

## 博士論文の要旨

専攻名 Science and Advance Technology

氏名(本籍) NUTTHACHAI PRONGMANEE  
(THAILAND)博士論文題名 Polymerized Bentonites and  
Their Applications in Geosynthetic Clay Liner  
(重合したベントナイト及びジオシンセティック  
スクレイライナーへの応用)

## 要旨

To increase the swell potential of bentonite in high cation concentration solutions and corrosive solutions, effectiveness of polymerizing bentonites was investigated experimentally. Firstly, the optimum conditions for producing polymerized bentonite (PB) were investigated systematically by varying initiator type, pH value, monomer to initiator ratio etc. Free swelling index (FSI) of the produced PB is used as an index to judge the optimum conditions. The proposed optimum conditions are using the free radical polymerization method, with sodium acrylate as the monomer and KPS as the initiator, pH of 7, the initiator ( $I$ ) to monomer ( $M$ ) ratio,  $I/M$ , of 0.2 and the monomer content of 10%.

The result of X-ray diffraction (XRD) pattern of the PB indicates that polymerizing the sodium polyacrylate onto the bentonite particles does not modify the interlayer spacing of the bentonite. Additionally, scanning electron microscope (SEM) image of the PB showed rounder edges compared with that of the untreated bentonite (UB). It is considered that the polymer coated onto the bentonite particles.

The properties of the PB in aggressive chemical solutions were investigated subsequently through a series of consolidation test, permeability ( $k$ ) test, and swelling pressure test by considering effect of cation concentration, valence of cation and pH levels of the solutions. The test results indicated that the PB had higher compression index ( $C_c$ ), swelling index ( $C_s$ ), and lower coefficient of consolidation ( $c_v$ ) in the aggressive solutions compared with that of the UB. Under the identical void ratio ( $e$ ), the PB had much lower  $k$  value than that of the UB. The results of swelling pressure tests, under a comparable initial dry density, PB had higher swelling

pressure than that of the UB for all tested liquids. The higher swelling potential of the PB in cationic solutions is that a negatively charged functional group ( $\text{COO}^-$ ) of the sodium polyacrylate may attract to some cations in the solutions before it tries to enter into the interlayer of the bentonite particles. It is suggested that the PB can be used as a core material for a barrier system, such as geosynthetic clay liner (GCL) to be used for aggressive chemical solutions.

Then, the self-healing capacity of the GCL using the PB as core material (PB-GCL) have been investigated experimentally through a series of small scale and large scale leakage rate tests. The results of small scale leakage rate test show that the PB-GCL specimens had higher self-healing capacity than that of the corresponding GCL specimens using the UB (UB-GCL). Especially, when using 0.6 M  $\text{CaCl}_2$  solution, for a 20 mm in diameter damage hole, the UB-GCL specimen gave a zero-healing ratio (healed damage area/total damage area), but the PB-GCL specimen resulted in about 76% healing ratio. The self-healing capacity of the

PB-GCL and the UB-GCL was then investigated by considering of the effect of the pH level through a series of large scale leakage rate test. The test results showed that the PB-GCL resulted in the higher self-healing capacity compared with that of the UB-GCL, and consequently lower permeability of damage hole ( $k_{hole}$ ) in all tested solutions. It is very interesting to note that the PB-GCL had increasing in the barrier performance when interacted with a corrosive alkaline solution (pH =13), i.e. higher swelling potential, lower permeability compared to that in deionized water. The possible reason is that the increasing in  $\text{OH}^-$  concentration increases the repulsive force between the chained anionic polymer, and resulting in increase in swelling capacity. Based on test results in this study, the PB-GCL can be recommended as an effective barrier for containing an aggressive liquid waste.