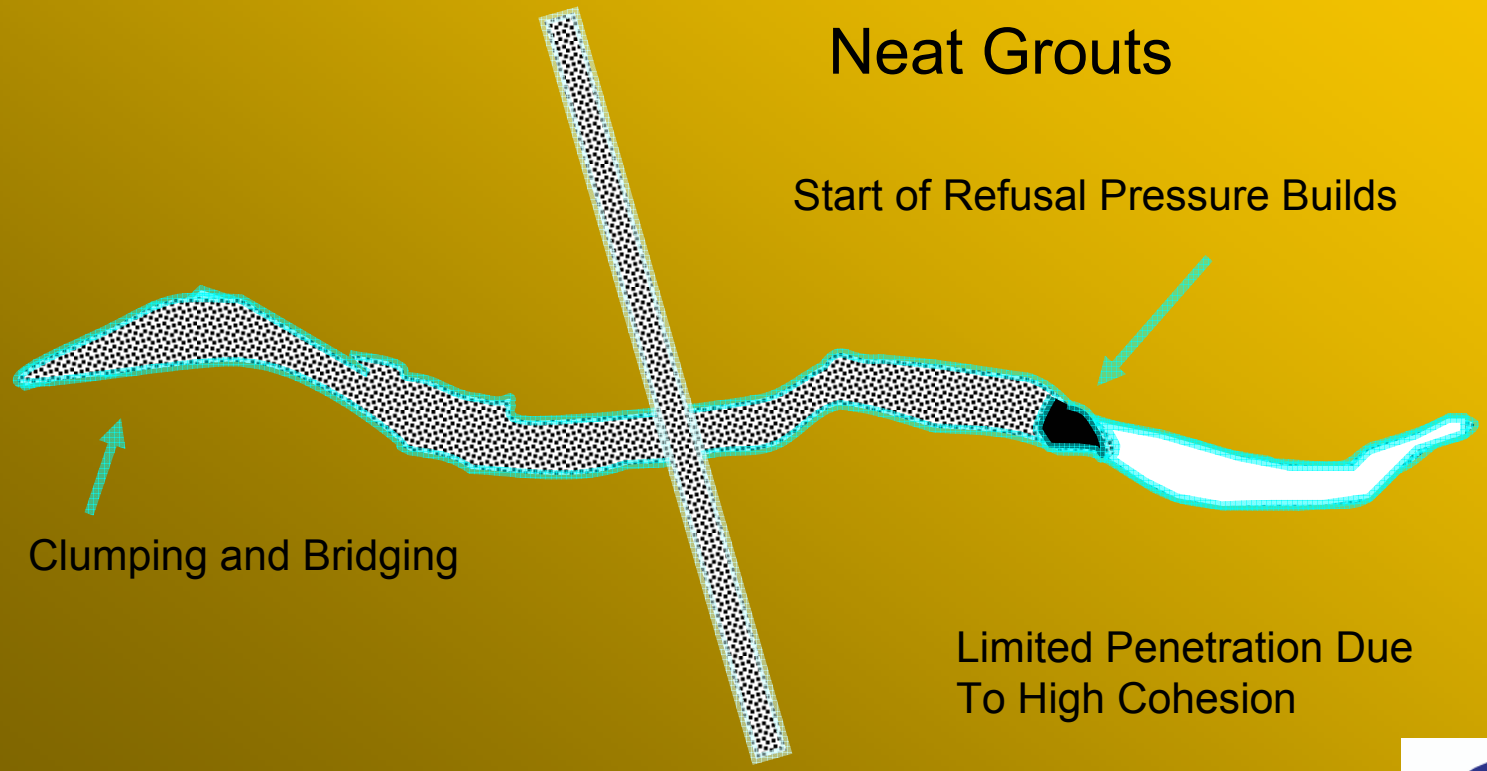
Stabilized vs. Neat Grouts

Grout Injection Theory

Neat Grouts

Start of Refusal Pressure Builds



Clumping and Bridging

Limited Penetration Due
To High Cohesion

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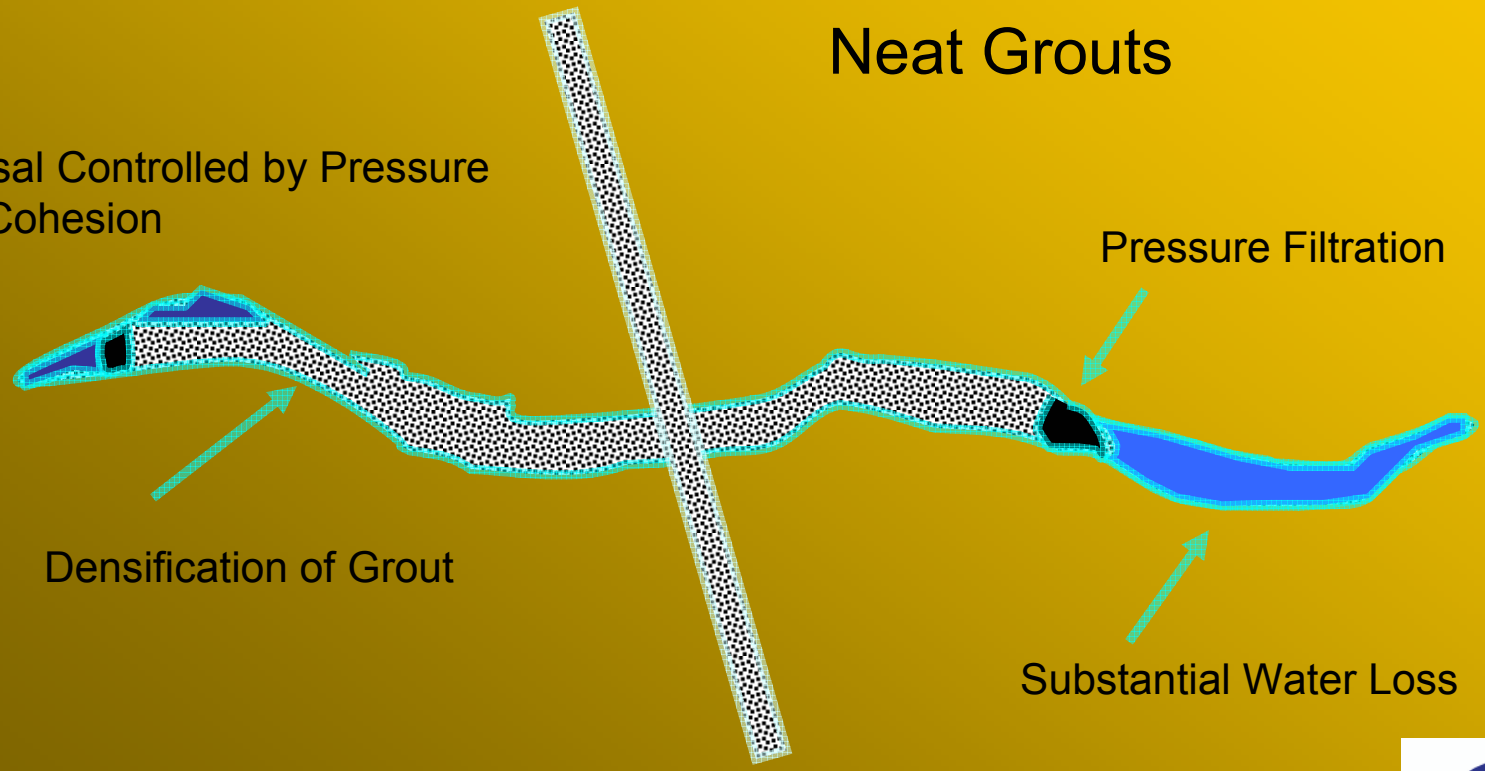
Stabilized vs. Neat Grouts

