Poulos, seems to be significantly greater than indicated by most horizontal permeability data determined by small-scale laboratory and field permeability tests.

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Pedotechnical Aspects of Organic Soil Classification and Interpretation

GILBERT WILSON

ABSTRACT

Exploration and classification of organic soils in transportation research is done primarily to predict performance and impacts of construction activities. In the preliminary stages, published maps are included in the data base. There is a continuing need for improved methods of interpreting surveys performed by mapping agencies as the state of their art develops. For Canadian soil survey applications, the pedotechnical setting sheet has been proposed. The setting sheet is a modular framework in which soils and landscape data pertinent to engineering are presented graphically. The site-specific appearance of the mapping unit data has resulted in slow acceptance. This question is addressed using the case history of a geotechnical site appraisal for embankment construction over highly organic soils. A feel for soil behavior is developed as the site investigation proceeds. In retrospect, it is seen that the graphic data, which are superimposed on the setting sheet background, pertain to the central concept of the mapping unit, and they are presented in this form in order to pass on the feel for soil behavior to others, with minimum effort and cost.

In transportation research the interest in classification of highly organic soils stems from the need to better predict performance and impacts of construction (1). For site appraisals, published maps and surveys may represent the only data base and interpretations of mapping units are provided in many areas (2). A continuing need exists for improved methods of classification and interpretation. For geotechnical applications, improvement should be such that a better feel for the soils mapped can be developed (3). The practical uses and limitations of existing classification schemes for organic soils are discussed by tracing the stages of a typical but difficult site investigation. Stemming from this is a proposal to make more effective use of this type of site experience and to assure that the information gained is made available for subsequent application.

METHOD AND MATERIALS

The method adopted is to review an actual case history of a geotechnical appraisal of a site for a low embankment structure, which took place more than 12 years ago, and then to compare the information available at the time with what is available today to see whether the same problems are recurrent.

Preliminary information for this site appraisal was obtained from the only readily available source, the Yarmouth County Soil Survey Report 9 (1960) (4) (Figures 1 and 2). Information from that source is then supplemented by field tests taken during the site investigation described (5). As the program of field testing proceeds, those responsible gradually develop a better feel for assessing the engineering parameters of the soils at the site. Although initially it might appear that these parameters are only applicable on a site-specific basis, by the time the investigation is complete it may be noted that a classification of regional significance develops.

FIGURE 1 Key to soil surveys, Nova Scotia.

The classification systems presently in use for interpreting organic soils information are discussed as are the more detailed type of geotechnical information needed and eventually obtained from the site investigation and a 1982 survey of the same area. The proposed graphic approach for improved information transfer is presented.

CASE HISTORY

A site appraisal was required to assess feasibility of embankment construction. Only a minimum amount of field work was to be done. (Note that appraisals may sometimes be required on condition that no evidence of exploratory work at sites be made public because of land speculation and other considerations.)

Published Surveys

In 1972 the only readily available source of soils information was the Yarmouth County Soil Survey Report. The site was located in mapping unit SM (Figure 2), which was defined on the map legend under the heading Miscellaneous Soils as salt marsh (SM), grey silt loam over dark grey silt loam, tidal deposit.

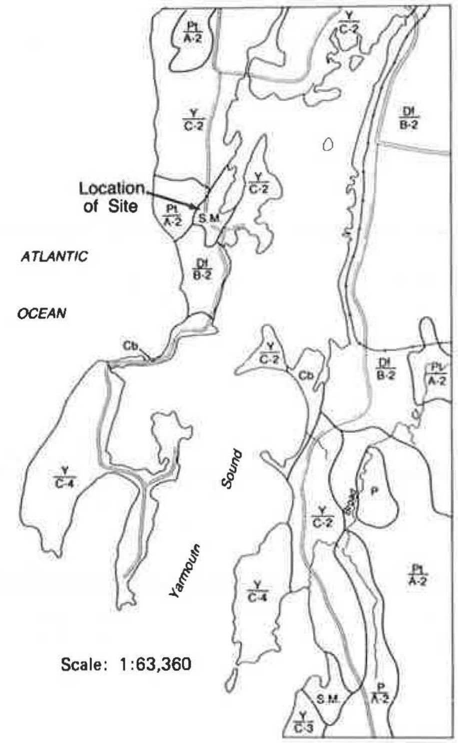


FIGURE 2 1958 soil map.

