Highway Research Board Committee Activity

AD HOC COMMITTEE ON RESEARCH NEEDS OF THE DEPARTMENT OF SOILS, GEOLOGY AND FOUNDATIONS

RESEARCH NEEDS IN SOILS, GEOLOGY AND FOUNDATIONS

January 1964

The Department of Soils, Geology and Foundations, realizing the potential value to the highway program of a current listing of needed research, formed a committee with representatives from each of its project committees. The first objective was to prepare an initial listing of the items considered to be of prime interest for research within the scope of the Department.

After study and review a listing of 52 items was compiled. They were arranged in the following general areas:

I. Subsurface Drainage
II. Soil-Calcium Chloride Roads
III. Soil-Portland Cement Stabilization
IV. Soil-Sodium Chloride Stabilization
V. Stress Distribution in Earth Masses
VI. Survey and Treatment of Marsh Deposits
VII. Frost Heave and Frost Action in Soils
VIII. Surveying, Mapping and Classification of Soils

The order of listing of the areas of needed research and the problem statements are without reference to any priority assigned by the committee. Furthermore, the committee recognizes that the compilation of research needs may be redundant with other lists compiled earlier.

Much has been accomplished over the past years on many of the items included in this listing of research. In some cases, items presently considered important were also important several years ago. The committee believes that this serves to emphasize that the problems are continuing and that as research is reported there is always a need to develop this research to greater refinement of a particular problem.

It is the intent of the Department of Soils, Geology and Foundations to bring this listing of research needs up to date from time to time and to make the listing available to researchers throughout the world. It is believed that the statement of research needs should be especially beneficial to educational institutions, inasmuch as the listing outlines the principal problems of the practicing soils engineer.

RESEARCH NEEDED ON SUBSURFACE DRAINAGE

Research Problem Statement Number 1

Survey Effectiveness of Existing Subsurface Drainage Installations.

Considerable evident lack of adequate subsurface drainage shows need for study. Review of original condition, design of drainage, construction, maintenance records and present condition would provide data for improving design of subsurface drainage to maintain pavement stability.

Research Problem Statement Number 2

Determine Properties of Subsurface Drainage Conduits.

To aid in selecting the best conduit for a particular situation, an inventory is needed of engineering properties of conduits of various materials and configurations. These properties include cost, strength, durability, installation, and characteristics of flow into and through them.

Research Problem Statement Number 3

Determine Drainability of Soils, Bases, and Subbases.

Study by full-scale tests the effectiveness of various materials and geometry under various typical situations of soil and water for stabilizing soil and pavement. Provide engineering criteria for design selection.

Research Problem Statement Number 4

Refine Criteria for Filter Material in Subdrains.

Although criteria for selecting one-size materials for filters are well established, tests are needed to better specify use of widely graded materials against soil and adjacent to perforations or joints between pipes.

RESEARCH NEEDED FOR SOIL-CALCIUM CHLORIDE ROADS

Research Problem Statement Number 5

Determine Effects of Calcium Chloride on Performance of Unpaved Granular Shoulders.

Additional data are needed concerning the variables that influence the performance of various shoulder types. With respect to granular shoulders, the incorporation of calcium chloride may affect significantly many of the design features or performance variables; e.g., aggregate type and gradation, compaction characteristics, drainage, construction procedures and control, environmental factors, traffic, etc.

Studies should be undertaken to determine the uses and limitations of calcium chloride in the construction and maintenance of granular shoulders.

Research Problem Statement Number 6

Determine Effects of Calcium Chloride on Performance of Unpaved Roads.

Many qualitative statements and reports are available ascribing certain virtues to the use of calcium chloride in the construction and maintenance of unpaved roads. However, few reports have been made as a result of research that has been closely controlled technically.

There is a need for research relating to the uses and limitations of calcium chloride on unpaved roads as a means of maintaining density, reducing dust, and aggregate loss at various levels of traffic volume. These factors are important not only in regard to secondary road programs but also in relation to stage construction of primary routes.

Research Problem Statement Number 7

Determine Effects of Use of Calcium Chloride in Soil-Cement or Cement-Treated Aggregate Base or Subbase Courses.

The use of calcium chloride in soil-cement or in cement-treated aggregate base or subbase may result in several important advantages. Research is needed to relate the effectiveness of calcium chloride in (a) accelerating strength gain, (b) achieving and maintaining optimum moisture and uniform density, (c) reducing reflective cracking, and (d) reducing cement content.

