SOIL ENGINEERING — OKINAWA

GENERAL STATEMENT

This report is a summary and interpretation of the soil conditions as they affect engineering, and deals with soil in the meaning of that term used by engineers—any earth or relatively loose, finely divided material to whatever depth it may reach—but is devoted primarily to soil within 6 or 10 feet of the surface, which is of major concern in road and airfield construction.

The aim and function of this report is to provide information for overall and preliminary planning—to aid in selection of sites for construction, to assist in appraising the practicability of construction, and to indicate the soil problems likely to be encountered in a given locality. The data are entirely inadequate for the specific design of any major construction; it is not the purpose nor intent of this report to take the place of detailed engineering studies of specific sites, which are essential wherever important construction is undertaken.

In the northern mountainous parts of Okinawa, the soil is mostly lean clay very shallow over more-or-less rotten bedrock (Unit 9 and part of Unit 7); the mountainous western half of Motobu Peninsula is essentially an outcrop of hard crystalline limestone with very little soil (Unit 10). In all the mountainous areas, the soil is so scanty that it hardly affects construction, and the engineering problems are determined by the topography and the properties of the bedrock. Along the northwest side of Motobu Peninsula, there is a narrow plain occupied by fat clay deep to shallow over limestone (Units 5 and 8). In the floors of the estuarine valleys that reach almost across the base of Motobu Peninsula, northwestward from Naha to the northern coast, the soil is lean clay many feet deep with high water table (Unit 2) and occupied by paddyland. In the steeply dissected hilly upland that comprises the isthmus between Naha and Ishikawa, the soil is sandy clay 3 to 20 feet deep over rotten or relatively weak bedrock (Unit 7). Fringing the coasts, there are many narrow raised beaches of impure coral sand (Unit 4) and, in the southern half of the island, wet coastal flats up to about a mile wide occupied by fat clay many feet deep (Unit 3). In the south-central and southern parts of Okinawa, where the bulk of the military installations lie, the prevailing soils are fat clays deep to shallow over limestone (Units 5 and 8) or shallow over clay bedrock (Unit 6).

In general, the soils of Okinawa, especially in those parts of the island occupied by military installations, are fat clays having a relatively low coefficient of expansion and contraction with changes in moisture content. The prevailing soils are such that construction costs are increased and close engineering control is essential; but they do not present extreme problems of soil engineering nor preclude good construction. These fat clays have been successfully and extensively used as subgrade and for fills in the numerous roads and airports built by the U. S. Armed Forces during and since World War II. Subgrade failures and maintenance have been surprisingly low; no major pavement failure attributable to unsatisfactory soil or inadequate soil treatment has occurred.

The information in this report is derived from the data given in the map "Soils of Okinawa", scale 1:50,000, published 1949; an unpublished report "The Soils of Okinawa"; and unpublished geological reports; supported and supplemented by laboratory tests on a few samples from representative areas, and evaluated in the light of the extensive construction experience on Okinawa. This map is a simplification of the map "Soils of Okinawa"; all the soils are grouped into ten units based on differences in engineering properties and described in the terminology of the Corps of Engineers Uniform Soil Classification. The areas shown on the map are areas within which the kind of soil indicated obtains to the near exclusion of other kinds. Practically all the areas on the map include minor inclusions of other soils occurring in areas smaller than can be shown on a map of this scale. The most important of these are: (1) small valley bottoms of Units 1 and 2 included in areas of Units 7 and 9, and of Unit 3 included in areas of Unit 6; (2) many small areas of Unit 8 included in areas of Unit 5, and vice versa; and (3) included within Unit 6, in the areas that correspond to the outcrops of Shimajiri sand, especially in the vicinity of Naha, many small hills and narrow, steep slopes in which the soil is clayey sand to sandy clay 5 to 20 inches deep over bedrock of compacted clayey to silty sand. The intensiveness and detail of the survey made it possible to place boundaries within 100 feet of their true positions, and to indicate areas larger than about 3 acres. As each soil unit on the map contains inclusions of other soils which have dissimilar engineering properties, reliability throughout any entire unit is therefore considered poor for the estimates of the ranges in percentages of fines, liquid limit, and plasticity index given in the map legend, and for most of the evaluations of engineering properties given in Table 1.

