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HIGHWAY RESEARCH CIRCULAR

Number 111 Subject Area: Exploration-Classification (Soils), Foundations (Soils), Mechanics (Earth Mass), Soil Science, Construction, General Materials, Photogrammetry, Highway Design, Pavement Design October 1970

COMMITTEE ACTIVITY
Committee on Research Needs
Department of Soils, Geology and Foundations
Highway Research Board

Supplementary Research Needs Statements

The research needs statements presented here are supplementary to those presented in Highway Research Circular No. 37, August 1966. Some are restatements of previous research needs, while others are new statements. There is also a group of restatements of urgency for some of the previous problems. The reader is referred to Circular No. 37 (73 pages) for a more complete listing of research needs in the soils areas.

These statements were furnished by the committees of the Soils, Geology and Foundations Department and correlated and assembled by the SGF Research Needs Committee. Statements are numbered in keeping with the scheme developed in Circular No. 37.

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As of December 1969

A2-7 Problem: TO DETERMINE EFFECTS OF USE OF CALCIUM CHLORIDE IN CEMENT-, LIME-, OR LIME-FLY ASH-TREATED SOIL AGGREGATE BASE OR SUBBASE COURSES. (This is a rewrite of A2-7 of Circular No. 37.)

Problem Area: Difficulties with the construction of cement-, lime- or lime-fly ash-treated soil aggregate base or subbase courses many times occur toward the end of the construction season. This makes desirable a means of accelerating strength gains. Some hot weather projects are faced with the problem of rapid evaporations and need a means of achieving and maintaining optimum moisture and uniform density. Some stabilized base courses evidence contraction cracks which reflect through the flexible surface. There is a definite need to reduce this cracking and its attendant problems. In addition, many soils will not stabilize with cement primarily due to the presence of organic matter.

Objectives: (a) To determine the effects of an admixture of calcium chloride on cement-, lime-, or lime-fly ash-treated aggregate base or subbase courses in accelerating strength gains.

(b) To determine the effects of the admixture in achieving and maintaining optimum moisture and uniform density.

(c) To determine the effects of the admixture in reducing reflective cracking.

To determine if calcium chloride under actual field conditions will be an aid in constructing soil-cement bases in soils that normally will not stabilize with cement because of organic materials contained in the soils. Laboratory tests indicate that calcium chloride will stabilize such soils, however, field problems should be instigated to verify the laboratory test results.

Urgency: The continuing efforts to improve the secondary and tertiary road systems will continue to result in thousands of miles of flexible pavements, and this knowledge is needed to facilitate construction and reduce maintenance. In addition, in many areas aggregates for base material have to be shipped long distances, consequently this is very expensive. If soil-cement stabilization can be used this would result in considerable savings.

A4-1 Problem: TO DETERMINE THE LOAD-DEFLECTION CHARACTERISTICS OF SOIL-LIME FOUNDATION LAYERS.
(Restatement of Urgency)

Urgency: Our rapidly dwindling supply of local materials makes it imperative that we know to what extent we can reduce our total thickness of granular materials due to the added strength gained by use of subgrade lime additive.

A4-2 Problem: THE DETERMINATION OF UNIFORM TEST PROCEDURES FOR QUALITY CONTROL AND DURABILITY OF LIME- OR LIME-FLY ASH-TREATED SOILS AND AGGREGATES.
(Restatement of Urgency)

Urgency: Many of the people who are controlling the lime work in the field know very little about the importance of handling and testing the lime, as it is used in stabilization work. A good uniform test procedure would do much in helping to produce better quality and uniformly stabilized subgrades.

A4-5 Problem: TO DEVELOP A RATIONAL DESIGN PROCEDURE FOR SOIL-LIME MIXTURES.
(Restatement of Urgency)

Urgency: This problem is somewhat related to the A4-1 problem but further, we need to know how the added subgrade strength relates to the individual component parts of the flexible pavements in regard to load carrying capacity, especially in the northern states, where frost damage to subgrades is always a springtime problem.

A5-6 Problem: TO DETERMINE VOLUME CHANGE AND SHRINKAGE CRACKING RELATIONSHIPS IN SOIL-CEMENT MIXTURES.
(Restatement of Urgency)

Urgency: Reflection cracks are showing up early in the life of soil-cement pavements, adding to their cost through increased maintenance.

B3-13 Problem: DEVELOPMENT AND CORRELATION OF AN IN-PLACE SOIL SHEAR STRENGTH TESTER. The development and correlation of a simple method of determining the "in-place" shear strength of various soil materials with an instrument lowered into a cored hole and used during foundation exploration is needed. The shear strength of various soils are now determined by triaxial tests on undisturbed samples provided they can be obtained, from in-place vane shear tests in the weaker soils or by various penetrometer tests. Due to the variable nature of foundation soil materials, engineers need a reliable method of determining shear strength of all soil materials in-place to be used in foundation design.
(New Statement)

Problem Area: The problem pertains to the design, development and correlation of an "in-place" shear strength test instrument to obtain reliable data during foundation exploration for foundation design.

