SUB-SECTION VIII f

MISCELLANEOUS

VIII f 4

CLASSIFICATION OF SOILS FOR AIRPORT CONSTRUCTION

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Like most engineering classifications of soils, the CAA classification was formulated to aid in solving a specific problem; namely, to establish a relationship between the type of soil and the required thickness of pavement to support aircraft wheel loads. Our knowledge of load distribution and stress-strain characteristics of soils has not advanced far enough to arrive at a formula giving a direct mathematical solution of this problem. As a result, pavement thickness requirements are based on a combination of a theoretical analysis of load distribution through pavements and soils, the analysis of experimental data, and a study of the performance of pavements and soils under actual service conditions. For this reason, a soil classification, to be usable, must serve as a guide to the behavior of the soil under variable environmental influences. Experience during the past several years indicates that this purpose is served by the CAA classification.

This classification requires the performance of only three tests, the mechanical analysis, liquid limit and plastic limit. These tests have been utilized for many years by highway engineers all over the world as a means of evaluating soils for use in the construction of embankments and subgrades for pavements. Information accumulated by correlating the results of these tests with soil behaviour under all conditions of environment forms the basis for the CAA classification. The test results identify the soil as having physical properties similar to those of soils of known behavior. Therefore, they can be expected to furnish the same degree of stability under the same conditions of moisture and climate.

SOIL GROUPS

Distinguishing details of the classification are given in Table 1. The mechanical analysis furnishes the data to separate the granular soils from the fine grained soils while the different groups are arranged in the order of increasing values of liquid limit and plasticity index. As these values increase, the suitability of the soils as a foundation for pavement decreases.

Granular soils are comprised in groups E-1 to E-4 and the division between granular and fine-grained soils is made on the requirement that granular soils have less than 45 percent of silt and clay combined. All soils having more than 45 percent of silt and clay combined are grouped under fine-grained soils. These include groups E-5 to E-10. Determination of the sand, silt and clay fractions are made on the portion of the sample passing the No. 10 sieve since this is considered the critical portion with respect to changes in moisture and other climatic influences. Also, this permits a textural classification that is useful and in connection with turf development and drainage.

Group E-1 includes well graded coarse granular soils that are stable even under poor drainage conditions and are not subject to detrimental frost heave. Soils of this group may cônform to requirements for soil type base courses such as well graded sand-clays with excellent binder.

Group E-2 is similar to group E-1 but has less coarse sand and may contain greater percentages of silt and clay. Consequently, soils of this group may become unstable under poor drainage conditions as well as be subject to frost heave to a limited extent.

Groups E-3a and E-3b include the fine sandy soils of inferior grading. They may consist of fine cohesionless sand or sand-clay types with a fair to good quality of binder. They are less stable than group E-2 soils under adverse conditions of drainage and frost action.

Group E-4 comprises all poorly graded granular soils having more than 35 percent and less than 45 percent of silt and clay combined. This group includes, also, all soils with less than 45 percent of silt and clay and plasticity indices greater than 10. A plasticity index greater than 15, even though the soil may have more than 55 percent of sand, would cause it to be classified with the fine-grained soils.

The E-5 group consists of the silts and silty loam soils having zero to low plasticity. These soils are friable and quite stable when dry or at low moisture contents. They lose stability and become very spongy when wet and for this reason are difficult to compact unless the moisture content is carefully controlled. Capillary rise in the soils of this group is very rapid and, more than soils of any of the other groups, are subject to detrimental frost heave.

Group E-6 includes the clay loams, silty clays, clays and some sandy clays. They range from friable to hard consistency when dry and are plastic when wet. These soils are stiff and dense when compacted at the proper moisture content. Variations in moisture are apt to produce detrimental volume change. Capillary forces acting in the soil are strong but the rate of capillary rise is relatively slow, and frost heave, while detrimental, is not as severe as in the E-5 soils.

Group E-7 soils are similar to the E-6 soils but the higher liquid limits indicate a greater degree of compressibility, expansion and shrinkage and lower stability under adverse moisture conditions.

Group E-8a comprises the silts and clays containing micaceous and diatomaceous materials. They are highly elastic and very difficult to compact. They have low stability in both the wet and dry state and are subject to frost heave.