This soils engineering report and map is the contribution of a team of soil scientists and geologists who mapped the soils and geology of Okinawa during 1946-49. A. H. Nicol, engineering geologist, U. S. Geological Survey, organized and wrote the major portion of the report. E. H. Templin, senior soil correlator in the Soil Survey, U. S. Department of Agriculture, made the evaluations of the engineering properties of the soils and prepared descriptions of the units. D. E. Flint, geologist, U. S. Geological Survey, and chief of the Okinawa party, reviewed and coordinated the work.

TABLE 1. ENGINEERING PROPERTIES

Unit No.	Unit Name and Corps of Engineers Classification	Landform	Prevailing Gradient of Surface %	Extent in Acres*	Depth to Water Table	Drainage: Surface Run-off	Drainage: Internal Drainage	Dry Strength	Excavation Conditions: Facility**	Excavation Conditions: Observed Slope Stability	Excavation Conditions: Estimated % Gravel and/or Boulders	Embankment and Fill Conditions: Shrinkage-Expansion Elasticity	Embankment and Fill Conditions: Estimated Slope Stability	Embankment and Fill Conditions: Compaction Characteristics	Foundation Conditions ***	Suitability of Soil Material for: Subgrade and Base Course	Borrow for Fills	Topsoil	Sand	Gravel	Binder Soil	Granular Material for Stabilized Base	Airfields	Trafficability	Remarks
1	Well-drained alluvial sandy clay and clayey sand. CL - SC	Narrow valley bottoms and coastal plains.	1 - 3	2,100	4 to 10 ft.	Slow	Rapid drainage down to water table.	Low to medium	Easily excavated. Water table hinders excavations below 4 to 10 ft.	Above water table, stable in cut slopes up to 3/4 to 1 for shallow cuts of less than 10 ft. No data available for underwater stability.	Less than 5 in 90% of units; up to 30 in a few local areas.	Negligible to slight	Stable in fill slopes up to 1 to 1, if compacted.	Good, by rolling.	Good for light structures; unsuitable for heavy structures which require footings in bedrock which occurs at depths of more than 10 ft. below the alluvium 1/	Good as subgrade if compacted. Unsuitable for base course.	Good	Very good	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable for sites; terrain unfavorable.	Good cross-country movement for vehicles during dry weather. Fairly good for foot travel during wet weather, but poor for vehicles.	The soil is alluvium, which continues down to bedrock without change. 1/ Because of flood hazard, areas in narrow valleys should be avoided as sites for permanent buildings.
2	Wet alluvial sandy clay and clayey sand. CL	Level lowlands of coastal plains, and valley bottoms.	0	8,850	2 ft. or less. Paddies are usually covered by a few inches.	Ponded 1/	Drainage is slow, prevented by high water table 1/	Low to medium	Easily excavated above the water table. High water table hinders excavations below 2 ft.	No data available above and below water table.	Less than 5	Low	Stable in fill slopes up to 1 to 1.	Good, when drained.	Fairly good for light structures; unsuitable for heavy structures, which require footings in the underlying bedrock.	Good as subgrade if drained and properly compacted. Unsuitable for base course.	Good	Good	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Generally unsuitable.	Very poor in all weather; paddies are impassable for wheeled vehicles, difficult or impassable for tanks and tracked vehicles, and slow to difficult by foot.	The soil is alluvium, continuing down to bedrock without change. Engineering properties are similar to those of Unit 1, except for high water table and poor drainage. 1/ In most areas poor drainage is artificially induced by rice cultivation, and will greatly diminish or disappear once the paddies are put to other use. Effective drainage can be accomplished by cessation of artificial flooding, and by drains and open ditches.
