SOIL IMPROVEMENT

HW #1

1. Write down the laboratory tests that may be performed to determine the strength properties of compacted clay soils.

2. The wearing surface of the highway pavement may be damaged due to swelling-shrinkage potential of the subbase, subgrade and base course of the highway pavement. What kind of stabilization methods can be applied to prevent or reduce this potential?
3. According to sieve analysis and consistency limit test results, a soil sample is characterized as SC according to USCS classification system. By using the information given in Table 4.1 and Table 6.1, answer the following questions;
   a. Give approximate ranges of typical properties of this type of soil if it is compacted (Use Table 4.1).
   b. Rank its suitability as a fill material for a water retaining earth dam (Use Table 6.1).

4. Write down two main reasons for the use of bitumen as a stabilization admixture.

5. The compaction results of two similar clay samples with lime and without lime are given in the below figure. According to the given experimental results, answer the following questions:
   a. How the optimum water content of the clay changes with lime addition?
   b. Compare the compaction curves obtained from two samples and explain the difference with reasons.

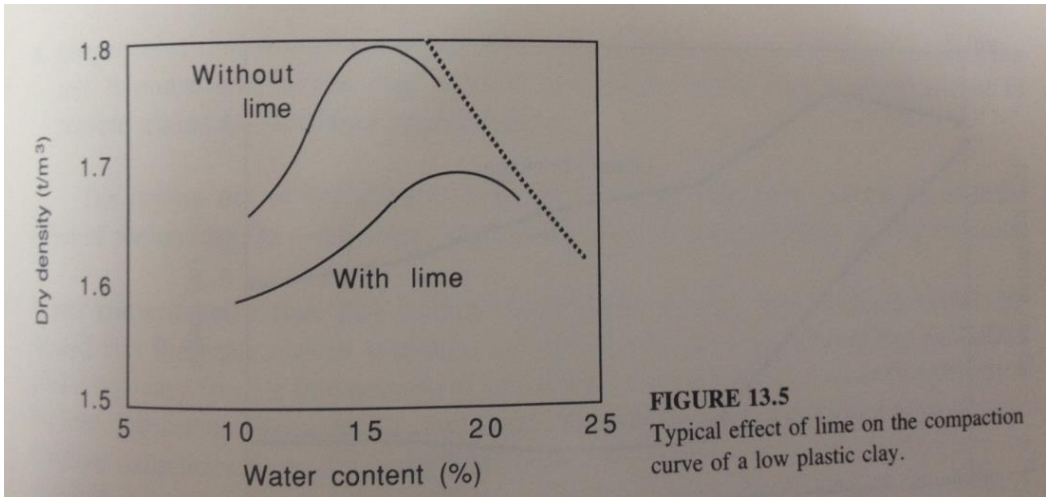

FIGURE 13.5
Typical effect of lime on the compaction curve of a low plastic clay.

6. Considering the engineering properties of fly ash, answer/complete the following

- The average grain size (D_{50}) of the fly ash is ……
- The plasticity index of fly ash is ……
- The friction angle of fly ash is
- The compaction properties of fly ash ……
- The compressibility properties of fly ash……
- The permeability of fly ash ……

TABLE 6.1
Relative desirability of soils as compacted fill

		Relative desirability for various uses (no. 1 is considered the best; no. 14 is least desirable)									
		Rolled earth fill dams			Canal sections		Foundations		Roadways		
Group symbol	Soil type	Homog. Embank-ment	Core	Shell	Erosion resistance	Comp. earth lining	Seepage important	Seepage not important	Frost heave not poss. (fills)	Frost heave possible (fills)	Surfacing
GW	Well-graded gravels, gravel-sand mixtures, little or no fines	–	–	1	1	–	–	1	1	1	3
GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	–	–	2	2	–	–	3	3	3	–
GM	Silty gravels, poorly graded gravel-sand-silt mixtures	2	4	–	4	4	1	4	4	9	5
GC	Clayey gravels, poorly graded gravel-sand-clay mixtures	1	1	–	3	1	2	6	5	5	1
SW	Well-graded sands, gravelly sands, little or no fines	–	–	3 if gravelly	6	–	–	2	2	2	4
SP	Poorly graded sands, gravelly sands, little or no fines	–	–	4 if gravelly	7 if gravelly	–	–	5	6	4	–

TABLE 6.1 *(Cont.)*

SM	Silty sands, poorly graded sand-silt mixtures	4	5	–	8 if gravelly	5 erosion critical	3	7	6	10	6
SC	Clayey sands, poorly graded sand-clay mixtures	3	2	–	5	2	4	8	7	6	2
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	6	6	–	–	6 erosion critical	6	9	10	11	–
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	5	3	–	9	3	5	10	9	7	7
OL	Organic silts and organic silt-clays of low plasticity	8	8	–	–	7 erosion critical	7	11	11	12	–
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	9	9	–	–	–	8	12	12	13	–
CH	Inorganic clays of high plasticity, fat clays	7	7	–	10	8 volume change critical	9	13	13	8	–
OH	Organic clays of medium-high plasticity	10	10	–	–	–	10	14	14	14	–

Source: "Design Manual 7.2," U.S. Navy, 1982.
"–" = not appropriate for this type of use.