Research Problem Statement Number 8

Determine Effects of Use of Calcium Chloride in Lime- or Lime-Fly Ash-Treated Soil Aggregate Base or Subbase Courses.

The use of calcium chloride in lime- or lime-fly ash-treated base or subbase courses may result in several important advantages. Research is needed to relate the effectiveness of calcium chloride in (a) accelerating strength gain, (b) achieving and maintaining optimum moisture and uniform density, and (c) reducing reflective cracking.

Research Problem Statement Number 9

Determine Effects of Calcium Chloride on Performance of Granular Bases.

The AASHO Road Test established the need for improving the uniformity of compaction and of strength of flexible pavement subsurface materials to minimize differential settlement along the wheelpaths.

Studies should be undertaken to determine the effects of calcium chloride on the compaction characteristics and performance of various types of granular base courses at various levels of compactive effort.

Research Problem Statement Number 10

Determine Effects of Calcium Chloride on Various Clay Minerals.

A dearth of information exists concerning the physico-chemical effects of adding calcium chloride to soil mixtures. Basic research of this nature is needed to determine more specifically the role of calcium chloride in highway soils engineering.

RESEARCH NEEDED FOR SOIL-PORTLAND CEMENT STABILIZATION

Research Problem Statement Number 11

Soil-Cement Construction Control Testing.

Study the methods of control testing now in use in connection with soil-cement construction to determine whether any improvements can be effected and study other methods that might possibly be applied to this work, with the objective of improving the ability to control soil-cement construction.

Research Problem Statement Number 12

Soil-Cement Construction Procedures.

Study presently used soil-cement construction procedures and equipment to determine whether any improvements can be effected and investigate the possibility of new procedures and equipment, with the objective of developing improved soil-cement construction procedures.

Research Problem Statement Number 13

Thickness Design for Soil-Cement Mixtures.

Investigate the physical properties of soil-cement mixtures in relation to existing or newly developed design procedures to develop a rational design procedure for soil-cement pavements, with the objective of developing a rational thickness design procedure.

Research Problem Statement Number 14

Re-evaluate Soil-Cement Test Methods and Criteria.

Re-evaluate present test methods and criteria for determining cement requirements for soil-cement, recommend changes and/or devise new test methods and criteria that determine cement requirements in one week's time.

Research Problem Statement Number 15

Chemistry of Soils and Soil-Cement Mixtures.

Study the chemical properties of soils to determine the relationship between these properties and the soils' reaction with portland cement, with the objective of developing a rational basis for the design of soil-cement mixes based on the chemical properties of the soil.

Research Problem Statement Number 16

Volume Change and Shrinkage Cracking in Soil-Cement Mixtures.

Evaluate factors which cause volume change in soil-cement mixtures and study ways and means of diminishing or eliminating reflective cracking through the bituminous surface, with the objective of devising practical means of reducing or eliminating the reflection of shrinkage cracks through the bituminous surface on soil-cement base courses.

RESEARCH NEEDED FOR SOIL-SODIUM CHLORIDE STABILIZATION

Research Problem Statement Number 17

Develop Laboratory Tests to Evaluate Effects of Sodium Chloride.

The area of soil-sodium chloride stabilization is lacking in basic research on the mechanism, economics, and effectiveness. The mechanism of sodium chloride stabilization requires laboratory study to better understand and thereby determine the most efficient usage of sodium chloride in the improvement of engineering soil properties. Laboratory tests would need to be correlated through controlled field test installation in normal road sections. The objective is to develop laboratory tests to indicate both qualitative and quantitative improvement of engineering properties of soil materials due to stabilization with sodium chloride.

RESEARCH NEEDED ON STRESS DISTRIBUTION IN EARTH MASSES

Research Problem Statement Number 18

Summary of Existing Methods for Determination of Stresses and Deformations in Semi-Infinite Media.

In view of the large amount of information available regarding stresses and deformation in semi-infinite media, it appears worthwhile to bring this information together in one publication, so that engineers would have available in one source all of the existing methods for stress and deformation analysis. The report should summarize these efforts into logical groups and include a critical examination of the assumptions and limitations of the work.

Research Problem Statement Number 19

Theoretical Analyses of Multilayer Elastic Systems.

