Application of Soil Survey Data to Highway Engineering in Kansas

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● SOIL surveys conducted by the Kansas Highway Department are divided into three types. About 200 mi. of preliminary soil survey are conducted each year in conjunction with preliminary plan surveys on locations that are to be completely regraded. After grading is completed on each project a subgrade survey is made on locations where a flexible surface is planned to determine the final subgrade stability and the base and surface thickness requirements. On one or two projects each year, high embankments are planned across locations where the foundation soils appear to be so weak that a subsurface investigation is deemed advisable to determine safe fill heights and slopes.

As shown in Figure 1, during the preliminary soil surveys test borings extending below all probable excavation limits are made at intervals along the project. The soil layers encountered in each test hole are tentatively classified into their textural grading groups and their plastic index is estimated. The existing soil density is determined at intervals of from ¼ to ½ mi., depending upon the frequency of soil changes and the volume of excavation that will be involved during construction.

Samples representing each soil type on the project are submitted to the laboratory, where plasticity and textural grading tests are conducted for identification purposes. Standard compaction tests are made for use in cut to fill shrinkage computations, and for compaction control during construction, and triaxial-compression tests are conducted to determine stability and surface thickness requirements.

Thus, for a grading project the available soils data includes the type and extent of each soil on the job, its in-place density, its probable final density in the grade, and its supporting value as a subgrade material. Accompanied by a written report this data is forewarded to the road design engineer who applies it during the preparation of grading plans.

One of the primary uses of this data is in the computation of earth-work quantities. When the existing soil density and the required compacted density are known the cut-to-fill shrinkage can be accurately computed, with a reduction in the amount of soil wasted or borrowed during final stages of the grading operations. It has been found that the computed shrinkage based on comparative soil-density values agree quite closely with the actual shrinkage that occurs during construction.

A second important use made of soil-survey data during plan preparation is soil selection. The triaxial-compression test results accurately indicate the stability or bearing power value of each soil when used for subgrade construction. It is therefore comparatively easy to determine whether or not it is economically feasible to bury the weak soils in the bottoms of embankments and place the most stable ones at the top of the road structure where they will effectively reduce base-and surface-thickness requirements. Where the majority of soils have about equal stability, soil selection is not economically feasible, but on locations where highly stable granular materials are available they have been placed on top of the grade during earthwork construction with a resultant saving in surfacing costs due to lower base-thickness requirements.

Likewise, where expansive betonitic clays and weak partly weathered clay shales are found within excavation limits, the plans require that they be topped with more-stable soils through both cut and fill sections. Shoulders and slopes constructed of clean sands are topped with the more fertile A horizon soils to encourage plant growth and reduce erosion losses.

A third application of soil-survey data to road design is in the advance prediction of the approximate thickness of base course and wearing surface that will be required to carry expected traffic loads

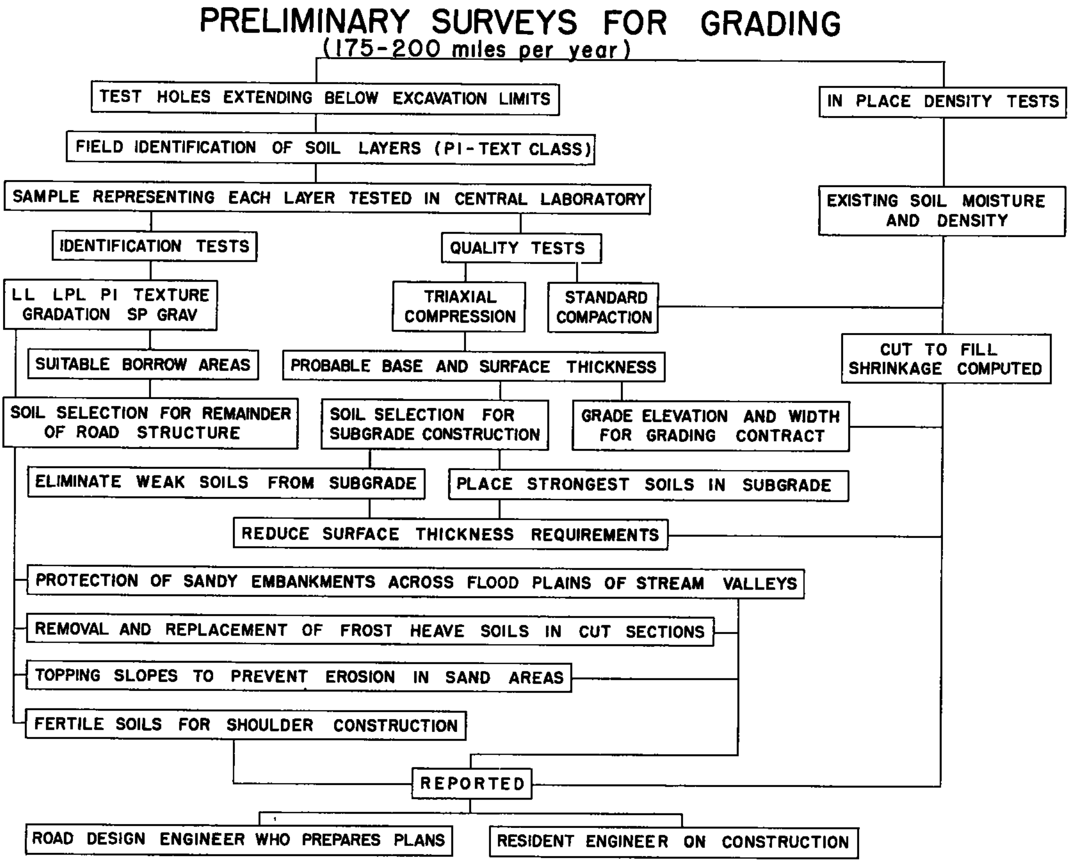

Figure 1.

over the soils that are available for subgrade construction.