3	Alluvial fat clay. CH	Level lowlands and extensive low flats up to 3/4 mile wide and several miles long along the coast; also some inextensive valley bottoms within the clayey uplands.	0 - 3	16,200	Surface to 5 ft.	Very rapid	Slow	High	Easily excavated. Moderately adhesive to equipment. High water table hinders excavations below 2 to 5 ft.	No data available above and below water table.	None	High	With good compaction, slopes of 1 1/2 to 1 may be stable for shallow fills; with poor compaction and in deep fills, slopes may be unstable if steeper than 3 to 1.	Very poor.	Poor to fair for light structures but unsuitable for heavy structures, which require footings in the underlying bedrock.	Poor as subgrade. Unsuitable as base course.	Poor	Fair	Unsuitable	Unsuitable	Good	Unsuitable	Terrain is favorable; drainage and subgrade conditions are generally similar to those at Awase, Yonabaru, and Naha airfields, which require special engineering treatment.	Good during dry weather. During wet periods impassable for wheeled vehicles, difficult or impassable for tanks and tracked vehicles, and slow to difficult by foot. Several days to weeks are required for the soil to dry after heavy rains.	The soil is fat-clay alluvium, which continues down to clay bedrock without change; except in the seaward margins of the coastal flats, where much of the clay alluvium is underlain by old beach sand at depths of 2 to 6 ft., the depth to sand generally increasing with the distance from shore.
4	Coral sand. SP	Nearly level to undulating slightly elevated beaches.	0 - 3	2,650	Mostly 6 to 20 ft., related to elevation; the water table is no more than 1 ft. above sea level.	Slow	Very rapid	None	Very easy. No cemented layers. Water table hinders excavations below 6 to 12 ft.	No data. Side walls cave badly.	Less than 5 in 95% of area.	Almost none	Probably unstable on slopes steeper than 1 1/2 to 1 unless some binder is added.	Good	Good support for light structures if the sand is confined; poor for heavy.	Good as subgrade; improved by addition of binder. Unsuitable as base course.	Good; some binder may be needed.	Poor	Subsoil is fair for blending sand for fine aggregate.	Unsuitable	Unsuitable	Good	Suitable only for small temporary strips, but most areas are occupied by villages.	Good in all weather, for all vehicles and by foot. Soil is firm when wet or moist, and loose when dry. (Soil seldom dries out to appreciable depth).	The soil has a darkened surface layer of silty sand about 12 in. deep over impure coral sand.
5	Permeable fat clay, deep over limestone. CH	Upland limestone plains.	1 - 8 8 - 15 15 - 25 Total:	22,400 5,200 2,900 30,500	Water table is in the underlying limestone and is more than 20 ft. below surface.	Medium to rapid	Medium	Medium to high	Easy down to bedrock. Wet clay adheres to equipment. 1/	2 1/2 to 1 slopes are stable in cuts less than 15 ft.; possibly 3 to 1 slopes for deeper cuts. 2/	None	Medium to high.	Probably unstable on fill slopes steeper than 1 to 1 unless carefully compacted.	Fair to good.	Fair for light structures; poor for heavy. Cavernous conditions in underlying limestone bedrock necessitate detailed site investigations.	Good as subgrade if well-compacted; otherwise poor. Unsuitable as base course.	Fair	Upper 10 in. good; remainder only fair.	Unsuitable	Unsuitable	Good	Unsuitable	Terrain in the gently sloping areas is favorable for sites. Cavernous underground conditions in the limestone, however, make special investigation essential to avoid subsidence and collapse of subgrade and runway.	Generally good only for tracked vehicles when dry; slow to difficult when wet. Steep areas when wet are very difficult. Precipitous valley sides are impassable.	1/ The contact with the underlying limestone is extremely irregular, with pinnacles of rock rising several feet into the clay and tongues of clay reaching 10 ft. or more into the limestone. 2/ Erodes rapidly unless protected by vegetation.
