Pedologic Classification of Peat

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ABSTRACT

Peat is classified in the order Histosols in the U.S. Department of Agriculture pedologic classification system. Histosols constitute one of the 10 orders of the hierarchical system that was developed from 1951 to 1974. (It was published as Soil Taxonomy, A Basic System of Soil Classification for Making and Interpreting Soil Survey, USDA Agriculture Handbook 436, 1975.) Histosols, unlike other soils, developed primarily from organic parent material and are saturated with water unless they are artificially drained. They are characterized by low bulk densities and are subject to large degrees of subsidence when drained; therefore, they present unique problems for use and management. The formation of Histosols, the differentiae used in classification, and the properties identified that affect engineering use are discussed.

The terms "peat" and "organic soils" have been used and are still used in a general sense to refer to soils that are characterized by a high organic materials content. The origin of the organic materials is the vegetation that has grown and is presently growing on the area. These plant remains are in various stages of decay and decomposition. Numerous criteria and subsequent systems have been used in classifying organic soils. Most were developed for a specific region or purpose. The scheme that appears in the U.S. Department of Agriculture pedologic classification system (1) is the result of the efforts of many soil scientists who were interested in the classification and management of peat soils. Peat soils are classified as Histosols. Some of the criteria used in Soil Taxonomy (1) for the various hierarchical classifications of Histosols are outlined and criteria that affect engineering use are identified.

DISTRIBUTION AND EXTENT

Histosols occur on all continents and within all of the major climatic zones of the earth--even in arid regions, as long as water is present. Histosols occur predominantly, however, in areas where precipitation usually exceeds evapotranspiration. Canada and the United States have approximately 14 percent of the known organic soils in the world (2). In the United States, organic soils are concentrated mostly in the northern states and along the Atlantic and Gulf coasts. Table 1 gives, by state, in the "Histosols Currently Mapped in State" column, the extent of Histosols identified to date in the National Cooperative Soil Survey (NCSS) program. The column "Estimated Total Histosols in State" shows the total hectares of Histosols in each state using the figures in the "Histosols Currently Mapped in State" column as a basis for the estimate.

TABLE 1 Extent of Histosols in the Coterminous United States (Tidal Marsh Not Included)

State	Histosols Currently Mapped in State (ha)	Histosols as a Percentage of All Mapped Soils in State	Estimated Total Histosols in State (ha)
Alabama	244 000	0.3	38 800
California	19 300	0.08	30 400
Connecticut	2700	0.2	26 800
Florida	545 600	6.7	898 400
Georgia	12 100	0.1	14 900
Idaho	6100	0.06	13 400
Illinois	54 800	0.6	86 000
Indiana	104 000	1.3	120 000
Iowa	9900	0.08	11 300
Louisiana	239 200	3.2	366 400
Maine	33 000	0.9	71 600
Maryland	1000	0.04	1000
Massachusetts	21 000	1.3	25 800
Michigan	193 400	2.5	373 600
Minnesota	318 400	3.0	612 800
Mississippi	29 900	0.3	36 200
Missouri	300	0.0	500
Montana	1000	0.01	3700
New Hampshire	10 400	0.6	13 800
New Jersey	17 200	0.9	17 200
New York	77 200	1.0	121 600
North Carolina	121 200	1.6	200 400
Ohio	52 000	0.6	62 800
Oregon	11 500	0.1	24 600
Pennsylvania	5300	0.05	5800
Rhode Island	10 500	3.9	10 500
South Carolina	43 200	0.6	46 400
Texas	1400	0.0	1600
Vermont	4800	0.3	7100
Virginia	20 300	0.4	40 200
Washington	27 800	0.2	34 300
Wisconsin	369 500	3.6	502 000
Total	2 393 400	0.5	3 819 900