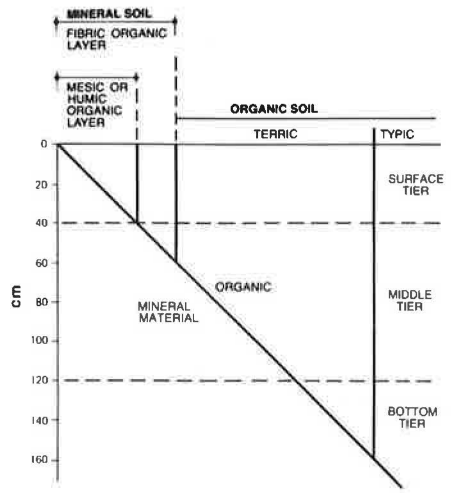
In the text of the soils report the mapping unit was further described as follows:

> The areas of salt marsh have developed as a result of repeated salt-water flooding of low lying coastal areas. Deposition of sediments at high tide has built up deep, medium textured deposits along tidal stream channels and in protected bays and inlets. The sediments deposited by tidal action in Yarmouth County are gray to olive in colour and are a uniform silt loam in texture. The surface is covered with salt-tolerant vegetation, chiefly marsh grass, sea blite and spurrey. Utilization: At present the salt marshes are of no value for agriculture. A number of areas in the county are under consideration for reclamation. If properly dyked and drained, the soils should be very fertile and productive (4,pp.35-36).

Interpretation for Site Appraisal

Consideration of different approaches to soil classification is necessary for interdisciplinary exchanges of information. The SM soil series was classified as miscellaneous and not organic soil because it did not meet the (pedological) requirements of 30 percent OM (6) (Figure 3). This requirement is contrasted with the geotechnical classification (7) (Figure 4). However, in terms of mode of deposition, salt marshes are generally equated with the "filling-in" process of peat soil deposition (8) (Figure 5). In geotechnical terms, this translates as normally consolidated soft or loose material.

The land use capability classification suggested no conflict between agriculture and proposed road construction (except for possible areas to be reclaimed as mentioned previously).



VON POST SCALE OF DECOMPOSITION

FIBRIC (Of)
1 **Undecomposed:**
2 **Almost undecomposed:**
3 **Very weakly decomposed:**
4 **Weakly decomposed:**
no peat substance escapes between the fingers

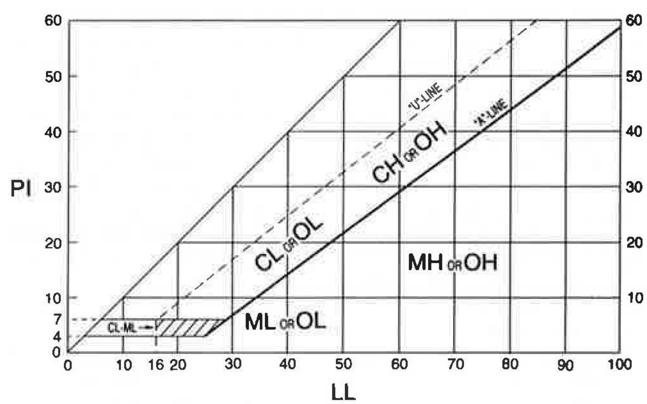
MESIC (Om)
5 **Moderately decomposed:**
6 **Strongly decomposed:**
a third of the peat escapes between the fingers

HUMIC (Oh)
7 **Strongly decomposed:**
half the peat escapes between the fingers
8 **Very strongly decomposed:**
9 **Almost completely decomposed:**
10 **Completely decomposed:**

OM = 30%

Organic soil > Mineral soil

FIGURE 3 Organic soil classification–pedology.



$$\frac{\text{LL (air)}}{\text{LL (oven)}} = .75$$

Organic soil < Inorganic soil

FIGURE 4 Organic soil classification–geotechnics.

