



MODERNIZATION OF WELLS/EQUIPMENT AND IMPROVEMENT OF TECHNOLOGY FOR PREPARING CEMENT SLURRIES

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Abstract. Cementing gas wells in methane formations by using conventional lightweight cement mortars and/or foam cement significantly increases the likelihood of maintaining circulation during cement placement. Foam cement for gas wells and properties of cementing was studied. The test results obtained are shown in graph form.

Keywords: Coal bed methane (CBM), foam cement, compressive strength, low density, additives, filter press.

Introduction. Cementing CBM wells usually requires a cementing system that reduces the risk of lost circulation, while providing excellent annular displacement efficiency with the aim of achieving 100% annular fill. When set, the cement should give complete zonal isolation for the life of the well (stimulation, production, and selective workover) while providing lateral pipe support to combat compaction-induced failures. Foamed cement has historically fulfilled these requirements. Foam cement offers many advantages, including the following:

- *Low hydrostatic pressure.* Circulation losses while drilling and completing in CBM fields are common. A reduction of cement density from 1920 to 1440 kg/m³ (16.0 to 12.0 lb/gal) can reduce the hydrostatic pressure in a typical WCSB well by ~5.5 MPa, or 400 psi.
- *Dynamic control of losses.* The thixotropic and expansive nature of foam, together with the structural features of the bubble cells, helps reduce losses to vuggy or fractured formations and helps reduce fluid loss to permeable formations.
- *Strength-to-density ratio.* Foamed-cement slurries can yield higher strengths than low-density slurries extended by adding water only.
- *Mechanical properties of set cement.* The high ductility and bubble structure of foamed cements has been shown

to be beneficial when the cemented annulus is subjected to thermal and mechanical loading. These features of foamed cements can enable internal deformation without cracking.

Research objects and methods. To determine Foam Cement with additives compressive strength, fluid loss, porosity, and permeability variate with foam cement density and cement composition.

Experience Part. Foamed cement has numerous uses in Oil and Gas industry stretching from mud displacement to prevention of lost circulation in oil and gas Industry. Due to its obvious advantages over conventional cement, it is widely used in Oil and gas Industry. The scope of study firstly involves the literature review on the identification of the reservoir properties

analysis. From the information obtained, the experiment parameters such as reservoir pressure and temperature and cement properties to be tested will be determined. This is followed by the preparation of the cement slurry for foamed cement with additives. Foam generator will be used to generate foam for the foamed slurry. Curing under reservoir conditions will be conducted using the pressurized curing chamber and cured for 24 hours in water bath. The compressive strength tester is used for the compressive strength determination, poroperm for porosity and permeability, fluid loss filtration tester for fluid loss. A total of 50-80 cubes are required for the experiment for compressive strength test, and sampling.

1. The Class G cement and fresh water is weighted using the electronic balance.
2. Cement density is adjusted by varying foam quantity introduced in cement while keeping water cement ratio constant at 1:2 for both additives i.e. microsilica or BJ Ultra whether used separately or used together with each other. The content of both additives is kept constant at 35% of weight of cement (WOC)
3. The appropriate amount of water and additive (liquid form i.e. ULTRABJ) is poured into the mixer container.
4. The power is turn to ON in FIXED position. The START button is pushed to start the motor and begin timer from 50 seconds. Cement and additive (powder form i.e. MICROSILICA) is slowly added to the water during the first 15 seconds at low speed at MIX 1. (4000rpm)
5. The cover is placed on the container after cement has been added. When timer reaches 35 seconds, MIX 2 button is pressed to mix at high speed. (12000rpm).
6. Water and foam agent of ratio 30:1 is added into the Portafoam.
7. Pressure is allowed to reach 4MPa before white foam is allowed to be generated through the outlet lance. The foam is mixed with the base slurry thoroughly and ready to be tested.

The data analysis section consists of 3 main testing methods to evaluate the variation in properties of foamed cement depending on type of additives used. The Compressive Strength Tester will be used to determine the compressive strength, the OFITE HPHT Filtration Press to determine fluid loss and finally the Poroperm to determine Permeability and porosity. Several foamed cement cubes were produced with densities ranging from 9 ppg to 12 ppg. A base slurry of density 15.6 ppg as per API standards were produced first and then density was altered by introducing foam into cement slurry. The foam quality introduced in the cement ranged from 18% to 38% which is optimum foam quality. For each density, first; microsilica and BJ Ultra additives were used separately to examine individual effect of these additives on cement properties and then, both additives i.e. microsilica and BJ Ultra were used together to examine the collective effective on cement properties. The additive percentage introduced in cement was kept constant at 35% BWOC for each additive.