6	Fat clay, shallow over clay bedrock. CH	Undulating to steep uplands.	1 - 8 8 - 25 25 - 100 Total:	9,300 18,200 11,200 38,700	1/	Medium to rapid	Very slow.	High	Fairly easy; moderately adhesive to equipment when wet.	2/	None	High	With careful compaction, fill slopes of 1 1/2 to 1 may be fairly stable in shallow fills. If poorly compacted, and in deep fills, slopes of 2 1/2 or 3 to 1 may be required for stability. 1/	Very poor.	Soil is very poor; foundations should rest in underlying compact bedrock which has good bearing value in the dry, undisturbed state.	Subgrade conditions in soil and disturbed bedrock are unsatisfactory, but fairly good in undisturbed bedrock. Unsuitable as base course.	Poor	Soil layer is fair, but subsoil and clay bedrock are unsuitable.	Unsuitable	Unsuitable	Good	Unsuitable	A few gently sloping areas may be suitable, but drainage and subgrade conditions require special study.	Generally good when dry; but when wet this unit is very difficult to impassable for all types of vehicles.	The soil is a fat clay 7 to 30 in. deep over very compact, impervious clay bedrock. 1/ One boring more than 4,000 ft. deep did not reach water table. Locally, in valleys and basins, perched water tables occur near surface. 2/ This soil is very thin; most excavations are in the bedrock. 3/ Applicable to the soil layer and to the clay bedrock.
7	Sandy clay, deep over bedrock. CL	Maturely dissected marine terraces, and hilly uplands.	5 - 15 15 - 25 25 - 75 Total:	4,180 3,400 34,900 42,480	Over 20 ft.	Very rapid to medium	Medium	Medium	Easy	Ranges between 1 to 1 and 2 to 1. 1/	None	Medium	Unstable on fill slopes steeper than 2 to 1. 2/	Fair to good.	Good for all structures.	Good as subgrade when properly compacted; may lose stability when wet. Unsuitable as base course.	Fair to good.	Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Terrain is unsuitable for sites. 2/	Good. Generally passable for all vehicles when wet or dry, except in the steep areas.	Soil consists of thin surface layer of very sandy clay or clayey sand 5 to 10 in. deep, over more plastic and more clayey sandy clay continuing to 3 or 4 ft. deep, over substratum of somewhat less plastic sandy clay of good bearing capacity. Substratum is lacking in local areas less than 4 or 5 ft. deep over bedrock. 1/ Cuts and fills erode rapidly and gullies form unless vegetation or other protective measures are used. 2/ Terrain is generally unfavorable for the design of roads free from sharp curves and steep grades.
8	Stony clay, shallow over limestone. CH	Limestone upland.	1 - 8 8 - 15 Total:	6,400 5,150 11,550	Deep	1/	1/	1/	2/	2/	20 to 50 in soil layer 2/	1/	1/	1/	2/	Good as subgrade if well-compacted; otherwise poor. Unsuitable as base course.	Fair	Good, but difficult to obtain.	Unsuitable	Unsuitable	Good, but difficult to obtain.	Unsuitable	Favorable terrain is somewhat limited and restricted to the eastern side of the Motobu Peninsula, to Bolo Point, portions of the Chinen Plateau in southern Okinawa.	Good footing when dry, fair when wet. Surface stone hinders use of vehicles in any weather; the gently sloping areas are fair for tanks and always passable; the steep areas are difficult to impassable for tanks; unsurfaced roads are always firm and never become impassable.	The soil is a thin layer of fat clay mixed with fragments and boulders of limestone, over pinnacled limestone bedrock. 1/ The engineering properties of this unit are similar to those of Unit 5, but the soil material is much thinner, and stony. 2/ The soil is so thin that in most construction practice it can be disregarded. The engineering problems become essentially those of the bedrock.
9	Lean clay, shallow over bedrock. CL	Steep, mountainous uplands.	25 - 100	120,200	Deep	Very rapid	1/	1/	2/	2/	2/	1/	1/	1/	1/ 2/	Good 1/ 2/	Good, but difficult to obtain.	Poor to fair; difficult to obtain.	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Impassable for cross-country movement for all vehicles. Slow to difficult by foot.	1/ The engineering properties of this unit are similar to those of Unit 1. 2/ This soil material is so thin that it can generally be disregarded in normal construction practice. The engineering problems are primarily those of the bedrock.
10	Rough stony land.	Limestone mountains, escarpments, ridges, and steep to hilly slopes.	25 - 100	14,900	Deep	Very rapid	1/	1/	1/	1/	1/	1/	1/	Fair to good 1/	1/	1/	1/	1/	1/	1/	1/	1/	Unsuitable	Impassable for cross-country movement for all vehicles. Very difficult by foot.	1/ This soil is so thin over most of the area that it can be disregarded in normal construction practice. The engineering properties and problems of this unit are therefore directly related to the bedrock.