To better understand pavement behavior and to permit extension of design to situations beyond the scope of today's problems, extension of the existing methods of three-layered analysis should include theoretical analyses of at least the following:

(a) Stress and deformation at any point within layered system.
(b) Effect of stress-transfer conditions at interface.
(c) Stress and deformation resulting from other shapes of loaded areas (e.g., ellipse) and pressure conditions other than uniform.
(d) Effect of multiple loads; e.g., dual wheels and tandem axles.
(e) Material properties different in tension and compression.
(f) Effect of shear stresses induced by braking and acceleration.

(g) Effect of finite rather than infinite boundary conditions (e.g., loading conditions near edge of portland cement concrete slab or in outer wheelpath of asphalt concrete pavement adjacent to unpaved shoulder).

In addition, practical solutions should be made available for an elastic system consisting of four or more layers and include the factors noted above for the three-layered system. This project would of necessity require extensive use of electronic computers.

Research Problem Statement Number 20

Theoretical Analyses of Multilayer Viscoelastic Systems.

This area should embrace the same general scope as Research Problem Statement Number 19 listed above. Of necessity it would require analysis of much simpler systems initially, because of the lack of available information on this type of behavior. This type of analysis would appear useful in evaluating the accumulation of small deformations in the pavement system under repetitive loadings, the effect of static wheel loads, and the effects of temperature changes.

Research Problem Statement Number 21

Theoretical Analyses of Multilayer Elasto-Plastic Systems.

This area should also embrace the same general scope as Research Problem Statement Number 19. As in Number 20, however, initial efforts should be directed toward the analysis of simple systems. This approach has the potential for consideration of effects of large shearing deformation.

Research Problem Statement Number 22

Evaluation of Material Properties.

Although material property evaluation falls within the scope of many committees of the Highway Research Board, specific material property determinations suitable for use in the four above-listed theoretical developments would appear to fall within the purview of the committee on stress distribution. Thus, indication of the following types of behavior is necessary:

(a) Elastic or pseudo-elastic behavior through;
  (1) suitable laboratory testing;
  (2) field testing, including a critical evaluation of vibratory testing (see Research Problem Statement Number 24).
(b) Viscoelastic behavior.
(c) Elasto-plastic behavior.

Research Problem Statement Number 23

Field Verification of Layered System Behavior.

In order that research in Research Problem Statements Number 18 through 22 will have engineering application, it is important that field performance under well-controlled test conditions be obtained. The area should embrace:

(a) Analysis of existing test road and test tract data, such as the results of the AASHO and WASHO Road Tests and Corps of Engineers test sections.
(b) Evaluation of in-situ equipment:
  (1) Pressure cells—over- and under-registration due to arching resulting from cell deformation.
  (2) Deflection and strain indication.
(c) Correlation of theoretical development with actual performance criteria. This latter is extremely important so that the preceding determinations are not merely academic exercises.

Research Problem Statement Number 24

Dynamic Pavement Behavior.

The dynamics of soil vibration are becoming of increasing importance in connection with compaction and with subgrade and pavement evaluation and in regard to the determination of suitable soil values (elastic and shear moduli and the equivalent) for use in connection with theoretical developments proposed for design. All of these add to the growing need for research results in soil dynamics as it applies to pavements.

Research Problem Statement Number 25

Stress Distribution in Soil Adjoining Culverts Due to High Fills and Live Loads.

Despite various research efforts both in regard to theorizing and to testing, there is little clear-cut knowledge of the pattern of stress distribution around buried culverts and of the effects of the culvert and loading characteristics on this pattern. Further effort is needed to collect and collate existing knowledge and to significantly extend this knowledge.

Research Problem Statement Number 26

Stress Distribution in Slopes, Embankments, and Underlying Materials.

At present there does not exist for common usage an analysis of the stresses and deflections induced in underlying materials due to embankment loadings. Available methods are predicated on replacing an embankment loading by an equivalent hydrostatic distribution with no shear condition either in the embankment or at the embankment-foundation interface. Analysis should also be directed to the determination of stresses and deflections in the embankment material.

RESEARCH NEEDED FOR SURVEY AND TREATMENT OF MARSH DEPOSITS

Research Problem Statement Number 27

Effect of Vertical Sand Drains, Including Comparison of Various Methods of Installation.

