compressibility and those of relatively high compressibility. Sandy soils having some plasticity will usually plot to the left of line "C" and above line "A". Silty soils having some plasticity and organic silty clays will generally lie below line "A" and to the left of line "B". Organic clays and micaceous or diatomaceous silty soils will also plot below line "A", but to the right of line "B".

7. General characteristics which are of importance in relation to the behavior of soils as subgrade or base course materials are tabulated in columns 7 through 14 of Table 5. However, it should be emphasized that the characteristics of each soil should be carefully checked by actual tests before being used in design.

Soil Classification and Evaluation of Subgrade Supporting Power for Airfields

Prepared by A. H. Hadfield, Civil Aeronautics Administration

The establishment of airports and landing fields by the Civil Aeronautics Administration is accomplished by engineers working out of eight regional offices. Adherence to a common standard in pavement design was found difficult due to the wide range of soil types encountered on sites situated throughout the United States and Alaska, and lack of a method of classifying these soils on the basis of their relative value as foundation materials.

To meet the need for a method of soil classification and evaluation of the soils as subgrade supporting materials, which could be applied directly to the problem of determining pavement thicknesses, the classification shown in Table 6 has been devised.

The classification is based on the mechanical analysis, plasticity characteristics, expansive qualities and California bearing ratio of the soils The values fixed for these properties are those that the soils would normally be expected to have. Most soils are found to fall into one of the ten groups, although frequently the CBR values determined will place the soil in a different group than the other properties and in such a case, the soil is placed in the lower of the groups in question or an interpolation made. It is believed that a soil classification based on the physical characteristics, together with bearing tests, will provide a more accurate rating of the soil than if the classification and evaluation were based on only one of these values.

The California bearing test was chosen because it measures the relative bearing power of the natural soil under conditions more nearly approximating the worst conditions that can be expected Also, this bearing test is coming into wide use and correlation of the results of the tests and service records on a large number of airports is becoming available.

Plate bearing tests are generally made and used as a check on the modulus of subgrade reaction (k) in connection with the design of rigid pavements

It will be noted that like other soil classifications, there are two groups: the E-1 to E-4 "granular soils" containing 55 per cent or more of sand and the E-5 to E-10 "non-granular soils" containing less than 55 per cent sand (the E-5 has 65 per cent or less sand) The granular soils are further divided into non-frost heave soils, Groups E-1 and E-2, and soils subject to frost heave, Groups E-3 and E-4. The E-1 soil is a free-draining, non-plastic sand corresponding to the Public Roads classification A-3. The E-2 soil is a sand containing slightly more silt and clay than the E-1. The E-3 corresponds to a non-plastic and moderately plastic Public Roads A-2 type and the E-4 is equivalent to Public Roads A-2 plastic type.

In the non-granular group the E-5 soil corresponds to the non-plastic or moderately plastic A-4 silt, and the E-6 to the more plastic A-4 silts, the A-4 and A-6 silty clays, and the A-6 or A-7 clays of low plasticity. The E-7, E-8 and E-9 groups include clay soils of average plasticity, high plasticity and very high plasticity, respectively, covered by Public Roads A-6 and A-7 soil groups. The E-10 is the highly elastic soil classed as A-5 by Public Roads Administration.

Since soil characteristics and supporting power can be so greatly affected by excessive moisture and frost, identifying F and R sym-

TABLE 6
SOIL AND MATERIAL CLASSIFICATION
(Civil Aeronautics Administration) Revised April 23, 1946

