Field Device to Measure Viscosity, Density, and Other Slurry Properties in Drilled Shafts

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Presented by: Kevin R. Johnson, MCE, E.I.

USF UNIVERSITY OF SOUTH FLORIDA

Civil & Environmental Engineering

Problem Statement

- Drilled excavation requires slurry that falls within a set of parameters regarding density, viscosity, pH and sand content; typically, each slurry property is tested using a unique, separate test method.
- Slurry properties are measured every 2 hours for the first 8 hours and 4 hours thereafter.
- A downhole device to measure all properties real time may improve data quality and expedite construction.

Research Approach

- Task 1 Literature Review
- Task 2 Component Development
- Task 3 Laboratory Trials
- Task 4 Field Testing
- Task 5 Draft Final and Final Report

Research Approach

- Task 1 Literature Review – Current Practices
- Task 2 Component Development
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FDOT Standard Specifications for Road and Bridge Construction Section 455-15.8

Mineral slurries

Item to be measured	Range of Results at 68°F	Test Method
Density	64 to 73 lb/ft^3 (in fresh water environment) 66 to 75 lb/ft^3 (in salt water environment)	Mud density balance: FM 8-RP13B-1
Viscosity	30 to 50 seconds	Marsh Cone Method: FM 8-RP13B-2
pH	8 to 11	Electric pH meter or pH indicator paper strips: FM 8-RP13B-4
Sand Content	4% or less	FM 8-RP13B-3

Polymer slurries

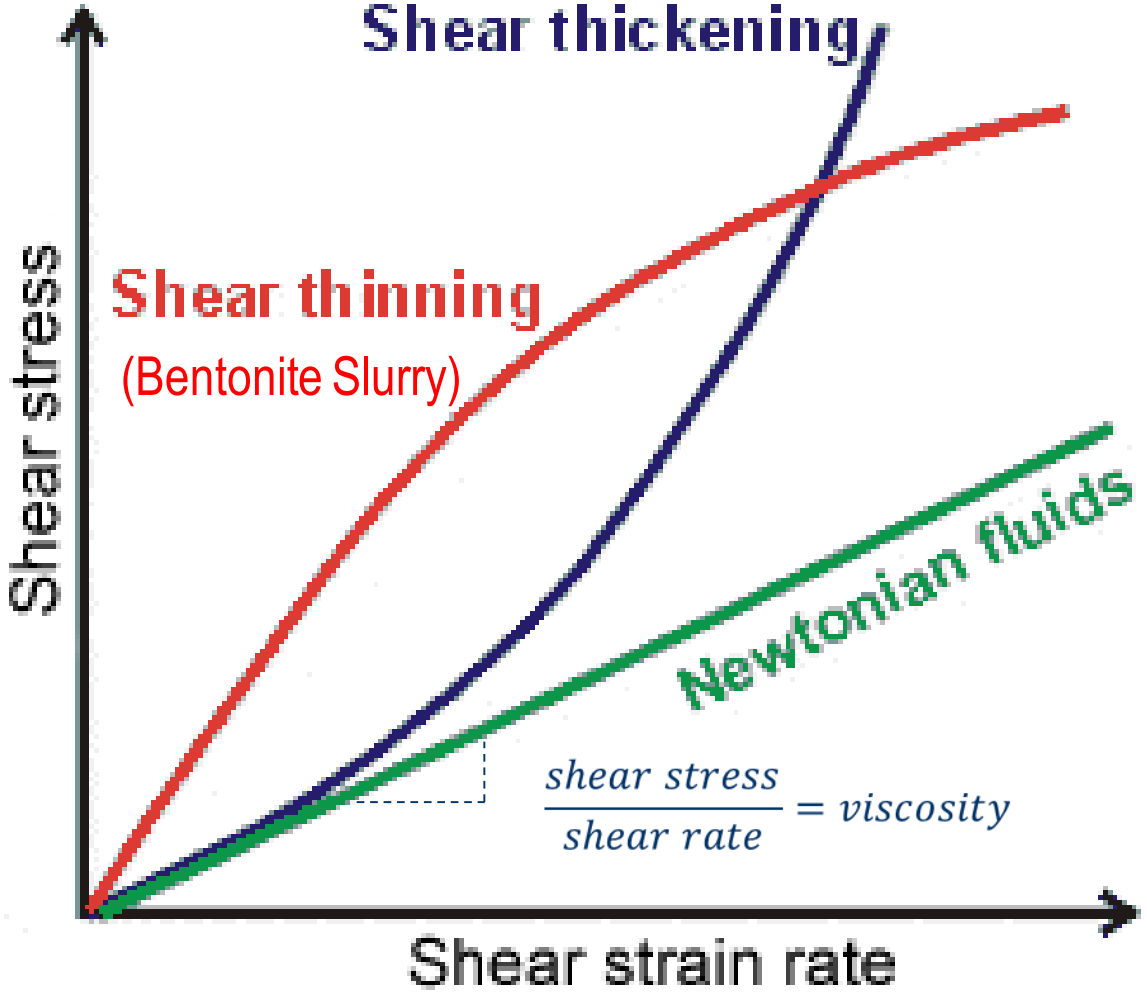
Mixed Polymer Slurry Properties		
Item to be measured	Range of Results at 68°F	Test Method
Density	62 to 64 lb/ft^3 (fresh water) 64 to 66 lb/ft^3 (salt water)	Mud density balance: FM 8-RP13B-1
Viscosity	Range Published By The Manufacturer for Materials Excavated	Marsh Cone Method: FM 8-RP13B-2
pH	Range Published By The Manufacturer for Materials Excavated	Electric pH meter or pH indicator paper strips: FM 8-RP13B-4
Sand Content	0.5% or less	FM 8-RP13B-3