The installation of vertical sand drains has considerable effect on the engineering characteristics of the material into which the drains are placed. Some of this effect may be detrimental to the efficiency of the sand drains. The effects are also probably greatly dependent on the methods, equipment and procedures of installation. The objective is to investigate, by field tests and observations on various construction projects throughout the country, the actual and practical effects of the installation of vertical sand drains, including the effects of various methods of installation in order that rational design and construction procedures may be evolved.

Research Problem Statement Number 28

Investigation of Secondary Compression Characteristics of Organic Deposits.

Highway embankments constructed on organic soils often undergo long-time post-construction settlements that are often detrimental to performance and riding qualities of the pavement. A large portion of this settlement can be attributed to the secondary consolidation characteristics of organic soils. Basic information of the settlement properties of organic soils is required in order to determine the most economical and satisfactory methods of stabilizing these soils.

The objectives are:

(a) By means of laboratory investigations, to determine the settlement characteristics of various organic soils, including the limitations of applying the present "primary" and "secondary" consolidation concept to organic soils. New test procedures may be required.
(b) To compare the results of long-term field settlements of embankments constructed on organic soil with laboratory test results and design analysis.

RESEARCH NEEDED FOR FROST HEAVE AND FROST ACTION IN SOILS

Research Problem Statement Number 29

A Study of Strength Characteristics of Soil in the Frozen and Thawed State.

An evaluation is needed of the tensile, compressive and shear strength plus elastic and plastic constants of frozen soils of various compositions, textures, porosities and moisture contents, under ranges of subfreezing temperatures. The adfreezing strength inherent to frozen contact between subgrade base and strength inherent to frozen contact between subgrade, base and pavement material should also be developed. Further work needs to be done in determining reductions in load-carrying capacity on thawing with regard to various soil types and climatic conditions. These studies should be closely correlated with the amount of ice segregation and heave. The degree of saturation before freezing changes in the soil condition from prefrozen to thawed with regard to the moisture content, increase in soil porosity and modifications in the soil structure and position and movement of the water table. Attention should be given to the cycles of climatic variations of the regions in question.

Research Problem Statement Number 30

A Study of Volume Changes Due to Frost Action in Soils, Including Swell and Shrinkage.

A systematic matter of defining the different degrees of heaving according to the degree of detriment and identifying and classifying ground conditions which are pertinent to the different intensities of heaving are necessary. Shrinkage due to soil freezing needs to be identified as to conditions which cause the shrinkage and the degree in which it is detrimental. Studies are needed to determine the temperature, moisture content, and density conditions necessary to bring about shrinkage of the type associated with cracking of the ground surface. Full-scale field tests to determine the validity of criteria established and the climatic and soil conditions under which they were obtained are necessary.

Research Problem Statement Number 31

A Study of Influence of Degree of Densification on Ice Segregation and Heaving of Soils.

The objective of this study is to determine the influence of degree of densification on not only ice segregation and heaving but also on the magnitude and rate of reduction in load-carrying capacity following the beginning of the thawing period. Included in this study should be the influence of densifications on soils treated with various admixtures which have possibilities in reducing frost effects. Also needed are supplementary field studies permitting the correlation of and possibly better interpretation of the laboratory data.

Research Problem Statement Number 32

A Study of Forces Which Prevail Throughout Both Freezing and Thawing Processes and How the Elements of Time and These Forces Affect Soil Moisture Movements.

The objectives of this study are to: (a) establish more clearly the forces operating in moving water during freezing; (b) establish the relative distances through which these forces are effective and the influence of time on their relative effectiveness in soils with differences in texture and chemical composition for different degrees of saturation; (c) evaluate the forces operative in causing a redistribution of water following thawing; and (d) establish more clearly that both field and laboratory experiments experience the real significance of water movement in the form of vapor.

Research Problem Statement Number 33

Develop Reliable Thermal Data on Various Types of Soil Existing Under a Wide Range of Conditions of Moisture Content, Density, and Cover.