Grout Injection Theory

Neat Grouts

Refusal Controlled by Pressure and Cohesion



Pressure Filtration

Densification of Grout

Substantial Water Loss

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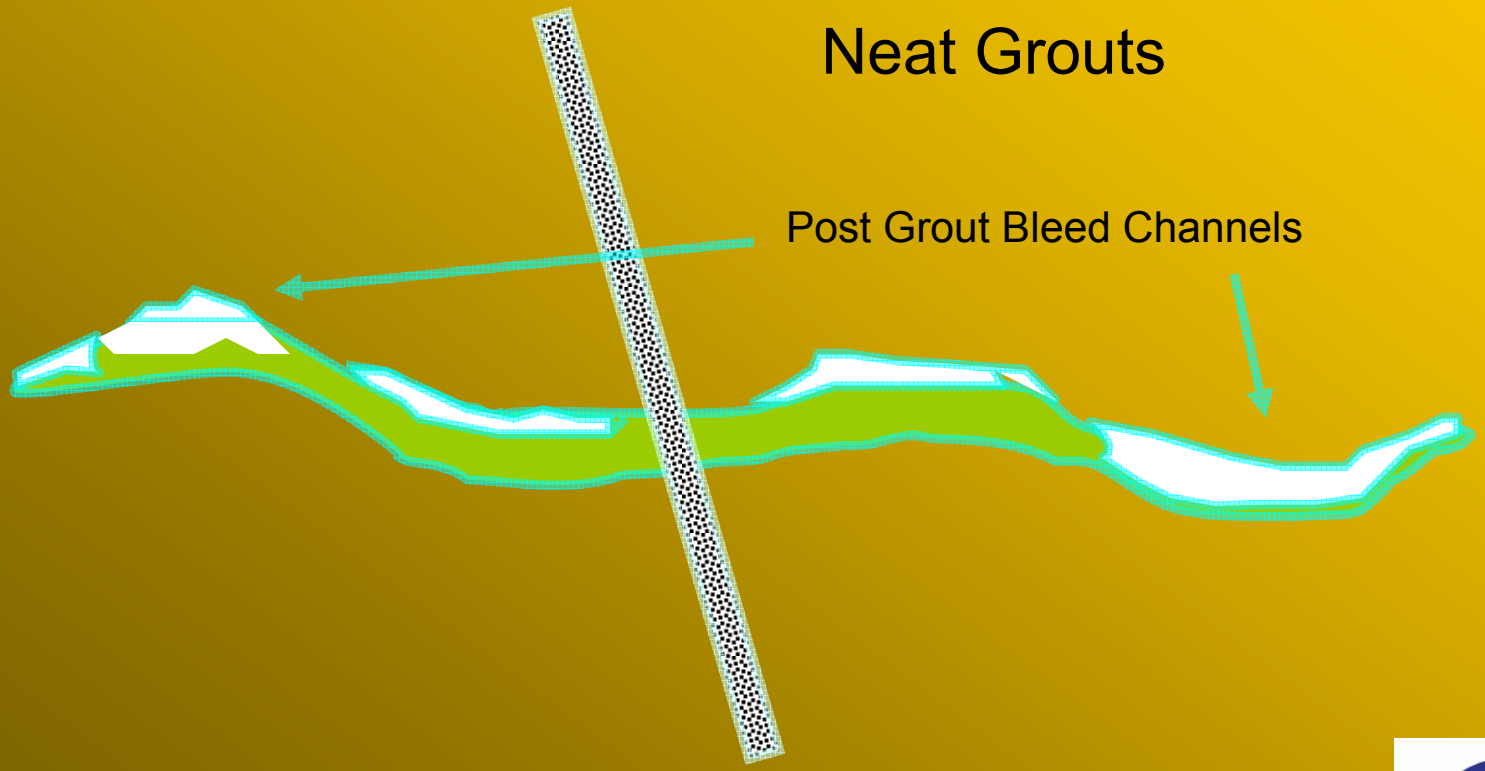
Stabilized vs. Neat Grouts