Objectives: The objectives of this research problem are:

(a) To search the literature for available in-place soil shear testers.

(b) To select and evaluate an instrument which fits the need or design a new instrument to meet the necessary requirements and specifications.

(c) To correlate and prove out the instrument and furnish necessary design aids, charts, etc.

References: "Menard Pressure Meter" distributed by Geocel, 16027 West 5th Avenue, Golden, Colorado 80401. This equipment is presently being evaluated by J. L. Beaton, Materials and Research Engineer, California Division of Highways; by Mr. Frank Higgins, Soils Research Engineer, Louisiana Department of Highways; Mr. Clyde F. Silvus, Bridge Engineer, Texas Highway Department; Geocel (Terrametrics) test services performed in Kansas for Van Doren, Hazard, Stallings, Schnacke and the Kansas Highway Department in conjunction with drilled shaft load test research; scheduled research for Illinois Department of Highways on July 1st for a Mississippi River Bridge.

"A Study of Bearing Capacity of Deep Foundations," Aleksandar S. Vesic, Georgia Institute of Technology, Atlanta, Georgia, Research Project B-189 in contract with State Highway Department of Georgia and BPR, use of a static penetrometer test March 1967.

"Friction Jacket Static Cone for Soil Exploration," by John H. Schmertmann, Professor of Civil Engineering, University of Florida, Gainesville, Florida.

Urgency: More realistic foundation design with resultant economics may be realized provided a more realistic method of determining the shear strength of all soils in-place can be developed.

B3-14 Problem: MEASUREMENT OF STRESS AND STRAIN IN SOIL. Although stress, and to a lesser extent strain, measurements have been made in soil for many years, there has been little critical evaluation of the gages and techniques used. There are many contradictory opinions on the subject and available reports suggest that much of the data obtained may be incorrect or uninterpretable because of a lack of understanding of the factors influencing such measurements. (New statement)

Problem Area: Many significant soil mechanics problems involve a knowledge of the stresses and strains in the soil, for example design of buried structures or pavements. These stresses and strains can generally only be assessed indirectly or estimated theoretically because of lack of suitable methods for direct measurement. There are many important phenomena which can never be completely understood until adequate experimental techniques become available. One example is the mechanism of load transfer around buried structures because of the difference in stiffness between the soil and the structure. Because gages are in themselves buried structures this subject is appropriate for the buried structures committee of HRB.

Objectives: A variety of stress and strain gages are available. The most pressing need is for adequate methods of evaluating the capability of these gages, the techniques for placement in soil and the important factors involved. The latter will aid in improving gage design.

References: "A Review of Stress and Strain Measurement in Soil,"

Proceedings of the Symposium on Soil-Structure Interaction, University of Arizona, Tucson, Arizona, pp. 172-186, Sept. 1964.

Urgency: Many of the most important questions regarding soil-structure interaction will remain unanswered until suitable measurements of stress and strain in the soil can be obtained.

C1-1, 2, 3, 4, 5

Problem: RESEARCH IN INTERPRETATION TECHNIQUES UTILIZING COMBINATIONS OF CONVENTIONAL AERIAL PHOTOGRAPHY AND INFRARED THERMAL IMAGERY. The techniques of combining Panchromatic, Color, and Infrared photography with Infrared Thermal Imagery have not been developed for the purpose of conducting soils and materials surveys, although each of the types of aerial films has been found useful in terrain studies and for particular purposes related to soils, drainage and foundation condition investigations.
(A restatement and combination of previous problems C1-1, 2, 3, 4, 5)

Problem Area: This problem is in the broad area of airphoto interpretation of soils and search for road building materials.

Objectives: To develop the techniques of combining several types of films for investigating and procuring data on soils and terrain for highway engineering design purposes.

References: Some work has been accomplished at The Ohio State University, USAF, Cambridge Research Laboratories, and the University of Michigan with different conventional film types, camera configurations and thermal imagery, respectively.

Urgency: This is a very important research that can be conducted to improve the usefulness of the techniques of photo interpretation of soils as an investigative means for determining soils, drainage and foundation conditions.

C1-11

Problem: THE EFFECT OF DATE OF PHOTOGRAPHY ON AIRPHOTO INTERPRETATION FOR SOIL STUDIES. The airphoto appearance of land areas is not the same throughout the year. Airphotos taken of the same area on different dates have different tonal patterns and this complicates the interpretation process, especially when one is using airphoto interpretation to predict soil conditions.
(New statement)

Problem Area: This problem belongs in the broad area of airphoto interpretation of soils.

