Plugging and Abandonment of CSG Wells with Bentonite

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Project Motivation and Objective

Sodium bentonite is an alternative to cement that can be used in plugging and abandonment (**P&A**) of oil and gas wells.

Bentonite Plug Advantages:

- Natural ability to swell
- Self-healing
- Strength: Ability to hold bottom well pressure

Project Objective: To use the relationship derived from experimental results collected by Mortezapour, 2016 to predict the dislodgement pressure of a plug subjected to a crossflow pressure of 75 psi.

Crossflow Experiment

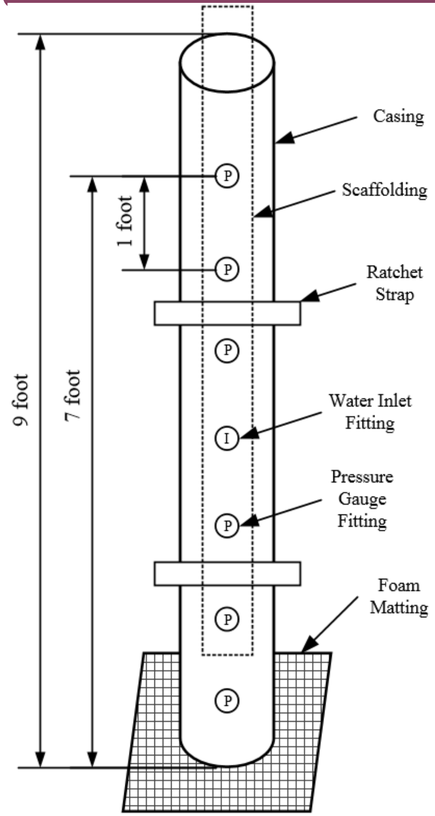


Figure taken from (Wilson, 2016)
Schematic and Photographs of the Washout Apparatus

Purpose: To investigate if applying a cross flow pressure to a bentonite plug causes wash out.

Experimental Set- up

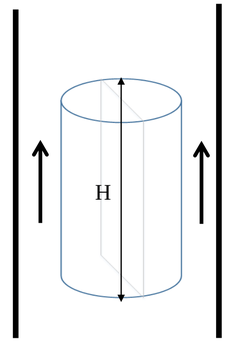
- Start of hydration date: 7th June 2016
- Applied pressure at the water inlet is 75 psi. Using 0.433 psi/ft, the hydrostatic pressure gradient for freshwater, it is calculated that the field environment pressure which a 5ft column of bentonite plug would be subjected to is approximately 2.2 psi.

Result: Trials indicate failure by visually observing pressure readings, plug movement and fluidisation.

Experiment Recommendation:
The crossflow pressure applied should be representative of the field environment. The pressure for the cross should be reduced to 3 – 6 psi for the 5ft column of bentonite plugs.

Hydrated Bentonite Plug Failure Modes

By analysing dislodgement pressures and building upon the mathematical models derived by Towler and Ehlers (1994), the failure mode of a plug can be better understood.



Frictional failure:
Frictional failure occurs when the plug loses grip on the wall of the well-bore.

- The internal swelling pressure of the bentonite plug is considered to contribute to plug strength as per:

$$P = K_b\left(\frac{\rho_b g H^2}{D} + \frac{\rho_w g L_w H}{D}\right) + \rho_b g H + \rho_w g L_w + \in e^{K\rho_b}$$

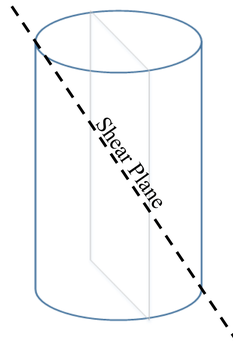
- A frictional factor ($\boldsymbol{K_b}$) denotes plug resistance

Shear failure:
Shear failure occurs when the plug cracks internally.

- Shear failure is expressed as:

$$P = \frac{4H\tau_s}{\pi D} + \rho_b g H + \rho_w g L_w$$

- ($\boldsymbol{\tau_s}$) signifies shear strength



K_b and τ_s Parameters

Both the friction factor (K_b) and shear strength (τ_s) parameters are dependent on the:

- Moisture content of raw bentonite
- Hydrated plug density
- Salinity of the hydrating medium

Plug Features

Plug composition:
98% Bentonite
2% Water

Bullet shape: To position the plug without prematurely blocking the well

Bullet shaped 3.5” plug