Herbert Wertheim College of Engineering
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# Lessons learned from non-proprietary UHPC mix design

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# Non-Proprietary Mix Design Goals

- Use local materials from Florida
- Design mixes with a range of compressive strengths, from 12-21 ksi
- Test the mixes to see how compressive strength affects mechanical and durability properties.

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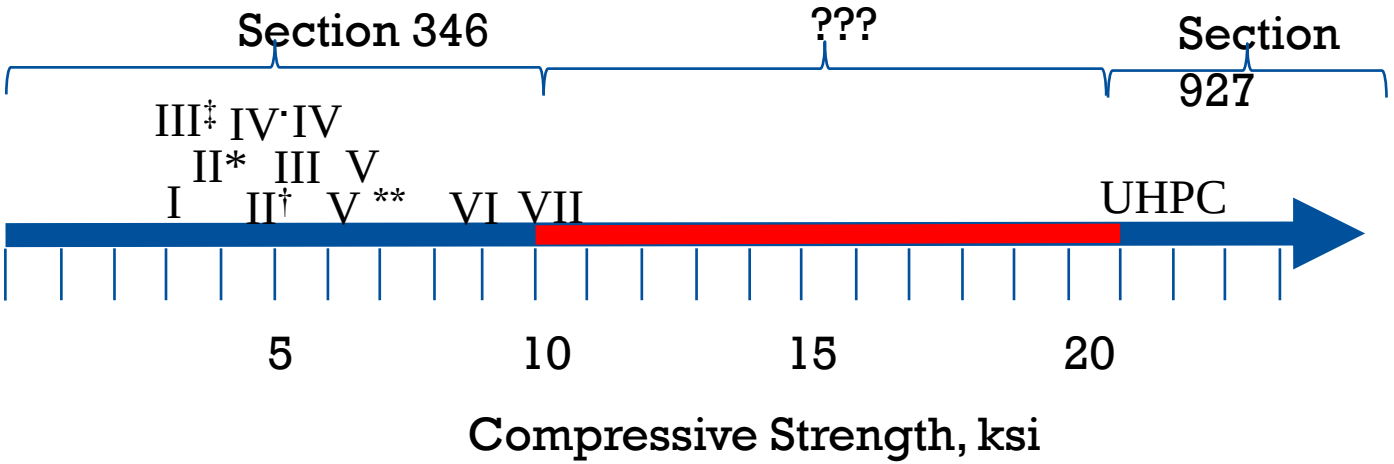
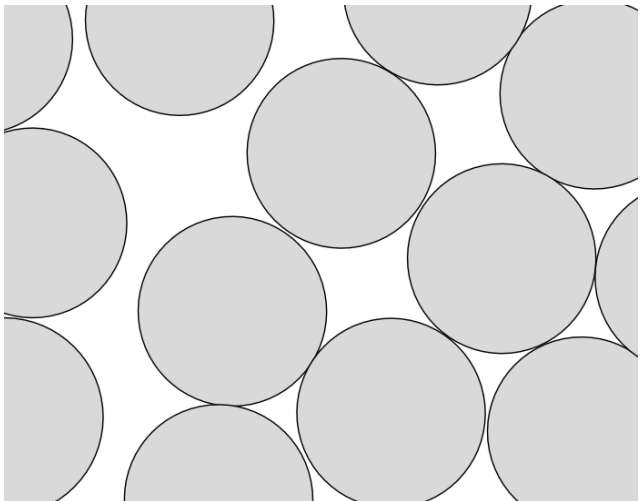
# FDOT Concrete Classes

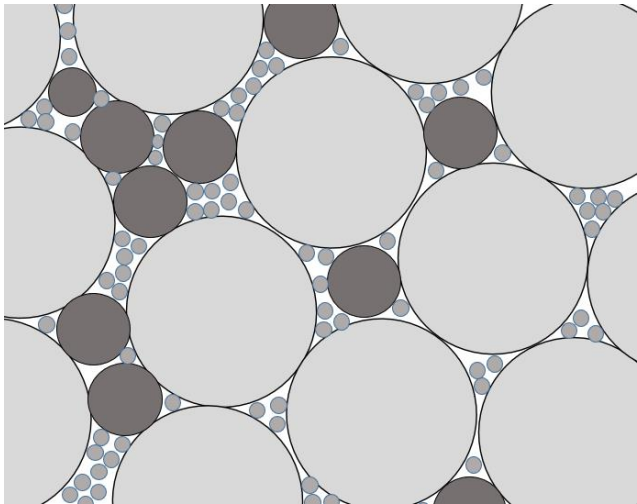



*pavement
†bridge deck
‡Seal
·Drilled Shaft
**Special

# Particle Packing

- Use fine materials to reduce voids between particles.
- Better particle packing reduces water demand and increases strength.

