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COMMITTEE ACTIVITY
Committee on Soil-Sodium Chloride Stabilization
Department of Soils, Geology and Foundations
Highway Research Board

STATEMENT OF THE ART OF SOIL STABILIZATION WITH SODIUM CHLORIDE

Introduction

The committee feels that a description of the present knowledge of soil stabilization with sodium chloride should be made initially so as to emphasize and clearly indicate the need for research. Since such a statement cannot be made clearly and concisely without definitions some discussion of soil stabilization and related terms is necessary.

The term "Soil-Sodium Chloride Stabilization" in its broadest sense implies the use of sodium chloride as an admixture in soil or aggregate for the purpose of improving the material. In past years, however, sodium chloride has been used primarily as an admixture in base courses and subbase courses and very little has been used as an admixture in subgrades. Other common stabilization uses of this chemical are for granular surface courses, shoulders and stage construction.

The committee recognizes that stabilization by addition of sodium chloride to both soil and soil-aggregate mixtures falls within the scope of the committee work but has agreed that primary consideration should be given to the effects of sodium chloride on properties of soil-aggregate mixtures since this represents the most common application of the method in highway construction.

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Definitions

Definitions pertaining to soil stabilization are in a large part provincial. Many of the terms used by engineers have been developed over the years to fit specific conditions. These terms, in some cases, have been applied loosely to other situations of the same general nature, and as a result have different meaning when used by individuals from different geographic locations.

The committee feels that complete standardization of definitions and terms relative to stabilization is not necessary and therefore has defined only the terms listed below.

Soil Stabilization

Is any regulated process that alters or controls the properties of soil or soil-aggregate mixtures for the purpose of improving the capacity of the material to perform and sustain an intended function.

Soil-Aggregate Mixture

Is a mixture of aggregate and fine grained material usually proportioned for maximum density. The aggregate portion may be natural or processed gravel or crushed rock retained on a No. 200 mesh sieve. The fine fraction, passing a No. 200 mesh sieve, may consist of inorganic silt and clay or fine particles resulting from the process of crushing rock. The mixture may be dense-graded or open-graded depending upon its grain size distribution. For high type construction the mixture may be plant mixed so that grain size distribution and density of the compacted mix may be closely controlled during construction.

Soil-Aggregate Stabilization

Is a particular type of "soil" stabilization in which a fine grained soil is mixed with an aggregate such as pit-run gravel or crushed stone and is normally used in the construction of surface courses. The fine fraction carries out the function of a cement that holds the larger particles together in one common mass.

Soil-Sodium Chloride Stabilization

Is essentially a special form of soil-aggregate stabilization in which sodium chloride is added to the soil-aggregate mixture either in dry form as crystals or as a brine.

Mechanics of Sodium Chloride Stabilization

Sodium chloride treated material produces a tougher and more durable surface course or base course than a comparable non-treated material as evidenced by numerous existing roads. The chemically treated material also seems to withstand the ravages of winter and spring break-up better than non-treated material.

The mechanism by which sodium chloride stabilization brings about the changes that cause soil materials to give improved performances is not completely understood. It is thought that the primary changes occur in the colloidal fraction which then affect the overall properties of the entire mixture. Possibly the greatest single change affecting the material is the substitution of sodium ions, furnished by the chemical, for the naturally occurring ions associated with the clay mineral portion of the mixture.

A number of processes and phenomena are known which the addition of sodium chloride to a soil-aggregate mixture cause and which are thought to contribute to the stability of a treated material. The vapor pressure of the soil water is reduced thereby retarding the rate of evaporation. The freezing point of the soil water is lowered and the freezing point of the mix is thereby reduced, depending upon the amount of salt present it is generally in the vicinity of 22^{o}F. The salt re-crystallizes when the material dries out and aids in forming a hard surface. Sodium ions also cause expansion of certain clays which causes a decrease in permeability of the compacted mass as compared to a non-treated similarly compacted material.

It is significant to note that sodium chloride is soluble in water. Hence, leaching of the salt may result from percolating water. Time is always an important factor and time limitations should be completely understood. Sodium chloride remains effective up to eight to ten years depending on the traffic, climate, drainage characteristics of the road and other factors.

Sodium chloride has been used by engineers as an admixture in soil-aggregate mixes for many reasons, the most prominent being: to act as a dust palliative, to produce a harder surface course, to stabilize shoulders, to reduce the loss of stability during freezing and thawing, to assist in the compaction process by promoting uniformity in the mixture and reducing the amount of water evaporation which combine to give a more uniform degree of compaction, to lower the freezing point of the soil water so that construction will be easier during cold weather, and as a phase of stage construction whereby the salt treated portion is used as a wearing surface for several years and then as a subbase for a high type pavement.

