CHAPTER 3

EXPERIMENTATION PROGRAME, APPARATUS AND MATERIALS

3.1 EXPERIMENTATION PROGRAME

A ϕ-10cm×10cm plastic chamber was employed as the main apparatus. Drainage was allowed from the top and bottom platens. Overburden stress was applied by hydraulic pressure on inside plate, controlled by air-regulator. There were two volume change measurement systems in the test. The first set of about 3000cc burettes was connected to the drainage tubes. It was to measure the volume changes during consolidation and flow rate during permeability test. Another set of much smaller burettes was used to apply the lateral water pressure to the sample. A differential-pressure-transducer was used to read the amount of volume change.

Water pressure is applied at the center of the sample through a small circular slot. It is called, herein, starter slot. It is made of two thin circular stainless steel plates, at which their spacing forms a continuous 1-mm wide opening. During compaction, the pipe connecting the starter slot is loosely fixed to the bottom of the chamber to allow vertical movement. It is, then, tightened before the overburden stress is applied and main part of consolidation is completed.

Fig.3.1 shows the general testing procedure adopted for the study. Dry sand and bentonite powder is thoroughly mixed before a certain amount of water being added to the mixture. The composition of the wet mixture is checked from time to time during mixing. Not until a certain level of uniformity is attained, the mixing process is completed. The vertical overburden stress is applied and kept constant during testing. De-aired water is, then, allowed to flow through the sample under pressures in order to attain as high saturation as possible. During this process, the hydraulic conductivity of the sample is checked from time to time. Stabilities of the vertical displacement and hydraulic conductivity are used as two main indicators of the completion of consolidation. It usually takes weeks before the sample being ready for test, depending on its overburden stress, mix proportion and density. During the test, water pressure inside the starter slot is increased, step by step, and flow rates corresponding to each pressure level are recorded.

Applied water pressure rate of hydraulic fracture tests, divided into 2 methods, slow rate test and quick rate test. Pressure rate of slow rate test adjusted by the volume of flow in water, measured from much smaller burette. For low water pressure, more than 24 hours used for 10 kPa increase of water pressure, and at least 3 hours for higher pressure (depend on volume change of supplied water). Quick rate test has controlled by time counter, 10 kPa per 30 seconds of water pressure rate was applied.

Slow Rate Test. Pressure rate of slow rate test adjusted by the volume of flow in water, measured from much smaller burette. For low water pressure, more than 24 hours used for 10 kPa increase of water pressure, and at least 3 hours for higher pressure.

Quick Rate Test. Quick rate test has controlled by time counter, 10 kPa per 30 seconds of water pressure rate was applied.

3.2 APPARATUS

Basic engineering properties test use standard apparatus of soil laboratory, of civil engineering department of Chulalongkorn University. Hydraulic fracture test apparatus was developed for this study. Main apparatus composed of electronic air pump, burette for water measure, and compacted mold. Fig. 3.2 shows the schematic view of main apparatus. Water pressure is applied at the center of the sample through a small circular slot. It is called, herein, starter slot. A schematic view of the starter slot is shown in Fig.3.3. It is made of two thin circular stainless steel plates, at which their spacing forms a continuous 1-mm wide opening. During compaction, the pipe connecting the starter slot is loosely fixed to the bottom of the chamber to allow vertical movement.

A 2 liters water perpex tank, built to sustain high pressure, was used to supply water under pressure. The water in the tank was pressurized using an air compressor. The pressure divided into two systems one for overburden pressure supplied on steel plat in compacted mold over specimens, another is induced water pressure supplied through starter slot. The pressure was increased at a predetermined rate using a pressure regulator.

As described above, main apparatus has developed, water pressure controlled by regulator. Step of hydraulic fracture test by using developed apparatus (See photos in Appendix B.) has list as following;

1. Perpex mold has prepared, check of all system such as; water flow out from starter slot, connection of pipe, before installed starter slot at the middle of lower plate.
2. Dry mix of sand bentonite on 2 minutes and then added water and mixed for 3 minutes was prepared. Mixture was compacted in perpex mold, by divided into 3 layers, and used standard compaction hammer of 25 bowls per layer to compact.
3. After compacted sample has fixed and sealed in the perpex mold, dial gauge for vertical measurement was installed.
4. Overburden water pressure has applied on the inner steel cap as design suddenly (Over burden pressure = 100kPa, 200kPa, 300kPa). Water pressure was controlled by air regulator, and gave constant pressure. Vertical movement was recorded, at least 24 hours until vertical displacement rate is very low or not changes.
5. Hydraulic conductivity was tested, by applied water in the pipe with connected with the inner plate, flow in water with time was recorded. More than 12 hours of this test process used to observed constant flow in rate.
6. The overburden pressure and vertical movement always recorded during hydraulic conductivity and hydraulic fracture test. For hydraulic fracture test water pressure was applied in starter slot, flow in water was recorded. Depended on type of rate test, increased of water pressure was controlling by air regulator.
7. Quick flow in of water level was observed when the fracture occurred in sample, then flow out water from upper or lower or both was seen. Hydraulic conductivity was tested again to compare with initial values.
8. Fracture of sample was sketch, water content and dry unit weight was determined. The data test records were calculated.

3.3 MATERIALS

3.3.1 Sand

This study use Singh River sand. Fig.3.4 shows the grain size distribution of the sand used in the present study. Its average diameter, D_{50}, is about 0.6 mm, with the coefficient of uniformity, U_c, of 3.95. Note that its natural fine content (smaller than 75 μm) was excluded before mixing with bentonite powder. Table 3.1 shows the physical properties of this material.

3.3.2 Bentonite

Bentonite used in this studied is "MAC-GEL" which product by THAI NIPPON CHEMICAL INDUSTRY CO. LTD. This bentonite is sodium bentonite, and it is product of Thailand from Rayong Province. Main component is montmorillonite, and the properties following the standard of API SPEC 13A. The liquid limit (LL) and plasticity index (PI) of this bentonite used in this investigation are typical of values reported in the manual. The Chemical and Physical properties show in Table 3.2 and 3.3, respectively.

Most bentonite are either sodium or calcium bentinite, and are characterized by the type of external cation (i.e., calcium or sodium) that is adsorbed onto the surface of the clay particle during mineral formation, or, for treated bentonites, during processing of the bentonite. Sodium bentonite is used more extensively than calcium bentonite because of its superior swelling capacity and its very low hydraulic conductivity to water. Although calcium bentonite has a smaller swelling capacity and a higher hydraulic conductivity to water than sodium bentonite, some researchers have suggested that calcium bentonite may be more stable than sodium bentonite when exposed to chemical constituents in permeating fluids. Na bentonite is the most apply bentonite, in this study used Na bentonite, and the chemical property was neglected.

3.3.1 Sand-Bentonite Mixtures

Air-dry bentonite was mixed with dry sieved sand by electronic mixture. Fig.3.5 shows electronic mixture which can control speed of mixing. Tap water was added to the sand-bentonite mixtures to obtain the desired water content. The sand-bentonite mixture was compacted per ASTM D698 (i.e., standard Proctor compaction test). Specimen moisture contents were typically 15 – 18% (i.e., 1-4% wet of optimum moisture content), and dry unit weights were 14 – 16 kN/m^3. Hydraulic conductivity tests and hydraulic fracture tests were performed on the compacted specimens in the compaction mold.

For most tests, the specimens were permeated with tap water, and, after the measured hydraulic conductivity stabilized, the induced hydraulic fracture water pressure was supplied. The duration of testing was two to four weeks.