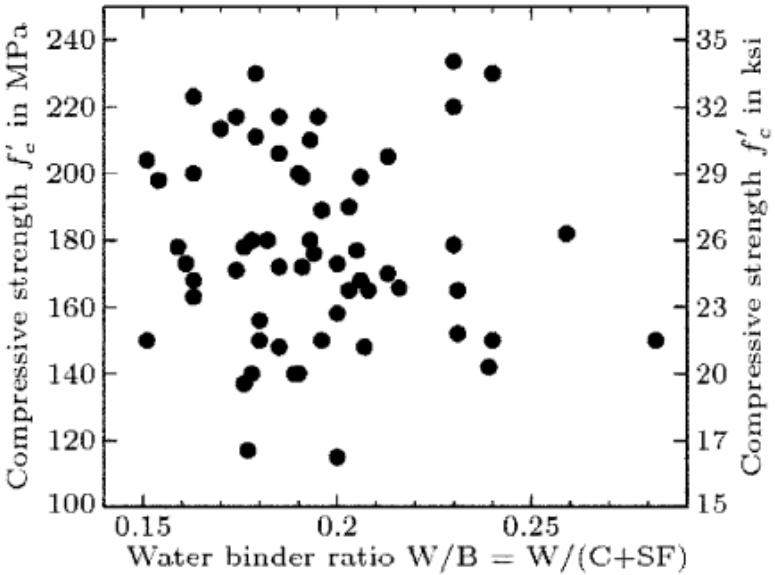




# Mix Design procedure

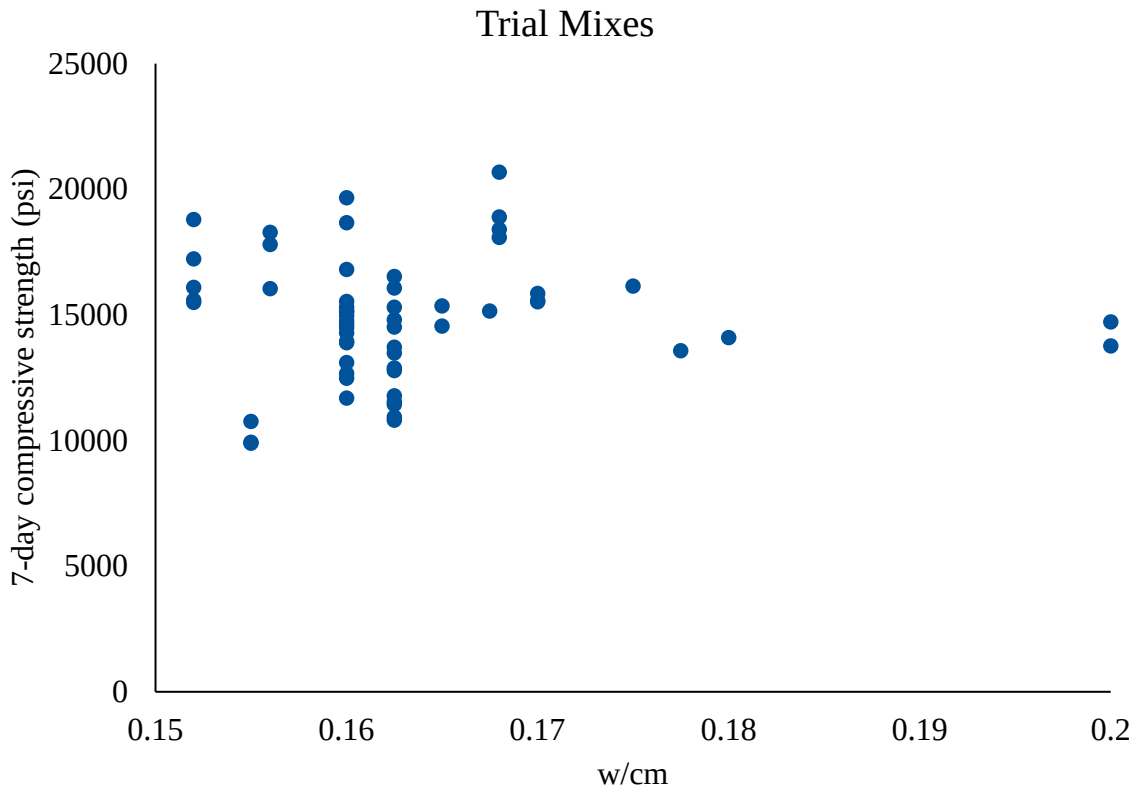
1. Make small batches of concrete to test mix flows
2. Make larger batches of concrete to test 28 day strengths
3. Use mixes with target strengths for research