Research Needs

A subcommittee on research needs was appointed as a result of a discussion which focused attention on the existence of a wide variety of opinions concerning the need for research and methods of meeting this need. The subcommittee was given the task of formulating definite recommendations relative to the variables that should be considered in research involving field installations of sodium chloride stabilized material.

The primary objectives of research concerning field installations are to determine (1) whether or not the installations are successful and (2) the reasons for success or failure. Sodium chloride stabilization has been used for a number of years and many questions have arisen which have not been satisfactorily answered. Some of these questions can be answered by field research and some can be answered in the laboratory. Existing or proposed field installations must be treated as separate problems.

The committee feels that one of the primary deterrents to a more widespread investigation of this or any other problem is the prevailing misconception of what constitutes research. The committee also feels that if the meaning of this term were better understood, more engineers would be encouraged to publish results describing stabilization methods and the success or failure of these methods. Most engineers do some type of research to solve their own special problems but are hesitant to publish the results for one reason or another. The publication of these professional experiences should be encouraged so that others may profit thereby. Probably one of the main reasons for this hesitancy is that many an engineer feels that his methods and results are not of a sophisticated nature. It is well to bear in mind that the importance of research is not measured by degree of sophistication but depends on the usefulness of the results and that the accumulation, dissemination and use of knowledge is of paramount importance to progress.

The procedures and research needs recommended by the committee are separated into three categories so that anyone proposing to conduct field trials or desiring information on how to proceed in a field trial will have an outline of items that are considered necessary to the proper evaluation of such projects. The three categories are (1) Research on Proposed Roads, (2) Research on Existing Roads, and (3) Suggested Topics for Laboratory Research.

The committee has attempted to list important variables and realizes that some projects can not afford the luxury of collecting and interpreting the data for all items listed. Each engineer must use his own judgement as to how much of the outlined research work he can properly control and afford to undertake. The outlines have been prepared as research aids and are meant to encourage engineers to conduct research in soil-sodium chloride stabilization. Topics for laboratory research listed which, if answered, will shed further light on the subject and should aid in the improvement of this type of stabilization. The outlines and the topics for laboratory study represent the cumulative thinking of the committee.

Research on Proposed Roads

I. Design of Stabilized Test Road

A. State the purpose of the stabilized material
   1. If used as a base course
      a. Description of surfacing
      b. Give the traffic count or other reason which indicates the need for a high type surface road
   2. If used as a surface course
      a. Give the traffic count
   3. If used in stage construction
      a. Indicate reasons for choosing this method

B. Materials
   1. Soil
      a. classification
      b. gradation
      c. engineering properties
      d. other pertinent physical properties such as the type of predominant clay mineral
   2. Aggregate
      a. type
      b. gradation
      c. engineering properties
      d. other pertinent physical properties
   3. Sodium Chloride
      a. source
      b. type and purity
      c. gradation

C. Soil-Aggregate-Sodium Chloride Mixture
   1. Basis of proportioning
      a. particle size
      b. plasticity index
      c. choice of sodium chloride percentage
   2. Gradation
   3. Engineering properties
   4. Moisture-density relationships
   5. CBR values

D. Geometry
   1. Cross section showing
      a. stabilized sections
      b. crown
      c. surfacing if any
      d. sub-base and soil subgrade

2. Length of road

E. Subgrade soil
   1. Description and history pertaining to use as a road
   2. Density
   3. Geological and pedological classification
   4. Moisture conditions

F. Stabilized sections
   1. Describe any differences between sections
      a. in composition
      b. in construction procedure
   2. Indicate any changes in B, C or D above

G. Control section
   1. Include an untreated section for comparison of performance with treated sections. The control section should be identical with the treated sections with the exception of the addition of the chemical.