Group E-8b includes the silty clay and clay soils that form hard clods when dry and are very plastic when wet. They are very compressible, possess the properties of expansion shrinkage and elasticity to a high degree and are subject to frost heave. Soils of this

TABLE I

CLASSIFICATION OF SOILS FOR AIRPORT CONSTRUCTION

Soil Group	Retained on No.10 Sieve x)	MECHANICAL ANALYSIS: Material Finer Than No. 10 sieve: Coarse Sand	Fine Sand	Combined Silt and Clay	Liquid Limit	Plasticity Index	SUBGRADE CLASS: Good Drainage: No Frost	Severe Frost	Poor Drainage: No Frost	Severe Frost
		Percent	Percent	Percent						
E-1	0-45	40+	60 -	15 -	25 -	6 -	Fa R1a	Fa R1a	Fa R1a	Fa R1a
E-2	0-45	15 +	85 -	25 -	25 -	6 -	Fa R1a	Fa R1a	F1 R1a	F2 R1a
E-3a	0-45	-	-	25 -	25 -	6 -	F1 R1a	F1 R1a	F2 R1a	F2 R1a
E-3b	0-45	-	-	35 -	35 -	10 -	F1 R1a	F1 R1a	F2 R1a	F3 R2a
E-4	0-45	-	-	45 -	40 -	15 -	F1 R1a	F2 R1b	F3 R1b	F4 R2b
E-5	0-55	-	-	45 +	40 -	10 -	F2 R1a	F3 R2b	F4 R2b	F6 R2b
E-6	0-55	-	-	45 +	50 -	10-30	F3 R1b	F4 R2b	F6 R2b	F7 R2c
E-7	0-55	-	-	45 +	60 -	15-40	F4 R1b	F6 Rc2	F7 R2c	F8 R2d
E-8a	0-55	-	-	45 +	40 +	30 -	F5 R2b	F7 R2c	F7 R2c	F9 R2d
E-8b	0-55	-	-	45 +	70 -	20-50	F5 R2b	F7 R2c	F8 R2c	F9 R2d
E-9	0-55	-	-	45 +	80 -	30 +	F6 R2c	F8 R2d	F9 R2d	F10 R2e
E-10	0-55	-	-	45 +	80 +	-	F8 R2d	F9 R2e	F10 R2e	F10 R2e
E-11		MUCK AND PEAT - FIELD EXAMINATION					NOT SUITABLE FOR SUBGRADE			

x) CLASSIFICATION IS BASED ON SIEVE ANALYSIS OF THE PORTION OF THE SAMPLE PASSING THE NO. 10 SIEVE. WHEN A SAMPLE CONTAINS MATERIAL COARSER THAN THE NO. 10 SIEVE IN AMOUNTS EQUAL TO OR GREATER THAN THE MAXIMUM LIMIT SHOWN IN THE TABLE, A RAISE IN CLASSIFICATION MAY BE ALLOWED.

group are more difficult to compact than those of the E-6 and E-7 groups and require rather careful control of moisture to produce a dense, stable fill.

Group E-9 soils are similar to those of the E-8b group but have higher liquid limits. This group includes all soils with liquid limits between 70 and 80 and plasticity indices over 30.

Group E-10 comprises all soils having liquid limits over 80 regardless of their plasticity indices. They may be highly plastic clays that are extremely unstable in the presence of moisture or they may be very elastic soils containing mica, diatoms, or organic matter in excessive amounts. Whatever the cause of their instability, they will require the maximum in corrective measures.

Group E-11 takes in organic swamp soils such as muck and peat which are recognized by examination in the field. Their range in test values is too great to be of any value in a system of identification and classification. They are characterized by very low stability, very low density in their natural state and very high moisture contents.

This grouping is based on a few simple tests that are fully adequate for classification purposes. At the same time these tests are specified as the minimum testing requirements. In many instances it will be desirable to perform volume change, moisture equivalent, capillarity, California Bearing Ratio, and plate loading tests, in order to obtain information for estimating the performance of a soil. Also, shear, consolidation and triaxial compression may be required in connection with special foundation problems.

CHART FOR FINE-GRAINED SOILS

It is possible that a soil may contain certain constituents that will give test results which would place it, according to Table 1, in more than one group. This could happen especially with soils containing mica, diatoms or a large proportion of colloidal material. Such overlapping can be avoided by the use of Chart 1 in conjunction with Table 1.

Soils with plasticity indices higher than the maximum corresponding to the maximum liquid limit of the particular group are not of common occurence. When encountered, they are placed in the higher numbered group as shown on Chart 1. This is justified by the fact that for equal liquid limits, the higher the plasticity index, the lower the plastic limit at which a slight increase in moisture causes the soil to rapidly lose stability. This is counteracted somewhat by its lower permeability and greater resistance to penetration of water. However, in general, it is a less desirable soil. Also, it is more difficult to handle such a soil during grading operations as a result of its tendency to form hard clods which require more work to pulverize and compact when dry and to dry out when wet.