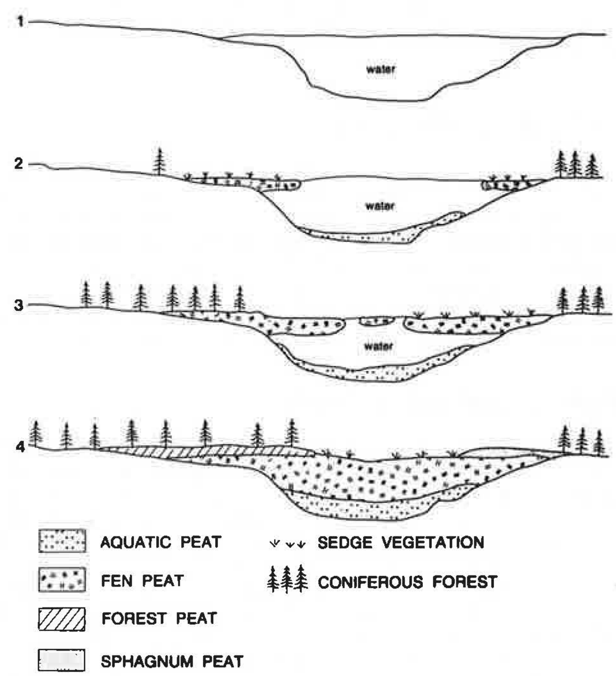


FIGURE 5 Stages of "filling-in" process.

Low embankment structures required for road construction might be feasible, but a rationale for deriving engineering strength parameters from organic soil classification symbols could not be found. In situ strength parameters normally will result from additional investigations performed at the site. The interpretation sheet (Figure 6) illustrates briefly the nature of the parameters required. Embankment height was related (by slip-circle and bearing-capacity analyses) to soil strength where the latter increases with depth as in normally consolidated soils. A brief investigation was undertaken to provide the required samples for laboratory testing and characterization of the SM soils at the site.

Site Investigation

Tidal conditions in the salt marshes indicated drilling from a fishing boat in the tidal channels would be most practical. The first significant finding was that the deposit in places exceeded 100 ft (approximately 30 m) in depth and appeared to be, as expected according to the "filling-in" process, loose and normally consolidated.

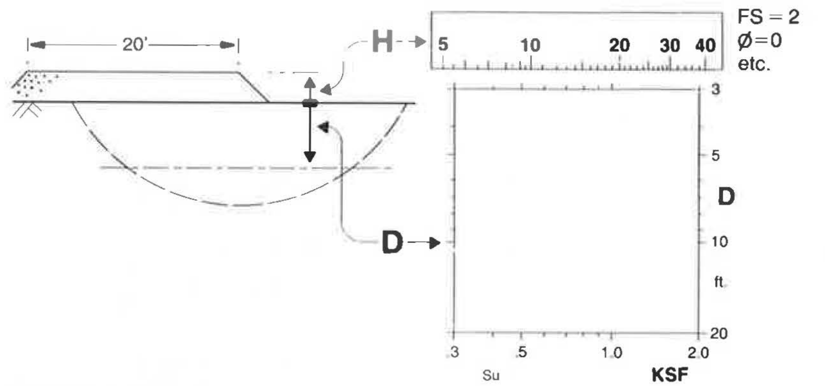


FIGURE 6 Embankment height: interpretation required.