II. Construction

A. Contract or non-contract
   1. Construction methods
   2. Inspection methods
   3. Personnel

B. Equipment used in construction

C. Aggregate production record
   1. Plant gradation control
      a. method
      b. success
   2. Gradation of material actually compacted

D. Subbase conditions at the time of placement of the soil-aggregate material

E. Procedure used in placing aggregate

F. Procedure used in adding sodium chloride
   1. Plant mix
   2. Road mix
   3. Mixing procedure
   4. Amount added in each section
   5. Brine or dry placement

G. Density achieved in construction
   1. Indicative methods used in determining density

H. Moisture content of the stabilized material at the time of surfacing if surfaced

I. Describe any additional work done or material added before surfacing if stage construction is used.

J. Cost data

III. Life of the Road

A. Describe traffic
   1. Type
   2. Amount

B. Maintenance
   1. Aggregate surface
      a. blading procedure
      b. additions of materials
      c. frequency that maintenance is required
      d. cost data
      e. density studies

   2. High type surface
      a. indicate any maintenance requirements
      b. repairs in surface or base

C. Sodium chloride retention
   1. Periodic sodium chloride content determinations with simultaneous moisture content determinations
   2. Trace where lost sodium chloride goes, if possible
   3. Make a sodium chloride balance from start to finish

D. Climatology records
   1. Rainfall
   2. Snowfall
   3. Temperature

E. Riding qualities of surface
   1. Roughometer records
   2. Sensual perception

F. Durability
   1. Wear
   2. Description of surface
   3. Failures
   4. Length of service before rebuilding is required

G. Sampling and testing
   1. Moisture and density of stabilized course
   2. Moisture and density of non-stabilized courses
   3. In-place strength tests
   4. Cores for laboratory tests

IV. Interpretation and Evaluation of Data

A. The engineer reporting these data should give his own interpretation and evaluation of the data and should attempt to explain the results in terms of economics and human reaction as well as engineering and scientific terms. This may not always be possible, in which case the engineer should present his own professional opinion.

V. List of References

Research on Existing Roads

Existing roads that have not been built as a part of a research project may be reported as successful roads or as roads that have failed. In either case the items listed under "Research on Proposed Roads" should be answered as far as possible.

In addition, any other comments that are pertinent to the problem should be recorded, such as comments indicating public opinion. If a road has failed or given a poor performance the cause should be determined or at least some opinion concerning the cause of failure should be ventured. Failures always raise such questions as — Did the sodium chloride delay or contribute to the failure? Can the failure be traced to an improper design? If so, was the stabilized section originally designed and constructed as a wearing surface and then used as a base course? In such a case the soil-aggregate mixture could have been too rich in fine material for a base course but correct for a surface course.

Laboratory Research

I. Basic research on the mechanism of sodium chloride stabilization

A. Effects of the different types of clay minerals on
   1. Cohesion or binding
   2. Strength properties of a soil-aggregate mixture
   3. Soil-water relationships

B. Effects of sodium chloride on the items in "A"

C. Chemical reactions caused by sodium chloride
   1. Do these reactions yield a product which contributes to the stability of the system by cementation or other means?
   2. Is a fresh surface etched on the face of mineral particles which aids in stabilization?
   3. Does limestone and sodium chloride react in any way?
   4. What are the solubility effects of sodium chloride solutions on different minerals?
   5. How does number 4 effect stabilization?

D. Crystallization of sodium chloride
   1. What effects do sodium chloride crystals have on the strength of a stabilized material?
   2. Does the crystallization of sodium chloride aid in stabilization as theorized? The answer to this question may be partially satisfied by the answer to Number 1.
   3. What is the minimum moisture content of a soil-sodium chloride-water system at which sodium chloride will begin to crystallize?

E. Establish relationships between density, compactive energy, moisture content and sodium chloride content in soil-water-sodium chloride systems.

F. Study the effect of NaCl content on the capillary potential of a soil, specifically correlate capillary potential and water content for several NaCl contents.

II. Develop tests to indicate improvement in the properties of soil materials due to stabilization procedures.

III. Develop a quick test to indicate improvement.

IV. Study the effects of combinations of chemicals with sodium chloride on stabilization.

V. Determine the range of soil-aggregate gradations for which sodium chloride is effective in stabilizing.

VI. Determine the types of soil binders which can be used in conjunction with sodium chloride for stabilization. These soil binders are not necessarily clay mineral types.

Laboratory studies on sodium chloride treated soil-aggregate mixtures should indicate the effects of the chemical treatment on (1) the amount of moisture retained at equilibrium with a given relative humidity (2) plasticity (3) density, compactive energy and moisture requirements (4) strength of treated material under a wide range of temperatures and (5) the surface tension of the moisture (salt solution) contained within a chemically treated soil-aggregate mix and its relation to the resultant engineering properties.

A leaching study using a model should give results indicating rates of leaching and the time of effective treatment or the time allowable before chemical retreatment becomes necessary. A study of this type should also indicate the effectiveness of salt treatment in reducing the permeability of soil-aggregate surface courses.

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