Objectives: To evaluate the effect of date of photography on airphoto interpretation for soil studies and to determine if there is an optimum time of year for taking aerial photographs for airphoto interpretation purposes. This problem is interrelated with those outlined in Research Problem Statements C1-1, C1-2, C1-3, and C1-4 as there may be some optimum film-filter-date combination for airphoto interpretation for soil studies.

References: Limited work on this problem has been accomplished at the University of Wisconsin under Project Wisconsin HPR-1 (2) (910) in cooperation with the Wisconsin Highway Commission and the U. S. Bureau of Public Roads.

"Airphoto Interpretation for Soil Studies" by Dr. Ralph W. Kiefer, Engineering Experiment Station, The University of Wisconsin, Madison, Wisconsin, December 1966.

Urgency: This is a required step in improving airphoto interpretation techniques for soils surveys and materials exploration.

C3-3 Problem: FACTORS INFLUENCING SWELL AND EQUILIBRIUM MOISTURE OR SUCTION POTENTIALS UNDER PAVEMENTS.
(a restatement)

Problem Area: Excessive soil moisture generally results in loss of strength. Moisture migration often extends over long periods of time before the accumulation is sufficient to cause troubles. Associated with the moisture migration is the problem of swell which causes damage to pavement structures.

Objective: To develop physico-chemical tests to predict ultimate subgrade suction profiles and swell under in-service conditions.

References: "Prediction of Swell Potential of Compacted Clays", Trans. ASCE, Vol. 128, Part 1, Proc. Paper No. 3501, 1963.

"Identification and Behavior of Compacted Expansive Clays," 5th I.C.S.M.F.E., Paris, 1961.

Urgency: The identification and prediction of suction profiles and swell in soils are necessary to the successful design of road pavements.

C3-4 Problem: DEVELOP PHYSICO-CHEMICAL TESTS AS INDICATORS OF ENGINEERING PROPERTIES AND SUITABILITY OF A SOIL FOR STABILIZATION.
(A restatement of C3-4)

Problem Area: Lack of a suitable test to describe the compositional and environmental factors of a clay-water electrolyte system has retarded our ability to predict the engineering behavior of soils.

Objectives: (a) To develop an indicator test. (b) To develop correlations with engineering properties and provide guides for the use of such tests.

References: "Electrical Dispersion in Relation to Soil Structure", Journ. Soil Mech. Found. Div. SM2 5853, 1968

"Low Frequency Dispersion of Clay-Water-Electrolyte Systems", Clays and Clay Minerals 16, 337-351, 1968

Urgency: These methods and guides are necessary to aid in the proper usage of the physico-chemical properties of soils in predicting engineering behavior.

C3-7 Problem: FUNDAMENTAL RESEARCH INTO RELATIONSHIPS BETWEEN PHYSICO-CHEMICAL AND MECHANICAL PROPERTIES OF SOILS.
(New statement)

Problem Area: The accurate characterization of the strength, compressibility and permeability of a soil under any set of boundary and environmental conditions, and the direction and magnitude of future changes in the above properties is needed for use in any soil mechanics problem. Physico-chemical considerations are necessary for explanation of the fundamentals of soil behavior.

Objectives: (a) Development of correlations between the geometrical arrangement of clay particles (fabric) and engineering behavior.

(b) Determination of the properties of adsorbed water on soils.

(c) Determination of the mechanisms responsible for friction and cohesion between soil particles.

(d) Determination of the influence of physico-chemical effects on conduction phenomena, compressibility, and shear strength of soils.

References: "Structural and Physico-Chemical Effects on the Properties of Clays", Proc. Seventh Int. Conf. on Soil Mech. and Found. Engineering, Vol. 3, pp. 455-471, Mexico City, 1969.

Urgency: The results of the above studies are necessary for selection of appropriate testing methods and interpretation of soil behavior for use in design and analysis of soil engineering problems.

C3-8 Problem: DEVELOP NEW STABILIZATION METHODS--THERMAL FUSION, ELECTRO-CHEMICAL HARDENING, PLASTIC AND RESINS AS STABILIZERS.
(New statement)

Problem Area: Poor soil conditions may threaten existing structures or eliminate sites as inadequate for support of pavements and structures. New techniques for increasing the strength and reducing the compressibility of both shallow and deep foundation layers are needed to supplement the conventional methods now used.

Objectives: (a) Development of thermal fusion methods for stabilizing fine-grained soils.

(b) Development of stabilization techniques using electro-chemical hardening.