The next significant finding, however, was the erratic nature of the test results obtained from the samples recovered. Undrained shear strength (Su) values varied from 0 to 1.0 KSF (0 to 50 Kpa), while direct shear tests indicated 0' values up to 50 degrees. Sample disturbance was suspected as the major cause, partly because of the influence on the sampling process of the vegetation and organic fibers coupled with adverse drilling and sampling conditions in the tidal zone. The first phase of the site investigation consequently did not greatly improve on the published soil survey information, and a reasonable interpretation of the shear strength characteristics of the SM soils could not be given.

Additional Laboratory Work

A laboratory testing program using the SHANSEP system of reconstituting soil samples was attempted (9). The reconstituted samples seemed to account for the disturbance of the softer soils, but the values obtained were still much less than those of the other (apparently less "disturbed") soils. The second phase of the site investigation consequently did not greatly improve on the initial information.

Additional Field Vane Testing

A program of additional in situ testing using the field vane was attempted to determine whether the SHANSEP reconstituted strength values were reasonable. The results of the in situ testing indicated only that strength values appeared to be as much as 3 to 4 times greater than those obtained by the other methods. It has also been reported elsewhere (10) that maximum torque in organic soils due to strength of fibers may occur at vane rotations exceeding 270 degrees. The additional in situ testing resulted in still less confidence in the site investigation work. This type of confusion, which often occurs when attempting to obtain practical interpretations from organic soil tests, has also been reported by others (11).

Additional in situ Testing

There is a method of soil sampling by which the undrained shear strength of cohesive soils in situ can be obtained while a good-quality undisturbed sample of the soil is recovered for laboratory verification (12). The in situ testing program was extended once more to include the square tube tests. The result was confirmation (for the SM soils in this area) that normal relationships generally existed between strength values determined by undrained compression tests on undisturbed samples and torque tests (e.g., field vane, square tube). The initial field vane test results were then suspect and eventually the high values that had previously been obtained were traced to errors due to inaccurate torque wrench calibration.

Interpretation of Extended Investigation

By checking and rechecking in situ strengths with carefully selected undisturbed samples, it was eventually substantiated that, despite the fact that the deposit was normally consolidated according to its depositional history and the "filling-in" process, the in situ strength varied significantly both horizontally and vertically throughout the deposit.

When this had been confirmed, confidence in the site investigation results was regained and sample disturbance was considered as only a minor factor. It was then possible to consider the genesis of such erratic strength characteristics of a normally consolidated loose deposit.

The soil moisture diagram (4) indicates that, for soils exposed at the surface during the months of June, July, and August, there is a potential soil moisture deficiency that could result in overconsolidated (stronger) surface soils due to moisture tension. Stronger soils could exist alongside normally consolidated deposits underlying the tidal channels. These two different surface conditions could account for the horizontal strength variations. If, however, at the same time, the land surface was also slowly subsiding, similar combinations of overconsolidated and normally consolidated soils could be expected to be repeated in depth. The dynamic action of the highly specialized vegetation would be evident maintaining the ground surface near the mid-tide level, keeping pace with subsidence, and acting as a medium for soil particle attraction and soil accumulation in the tidal zone.

With this interpretation it was possible to get a better feel for the probable engineering performance of these salt marsh soils. For low embankment construction, the marsh soils between the tidal channels might be significantly stronger than the soils underlying the channels. Consequently further investigation was warranted.

Additional Testing Between Channels

Additional testing of the tidal land between the channels confirmed higher strength values. It was

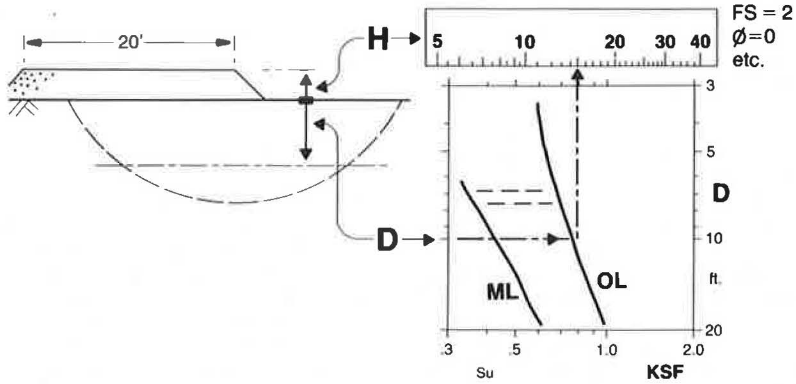


FIGURE 7 Embankment height: interpretation completed.