TABLE 4.1
Typical properties of compacted soils

Group symbol	Soil type	Range of max. dry unit weight, t/m³	Range of optimum moisture, %	Typical value of compression: At about 140 kPa, % orig. height	Typical value of compression: At about 350 kPa, % orig. height	Typical strength characteristics: Cohesion (as compacted), kPa	Cohesion (saturated), kPa	ϕ' (effective stress envelope), degrees	tan ϕ'	Typical coeff. of permeability, m/s	Range of CBR values	Range of subgrade modulus $k_s \times 1000$ kN/m³
GW	Well-graded clean gravels, gravel-sand mix	2.0–2.2	11–8	0.3	0.6	0	0	> 38	> 0.79	10^{-3}	40–80	80–140
GP	Poorly graded clean gravels, gravel-sand mix	1.8–2.0	14–11	0.4	0.9	0	0	> 37	> 0.74	5×10^{-3}	30–60	70–110
GM	Silty gravels, poorly graded gravel-sand silt	1.9–2.2	12–8	0.5	1.1	—	—	> 34	> 0.67	$> 5 \times 10^{-10}$	20–60	30–110
GC	Clayey gravels, poorly graded gravel-sand clay	1.8–2.1	14–9	0.7	1.6	—	—	> 31	> 0.60	$> 5 \times 10^{-11}$	20–40	30–80
SW	Well-graded clean sands, gravelly sands	1.8–2.1	16–9	0.6	1.2	0	0	38	0.79	$> 5 \times 10^{-7}$	20–40	55–80
SP	Poorly graded clean sands, sands, sand-gravel mix	1.6–1.9	21–12	0.8	1.4	0	0	37	0.74	$> 5 \times 10^{-7}$	10–40	55–80
SM	Silty sands, poorly graded sand-silt mix	1.8–2.0	16–11	0.8	1.6	50	20	34	0.67	$> 10^{-8}$	10–40	30–80
SM-SC	Sand-silt clay mix with slightly plastic fines	1.8–2.1	15–11	0.8	1.4	50	14	33	0.66	$> 10^{-9}$	5–30	30–80
SC	Clayey sands, poorly graded sand-clay mix	1.7–2.0	19–11	1.1	2.2	75	11	31	0.60	$> 10^{-10}$	5–20	30–80
ML	Inorganic silts and clayey silts	1.5–1.9	24–12	0.9	1.7	65	9	32	0.62	$> 5 \times 10^{-9}$ or less	15	30–55

TABLE 4.1 *(Cont.)*

ML-CL	Mixture of inorganic silt and clay	1.6–1.9	22–12	1.0	2.2	65	22	32	0.62	$> 10^{-10}$	—	
CL	Inorganic clays of low to medium plasticity	1.5–1.9	24–12	1.3	2.5	85	13	28	0.54	$> 5 \times 10^{-11}$ or less	15	15–55
OL	Organic silts and silt-clays, low plasticity	1.3–1.6	33–21	—	—	—	—	—	—	—	5 or less	15–30
MH	Inorganic clayey silts, elastic silts	1.1–1.5	40–24	2.0	3.8	70	20	25	0.47	$> 10^{-10}$	10 or less	15–30
CH	Inorganic clays of high plasticity	1.2–1.7	36–19	2.6	3.9	105	11	19	0.35	$> 5 \times 10^{-11}$	15 or less	15–40
OH	Organic clays and silty clays	1.0–1.6	45–21	—	—	—	—	—	—	—	5 or less	5–30

Source: Adapted from "Design Manual 7.2," U.S. Navy, 1982.

Notes:

1. All properties are for condition of standard Proctor maximum density, except values of k_s and CBR which are for modified Proctor maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from U.S.S.R. data.
3. Compression values are for vertical loading with complete lateral confinement.
4. ">" indicates that the typical property is greater than the value shown.
5. "—" indicates that insufficient data is available for an estimate.