(c) Development of new methods of admixture stabilization using plastics (foaming and non-foaming) and resins.

References: "Subgrade Stabilization Under an Existing Runway", Journal of the Aero-space Transport Division, Vol. 89, No. AT1, April 1963, Proc. Paper 3473.

"In-Place Treatment of Foundation Soils", Journal SMFD, ASCE, Jan. 1970.

"Soil Stabilization by Soil Mixer (Feasibility Study of)", Technical Report AFAPL-TR-69-18, Wright Patterson Air Force Base, Ohio, March 1969.

Urgency: The number of suitable foundation sites is decreasing rapidly. It is common at this time to build on sites that a few years ago would not have been considered. New methods of stabilization must be developed to alleviate this problem.

C3-9 Problem: RESEARCH ON THE EFFECT OF PHYSICO-CHEMICAL FACTORS ON THE EROSION OF SOILS.
(New statement)

Problem Area: Erosion of soils in earth slopes and in channels for drainage is of concern to highway engineers. Much of the research undertaken in the laboratory has been directed toward determining relationships between a critical boundary shear stress, above which a scour of cohesive material begins, and pertinent soil properties such as density, moisture content, percent clay, vane shear strength, plasticity index, liquid limit, shrinkage limit, soil gradation and type of ion adsorbed. However, the resistance of cohesive sediment to erosion is related to the electro-chemical bond between particles. This bond, in turn, depends on structure determining factors such as ionic charges on the particles, the type and amount of electrolyte, the mineralogy, etc. These factors are not considered in the erodibility study of cohesive soils. Further, there exists at present no engineering test which is universally acceptable and which can be used to predict the erodibility of soils in the field.

Objectives: (a) Selection of a suitable laboratory test to simulate the erosion in the field.

(b) Evaluation of the effects of physico-chemical factors on erosion.

(c) Development of indicator tests for erosion.

(d) Correlation of laboratory data with field performance.

(e) Development of new treatment methods to reduce erosion of unsurfaced soils.

References: "Erosion of Cohesive Sediments," Journal of Hydraulics Div. ASCE, July 1968.

Urgency: The above study of factors controlling erosion, development of laboratory tests to simulate erosion in the field, and development of an indicator test to predict erodibility of soils are necessary to predict the performance of highway slopes and drainage channels.

C4-8 Problem: A STUDY OF THE FEASIBILITY OF BLENDING EITHER NATURAL OR MANUFACTURED COARSE AGGREGATE WITH MARGINAL SOILS TO IMPROVE FROST HEAVE RESISTANCE.
(New statement)

Problem Area: Some soil gradations offer greater frost heaving resistance than others as well as increased stability. Many state and federal agency specifications require that gradations fall within specific limits. Gradations not meeting these requirements are rejected. It is believed that it may be possible to blend a mixture of various materials to obtain a desired product. Studies are needed to determine what combination of aggregates may be best to correct deficiencies found in natural deposits to make them suitable. This might make possible the effective use of material now being by-passed.

References: Preliminary studies by C. W. Kaplar and cooperative studies by University of New Hampshire investigators at USA CRREL have indicated improvement in frost heaving resistance merely by physical addition of coarse aggregate to a gradation containing excessive fines. Washing out of fines is another quite effective method of physical modification of dirty base courses.

Urgency: Suitable sources of frost free natural base course materials are almost depleted in many areas or otherwise unavailable. Considerable marginal or unsuitable material is believed available in substantial quantities. These should be used in most effective and economic manner possible.

C4-9 Problem: EFFECT OF FREEZING RATE ON DRY DENSITY OF COARSE-GRAINED SOILS.
(New statement)

Problem Area: Results could throw light on mechanics of soil freezing and on selection of base course material.

Objectives: To determine the rates of freezing that will not allow sufficient expulsion of water from saturated, coarse-grained soils to prevent a reduction in dry density, or to seek an answer to the

question: "Under what conditions will a so-called 'frost-free' soil prove susceptible to expansion when frozen and thus exhibit weakening when thawed?"

Urgency: This appears to be a basic sort of investigation and hence essential to a comprehensive knowledge of frost action in soil.

C5-5 Problem: EFFECT OF THERMAL GRADIENTS ON MOISTURE MIGRATION IN SOILS OF DIFFERENT COMPOSITIONS AND DEGREES OF SATURATION. (New statement)

Problem Area: Results could be valuable in predicting moisture conditions beneath slabs and in other circumstances where there are differences in moisture content and temperature.

Objective: The objective is to secure data on moisture movement, by vapor or other transfer, under thermal gradients for different soils and different degrees of saturation.

Urgency: Results are essential factors in any rationalization of moisture flow and accumulation caused by factors other than hydraulic head.