finally possible to complete the soil strength interpretation sheet and equate the SM map unit soils in terms of an appraisal for embankment construction (Figure 7). The low plastic organic silts (OL soils) between the channels had undrained strength values in a range that could be defined by a strength profile increasing from 1/2 KSF at 3 ft to 1 KSF at 20 ft. The dashed lines indicate that minor layers of normally consolidated low plastic silts (ML soils) could be expected at odd intervals. In terms of embankment height, this strength profile could be interpreted as indicating construction of embankments up to 15 ft (approximately 3 m) to be generally feasible.

The ML soils underlying the channels tend, however, to be mainly normally consolidated, with only minor layers of the stronger OL soils, indicated by the same dashed lines. Piled foundations for crossing structures would probably be required in these channel areas.

APPLICATION OF CASE HISTORY

Site investigations for embankments and other structures have been shown to be educational experiences for those taking part. Engineers generally have a more confident feel for the total soil environment at the site afterwards. A considerable waste of time and effort results if all of this site information is then lost or not made easily available to others. It should be noted that the hypothesis of a subsiding coastline was upheld when, toward the end of the investigation, some peat was recovered at a depth of 100 ft (approximately 30 m). Carbon dating indicated that coastline submergence has been occurring at an average rate of approximately 1 ft (0.3 m) per 100 years for the past 10,000 years.

It would be of value to know if other investigators would be likely to repeat the same lengthy process to answer a similar request today. Since the site investigation in 1972, the sources of published information for the area have increased. A section of the up-to-date Surficial Geology map (1982) is shown in Figure 8 (13). Neither the SM unit nor its surficial geology equivalent is described on the new map. This new map was compiled mostly for geochemical and mineralogical purposes as illustrated by the symbols and by the coastal section (personal communication with authors). Given time for scientific search and research, papers written on the question of submerging coastlines in Nova Scotia could be found, but the engineer involved in preliminary appraisals would have to be aware of the condition beforehand in order to find the information (14,15). Different personnel conducting a modern investigation would probably have to repeat the "educational" experience before being able to give a realistic appraisal of the same soils.

Soil surveys are based on the recurrence of similar landscape patterns within the same climatic region. Certain landscape parameters are likely to be common to all similar landscapes classified as one mapping unit. The mapping unit (e.g., SM) can be defined in terms of these general parameters. A specific map unit like the one SM unit discussed, will have these parameters plus others that are specific to it. Strength might appear to be in this category. Characteristics typical of a subsiding coastline, however, are likely to be of regional