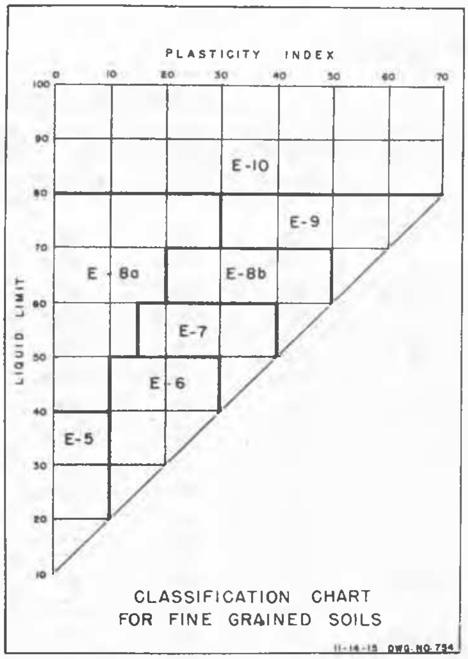

Chart 1

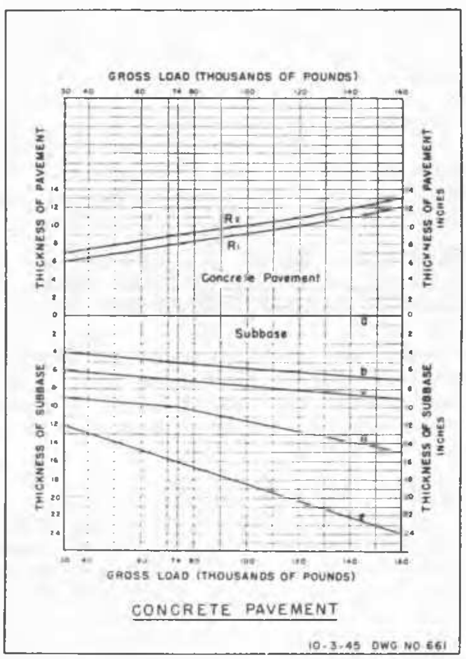

Chart 2

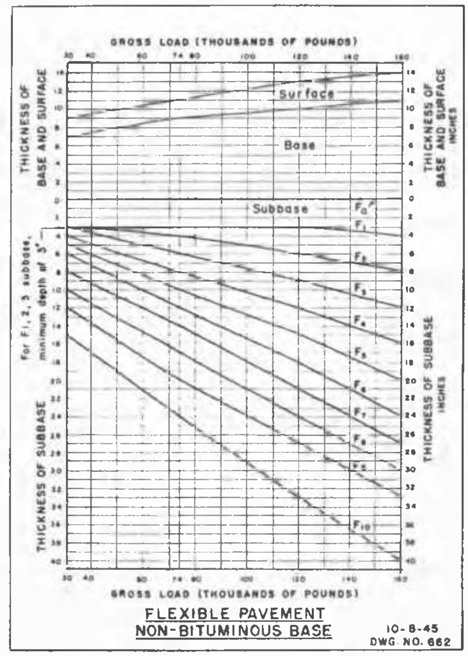

Chart 3

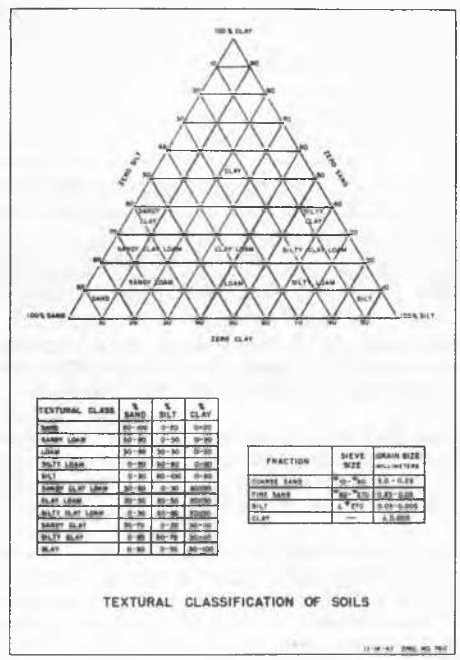

Chart 4

COARSE MATERIAL RETAINED ON NO. 10 SIEVE

Only that portion of the sample passing the No. 10 sieve is considered in the above described classification. Obviously, the presence of material coarser than the No. 10 sieve should serve to improve the overall stability of the soil. For this reason, up-grading the soil from 1 to 2 classes is permitted when the percentage of the total sample retained on the No. 10 sieve exceeds 45 percent of soils of the E-1 to E-4 groups and 55 percent for the others, provided the coarse fraction consists of reasonably sound material. However, it is necessary that the coarse fraction be fairly well graded from the maximum size down to the No. 10 sieve. Stones or rock fragments scattered through a soil should not be considered of sufficient benefit to warrant upgrading.

When an appreciable amount of material is retained on the No. 10 sieve, a sieve analysis of the total sample should be made and studied for compliance with specifications covering base course and subbase materials. In this connection, all soils in groups E-1 to E-4 may be suitable for use as granular subbase depending on climatic conditions and specification requirements.