Grout Injection Theory

Neat Grouts



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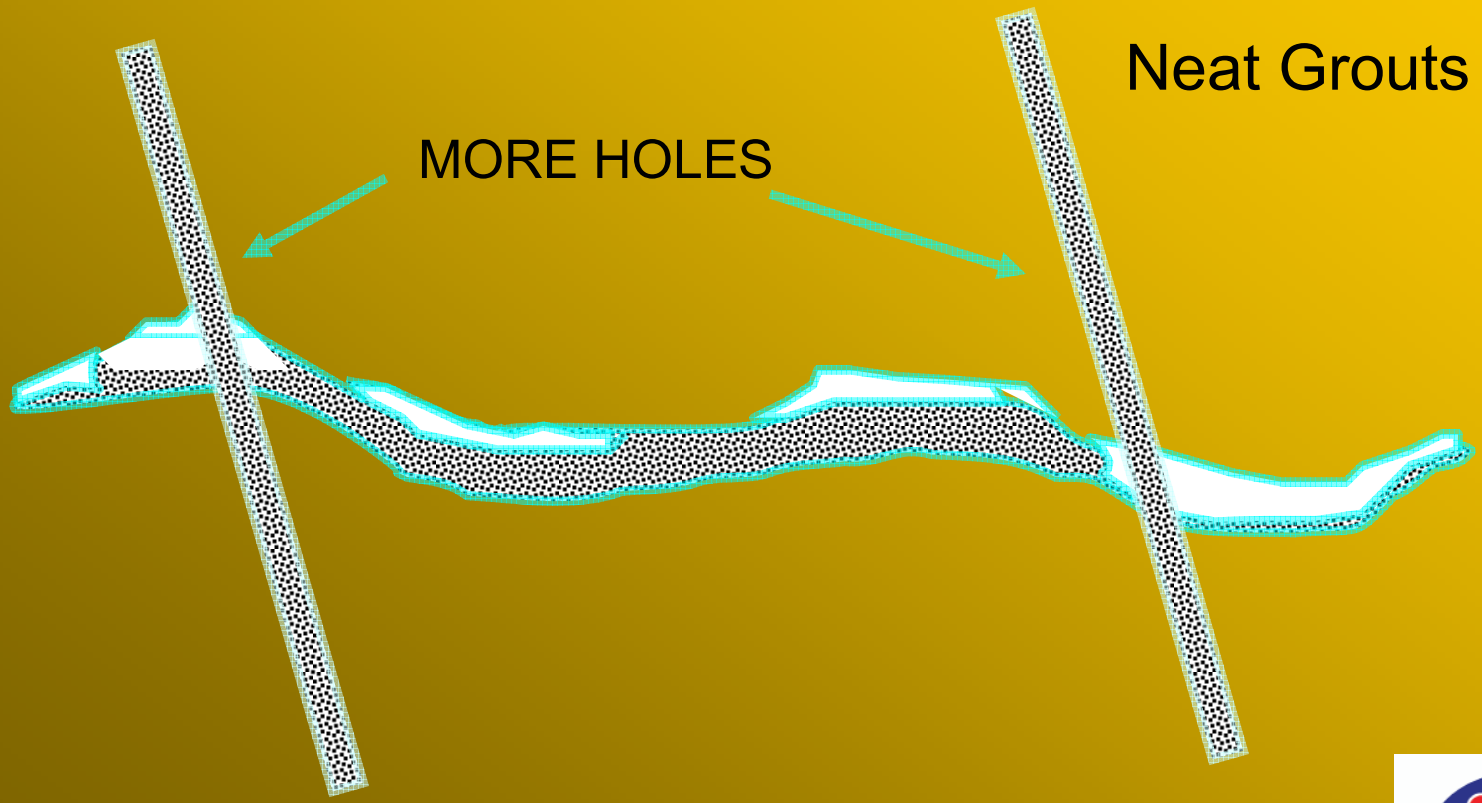
Stabilized vs. Neat Grouts