Density

Standard mud balance

Viscosity

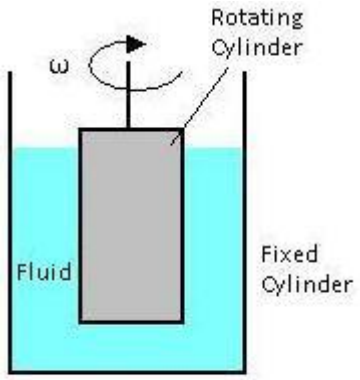
Newtonian vs. Non-Newtonian Fluids



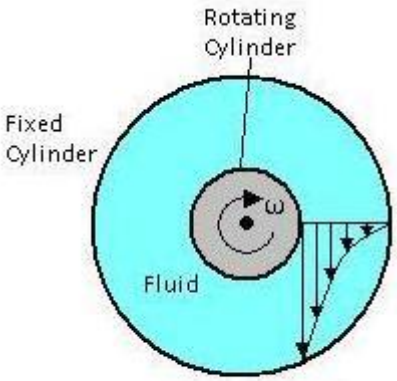
Viscosity
Viscometer Measurements

Newtonian fluids
- -Viscosity

Shear-thinning fluids
- -Apparent viscosity
- -Gel strength
- -Yield point



Side view



View from above

Viscosity
Marsh Funnel Measurements

- Time required for 950mL of fluid to flow from the orifice of a standardized funnel.
- Reported units is seconds

pH

Litmus paper or digital pH meter

Sand Content

Sand content is obtained by filling the measuring cylinder with drilling mud and then washing out the slurry through a #200 sieve screen, leaving behind the sediments.

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Measuring Viscosity
Shear Stress v. Shear Rate

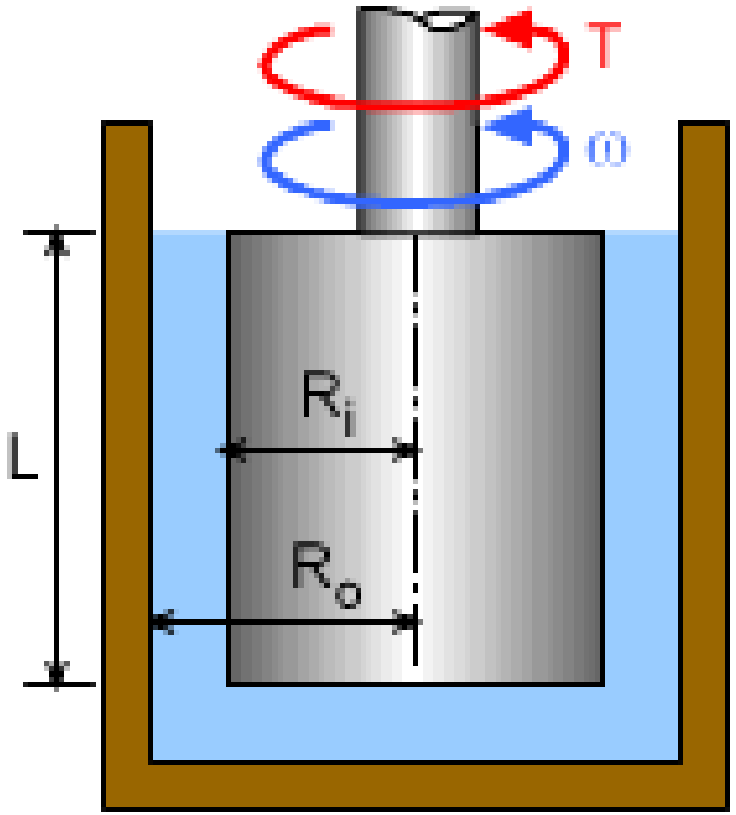
Torque v. Rotation Rate

Examples

Bob & Cup

Cone & Disc

Parallel Plates



Measuring Viscosity
Shear Stress v. Shear Rate

Pressure v. Flow Rate

<u>Examples</u>

Marsh Funnel
Efflux Cup
Capillary Viscometer
Float Viscometer
Variable Area Viscometer