SUBGRADE CLASSIFICATION

For each soil group there are corresponding subgrade classes based on the performance of the particular soil as a subgrade for rigid or flexible pavements under different conditions of drainage and frost. The subgrade classes and their relationship to the soil groups are shown in table 1 where R refers to rigid pavements and F to flexible pavements. These subgrade classes determine the thickness of subbase required in addition to the minimum pavement thickness for a given aircraft load as illustrated on charts 2 and 3. The charts are presented to assist in more clearly defining the subgrade classes as they indicate, quantatively, the relative stability of each of the classes. Pavement design will not be discussed in this paper.

With respect to rigid pavements, subgrades are divided into two broad classes, R_1 and R_2, and each is subdivided into five classes, a, b, c, d and e. Subgrades are placed in the R_1 class where the combination of soil, drainage and climatic conditions are favorable; otherwise they are classed as R_2. Subbase requirements are the same for R_1 and R_2 subgrades but the R_2 condition requires a concrete pavement one inch thicker than the R_1. For certain conditions an additional inch of rigid pavement is considered more desirable than a proportionate increase in subbase thickness. In this connection Table 1 shows that soils in groups E-8a, E-8b, E-9 and E-10 are classed as R_2 subgrades even under conditions of good drainage and no frost. Under these same conditons R_1 applies to soils ranging from E-1 to E-7, inclusive. Taking the other extreme of poor drainage and severe frost, R_1 is applicable only to soil groups E-1, E-2 and E-3a.

In the case of flexible pavements, subgrades classed a Fa furnish adequate subgrade support without the addition of subbase material. Soils in group E-1 fall in the Fa subgrade class under all conditions of drainage and frost while E-2 soils are classed as Fa subgrades only where the drainage is good. The other subgrade classes are designated F_1 to F_{10}.

Soils of the E-4 group, for example, may be classed as F_1, F_2, F_3 or F_4 subgrades depending on drainage and frost conditions as shown in Table 1. An F_4 subgrade, on the other hand, is the result of any of the following combinations:

Soil Group	Drainage	Frost
E-4	Poor	Severe
E-5	Poor	No
E-6	Good	Severe
E-7	Good	No

To distinguish between good and poor drainage requires a knowledge of the topography of the site, the properties and arrangement of the different layers of the soil profile, and the elevation of the water table. Poor drainage is defined as a condition where the subgrade may be rendered unstable owing to (1) inadequate internal drainage caused by the character of the soil profile, (2) capillary rise from a high water table, (3) topographic features such as a flat terrain at elevations only slightly above sea level, or (4) any other cause that may result in instability or produce saturation of the subgrade.

With respect to frost action, a "severe frost" condition exists if the depth of frost penetration for the particular site is greater than the anticipated thickness of surfacing, base and subbase as determined for "no frost" and the drainage condition as defined above. Otherwise the condition of "no frost" prevails.

FIELD CONDITIONS DETERMINED BY SOIL SURVEY

Information relative to the field conditions which determine the subgrade class is obtained by means of a soil survey. This survey includes a determination of the soil profile, sampling, and testing in accordance with the standard methods of the American Association of State Highway Officials. The different layers of the soil profile are identified by color, texture, structure, consistency, compactness and cementation. Samples representative of the various layers are taken and, when tested, the soil group and subgrade class of each layer can be determined.

The method of field identification is similar to that used by the U.S. Department of Agriculture for making soil surveys in connection with the preparation of county soil maps. This provides a textural classification (Chart 4) that is useful in drainage design and turf development. Intelligent use of published soil maps can be invaluable in a study of the soil on an airport site.

SUMMARY AND CONCLUSION

Summarizing the foregoing discussion the CAA classification of soils is an engineering classification and was developed for the specific purpose of determining pavement requirements for aircraft loads. It is based on the known behavior of soils as identified by soil test results that have been correlated with pavement performance under actual service conditions. These tests determine the soil groups while the drainage and soil conditions as determined by the soil survey, together with climatological data, establish the subgrade class. In addition the survey and tests reveal the texture, structure and other characteristics of the different layers of the soil profile. This furnishes information required for both surface and subsurface drainage.

Furthermore, in connection with its program of airport development the Civil Aeronautics Administration must consider soils in an agronomic as well as an engineering sense. The development of turf is a large item on any airport. Also, serious thought and study is currently being given to the cultivation of revenue producing crops on airports. Most soil classifications proposed by engineering organizations overlook these items or, at least, do not mention them. The textural classification similar to that used by the U.S. Department of Agriculture provides some data along these lines.

Finally, it is believed that since any system of classification must be correlated with performance under actual service conditions, there is a great advantage in the use of simple tests, provided they produce the necessary information. Correlation of test results with service behavior will be entered into more universally if the tests are such that can be easily performed with a minimum of testing equipment.

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