The objective of this study is to develop thermal data on the various soil types existing under a wide range of conditions of moisture contents and densities and thermal data on the various types of cover, including pavements and bases. The data need to be sufficiently inclusive that practical calculations can be made for almost any condition encountered. Studies of a highly practical nature need to be undertaken with typically fine-grained materials of common occurrence to ascertain the proportions of moisture frozen within these materials at temperatures below 32 F. The moisture content, density and rate of temperature change should be incorporated as variables in this study, as well as the character of the clay minerals and adsorbed ions. The thermal properties of soils at conditions of low density and for very high degrees of saturation are needed. The effect of various ice-stratified frozen structures on thermal values should also receive more study. Techniques of minimizing or compensating for moisture migration should also receive attention.

Research Problem Statement Number 34

A Study of Effect of Soil Composition on Frost Action.

The objective of this study is to relate frost susceptibility to the chemical composition as well as the physical composition of the soils, as it is believed that both of these determine the thermal and the physical properties of soils. The effects of organic matter, particularly in natural sands which are used in bases and subbases, should be studied. This study should include the effect of grain size distribution as well as the chemical composition of the various materials making up the soil. Included in this study should be the effect of the maximum permissible proportions of frost-susceptible fines for various types and gradations of material. As to maximum size, the relative frost susceptibility of different gradations from moisture contained within the sample should be a part of this study, as well as relating the grain size distribution in both the coarse and fine fractions more closely to the load-carrying capacity.

Research Problem Statement Number 35

A Study of the Limits of Moisture Content at Which Detrimental Frost Action Begins and the Degree of Saturation Necessary for Detrimental Frost Action.

This study is to expand determinations of the degree of susceptibility of more soils to detrimental frost action. Soils of different textures and different degrees of saturation at the beginning of freezing should be studied. This should provide data on the minimum degree of saturation at which ice segregation is possible in various types of soil without the availability of an adjacent supply of ground water. This study should also indicate the relative intensity of ice segregation which occurs in soils of the various textural groups at different initial degrees of saturation. In addition, the development for practical field use of automatic devices to record changes of the in-place moisture contents is desirable and also determines the seasonal and long-time ranges of moisture content of subgrades and bases of the various type classes of materials. The determination of practical techniques for effectively draining pavement subgrade combinations or of stabilizing the subgrade materials to reduce frost action is also desirable.

Research Problem Statement Number 36

A Study of the Influence of Soil Structure Conditions and Their Effect on Producing Frost Action in Soils and Methods of Preventing Detrimental Frost Actions in Various Types of Soil Structures.

Effort should be continued to formulate a practical engineering classification of soil structure in terms of its influence on the intensity of frost action. The classification should envelop both frozen and unfrozen ground so that a correlation could be made of structure and water availability to permit better prediction of the relative amounts and distributions of ice. In-place field studies to determine the relationship between various soil structure types and intensity of frost action are also needed. Experimental studies to determine the feasibility and the effectiveness of various methods to reduce or eliminate frost action for various soil struc-

tures conditions are also required. Soil stratification and its effect on water movement should be emphasized, as well as capillary movement. Variations in the moisture contents with a height above the water table and the rate of capillary flow are especially needed.

Research Problem Statement Number 37

A Study of Theoretical and Experimental Temperature Distribution in Soil Around Culverts Subjected to Freezing Temperatures.

The objective is to determine the temperature gradient around culverts during freezing weather and the effect of the freezing soil on the culvert. The study should lead to a more rational method of bedding culverts to prevent displacement of the culvert by frost action.

Research Problem Statement Number 38

A Study of the Mechanism Whereby Strengths of Bases, Subbases and Basement Soils Are Affected by Frost and Moisture.

The objective is to determine the seasonal movement of moisture beneath pavement surfaces, in particular the movement that occurs due to freezing, and to correlate the movement that occurs due to freezing, and to correlate the movement of moisture with local weather in order to improve the understanding of loss of strength when this unnaturally distributed moisture is released by thawing. A correlation of frost heave at the surface and at depths below the surface with localized climatic conditions may assess moisture movements beneath the pavement surface. Field measurements of moisture content changes will improve understanding of loss of strength due to release of this moisture by thawing.

Research Problem Statement Number 39

Effects of Frozen Layers of Compacted Soils on Performance of Highway Embankments.

The objective is to determine the effects on finished embankments and pavements of incorporating in the embankment several layers of compacted soil which are frozen after compaction. Both cohesive and granular soils are placed in embankments and compacted to required densities and then may be frozen during the night. What effect will leaving this material in the embankment and covering with compacted unfrozen soil have on the performance of the embankment and highway surface.