*Okinawa mainland only; offshore islands not included.

** By hand tools; scrapers, power shovel, dozers, and other power-driven equipment.

*** Strictly applicable to the soil; not applicable to bedrock except where bedrock is specifically indicated.

TABLE 2. ENGINEERING TEST DATA *

Unit No.	Unit Name and Corps of Engineers Classification	Test No.**	Depth of Sample (inches)	Relation of Sample to Soil Profile	Mechanical Analyses: Cumulative % Passing: No. 4	No. 10	No. 20	No. 40	No. 60	No. 140	No. 200	% of Total Sample: 0.05-0.005 mm. (Nos. 270-400)	<0.005 mm.	<0.001 mm.	Physical Test Constants of Fraction Passing No. 40: LL	PI	SL	SR	Specific Gravity	Moisture-Density Relation: Undisturbed: Field Moisture %	Disturbed: Optimum Moisture %	Undisturbed: Field Density, lb./cu. ft.	Disturbed: Optimum Density, lb./cu. ft.	Consolidation Test with 0.341 tons/sq. ft.: Initial Void Ratio	Void Ratio after 24 hrs.	California Bearing Ratio on Water-soaked Samples: % C.B.R. with 10 lb. Surcharge	% Swell during Soaking	Direct Shear Test, 3,000 lb./sq. ft. Vert. Load: Shear lb./sq. ft.	φ	Cohesion, lb./sq. ft.	Remarks
1	Well-drained alluvial sandy clay and clayey sand. CL - SC	No samples were tested from this unit.																													See Table 1 for other data.
2	Wet alluvial sandy clay and clayey sand. CL	No samples were tested from this unit.																													See Table 1 for other data.
3	Alluvial fat clay. CH	S-5	7-30	Although collected at particular depths, these samples represent the entire soil (or alluvium), which, down to bedrock, has no distinct layers.			100	99	99	97	95	48	45	14	52.2	26.4	16.8	1.70	2.70	-	-	-	-	-	-	-	-	-	-	-	Test No. U-1 was made on an undisturbed sample. Test No. S-1 was made on remolded and compacted U-1 material. Bearing value is poor, and is only slightly improved by compaction.
		S-1	18-26						100	99	98	51	46	13	56.5	29.2	23.6	1.61	2.77	-	18.6	-	106.2	-	-	6.6	3.13	-	-	-	
		U-1	18-26						-	-	-	-	-	-	-	-	-	-	-	30.3	-	90.5	-	0.893	0.888	2.7	0.39	2404	21°	1220	
4	Coral sand. SP	No samples were tested from this unit.																													See Table 1 for other data.
5	Permeable fat clay, deep over limestone. CH	S-8	0-7	Represents surface soil.		100	97	94	89	79	75	33	38	19	39.5	18.2	15.8	1.66	2.78	-	-	-	-	-	-	-	-	-	-	-	Test Nos. U-2 and 3 were made on undisturbed samples. Test No. S-2 was made on remolded and compacted U-2 material. Test No. 3 was made on an undisturbed sample taken from a different location from No. 0-3. Test No. 0-3 is a channel sample representative of the deep clay portion of this unit. Bearing value is improved by compaction.
		S-4	7-10	Subsoil of sandiest part of unit.		100	99	98	94	83	80	28	48	29	54.7	29.2	24.6	1.51	2.80	-	-	-	-	-	-	-	-	-	-	-	
		S-7	24-30	Subsoil from same location as S-8.		100	99	98	98	97	96	41	49	30	62.2	30.4	18.3	1.66	2.79	-	-	-	-	-	-	-	-	-	-	-	
		S-9	30-40	Subsoil. All these are samples of the same layer, but from different locations; differences are thus not related to depth of sampling, but to lateral variation.				100	99	98	97	38	50	32	72.0	38.8	19.1	1.69	2.86	-	-	-	-	-	-	-	-	-	-	-	-	
		S-2	30-40				100	99	98	81	75	37	32	20	52.6	21.5	34.4	1.40	2.80	-	25.5	-	102.2	-	-	15.3	0.70	-	-	-	
		U-2	30-40				-	-	-	-	-	-	-	-	-	-	-	-	-	30.7	-	87.5	-	1.086	1.073	5.3	0	3905	39°	1420	
		0-3	30-144±			100	98	96	93	86	85	20	59	51	57.0	7.2	33.3	1.41	2.78	-	-	-	-	-	-	9.7	0.11	-	-	-	
		3	?						100	99	99	40	51	1	70.2	22.2	30.9	1.46	2.85	47.3	-	74.6	-	1.481	1.472	11.3	0.12	2868	21°	1250	
6	Fat clay, shallow over clay bedrock. CH	S-17	0-20	Soil, same location as S-16.					100	98	97	40	56	15	55.8	31.3	31.3	1.43	2.78	-	23.0	-	98.7	-	-	3.3	6.36	-	-	-	Test Nos. S-16 and S-17 were made on remolded material. Test No. 9 was made on an undisturbed sample of the clay bedrock (Shimajiri formation) and Test No. 0-9 was made on remolded and compacted clay bedrock taken from a 20-ft. channel sample. The bearing value of the undisturbed bedrock is very good, but values for the remolded material are poor.