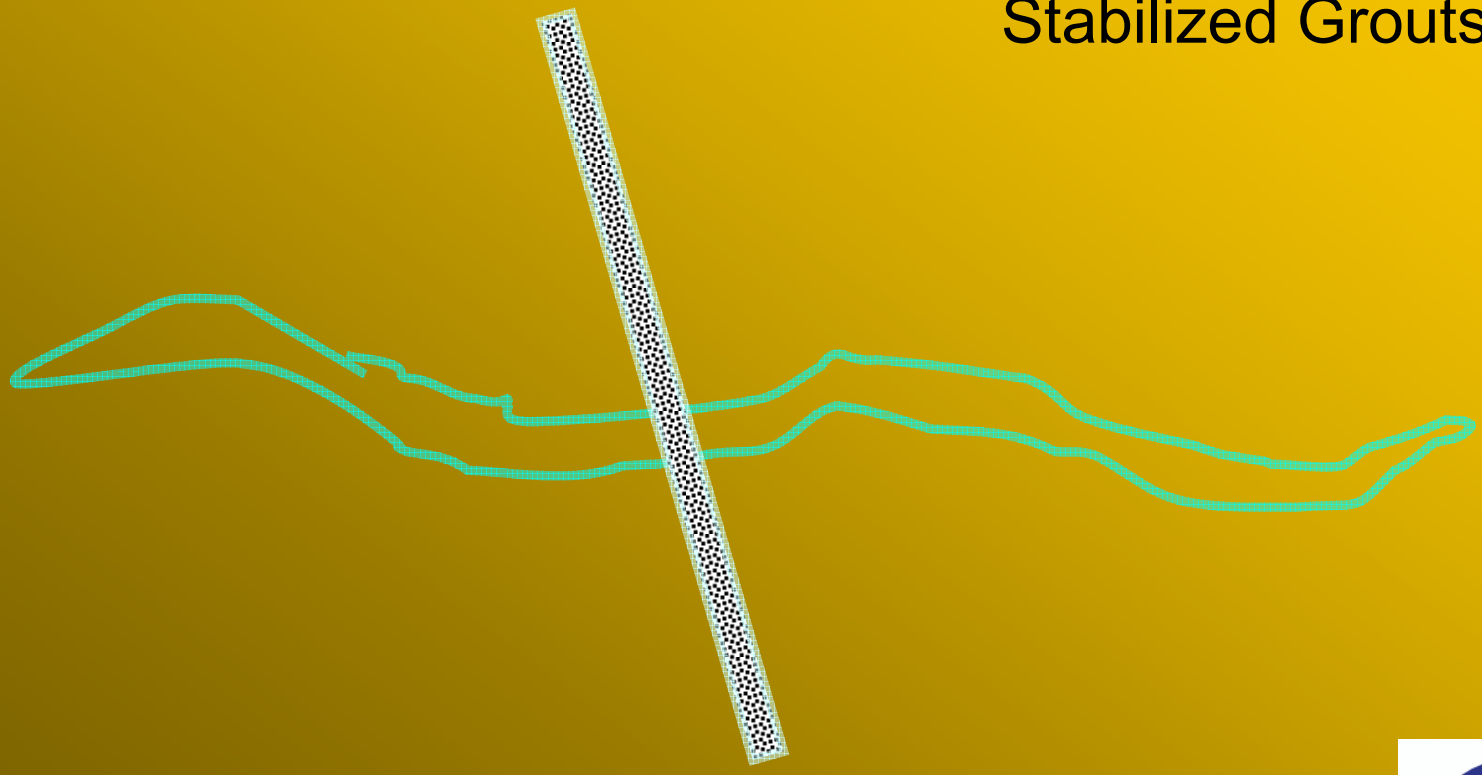
Grout Injection Theory



Stabilized vs. Neat Grouts

Grout Injection Theory

Stabilized Grouts



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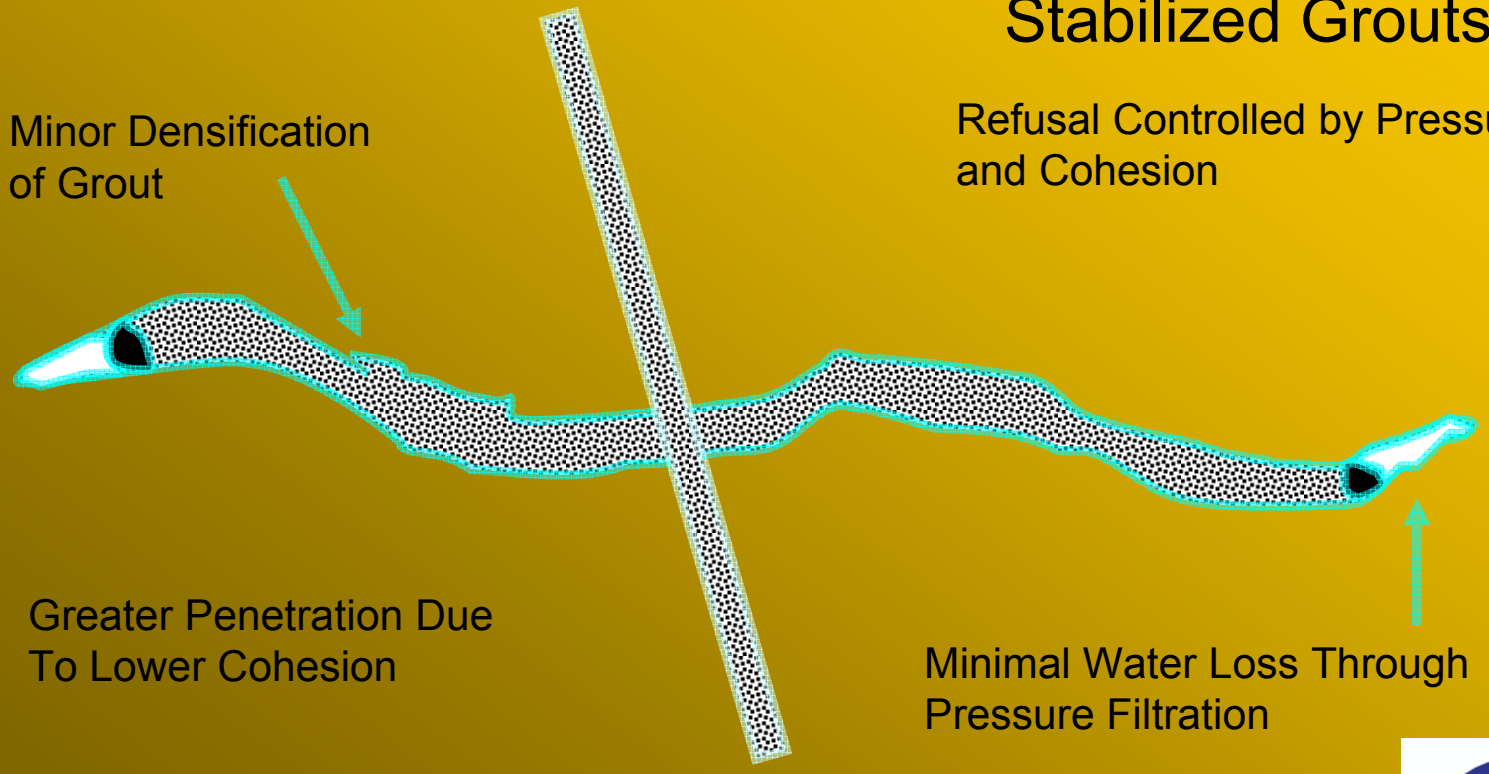
Stabilized vs. Neat Grouts