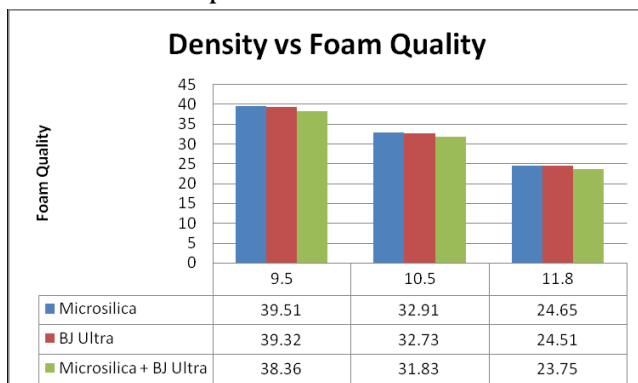


Figure 1. Effect of Foam Quality on Base Slurry.

The final density of the cement is dependent on the amount of the foam introduced in the neat slurry. As can be seen from Figure 24, the density of cement reduces as higher foam quality is introduced in the slurry. A foam quality of around 24 reduces the density of cement from 15.6 ppg to 11.8 ppg and when foam quality is increased to 38, the cement density is reduced from 15.6 ppg to 9.5 ppg. As more gas bubbles are injected into the slurry, the volume of slurry expands. This expansion of slurry affects the physical properties of the cement such as weight, permeability, porosity, compressive strength (strength-to-density ratio), fluid loss and setting time because the particle-particle interactions will be diminished or diluted by the presence of gas throughout the slurry.

The preparation of cement slurries varies from that of solid/liquid mixtures due to the reactive nature of cement. This explains why the cement slurry produced will have lesser volume compared to the volume of water and cement used.

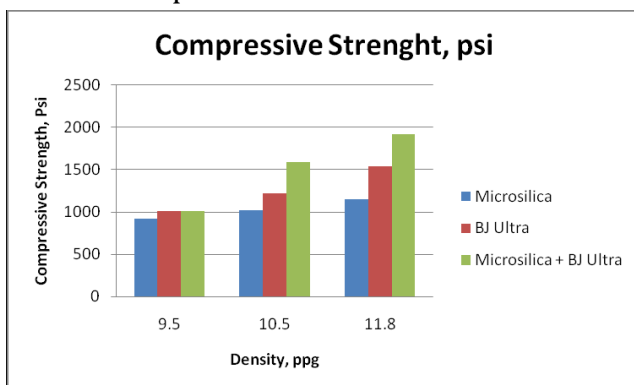


Figure 2. Effect of Additives on Compressive Strength of Foamed Cement.

From Figure 25, it is observed that microsilica yields the minimum compressive strength when used alone as additive in foamed cement for all the three (3) different densities. On the other hand, BJ Ultra which is a multipurpose product but commonly used for controlling fluid loss acts more efficiently than microsilica when used as additive in foamed cement for increasing the compressive strength. It is observed that difference between compressive strength yielded by microsilica and BJ Ultra when used separately increases as the density of foamed cement is increased with BJ Ultra becoming more effective compared to the microsilica.

The maximum compressive strength is obtained when both microsilica and BJ Ultra are used together. The combination of both additives for density of 11.8 ppg gives a compressive strength of 1920 Psi which is approximately 55% more than the compressive strength given by foamed cement without additives for the same density and slightly lower than compressive strength of neat cement without additives.

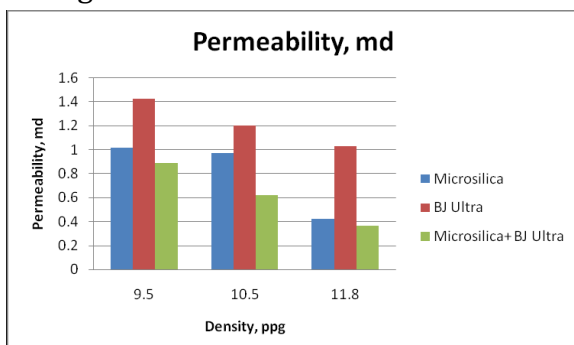


Figure 3. Decrease in Permeability of Foamed Cement Cubes with Increasing Density.



From Figure 26, it is observed that permeability reduces with increasing density. This phenomenon is associated with the fact that higher densities required lesser foam quality and hence the amount of nitrogen gas inside the cube is reduced resulting into reduction of pores in cement cube.

The explanation for the sharp increase of permeability with the decrease of foamed cement density can be seen in this manner. Imagine having a 100% compacted cube of cement with zero porosity, if we are to inject only 10 bubble size pores, the possibility of any of that pore to interconnect with each other is very low. Therefore even after 10 pores are injected, the permeability might not be changed. But if we are to inject 10,000 bubble size pores in that same volume of cement cube, most of the pores will interconnect (side by side), and therefore, as the number of injected pores are increased, the permeability of that cement cube start to have a sharp increase.

Conclusion. In order to optimize the cement properties i.e. maximize compressive strength, reduce fluid loss and reduce permeability and porosity, it is best to use microsilica and BJ Ultra together for the use in field. For all the experiments performed the most desirable results were obtained when both of these additives were used in combination. Although for some experiments when these additives were used separately they gave values exceeding the minimum requirements but they failed to give the satisfactory values for other tests.

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