SETTLING AND SEDIMENTATION BEHAVIOR OF FINE-GRAINED MATERIALS

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The settling phenomena of fine solid particles in liquid are affected by several factors such as initial concentration, material type, and salinity, as well as chemical and ionic characteristics. Depending on those factors, settling and sedimentation behavior can be described as one or combination of the following regimes: clarification, zone settling, and compression (Fitch, 1962, 1966; Holdich and Butt, 1995, 1996). In addition to regular settling and consolidation, a common but not widely recognized phenomenon randomly occurs: the formation of small paths transporting water and solid particles upward. These "channels" facilitate excess pore pressure dissipation from the bottom. Indeed, a channel, which can be visually recognized in many cases, is an important factor that affects settling and sedimentation characteristics as well as flocculation.

In this research, laboratory experiments were performed to examine the settling characteristics and channel formation by comparing the location of interfaces, flocculation, and pore pressure changes for different kaolins. Small settling columns were used for measuring the changes in location of interfaces, and a large settling column was built for measuring the excess pore pressure changes as well as observing the changes taking place within the slurry visually. Three materials, a calcined kaolin and two hydrous kaolins, were tested during the present study. Hydrous kaolin is water washed and air dried kaolin, whereas calcined kaolin is produced by heating ultra-fine natural kaolin to high temperatures over $1000\,^{\circ}C$. They have different particle size distributions, specific gravities, and other physical properties as well as different mineral compositions. They generally have different overall settling characteristics.

As a result, two main different settling behaviors were observed. In calcined kaolin and hydrous kaolin 121S, the degree of flocculation and settling rate was very small with calcined kaolin and hydrous kaolin 121S,. Thus the thickness of the consolidation zone was also small. The overburden pressure seemed to be not enough to generate excess pore pressure. Consequently, finer particles settled so slowly that there was enough time to dissipate the captured water. Therefore, it took significant time to complete settlement and no channel formation was observed.

On the other hand, hydrous kaolin Flat D showed sharp changes in interfaces with higher settling rate. Flocculation was also active. Channels were developed in different locations and with different magnitudes in flocculated suspension zone. It is shown that the flocculation during settling appears to be the prerequisite condition for channel formation in the suspension zone. In the consolidation zone, contacting particles and captured water developed excess pore pressure, and channels were also developed.

The interfaces with non-flocculated materials such as calcined kaolin and hydrous kaolin 121S did not change much in distilled water. However, the effect of salinity in liquid was significant in those materials. NaCl solution enhanced the flocculation so that the upper interface became clear and settling rate increased, and channel formation was observed.

Channels randomly occurred in time and space that it was not possible to develop typical rule of thumb from visual observation. However, significant pressure changes were observed when channels occurred although the pressure drops could not be solely caused by channels. The locations where pressure dropped were on the interface between consolidation and suspension zones. Therefore, channels seemed to work paths for relieving pore pressure that can accelerate the settling and consolidation process.

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