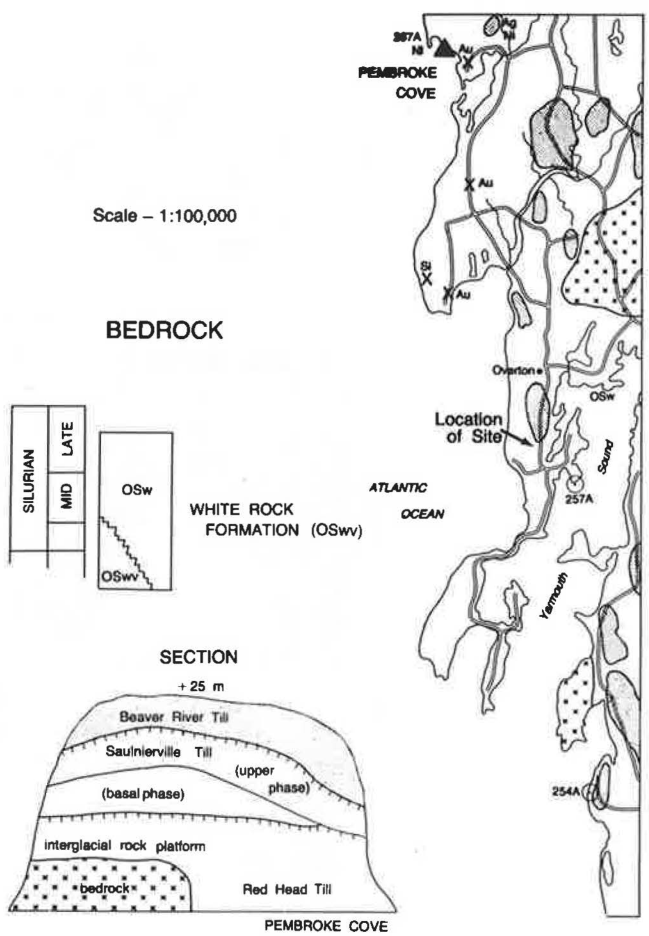


FIGURE 8 Pleistocene geology (13).

significance (14), and the nature of the strength profile given should also be characteristic, in a general way, of all landscapes denoted by the mapping unit. The interpretation sheet (Figure 7) could be considered an effective addition to the classification symbols ML and OL in describing the nature of the SM unit soils and their interpretation in terms of low embankment construction.

In the process of updating soil survey maps the addition of a graphic classification scheme defined by the setting sheet (16) has the advantage of making a considerable amount of in situ information readily available (Figures 9 and 10). In part 1 of Figure 9, for example, the story of the tidal channels and the land in between, the subsiding coastline, and so forth is told using only two or three lines and a few symbols.

Part 2 of Figure 9 is the soil-moisture diagram given in the soils report (4). Part 4 in Figure 10 shows textural characteristics and the guidelines by which determinations can be quickly and easily made (17). With information presented in this form, educational experiences do not have to be repeated indefinitely.

Also of interest are the land use interpretations. Reclamation of salt marsh soils by drainage, in the light of known regional coastal subsidence, no longer seems to be sound agricultural practice. It is evident that updating of soil surveys using simple graphics as illustrated would also improve the validity of land use interpretations.

CONCLUSIONS

Some very useful information for site appraisal purposes can be gained from existing organic soil classification systems using published surveys (in this case, a 1958 soil survey map). It often requires a considerable amount of detailed field work to improve on the information given.

As is true for most classification systems, improvements can be justified. Case history analysis can illustrate the nature of the improvements required. The graphic system proposed has had slow acceptance in Canadian soil surveys, partly because graphics give the impression that too much information of a site-specific nature is being given (18). The foregoing discussion demonstrates that the geotechnical use of published soil survey information has nothing to do with engineering design for specific sites and that site investigations cannot be circumvented by this type of generalized information. Site selection on the other hand can be made effectively on the basis of appraisals. In addition,

