CHAPTER III

EXPERIMENTAL INVESTIGATION

3.1 Materials

3.1.1 Soil

The investigation outlined herein is limited to the weathered or soft clay at Nong Ngoo Hao. The existing ground elevation at the site is about 1.0 m. above the Mean Sea Level. This area is subjected to the annual flood during September to December, and in the dry season the ground water level exists at a depth of about 1.0 m. below the ground surface. The samples were taken at a depth of 1.50 m. to 2.00 m. below the existing ground surface. The clay sample had the properties as shown in Table 1.

3.1.2 Stabilizers

3.1.2.1 Cement - Type I Portland cement (elephant brand) produced by the Siam Cement Company was used throughout the tests.

The chemical composition of cement :-

Chemical composition	% by weight
Silicon Dioxide (SiO_2)	21.63
Aluminium Oxide (Al_2O_3)	5.09

Ferric Oxide (Fe_2O_3)	2.92
Magnesium Oxide (MgO)	0.91
Sulphur Trioxide (SO_3)	1.68
Loss of ignition	0.82
Insoluble residue	0.11
Tricalcium Silicate ($3\ CaO.SiO_2$)	58.0
Tricalcium Aluminate ($3\ CaO.Al_2O_3$)	8.6

*Data based on average product supplied by The Siam Cement Company, Bangkok, Thailand.

3.1.2.2 Lime - A locally available commercial product, high calcium hydrated lime $Ca(OH)_2$ was used in this study.

3.1.3 Water

Distilled water was used throughout the study in all mixtures of soil and stabilizers.

3.2 Sample Preparation and Testing

3.2.1 Preparation of Natural Soil Samples

Since the natural moisture content of Nong Ngoo Hao clay was very high, hence for easy handling, the soil samples were air-dried for several days. The air-dried samples were pulverized with a rubber hammer to breakdown the clay lumps. Some of the samples were sieved through a U.S. sieve no. 40 for Atterberg test, a U.S. sieve no. 10 for unconfined compression test, a U.S. sieve no. 4 for durability test and a U.S. sieve no. 3/4 for C.B.R. test.

sieved samples were then stored in the plastic bags. The moisture contents of the samples were determined before testing.

Table 1 - General Properties of the Soil

Textural Composition :	
Sand, 2.000 - 0.074 m.m., %	7
Silt, 0.074 - 0.005 m.m., %	43
Clay, $<$ 0.005 m.m., %	50
Physical Properties :	
Natural Moisture Content, %	97.31
Liquid Limit[1], %	59.50
Plastic Limit[1], %	14.36
Plasticity Index, %	45.14
Specific Gravity[2]	2.73
Engineering Properties :	
Optimum Moisture Content[3], %	28.20
Maximum Dry Density[3], gm/cm^3	1.448
Unconfined Compressive Strength, ksc.	3.95
Classifications :	
Unified	CH
AASHO	A-7-6
Chemical Properties :	
pH	8.3
Organic Matter Content, %	3.8
Total Soluble Salt, gm/litre	6.2

[1]Determined for the fraction passing sieve no. 40

[2]Determined for the fraction passing sieve no. 10

[3]Determined by using Harvard Miniature apparatus.

3.2.2 Determination of Index Properties

3.2.2.1 Grain size determination - The wet sieving method was employed to determine the particle size distribution. The fine fraction of the soil which passing through sieve no. 200 were analyzed by the hydrometer method according to ASTM D 422 - 63.

3.2.2.2 Plasticity - Plastic limit and liquid limit, including plasticity index of Nong Ngoo Hao clay were determined according to ASTM D 423-66 and D 424-59.

In this test, lime was first added at 2, 4, 6 and 8 percents by oven-dried weight of soil to reduce the plasticity. These lime-soil mixtures were kept at room temperature for 7 days. The reduction of the plasticity of the mixtures were determined each day. The amount of days and lime content required for the highest reduction of plasticity of the mixtures was then observed. The amount of days and lime content (lime fixation point) determined from this test was one of the major finding in the first phase of this study. This finding is used in all tests in the second phase.

3.2.3 Preparation of Lime-Cement Stabilization

3.2.3.1 Mixing - The mixing of lime-Cement mixture in this study has been prepared in two steps as follows :

(a) Adding lime to the soil at the quantity of 6 % by oven-dried weight of soil the samples were hand mixed for 10 minutes and then kept at room temperature for two days. This preparation would reduce the plasticity of the soil, which made it

to the more friable and easily compacted. The amount of lime (6 % by oven-dried weight) and time (2 days) obtained from the first phase of study.

(b) Adding 3 %, 5 %, 7 % and 9 % of cement by oven-dried weight to the lime-soil mixtures prepared in step (a). These mixtures were mixed at various percentage of water content. The time used in mixing was about 10 minutes. It has been observed that the prepared sample is better than the one mixed by mechanical mixer because it posses more uniformity. The soil-lime-cement mixtures were compacted in Harvard Miniature mold to determine compaction characteristics and for unconfined compression test, Standard Proctor mold for durability test and Modified Proctor mold for C.B.R. test.

3.2.3.2 Molding of specimens - Immediately after mixing, a small portion of the mixture was taken for moisture content determination. Each of them was sufficient to mold one specimen. These samples were then wrapped in plastic bags to prevent craporation.

After being compacted, the specimens were extruded from the molds. They were weighed to the nearest 0.01 gm. and measured for diameter and height to the nearest 0.001 in. Both ends of the specimen were trimmed and smoothed to reduce imperfect seating of the loading pistol.

3.2.3.3 Curing of specimens - Specimens were kept in plastic bags and cured for periods of 7, 14 and 28 days at room

temperature and approximately 95 ± 5 % relative humidity.

3.2.4 Testing of Specimens

3.2.4.1 Determination of compaction characteristics - Six series of samples were tested to observe the compaction characteristics of soils i.e., the soil, the lime-soil mixtures (lime at fixation point) with 3, 5, 7 and 9 percents of cement content to determine the maximum dry density and the optimum moisture content. The soils were compacted in a Harvard Miniature compaction mold. This mold has a diameter of 1.312 in. and 2.816 in. in height. The samples were compacted at 25 blows per layer with 40 pounds spring tamper. This compaction effort is approximately equivalent to that of the Standard Proctor compaction method.

3.2.4.2 Unconfined compression test - In this study, the maximum strength of the stabilized soil is the main interests, therefore, the unconfined compression test was considered to be used for testing the strength of the specimens after curing. The specimens were tested at a rate of deformation of 0.1 in./min. And the maximum load that caused failure was taken as the compressive strength of the specimen.

3.2.4.3 California bearing ratio test - The purpose of this test is to evaluate the bearing resistance of the stabilized soils.

The specimens at the optimum moisture content were compacted in the 6 in. diameter and 7 in. height mold. In this

study Standard energy was applied to the specimens which compacted at 3 layers, 22 blows per layer, 10 pounds of hammer weight and 18 in. in height of drop. After extruded, the specimens were cured for 7 days. The surcharge weight of 10 pounds was used in the determination of swelling under soaked condition.

3.2.4.4 Durability test - In this test, the compacted specimens at various percents of moisture content and cement concentration were cured for 7 days. After 7 days of curing, the specimens were subjected to 12 cycles of wetting and drying test (ASTM D 559 - 57) in order to observed the maximum percentage of weight loss.