CLASSIFICATION OF HISTOSOLS

Order

Histosols are commonly called bogs, marshes, moors, muskegs, peats, or mucks (3). Most are deep organic materials, but a few are shallow over rock or fractured rock and rubble. Histosols, unlike other soils, are derived primarily from organic parent material. To be included within the order Histosols, a soil must be composed of organic materials in more than 50 percent of the upper 80 cm of the profile unless the soil rests on solid rock or fills the interstices of fragmented rock, in which case the thickness requirements are waived. Soils composed of 75 percent or more (by volume) sphagnum moss must extend to a depth of 60 cm or more to qualify as Histosols. The organic materials that make up Histosols that are saturated with water contain at least 12 to 18 percent organic carbon by weight, depending on the clay content of the mineral fraction. With few exceptions, Histosols are constantly saturated with water unless they are artificially drained. For naturally unsaturated organic soils, the minimum organic carbon content requirement is 20 percent by weight. Because of their organic character, Histosols have low bulk densities, generally less than 0.25 g/cm³.

Suborder

Three broadly defined states of decomposition are recognized for organic (histic) materials: little decomposed (fibric), moderately decomposed (hemic), and highly decomposed (sapric). The predominance of a particular decomposition state within a given profile gives rise to the names of the three most common suborders of Histosols: Fibrists, Hemists, and Saprists. A fourth suborder, Folists, is recognized. The suborders are defined in further detail as

1. Three suborders of Histosols that are saturated with water 6 months or more of the year or have artificial drainage:

Fibrists are composed of fibrous plant remains so little decomposed that they are not destroyed by rubbing and their botanic origin can be readily determined. Soils in this suborder tend to have the highest moisture content, commonly between 850 and 3000 percent of dry weight, and the lowest bulk density, less than 0.1 g/cm³. Fibric horizons or layers are designated in NCSS profile descriptions as Oi.

Hemists contain organic materials that are decomposed enough that the biologic origin of two-thirds of the volume cannot be easily determined, or they contain fibrous materials that can be largely destroyed by rubbing. They are wet, with moisture content commonly between 450 and 850 percent of dry weight, and usually have a bulk density between 0.1 and 0.2 g/cm³. Hemic horizons or layers are designated in NCSS profile descriptions as Oe.

Saprists consist primarily of highly decomposed organic materials. Commonly, few plant remains can be identified botanically. The moisture content is normally less than 450 percent of dry weight and the bulk density of the organic materials is usually greater than 0.2 g/cm³. Sapric horizons or layers are designated in profile descriptions as Oa.

2. A suborder of Histosols that is never saturated with water for more than a few days following heavy rains:

Folists are composed of litter, leaves, twigs, and branches in various states of decomposition, ranging from nearly undecomposed to, more commonly, highly humified materials. The organic materials must contain at least 20 percent organic carbon and rest either on bedrock or on fragmental materials that have interstices filled or partly filled with organic materials.

Great Group

At the great group level of classification, Histosols are separated based primarily on the soil temperature regime. The prefixes Cryo-, Boro-, Medi-, and Tropo- designate the most common great groups of Histosols. For example, Borohemists are Hemists with a frigid soil temperature regime. In addition, the term Sphagno is added as a prefix when a Fibrist is composed of three-fourths or more (by volume) sphagnum moss (i.e., Sphagnofibrists). Hemists with significant quantities of sulfidic or sulfuric materials are designated as Sulfihemists or Sulfohemists at the great group level. Soil Taxonomy recognizes 20 great groups of Histosols. Soils have currently been classified into 16 of these 20 great groups.

Subgroup

At the subgroup level, intergrades (transitional forms to other orders, suborders, or great groups) and extragrades (forms that are not typical of the great group but do not indicate transitions to other soils) are recognized.

A typical profile of a Borofibrist would be classified in the Typic subgroup, and the Borofibrist intergrading to a Borohemist would be classed in the Hemic subgroup (Hemic Borofibrist). If the soil were shallow over bedrock (an extragrade feature), the subgroup would be Lithic (Lithic Borofibrist). Soil Taxonomy presently recognizes 124 subgroups of Histosols. Soils have been classified into 55 of these subgroups.

Family

Subgroups are subdivided into families. Each soil family name consists of the subgroup name and several additional adjectives for class names based on particle size, mineralogy, reaction, temperature, and soil depth.