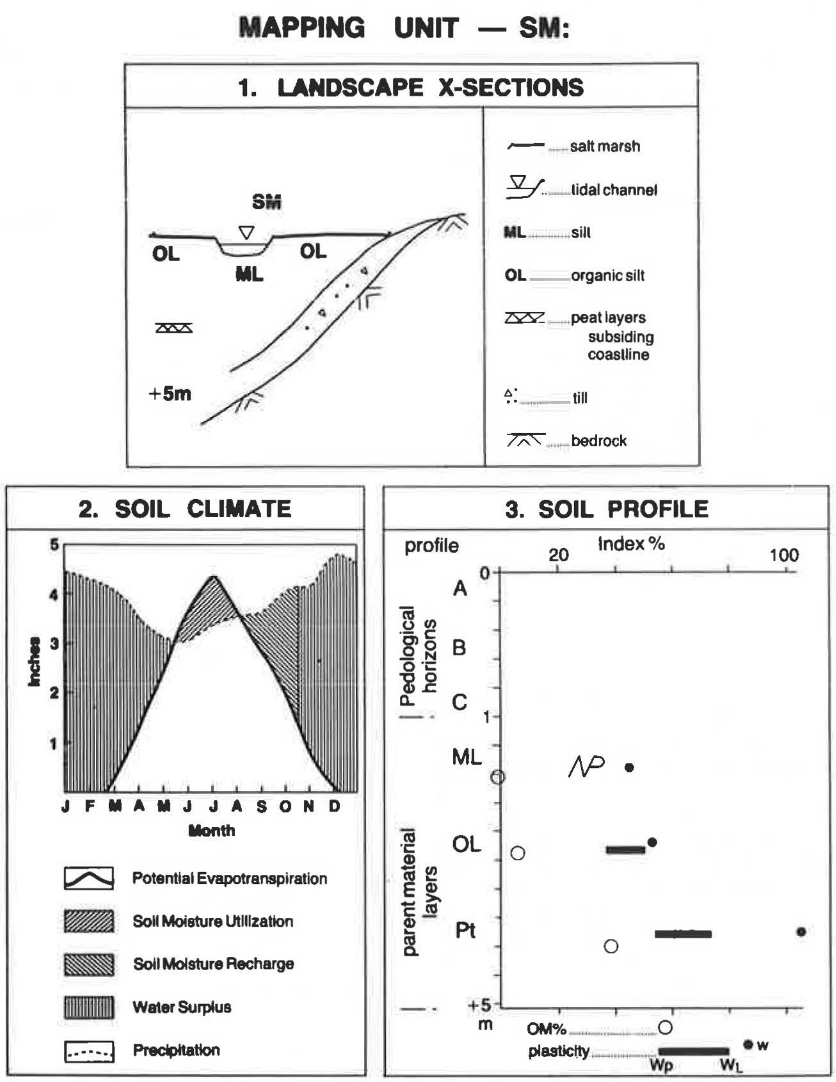


FIGURE 9 Setting sheet: parts 1, 2, and 3.

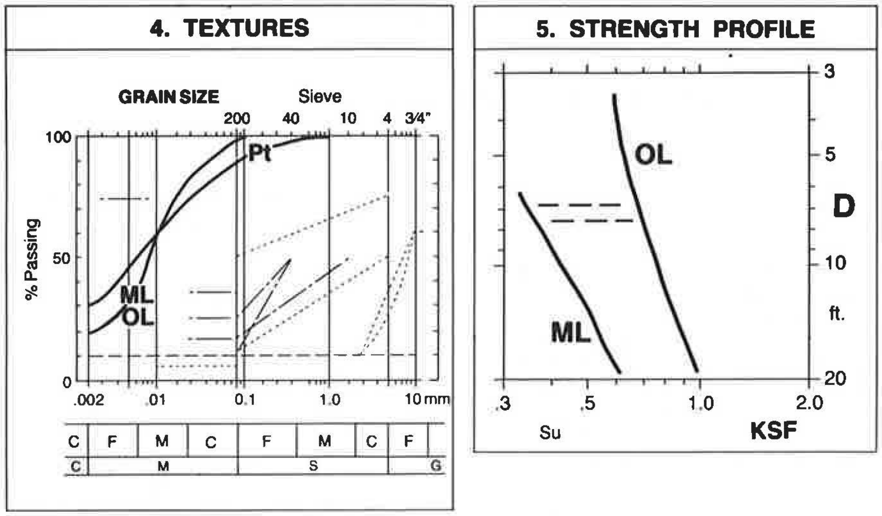


FIGURE 10 Setting sheet: parts 4 and 5.

the interpretation of site information can be greatly improved if a feel for soil behavior has already been developed from existing information.

These conclusions have been reinforced by the remarks of a reviewer who draws attention to yet another recent site investigation in this region where the same problems were found in attempting to interpret field tests in this type of organic soil.

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