Grout Injection Theory

Stabilized Grouts

Minor Densification of Grout

Refusal Controlled by Pressure and Cohesion



Greater Penetration Due To Lower Cohesion

Minimal Water Loss Through Pressure Filtration

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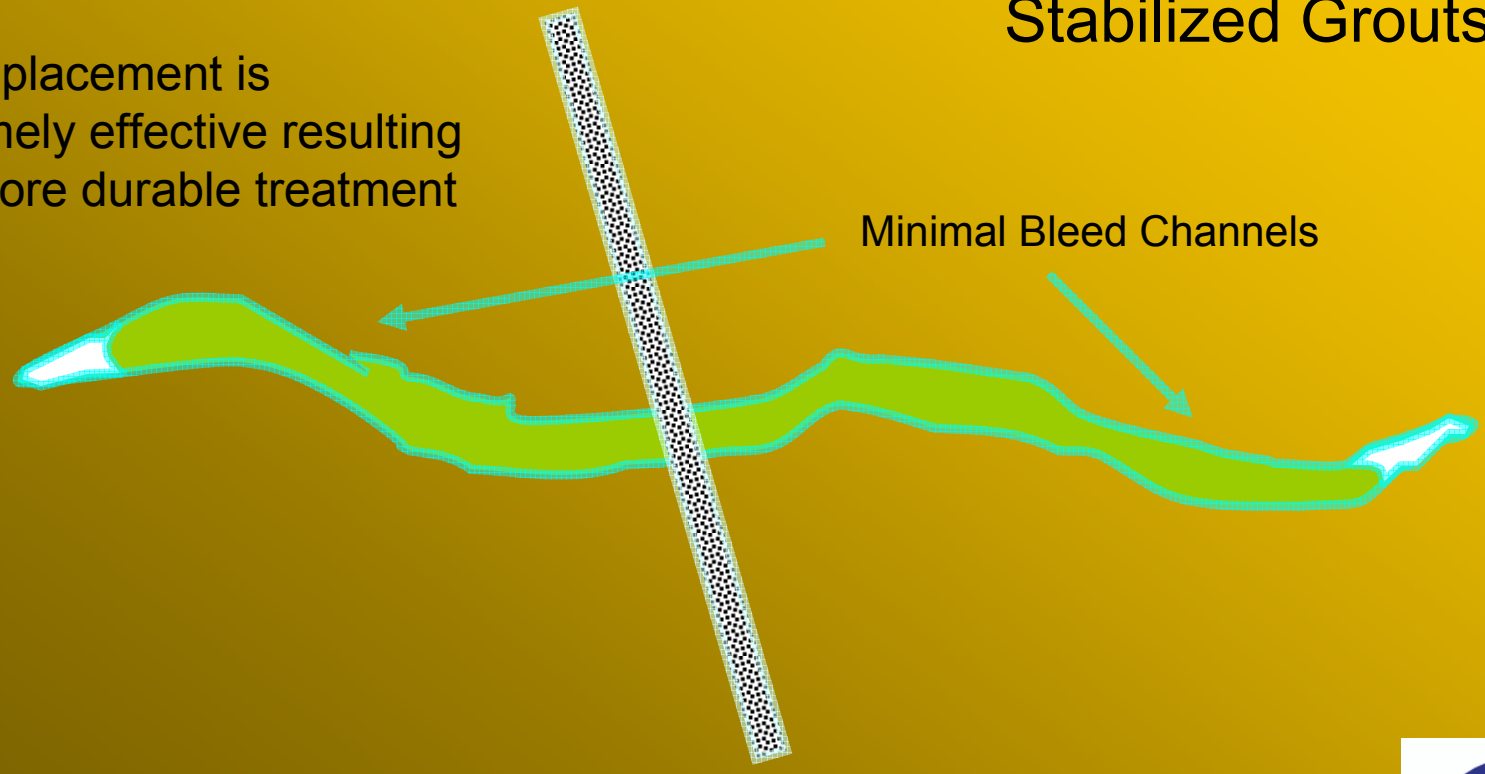
Stabilized vs. Neat Grouts

Grout Injection Theory

Stabilized Grouts

Grout placement is extremely effective resulting in a more durable treatment



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Characteristics of Balanced Stable Cement-Based Suspension Grouts

- Cement + water + additives + admixtures
- Minimal to zero bleed
- High resistance to pressure filtration
- Organized particles due to electrostatic and chemical interaction
- High durability

Characteristics of Unstable Water Cement Grouts

- Cement + water
- Considerable bleed potential
- Low resistance to pressure filtration
- Unorganized particles
- Lower durability

Advantages of Balanced Stable Grouts

- Dispersed structure, stable rheology and lower cohesion result in increased penetrability and greater radius of grout spread
- Minimal to zero bleed – The fractures that are filled remain 100% filled
- Increased penetration and minimal to zero bleed result in lower residual permeability
- Lower residual curtain and grout matrix permeability result in increased durability

Materials

Common Additives to Balanced Stable Grout

- Bentonite
- Silica Fume
- Flyash (Type C or F)
- Welan Gum
- Dispersant (Super Plasticizer)

Bentonite

- Product

  Natural sodium montmorillonite clay product.

  Typical dosage is 2-8 % by weight of cement.

  Should be pre-hydrated and added as a slurry.

- Characteristics

  Advantages
  Reduced pressure filtration
  Reduced final bleed
  Enhanced stability

  Disadvantages
  Increased cohesion
  Increased viscosity

Silica Fume

- Product

  By-product of the production silicon.

  Very fine spherical particulate.

  Typical dosage between 4-8 % by weight of cement.

- Characteristics

  Advantages

  Increased penetrability
  Reduced final permeability
  Enhanced durability
  Water repellant
  Reduces pressure filtration

  Disadvantages

  Increased Strength

Welan Gum

- Product

  High molecular weight bipolymer.

  Used to increase resistance to pressure filtration and for artesian conditions.

  Typical dosage is 0.1 % by weight of cement.

- Characteristics

  Advantages
  Reduces pressure filtration
  Reduced segregation
  Enhanced water repellant

  Disadvantages
  Increases cohesion

Dispersant

- Product

  Naphthalene sulfonate based.

  Enrobes cement particles with a negative charge so particles repell.

  Typical dosage is 1- 2% by weight of cement.