		S-14	8-16	Soil.			100	99	98	94	93	49	42	12	52.5	27.4	21.5	1.67	2.70	-	-	-	-	-	-	-	-	-	-	-	
		S-6	15-30	Shimajiri clay bedrock.			100	99	97	89	82	43	34	12	54.8	28.2	23.6	1.50	2.87	-	-	-	-	-	-	-	-	-	-	-	
		S-16	20-35	Shimajiri clay bedrock, same location as S-17.		100	99	99	98	96	95	46	48	12	49.4	22.3	20.1	1.63	2.76	-	17.0	-	103.5	-	-	6.3	4.41	-	-	-	
		9	64-72	Shimajiri clay bedrock.				100	99	96	94	51	41	11	54.0	28.9	33.4	1.35	2.81	23.4	-	103.2	-	-	-	35.0	0.14	3020	31°	1210	
		0-9	30-240±	Shimajiri clay bedrock.				100	99	95	94	45	40	18	55.0	31.3	21.3	1.60	2.73	-	-	-	-	-	-	2.3	0.76	-	-	-	
7	Sandy clay, deep over bedrock. CL	S-10		Subsoil; represents most clayey and most plastic part of unit, here developed in residuum from phyllite; underlain by phyllite at 5 ft.				100	99	92	89	29	56	27	52.0	20.6	22.3	1.54	2.88	-	-	-	-	-	-	-	-	-	-	-	Test Nos. U-3, 4, and 13 were made on undisturbed samples. Test No. S-3 was made on remolded and compacted U-3 material. Test Nos. 0-4 and 0-13 were made on remolded and compacted materials from channel samples. To a depth of 3 or 4 ft. the bearing value is poor but is improved by compaction; at greater depth the material becomes more sandy and bearing values are good.
		S-11		Subsoil; represents least clayey and least plastic part of unit, here developed in arkosic sandstone; underlain by sandstone at 30+ ft.				100	98	87	80	28	47	20	41.5	10.3	27.5	1.43	2.85	-	-	-	-	-	-	-	-	-	-	-	
		S-3	36-46	Subsoil; represents dominant condition of subsoil in unit. Similar material continues to 10+ ft.; underlain by phyllite.		100	98	93	89	83	81	33	47	28	48.4	16.7	34.6	1.39	2.79	-	18.0	-	107.7	-	-	12.3	2.06	-	-	-	
		U-3	36-46	Same as S-3.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	24.6	-	94.2	-	1.092	1.082	4.8	0.15	3178	30°	1380	
		S-13	120	Substratum; residuum from sandy conglomerate; underlain by conglomerate and gravel at 20+ ft.		100	97	91	73	60	53	25	23	9	28.6	Non-plastic	25.9	1.59	2.69	-	-	-	-	-	-	-	-	-	-	-	
		S-12	144	Substratum from same location as S-11; residuum from sandstone; underlain by sandstone at 30+ ft.	100	94	86	77	72	60	54	25	19	5	29.7	Non-plastic	33.6	1.44	2.76	-	-	-	-	-	-	-	-	-	-	-	
		0-4	30-156	Substratum; more sandy than average for unit. Underlain by sandstone at 30+ ft.		100	96	91	82	66	62	16	42	32	40.0	13.0	27.1	1.48	2.64	-	-	-	-	-	-	10.7	0.11	-	-	-	
		4	36-48	Same as 0-4.			100	97	88	74	70	17	50	33	49.1	15.6	29.7	1.53	2.79	30.6	-	85.4	-	0.884	0.878	11.7	0	2698	29°	1000	
		0-13	24-180	Substratum; more sandy than average for unit. Underlain by sandy limestone at 30+ ft.		100	94	85	72	48	43	20	18	5	25.0	2.3	20.7	1.67	2.72	-	-	-	-	-	-	19.0	0.19	-	-	-	
		13	100-108	Same as 0-13.		100	97	88	74	47	39	17	18	5	Nonplastic		19.6	1.68	2.74	11.7	-	116.8	-	0.596	0.575	29.7	0.57	Too sandy for test			
8	Stony clay, shallow over limestone. CH	No samples were tested from this unit.																													See Table 1 for other data.
9	Lean clay, shallow over bedrock. CL	U-2, U-3	0-7	Underlain by phyllite at 10 in.	-	-	-	-	-	-	-	39	26	-	42.2	22.5	21.8	-	2.67	-	-	-	-	-	-	-	-	-	-	-	Tests on these samples were made by Dept. of the Army, Corps of Engineers, Office of the District Engineer, Washington, D. C. Results shown are weighted averages.
10	Rough stony land.	No samples were tested from this unit.																													See Table 1 for other data.

** All tests on "S" samples are for disturbed materials.

* All tests were made and data supplied (unless otherwise noted) by Materials Testing Laboratory, Dept. of the Army, Corps of Engineers, Office of the District Engineer, Honolulu, T. H. All tests were determined in accordance with the A.A.S.H.O. and A.S.T.M. standard methods.