Research Problem Statement Number 40

A Study of Migration of Moisture Under Thermal Gradients for Different Degrees of Saturation, Various Gradients, and Soils with Different Permeabilities.

The research objective is to study the migration of moisture and changes in void ratio brought about by the actual freezing of granular soils at different rates of freezing and different initial degrees of saturation. Shearing resistances due to the change in density can be appreciable and measurements of the volume change would have to be highly accurate to give an indication of strength loss.

Research Problem Statement Number 41

Study of Effectiveness of Impervious Envelopes in Protecting Frost-Susceptible Soils from Moisture.

The research objective is to study the effectiveness of impervious membranes or envelopes in protecting frost-susceptible soils from the effects of frost. Moisture migration within the envelope and limitations on the placement moisture contents need investigation. The permeability of the membrane needs to be measured and thicknesses of enveloping materials need to be determined to effectively seal the enveloped soil from exterior moisture. The investigation should provide information regarding performance of frost-susceptible soils enveloped in impervious membranes subjected to the action of freezing and thawing.

Research Problem Statement Number 42

Load Support Capacity of Roadway Base Course Materials.

The objective is to evaluate the load supporting capacity of base course materials after freezing and thawing with differing percentages of fine material, differing moisture contents and rates of freezing. A minor change in the percentage of fines apparently has a great influence on the supporting capacity. The economics of this problem is serious and research is needed as a guide in preparing specifications for base materials.

RESEARCH NEEDED IN SURVEYING, MAPPING AND CLASSIFICATION OF SOILS

Research Problem Statement Number 43

Research in Photo Interpretation Techniques of Infrared Photography.

Infrared photography has been found useful in many fields, but has yet to be fully exploited for use in interpretation of soils. Research should be conducted to develop techniques of interpretation of this type of aerial photography and determine its limitations and advantages. This research should include study of filters to use with IR emulsion. The objective is to develop the technique of interpreting infrared photographs and evaluate their use for highway soil engineering purposes, including the evaluation of photography taken at different seasons and with different filters.

Research Problem Statement Number 44

Investigation of Photographic Spectral Range to Improve Airphoto Interpretation Techniques.

Aerial photography available and being made available utilizes broad portions of the spectrum and, therefore, often does not differentiate between different features that have different reflective characteristics. Research should be conducted utilizing conventional photography and narrow band filters to obtain aerial photography. Available spectrophotometer data should be used to select filters. The objective is to increase soils and terrain information from airphoto interpretation by developing best film/filter combinations utilizing narrow portions of the spectral response.

Research Problem Statement Number 45

Airphoto Interpretation Through Use of Multiband Sensing.

Airphoto interpretation techniques for several years have improved slowly. This is due to the limitations of the use of conventional panchromatic photography. Other emulsions will present different information and can be used to supplement conventional photography to aid the photo interpreter. The objective is to develop techniques of airphoto interpretation utilizing two or more different photographic types (such as panchromatic, infrared and color). Selective film/filter combinations should be studied.

Research Problem Statement Number 46

Investigation of Use of Low-Level (Large-Scale) Aerial Photography for Interpretation.

There has never been much information and detail available for establishing soil types and classifications accurately from aerial photographs. New and improved techniques should be added to present practices, when available, to improve the accuracy and effectiveness in this field.

It is believed that low-level (large-scale) photographs with sharp detail can increase the accuracy of the work of photographic interpreters. The military forces have demonstrated the effectiveness of low-level photography in identifying objects of all types, ground cover and general surface conditions.

The objectives are to study and evaluate the effectiveness, accuracy and general value of low-level (large-scale) aerial photography, using (1) several types of black and

white film, color film and possibly infrared film, (2) several types of cameras, (3) photograph obtained at several flight heights and flown under several lighting conditions; and to correlate results from this special photography with standard aerial photography and supported by ground studies.

Research Problem Statement Number 47

Effect on Photo Interpretation of Variance in Quality of Color Aerial Photography.

In using color aerial photography for photo interpretation, extreme variance in quality of photography is often noted when conditions of photography, processing or storage are allowed to vary. This difference in quality most often is evidenced by a change in hue of the color images of a single object presented in different photographs. Study is needed of the effect this variance in color quality has on optimum use of color aerial photography for photo interpretation. It is known that several variables have a definite effect on quality of photography, but exactly what effect they have is not always clear, and little is known of the effect these variables have on the quality of the photo interpretation that can be accomplished from the photographs.