- Characteristics

  Advantages
  Increased penetrability
  Increased pumping time

  Disadvantages
  Increases set time

Testing

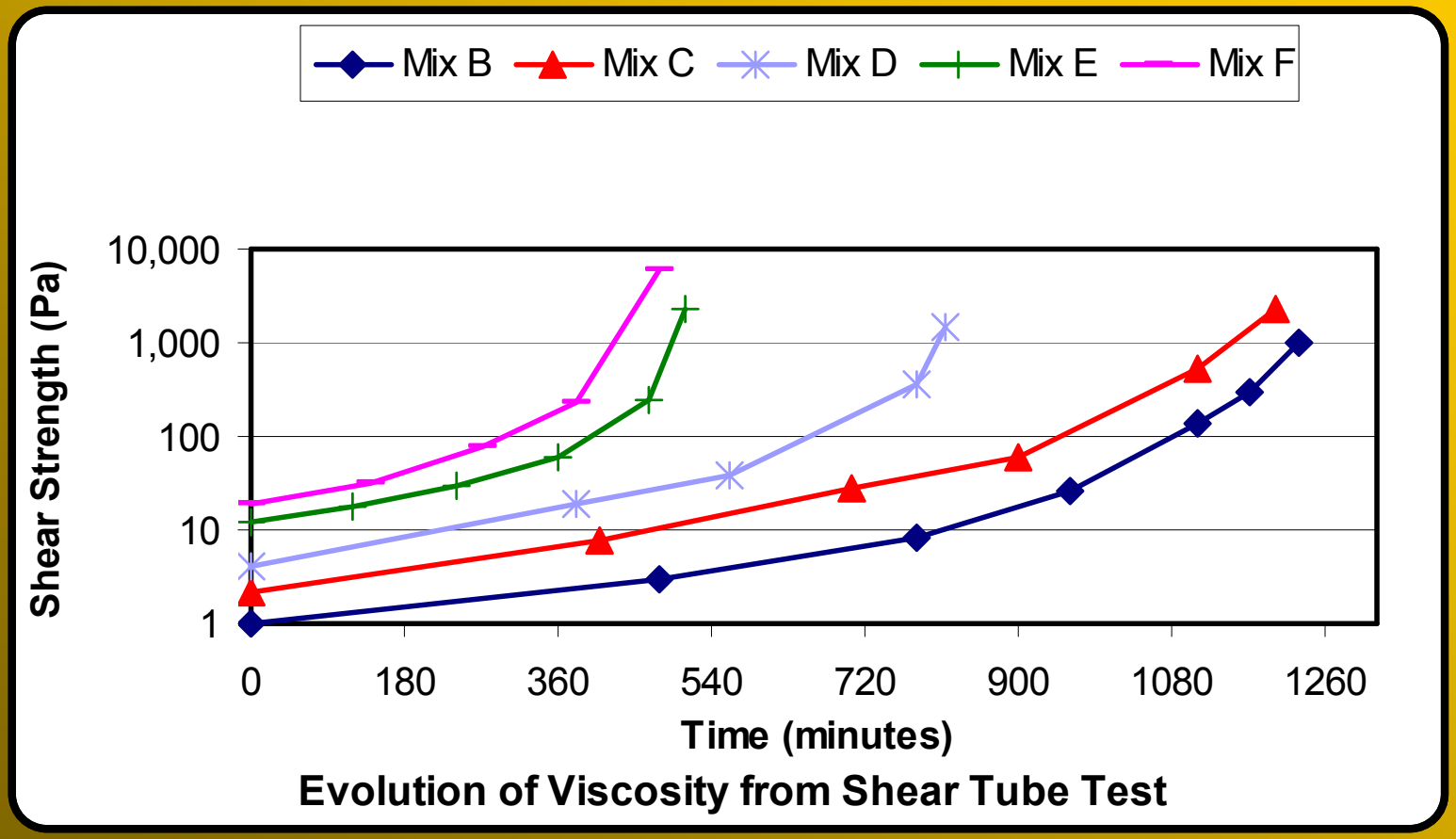
Properties	Test	Units
Cohesion	Viscometer	Pa
Viscosity	Marsh Funnel	Sec
Pressure Filtration	Filter Press	Kpf
Bleed	Cylinders	%
Density	Mud Balance	#/ft3
Set Time	Vicat Needle	Hrs
Compressive Strength	Cubes	psi

Cohesion Testing

- Viscometer Test
  - Cohesion

    pascals (Pa)

Evolution of Cohesion



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Viscosity (Marsh Funnel)

- Viscosity Reading seconds
- Measure of flowability of fluid grout
- Water = 28 sec
- Grout = 32 – 70 sec

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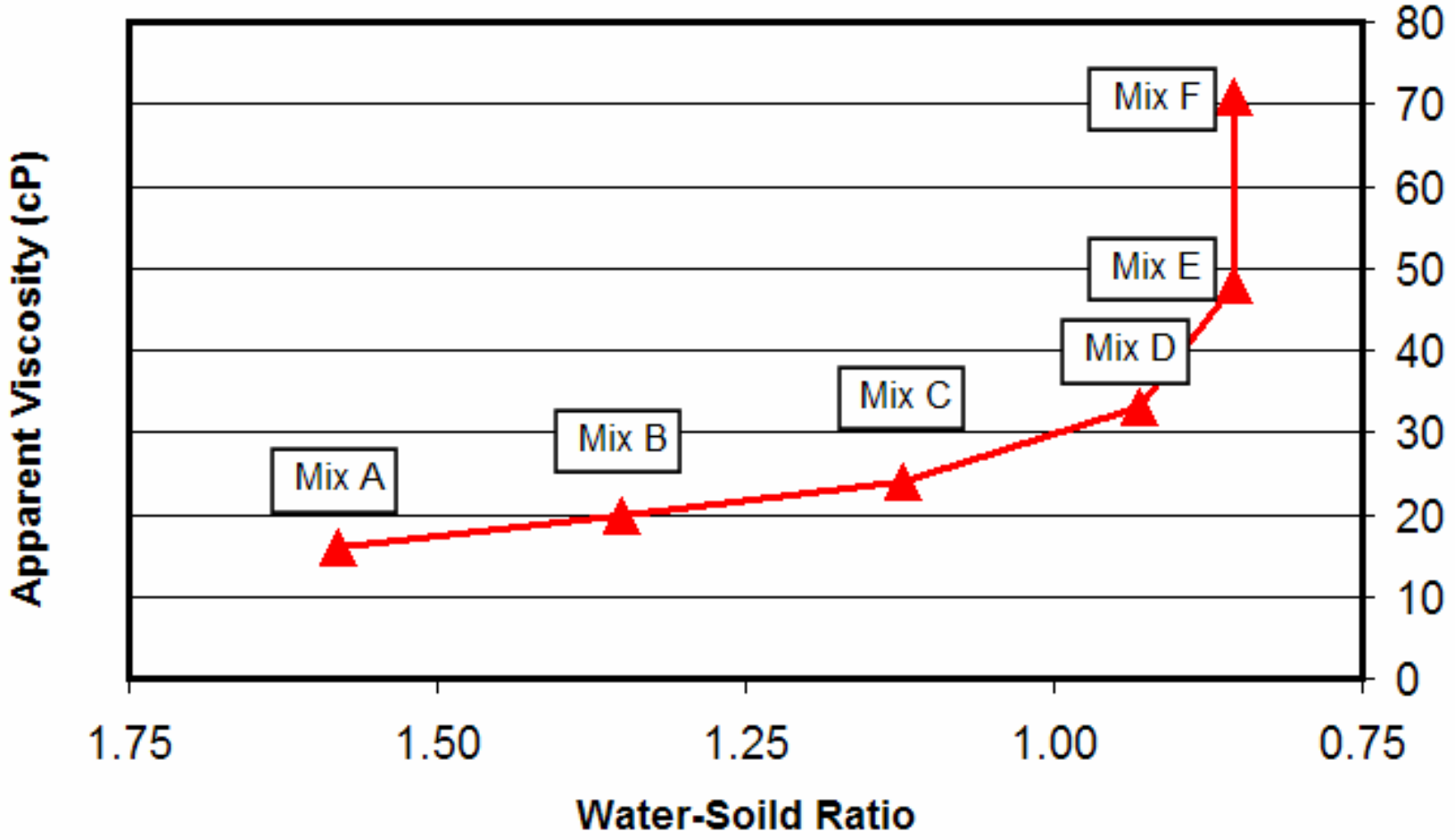