Since the surfacing contract is awarded separately from the grading contract, the grading operations are carried only to the bottom of the proposed base course and the earth shoulders are constructed later by the base contractor. It is therefore essential that the road-design engineer know the probable required base thickness, so he can establish the earthwork grade width and elevation at the proper distance below final crown grade for the project.

The soil-survey data and report also designates unfavorable borrow areas or channel-change location where the presence of rock, clean sand, or excessively wet soils will interfere with construction progress.

Occasionally high embankments must be placed on soils of doubtful stability. The general procedure followed during the investigation is shown in Figure 2. At such locations, more-detailed probe borings extending to sand, rock, or shale are made and undisturbed samples are obtained from each foundation soil layer. Values of internal friction and cohesion and the probable amount and rate of settlement are determined for each layer from triaxial shear and consolidation test results. The

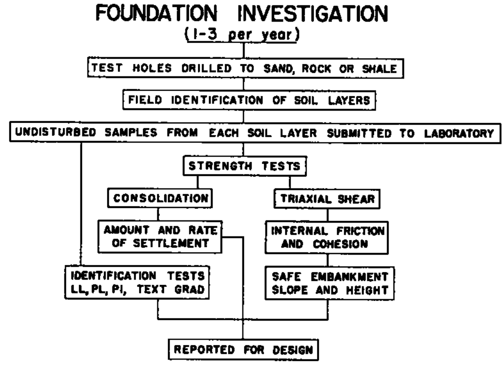

Figure 2.

safe height of fill for various embankment slopes are computed and the embankment is then designed in accordance with these findings.

As shown in Figure 3, during the subgrade survey two or more undisturbed samples of each type of soil are obtained from the upper 12 to 18 in. of the completed grade on roads that are to be improved with a flexible base and wearing surface. From three to five undisturbed samples per mile are sufficient for this type of survey, unless soil changes are very frequent or exceptionally weak soils are present. Triaxial-compression tests are conducted on these samples and the test results are used to evaluate the stability of each subgrade soil and its ability to support expected traffic loads.

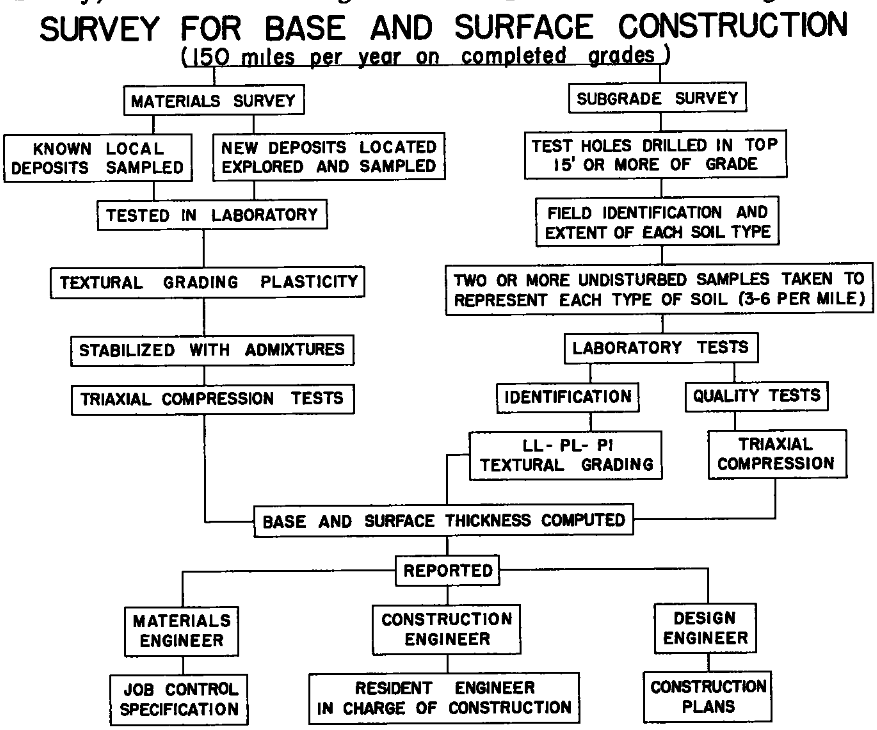

Figure 3.

During the subgrade survey deposits of aggregate that lie nearest the project are samples and combined in the laboratory with various proportions of portland cement or asphalt to produce a stabilized base material that is relatively unaffected by moisture. Triaxial-compression tests are conducted on these mixtures to measure their stability and the test results along with those obtained from textural tests conducted on the undisturbed subgrade samples are used to compute the final base-thickness requirements for the project.

The results of these tests and computations are reported to the road design engineer who prepares base and surfacing plans. The report specifies the base thickness required for each section of the improvement. Where tests show that weak subgrade soils occur the base thickness is increased and where the subgrade is found to be stable as measured by triaxial tests the base thickness is reduced.

The materials investigation and survey data are used to estimate construction costs and as a guide in writing project specifications. The specifications governing base materials are written to permit the contractor to make best use of roadside or nearby materials deposits, with a resultant saving in construction costs.

During earthwork construction the foregoing soil-survey data is applied to the control of soil compaction and in the proper selection and placement of soils for different portions of the road structure.

Materials data and base-thickness information is used by the engineer in charge of base construction to build a durable base capable of carrying current and predicted traffic loads.