Effect of Salty Polymer Solution on the Swelling Behavior of Bentonite Clay Characterized using Electrical Resistivity and Sodium Ion Leaching

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Abstract

In this study the expansive behavior of polymer treated bentonite clay was investigated. Properties investigated were the free swell index and plasticity index of bentonite clay. Effectiveness of the salty polymer treatment was also investigated, using exchangeable percentage of sodium in the soil solution as the parameter. It was found that 2.5% of salty polymer solution (0.02M NaCl in 100mL of 2.5% polymer) reduced the PI of bentonite from 630 to 418. Also, the free swell index reduced from 7 to 4 with the salty polymer solution. The electrical resistivity increased and sodium ion concentration decreased with the polymer treatment.

1. Introduction

Swelling clays are a problem in both onshore and offshore during the construction and service life of the infrastructure. Changes in soil water content or solution chemistry of clayey soils induce swelling pressures sufficiently large to fracture and damage structures and roads. Estimated damage is in excess of $7 billion/yr in the US. Problems caused by shales in petroleum activities are not new. At the beginning of the 1950s, many soil mechanics experts were interested in the swelling of clays, which are important for maintaining wellbore stability during drilling, especially in water-sensitive shale and clay formations. The rocks within these types of formations absorb the fluid used in drilling, which causes them and may lead to a wellbore collapse [3]. Two types of swelling may occur in clays. Surface hydration is one type, where water molecules are adsorbed on crystal surfaces. Osmotic swelling is a second type of swelling. Where the concentration of cations between unit layers in a clay mineral is higher than that in the surrounding water, water is osmotically drawn between the unit layers and the c-spacing is increased. Osmotic swelling results in larger overall volume increases than surface hydration, but only a few clays, like sodium montmorillonite, swell in this manner [2]. Inhibitors of swelling act by a chemical mechanism, rather than in a mechanical manner. They change the ionic strength and the transport behavior of the fluids into the clays. Both the cations and the anions are important for the efficiency of the inhibition of swelling of clays [4]. Swelling can be inhibited by the addition of KCl in relatively high amounts. Other swelling inhibitors are both uncharged polymers and polyelectrolytes [1]. This study was focused to investigate the swelling behavior of bentonite clay treated with salty polymer solution.

2. Objective

To investigate the effectiveness of salty polymer solution using electrical resistivity and sodium ion leaching and establish the optimum percentages of additives to be used.

3. Materials and Methods

Commercial Bentonite with a PI 630 was chosen to inhibit swelling index. The monomer, initiator and a catalyst were used to polymerize the polyamide. Also, 0.02M NaCl was used as another additive to reduce the swelling index. Atterberg Limit Test according to ASTM D4318 and Free Swell Index according to ASTM D 5890-06 were performed. Oakton CON 6+ handheld conductivity meter with probe was used to monitor the conductivity and HANNA ISE NaCl meter for Na^+ ion concentration.

4. Results and Discussion

Addition of 2.5% polymer solution reduced the PI of bentonite from 630 to 440 and 0.02M NaCl in 100mL of 2.5% polymer solution reduced the PI to 418 (Fig 1). Also, the Free Swell Index reduced from 7 to 4.5 using 2.5% polymer solution and it reduced to 4 with 0.02M NaCl in 100mL of 2.5% polymer solution (Fig 1). Resistivity of the bentonite-water suspension increased after the treatment and the concentration of exchangeable sodium reduced, indicating restriction of ion flow which explains the reduction in swelling index (Fig 2).

Type of addition	Swelling Index	Reduction %	Plasticity Index	Reduction %
Untreated bentonite clay	7	-	630	-
2.5% polymer solution	4.5	35.7	440	30.15
0.02M NaCl in 100 Ml of 2.5% polymer solution	4	42.8	418	33.8

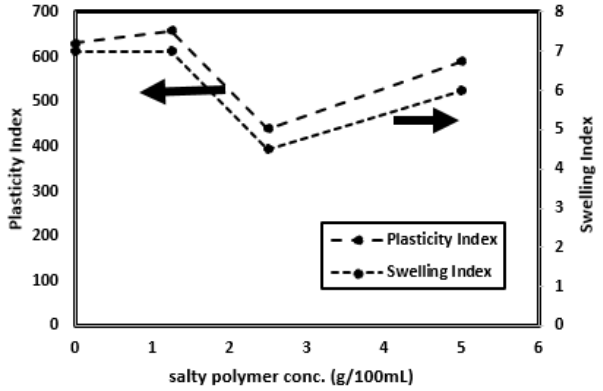

Fig 1: Variation of PI and swelling index of bentonite clay

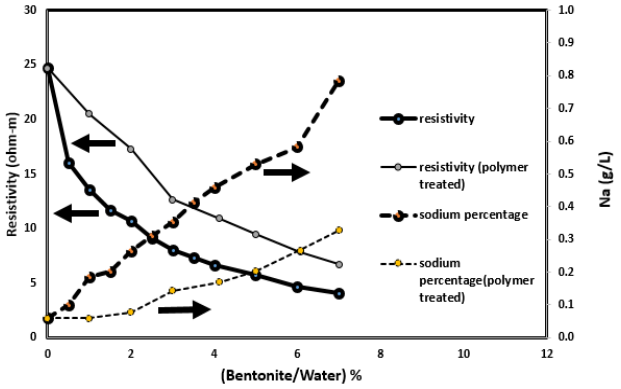

Fig 2: Change in resistivity and Na^+ ion leaching with bentonite to water ratio

5. Conclusions

1. 2.5% polymer solution reduced the plasticity and swelling indices.
2. Electrical Resistivity was found to increase after the treatment indicating reduction of ion flow. From reduction of Na exchange percentage we can conclude that polymer treatment has reduced the leachable Na^+ ion in the clay.

6. Acknowledgement

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7. References

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