Relationship of Apparent Viscosity and Water-Soild Ratio

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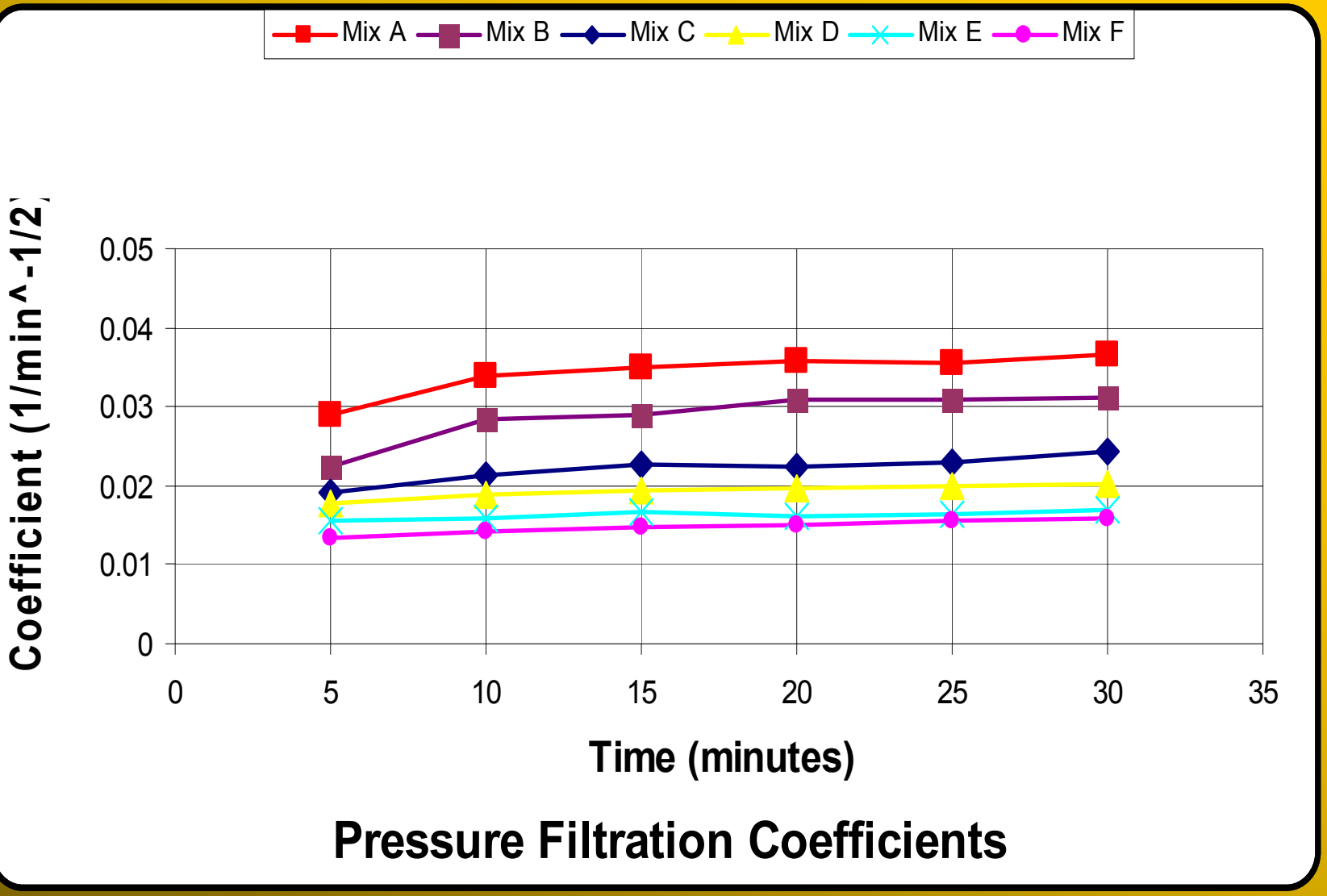
Pressure Filtration Testing

$$Kpf = \frac{\textit{volume of water ejected}}{\text{initial volume of grout x (filtration time (min))}1/2}$$