# Lesson 1: w/cm to strength correlation is low



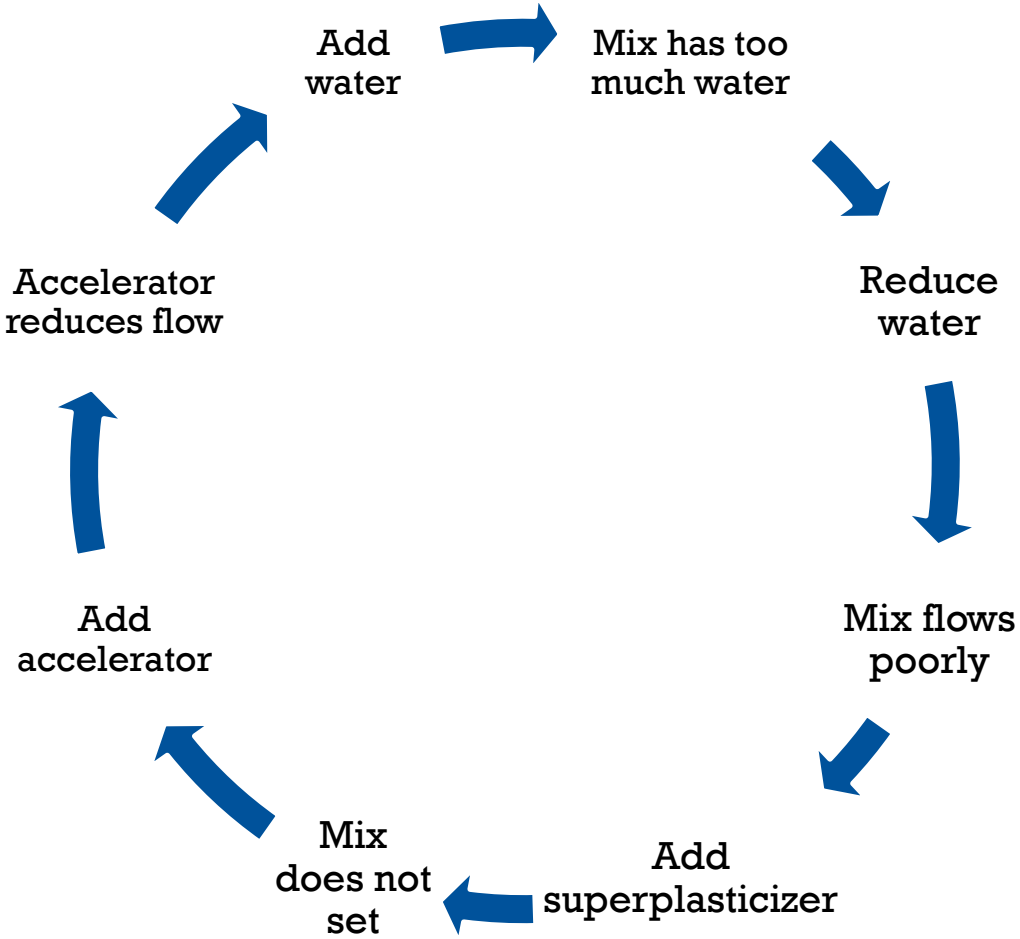

*(a) Influence of W/B*

Wille, K., A. Naaman, and G. Parra-Montesions. (2011). Ultra-High Performance Concrete with Compressive Strength Exceeding 150 Mpa (22 ksi): A Simpler Way. *ACI Materials Journal*, Jan-Feb 2011.