Series

Soil series are subdivisions of families that provide additional homogeneity of recognizable properties and features. Because series are commonly named for geographic locations, the name seldom indicates soil properties; series descriptions, however, convey the greatest amount of soil property information and are of special value for local investigations. Information given for soil series in published soil surveys of the NCSS include depth, percent organic matter, particle size distribution of the mineral fraction, percentage rock fragments, bulk density, permeability, available water capacity, soil reaction, and estimated subsidence. There are currently 201 soil series in the Histosol order.

PHYSICAL CHARACTERISTICS WITH ENGINEERING SIGNIFICANCE

Soil properties identified in the classification scheme that have significance for engineering use include state of decomposition, bulk density, soil temperature, reaction, ferrihumic material, sulfidic material, depth to bedrock, depth and thickness, particle size and mineralogy, and presence of marl or diatonaceous earth in the mineral layers.

Organic deposits (Histosols) subside after drainage (4). The potential rate of subsidence of Histosols after drainage is critical in making decisions regarding their use. The state of decomposition, bulk density, soil temperature, thickness of material, and percentage clay in the mineral fraction are soil properties used to estimate potential subsidence. Reaction and presence of sulfidic materials affect corrosion of steel or concrete conduits and are used to estimate such corrositivity, and the presence of ferrihumic material affects excavation.

Trafficability estimates are made considering thickness of organic material, bulk density, depth to bedrock or ferrihumic material, kind and depth of mineral layers present, and state of decomposition of the organic material. All of the soil properties used in the classification scheme are considered in the design, construction, and maintenance of drainage systems.

SUMMARY

Organic soils (Histosols) are classified based on quantitative criteria that can be determined in the

field by visual observations and by simple field tests. The order is identified by content of organic material; the suborder by the degree of decomposition of the organic materials; the great group by soil temperature; subgroups by intergrades to other great groups of organic soils; and the family by particle size, mineralogy, reaction, temperature, and soil depth.

The criteria used to classify peat soils identify soil properties that have significance for engineering purposes. Nomenclature used in the classification scheme is connotative and enables recognition of the properties.

The NCSS classifies and maps soils using Soil Taxonomy. Soil survey maps at scales of 1:15,840, 1:20,000, or 1:24,000 are available for about 1,660 counties in the United States. The maps and descriptions of peat soils can help engineers plan and conduct soil investigations for engineering purposes.

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Compression of Peat Under Embankment Loading

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ABSTRACT

Peat and organic soil are commonly avoided as sites for highway construction. There are situations when this is not possible or economical, and the peat must be dealt with. If the organic accumulation is relatively shallow, excavation and replacement are feasible. However, for deeper deposits other alternatives, including the preloading technique discussed here, need to be considered. Preloading both strengthens the peat, so that it can safely carry the intended load, and achieves long-term compression in an accelerated period. Prediction of the settlement of peat under both the service load and the preload is important. Rheological parameters can be derived from field testing to allow use of a method that predicts settlements and controls duration of preload. A case study involving a highway compares results predicted by the method with actual measurements.

Building highways over peat and other highly organic deposits has been avoided by engineers whenever possible. It has been customary to go around peat lands when planning a highway, and this is still the preferred solution. However, there are times when passing the highway alignment over the deposit may be an effective alternative.

When these deposits are relatively shallow (less than 5 m), excavation and replacement by granular materials are commonly used. However, when the deposits are deeper or of a large lateral extent, special foundation treatment is usually required.

One such treatment is preloading. As a result of expansion into areas with poor foundation soils, preloading techniques through surcharging have been developed with some success as a means of in situ improvement of soil properties. Preloading accelerates settlement and strengthens the deposit so that an embankment can be supported without failure or excessive settlement.

A major drawback to preloading peat has been the inability to predict the deformation characteristics of the organic deposit under loading. This lack of knowledge becomes apparent when attempting to determine the surcharge magnitude and duration required to accelerate settlement. The time rate and magnitude of settlement to be expected with peat are at best uncertain. Methods currently used to predict settlement give poor results when applied to large strain materials with significant secondary compression effects (i.e., peats). Thus, after a preload has been applied to peat, the rate and magnitude of settlement are often uncertain, and consequently the required duration of the surcharge period is unknown.