Pressure Filtration Coefficients

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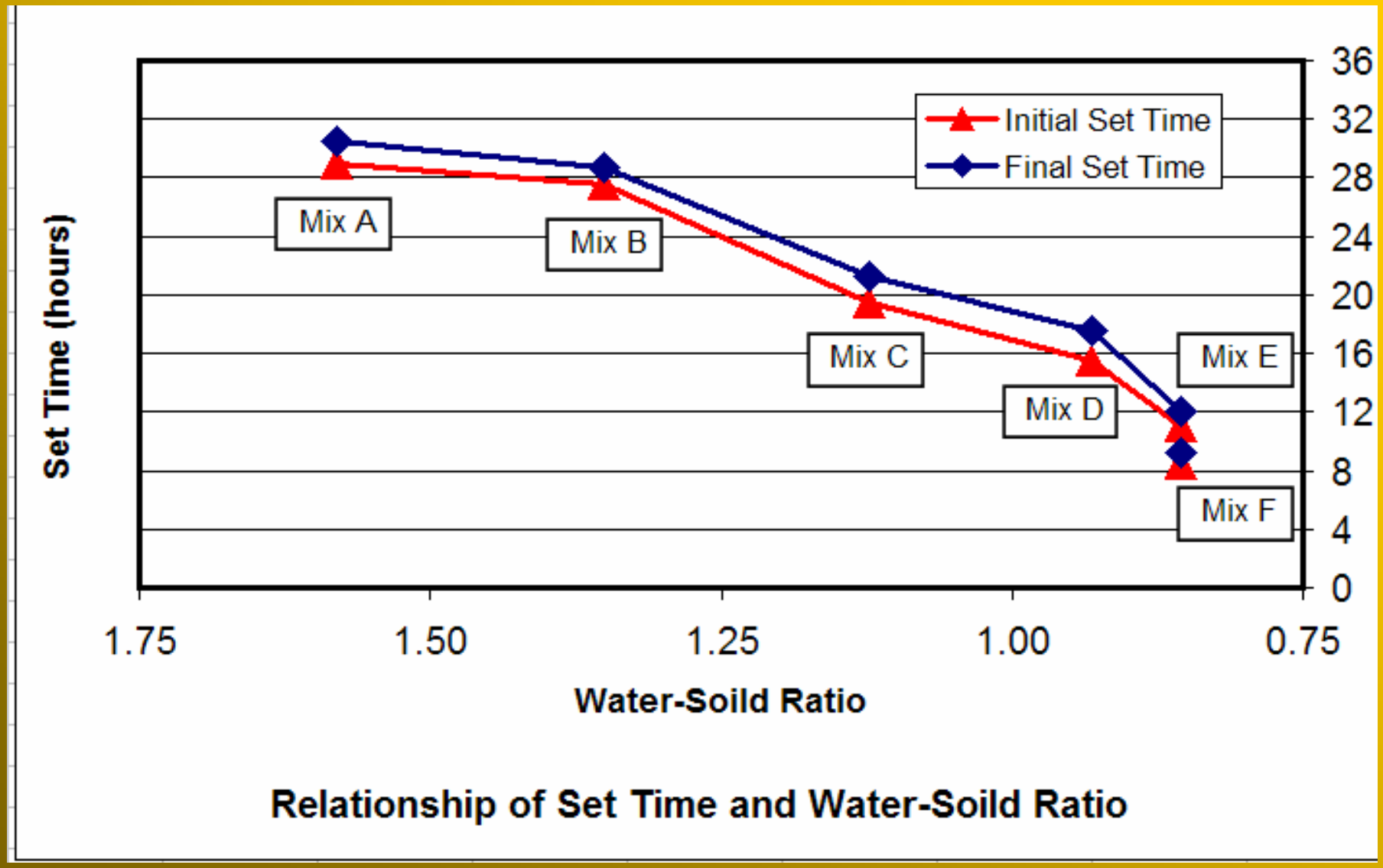
Mud Balance

- Measures Density
- Useful test for quality control on mix consistency

Set Time

- Vicat Needle
  Initial set 25 mm
  Final set 0 mm



Relationship of Set Time and Water-Soild Ratio

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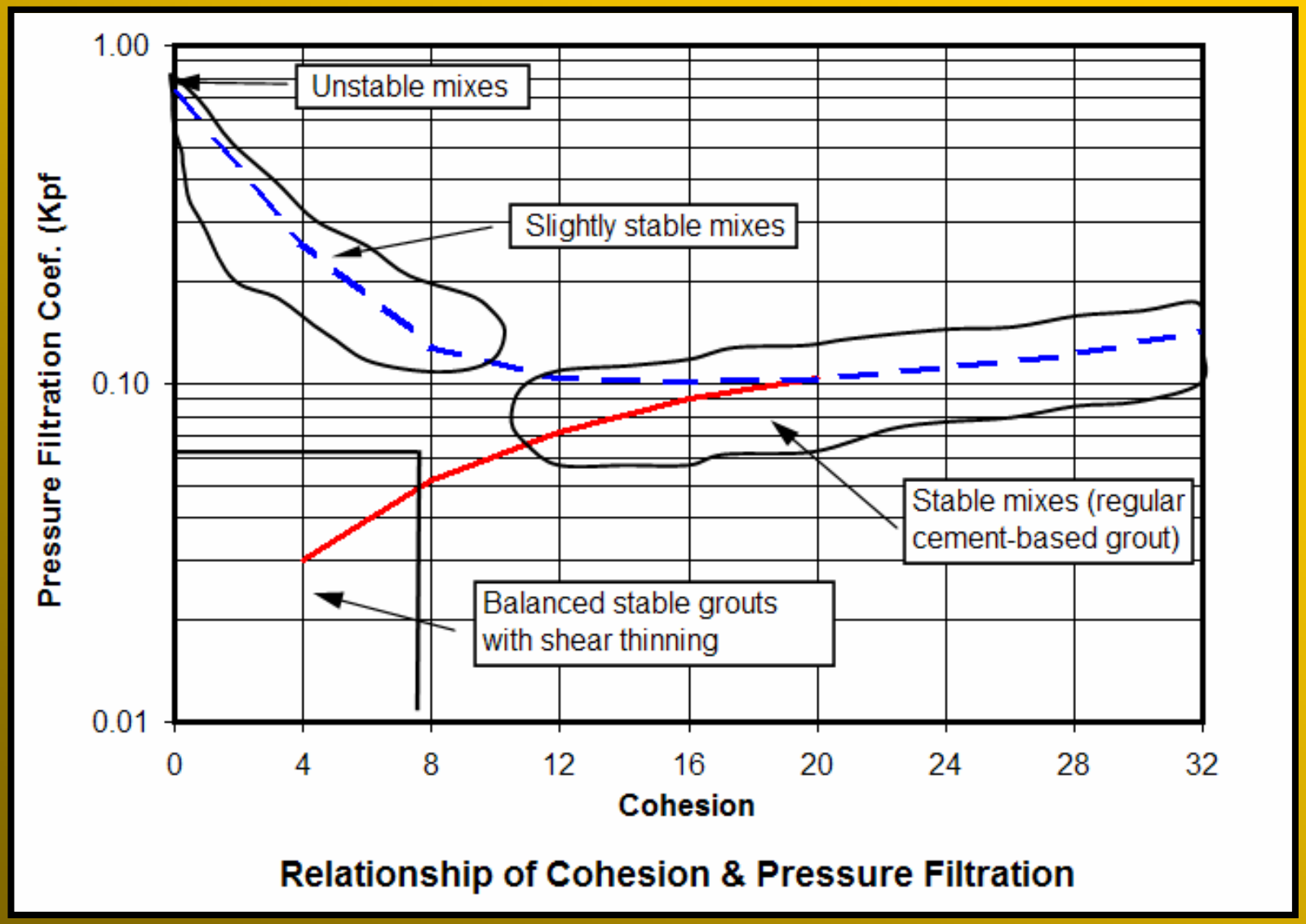

Relationship of Cohesion & Pressure Filtration

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THANK YOU

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