Trial Mixes
25000
20000
15000
10000
5000
0
7-day compressive strength (psi)
0.15
0.16
0.17
0.18
0.19
0.2
w/cm

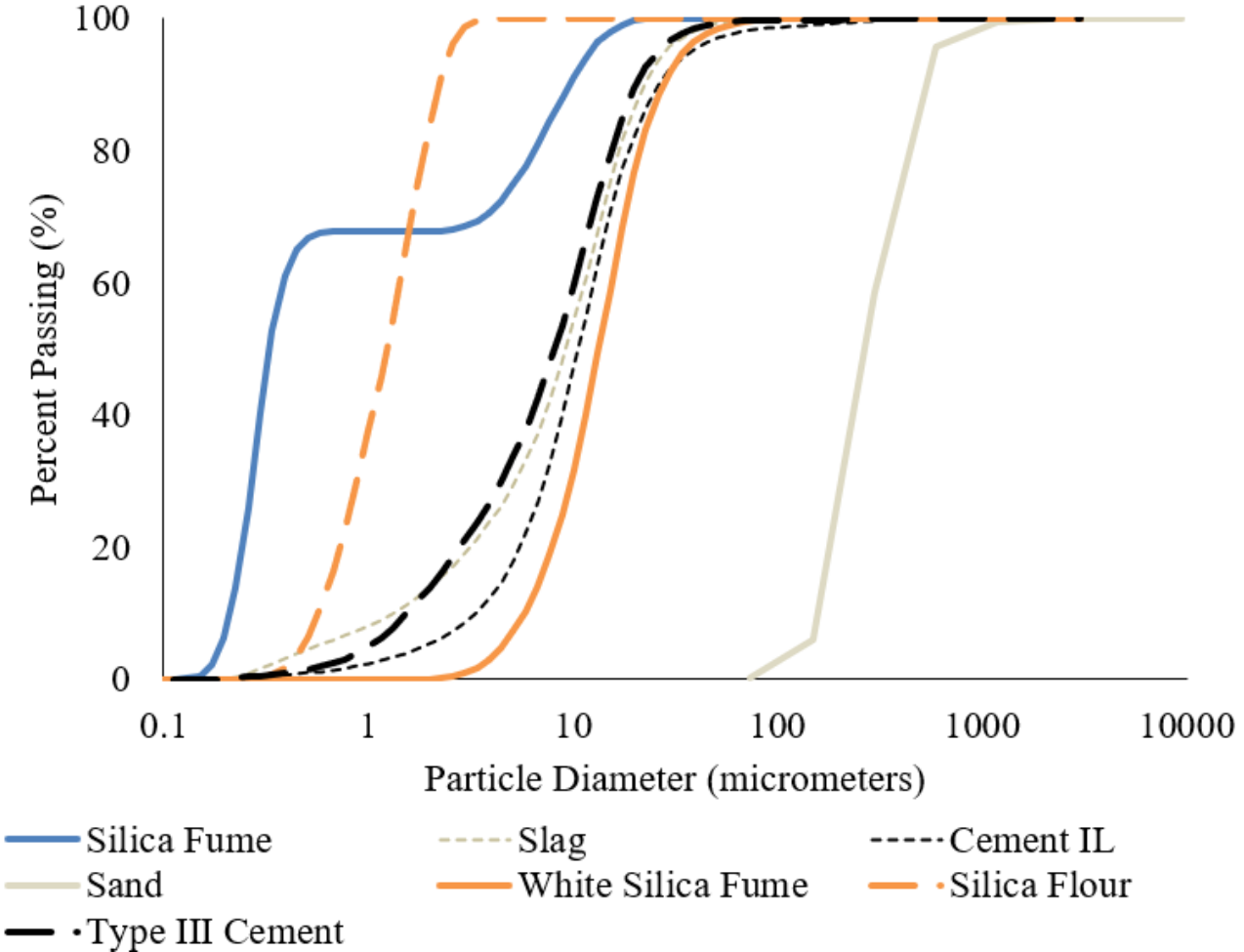
# Problems caused

- Concrete didn’t set at 1 day due to high superplasticizer
- Reluctant to use finer sand or more silica fume


Add water
Mix has too much water
Reduce water
Mix flows poorly
Add superplasticizer
Mix does not set
Add accelerator
Accelerator reduces flow

# Lesson 2: Finer materials increased strength and water demand

- Finer sand gradation
- More silica fume – white silica fume had larger particle size and improved flow
- Ground glass and silica flour (filler materials) improved strength


100
80
60
40
20
0
Percent Passing (%)
0.1
1
10
100
1000
10000
Particle Diameter (micrometers)
Silica Fume
Slag
Cement IL
Sand
White Silica Fume
Silica Flour
Type III Cement

# Lesson 3: Ice replacement improved flow and mix time

- Replaced 75% of water with ice
- Flow increased from 9.1 in. to 9.8 in.
- End temperature decreased 12 degrees F
- Mixing time decreased 25%

# Lesson 4: Mix procedure impacted results

- Flow values varied based on mixer:

6.0 in.