Soil	Total Aggregate[a] Ret on No 10	Material Passing No 10 Sieve				Material Passing No 40 Sieve			P R A Class[b]	Cap Rise, No 10 Material	C B R Soaked	Subgrade and Subbase Classification			
		Coarse Sand No 10–No 60	Fine Sand No 60–No 270	Silt	Clay	L L	P I	Volume Change at F M E				No Frost, Good Drainage	Severe Frost, Good Drainage	No Frost, Poor Drainage	Severe Frost, Poor Drainage
	%			%	%										
E-1	0–45	40–85 85+	5–55	0–10	0–5	25–	0–6	0–6	A-3 or A-1	0–12	30+	F_a R_{1a}	F_a R_{1a}	F_a R_{1a}	F_a R_{1a}
E-2	0–45	15–50 75+	25–75	0–15	0–10	25–	0–6	0–6	A-1 or A-2	0–36	20+	F_a R_{1a}	F_a R_{1a}	F_1 R_{1a}	F_2 R_{1a}
E-3a	0–45	0–25 75+	50–100	0–15	0–10	25–	0–6	0–6	A-3 or A-2	0–36	15+	F_1 R_{1a}	F_1 R_{1a}	F_2 R_{1a}	F_2 R_{1a}
E-3b	0–45	0–35 55+	30–80	10–40	0–20	35–	0–10	0–10	A-2	36+	15+	F_1 R_{1a}	F_1 R_{1a}	F_3 R_{1a}	F_3 R_{2a}
E-4	0–45	0–25 55+	30–75	10–30	5–25	45–	5–15	5–15	A-2	36+	13+	F_1 R_{1a}	F_2 R_{1b}	F_3 R_{1b}	F_4 R_{2b}
E-5	0–55	0–20 65–	20–65	20–75	0–20	45–	0–10	0–15	A-4 or A-2	36+		F_3 R_{1a}	F_3 R_{2b}	F_4 R_{2b}	F_6 R_{2b}
E-6	0–55	0–20 55–	0–45	5–70	15–50	50–	10–30	10–30	A-4 or A-6	36+		F_3	F_4	F_6	F_7
E-6 (Loess)	0–10	0–10 55–	0–25	50–98	0–15	50–	0–30	5–30	A-4	36+		R_{1b}	R_{2b}	R_{2b}	R_{2c}
E-7	0–55	0–20 55–	0–40	5–70	15–50	60–	15–40	20–40	A-4 or A-6	36+		F_4 R_{1b}	F_6 R_{2c}	F_7 R_{2c}	F_8 R_{2d}
E-8a Micaceous and Diatomaceous Silt-Clay	0–55	0–15 55–	0–40	35–75	15–35	30–60	10–50	10–40	A-5	36+		F_5 R_{2b}	F_7 R_{2c}	F_7 R_{2c}	F_9 R_{2d}
E-8b	0–55	0–15 55–	0–40	5–50	30+	70–	20–50	30–50	A-7 or A-6	36+		F_5 R_{2b}	F_7 R_{2c}	F_8 R_{2c}	F_9 R_{2d}
E-9	0–55	0–10 55–	0–45	5–50	30+	80–	30+	40–60	A-7 or A-6	36+		F_6 R_{2c}	F_8 R_{2d}	F_9 R_{2d}	F_{10} R_{2c}
E-10	0–55	0–10 55–	0–45	30–80	30–	60+	0–25		A7-5 A-4	36+		F_8 R_{2d}	F_9 R_{2c}	F_{10} R_{2c}	F_{10} R_{2c}
E-11 Muck or Peat	0–10	0–25 55–	0–50	10–60	5–25	60–400	0–60		A-8			Not suitable for subgrade			

[a] In the total aggregate percent retained on the No 10 sieve column the maximum limit shown indicates the limit over which a raise in classification will be allowed exclusive of E-6

[b] Identifying column—not essential for classification

bols are used to reflect the soil properties under such conditions. These F and R symbols are used to evaluate the various classes of soil as subgrade supporting material under varying conditions of moisture and frost and in determining from design curves thickness of pavement required for flexible (F) and rigid (R) pavements. Thus an E-1 soil is evaluated as a F_a or R_{1a} material on which no sub-base would be required under any conditions. An E-3 soil is an estimate of the poorest soil on which a base course for a flexible pavement could be placed under the most favorable conditions of no frost and good drainage and is evaluated as an F_a material for these conditions, but as an F_1, F_2, or F_3 material requiring sub-base of increasing thicknesses for conditions of severe frost-good drainage, no frost-poor drainage, and severe frost-poor drainage, respectively. Likewise, an E-5 soil characterizes the poorest material on which a rigid pavement could be placed without a sub-base for conditions of no frost, and under such conditions is evaluated as an R_{1a} material; while for frost conditions this E-5 soil is evaluated as R_{2b} requiring sub-base.

This method of soil classification has been in use for only 7 months and undoubtedly as additional information is assembled, revisions and adjustments will be found desirable. Classification of soils on all new projects, as well as on airports and landing fields already constructed, will result in sufficient information so that eventually the soils classification values can be adjusted to meet our requirements for design.

DISCUSSION

Application of the Classifications and Group Index in Estimating Desirable Subbase and Total Pavement Thicknesses

D. J. Steele, *Materials Engineer, San Francisco District, Public Roads Administration.* Under the heading "Subbase Thicknesses" the report lists several variables, in addition to properties of subgrade, which should be taken into account in designing thicknesses. The recommended procedure for arriving at adequate and economical foundation designs for a particular area is to identify subgrade types, determine thicknesses and types of existing pavements over these subgrades, and evaluate past performance with due regard for the traffic and other variables mentioned. However, the report recognizes that empirical thickness tables tied to test values may be helpful if applied to local conditions under competent engineering direction.

I have been requested to discuss and present examples of empirical thickness tables tied to the test methods and classification arrangement of the report. This assignment is accepted with some hesitancy as, firstly, it must be admitted that there are inadequacies in all presently known subgrade identification and test methods and, secondly, there is danger that any set of thickness tables or curves will be taken too literally without the adjustment to local conditions and performance which the report recommends and which requires the kind of engineering experience and skill not replaceable by tables or curves. Nevertheless, even approximately correct evaluation of test data on subgrades and local materials results in more nearly correct design than is possible without such evaluation. Therefore, the writer is presenting an outline which his experience indicates as approximating desirable practice under average conditions, and with the full expectation that those who take the trouble to check it against actual performance of existing roads in various localities will find it less than a perfect answer to an exceedingly complex problem.

The essentials of the outline are shown by the charts of Figure A. These charts purport to take care of three of the six variables mentioned in the report; subgrade characteristics, traffic, and justifiable factor of safety on basis of availability of satisfactory subbase materials The three other variables mentioned are discussed as follows:

Climate—It is considered that the over-all thicknesses shown by the charts should take care of most variations in climatic conditions, the probable exception being the effect of deep frost penetration. Counteracting the effects of frost penetration apparently involves provision for good drainage combined with use of