Measuring Viscosity
Shear Stress v. Shear Rate

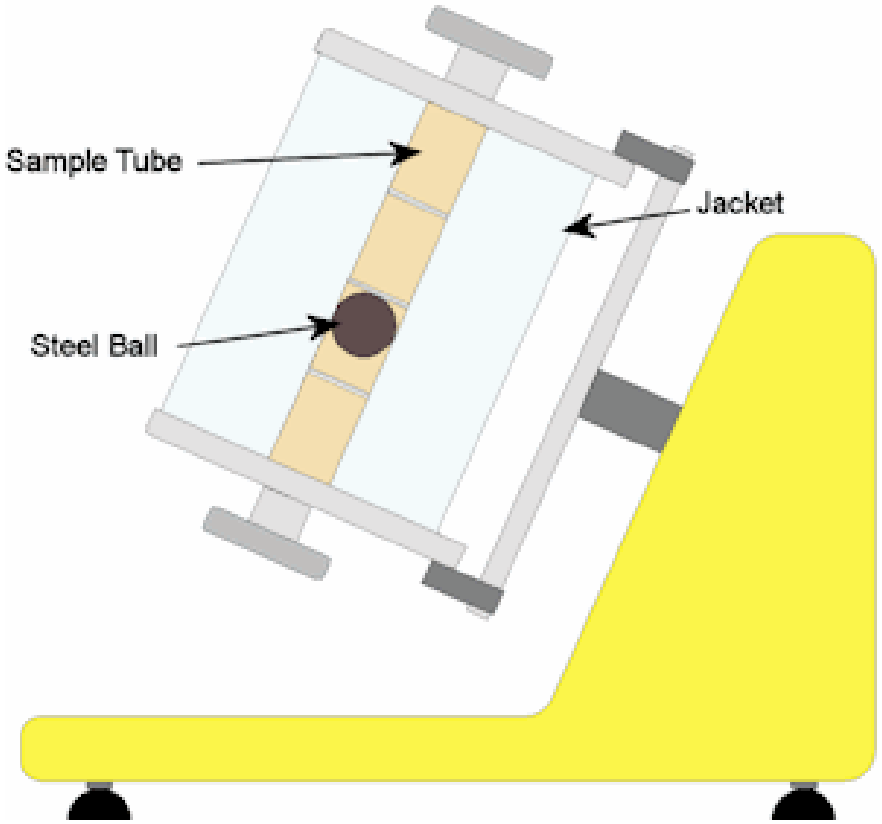
Force v. Velocity

Examples

Falling Ball

Falling Piston

Rolling Ball



Measuring Viscosity
Shear Stress v. Shear Rate

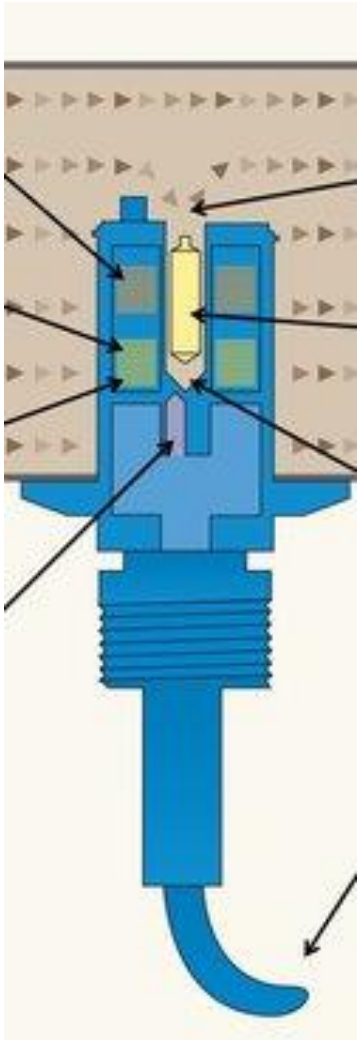
Vibration v. Damping

Examples

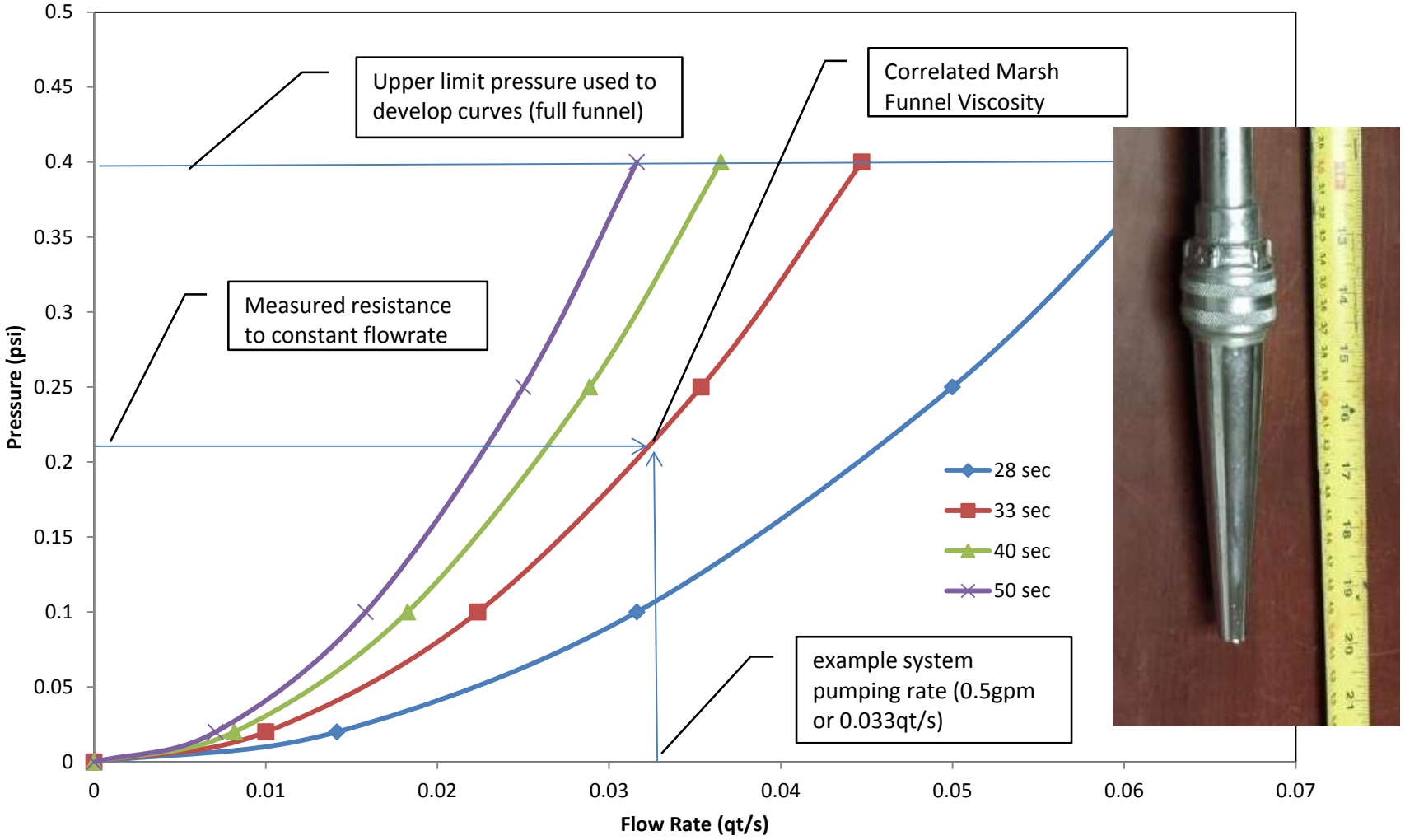
Vibrating Reed

Oscillating Piston

Oscillating Disc



Pressure vs. Flow Rate



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OTS Components

www.omega.com

Pressure Transducer

•Pressure transducers report pressure by converting strain from a strain gauge into pressure.

•Can be used for P v. Q viscosity as well determining density from hydrostatic pressure

www.omega.com

Submersible pH electrode

OTS Components

www.coleparmer.com

Ultrasonic Flow Meter

- Ultrasonic flow meters work by relating the change in frequency of a reflected sound wave to the rate of flow.

- Designed for water containing particulate matter.

www.omega.com

Variable area flow meter

- Measures force exerted on spring as fluid flow around a piston or disc.

- Measured force is a function of flow rate and viscosity.

OTS Components

www.omega.com

Electromagnetic Flow Meter

•An electromagnetic flow meter measures the voltage generated by the flow of a conductive fluid through a magnetic field.

•This type of flow meter may be used to gain insight on sand content due to the reduction of electrical conductivity of a slurry specimen with sand.

www.hw-well.com/Portable%20Sandmaster.htm

Sand Concentration Measurement Device

•Current sand concentration testing devices use flow rate, a laser and particle counting software to compute sand concentration.

Questions?