9.6 in.

9.4 in.

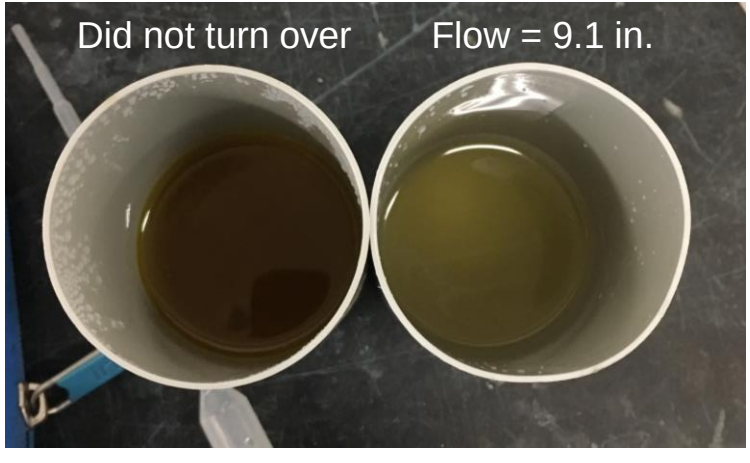
8.4 in.

# Preferred Mix design procedure

1. Make small batches of concrete to test mix flows
2. Make larger batches of concrete to test 28 day strengths
3. Test mixes with target strengths in full-size mixer
4. Use mixes with target strengths for research

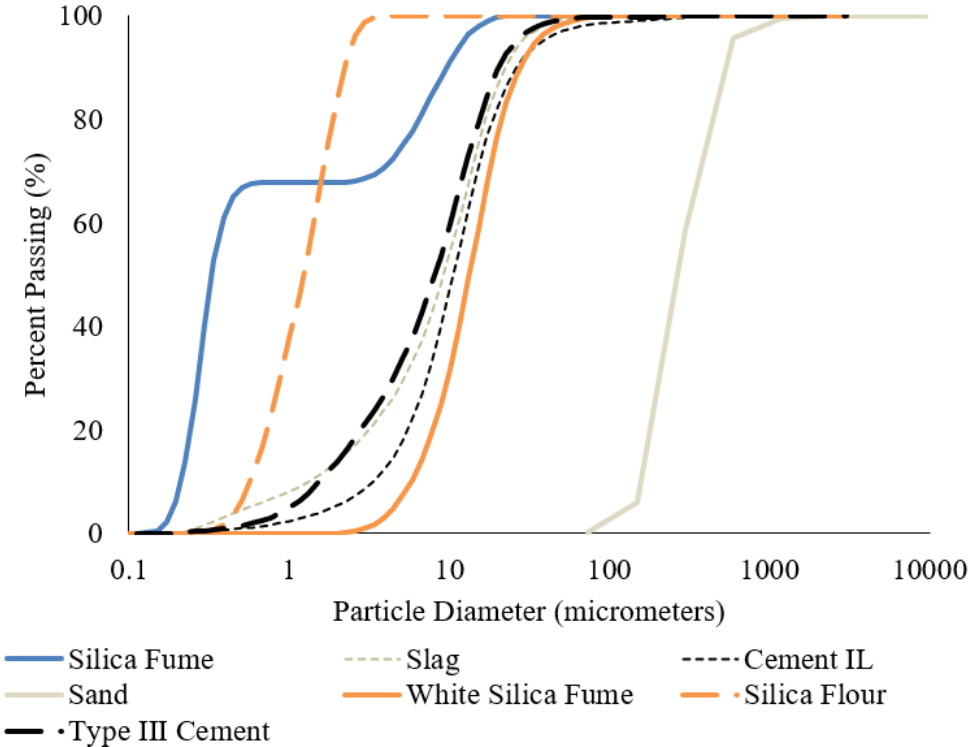
# Lesson 4: Mix procedure impacted results

- Best flow occurred when admixtures were added after water
- Mixing admixtures with mix water decreased flow
- Some admixtures could not be batched out together in advance (photo)