The objectives are to study the effects on quality of color photography of such variables as: (1) type of color film, (2) method of processing, (3) color prints versus transparencies, (4) time and conditions of exposure, (5) time of day of photography, (6) time of year of photography, and (7) fading of photographs under different storage conditions; and more significantly, to determine the relationship between each of these variables and the quality of photo interpretations obtained from color aerial photography.

Research Problem Statement Number 48

Evaluation of Equipment and Procedures for Sampling Sand and Gravel Deposits.

The difficulties encountered in attempting to obtain accurate representative samples of cohesionless or nearly cohesionless sands and gravels have been recognized for many years by those responsible for locating suitable natural sources of these materials. The problems seem to fall under several headings, as follows:

1. Sorting of material by the sampling equipment:
   (a) Samples coarser than the average source material.
   (b) Samples finer than the average source material.
   (c) Segregation or loss of intermediate sizes.
2. Contamination by overburden material as sample is brought to the surface.
3. Inability of equipment to bring samples to the surface. This occurs most frequently when the bed lies below the water table.

The objectives are to determine the effectiveness of presently available equipment to obtain accurate samples of sands and gravels above and below the water table, and to develop, if possible, new equipment and techniques that will be capable of taking accurate samples of sand and gravel under all conditions.

Research Problem Statement Number 49

Evaluation of Geophysical Apparatus and Its Applications in Highway Subsurface Explorations.

There have been numerous developments in geophysical instrumentation related to subsurface explorations during the past 30 years. Some of the equipment now available has been tested in some detail over a variety of geologic conditions. Other more recently developed apparatus has had a minimum of field testing in establishing its probable usefulness or limitation. There is need for a planned program dedicated to a more thorough analysis of new instruments and interpretative techniques.

The objective is to determine the usefulness of new geophysical equipment in a variety of subsurface explorations and compare it with other exploration equipment with regard to its cost and effectiveness.

Research Problem Statement Number 50

Revisions Needed in AASHO Soil Classification System.

Based on a questionnaire sent out to the state highway departments by the HRB Committee on Surveying, Mapping and Classification of Soils, there is a need for revision of the AASHO Soil Classification System. Consequently, the System should be re-evaluated, based on the experience gained in its use by the state highway departments and on the most recent knowledge of the performance of subgrade materials. Particular attention needs to be given to the soils having group indices of 0 and those having values of 20.

The objective is to determine the revisions that should be made in the AASHO Soil Classification System as determined by experience gained in its use by the state highway departments so that it will more accurately reflect the performance of subgrade materials.

Research Problem Statement Number 51

Classification of Organic Soils.

There is no quantitative basis for defining organic soils. Casagrande and others have indicated that organic soils (such as OL or OH) can be identified by first determining the liquid limit on a soil from its natural moisture condition (without first air drying), then performing the same test on air-dry material (standard test method); a major reduction in liquid limit indicates an organic soil. This criterion is not really satisfactory, because certain clay minerals and hydrous oxides also have irreversible structures. The liquid limit of such clay minerals will also decrease considerably upon ovendrying. The literature contains only a few publications which deal with the effect of organic material on the engineering properties of soils. Furthermore, in the present AASHO Soil Classification System, no allowance is provided for the classification of soils containing appreciable organic matter. An investigation is needed to determine the relationship between amount and type of organic matter present in an organo-mineral soil (natural or artificial mixture) and the physical properties of the soil, as measured by Atterberg limits, compressibility, moisture-density relations and some appropriate strength parameter.

The objective is to develop a rational basis for identification and classification of organic and organo-mineral soils which can be related to their probable engineering performance.

Research Problem Statement Number 52

Correlation of AASHO Soil Classification and Bearing Capacity or Strength of Soil and Aggregate Materials.

There is considerable published information on the various soil classification systems and on the various tests to determine strength or bearing capacity of soil and aggregate materials. However, there is need for a correlation between the classification systems and the strength properties. The objective is to develop the relationship between the AASHO Soil Classification System and bearing capacity or strength of soils as determined by CBR, triaxial compression, unconfined compression, R-value, etc.

DEPARTMENT OF SOILS, GEOLOGY AND FOUNDATIONS

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