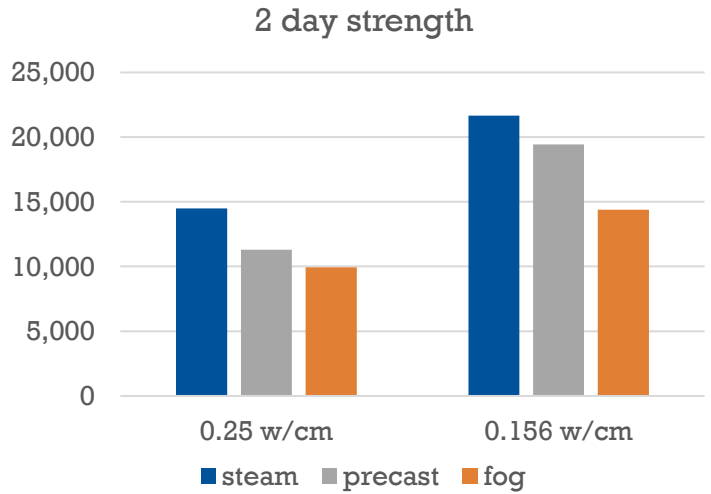
# Lesson 5: Cement type

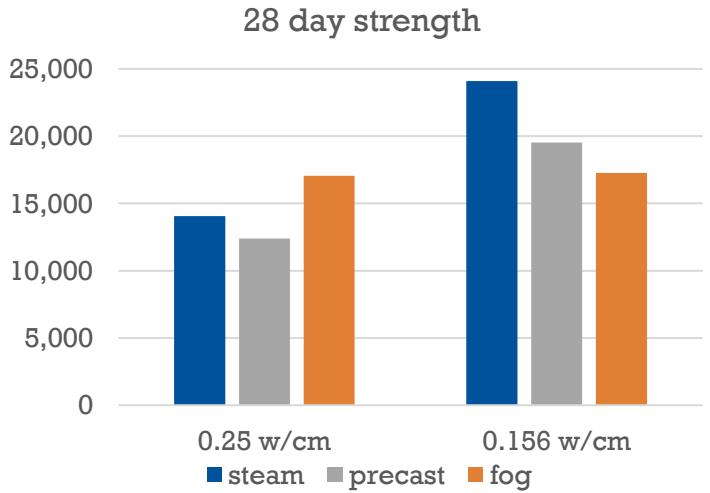
- Type IL cement had trouble reaching strengths above 19ksi
- Type III cement had finer particles and gave higher strength



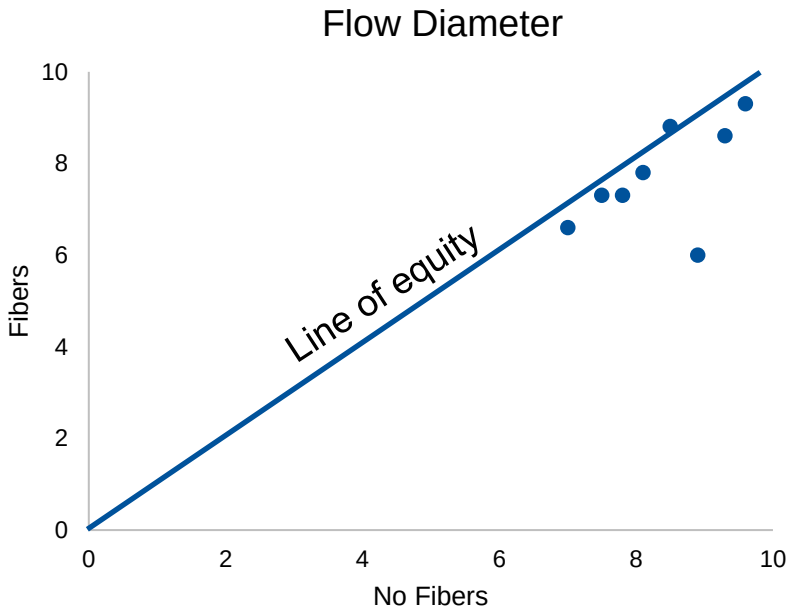
# Lesson 6: Heat treatment

- Heat treatment helped early age strength for all mixes
- Higher w/cm mixes had reduced strength from heat treatment at 28 days



# Lesson 7: Fibers reduced flow



# Thank You

- Florida Department of Transportation
- Taylor RawlinsonJosh Halford, Maria Parra, Max Armstrong, Connor Rice
- Material Donors: Edgar Minerals, Argos USA, Sika Corporation, U.S. Silica, Elkem, CHRYSO

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