SELECTED BIBLIOGRAPHY ON SOIL STABILIZATION

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INTRODUCTION

This bibliography has been prepared as part of the research done under Project M908-1 (Creole Petroleum Co., Venezuela) of the Engineering Research Institute. In this bibliography, 554 items are arranged in alphabetical order according to the author's last name. The contents have been classified into major divisions and indicated by letters as follows:

A . . . General

B . . . Mechanical Stabilization

C . . . Portland Cement Stabilization

D . . . Bituminous Stabilization

E . . . Lime Stabilization

F . . . Chemical Stabilization (including the use of calcium or sodium chloride, sodium silicate, aniline-furfural, plasmofalt, calcium acrylate, chrome-lignin, resins, etc.)

G . . . Electrical Stabilization

H . . . Densification (Dewatering and Compaction)

I . . . Soil Stabilization Equipment

In the following pages, each reference is followed by one or several of the above letter indices indicating which subject or subjects the article covers. A finding index is also prepared in which the references are listed under each major division in chronological order, starting from the most recent publications. It should be pointed out, in this connection, that the above grouping of the references is primarily done for the convenience of the users. In grouping these articles, there is no intent to propose a classification of methods of soil stabilization.

Aside from subject indices B to I which are self-explanatory, it should be noted that Division A includes publications which cover many phases of soil stabilization and items for which no classification has

been given. Various subjects such as Soil Stabilization for Highways, Soil Stabilization on Airports, Heat Treatment of Soils, etc. are all listed under A.

The references listed in this bibliography have been selected primarily from Index to Publications of the Highway Research Board (1921-1949), the Road Abstracts (compiled monthly by the Department of Scientific and Industrial Research, Great Britain), and the Engineering Index. Brief abstracts of the articles are either the complete abstracts or portions of the abstracts or synopsis of the original abstracting journals or articles. Quite a few abstracts have been abridged from the original articles. A few references are unobtainable and no abstracts are given.

Because of the recent development and growing interest of chemicals for soil stabilization, a list of chemicals, arranged in alphabetical order, which have been investigated for use as soil stabilizing agents has been prepared in the Appendix of this Bibliography. References to publications concerning the nature of the material and the results of its use as soil stabilizers are listed after each material.

In preparing this bibliography, the attempt has been made to include important publications concerning the subject of soil stabilization published in the past ten years. It is felt that the selection presented is reasonably comprehensive, although no claim for completeness is made for this list of references. It should be noted that many of the references listed contain bibliographies of their own specific topics which may be of great value for research purposes.

Finally, attention is called to the fact that the compilation of this bibliography was completed in August 1953. Owing to the large volume of work involved, the reproduction of this material has been delayed and there may be some valuable items that have been published since the summer of 1953 that are not included in this bibliography.

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BIBLIOGRAPHY

1 - Aaron, H., "Estabilizacion de Subrasantes y su Relacion con la Construccion de Pavimentos Flexibles y Rigidos," IV Congreso Panamericano de Carretoras Momoria, 1942, Vol. 1, pp. 734-748.

(A)

Stabilization of subgrades and their relation to construction of flexible and rigid pavements; object is to increase service of road pavement; preventing settling and deformation that produce failure; requirements for stabilization determined by study of materials in subgrade; classification of soils for subgrades; stabilization methods; prevention of deformation by freezing; drainage of subgrade. Bibliography.

2 - Aaron, H., Reports of the Committee on Lime-Soil Stabilization, American Road Builders' Association Technical Bulletin No. 147. Washington, D. C.: Am. Rd. Bldr's Assn, 1948. (16 pages)

(E)

Test methods are described. Laboratory tests and construction methods are outlined. More work is needed before definite conclusions can be reached.

3 - Aaron, H., "Soil Stabilization on Airports," Proceedings of Conference on Soil Stabilization, Mass. Inst. Tech., 1952, pp. 232-240.

(A)

Stabilization on airports has for its objective the improvement of the stability of a soil to the extent that it will meet certain service requirements important with respect to the operation of aircrafts. Two general types of stabilization are in current use: 1) Granular stabilization and 2) Stabilization of improperly graded soils by means of binders such as portland cement, lime, bituminous material or chemicals. However, the construction of base courses by means of soil stabilization is limited to secondary airports.

4 - Aaron, H., "Stabilization Control on the Washington National Airport", Proceedings Highway Research Board, 1941, Vol. 21, pp. 515-530.

(A)

This paper describes the stabilization on the Washington National Airport. The gravel in the runways was combined with soil from the adjacent upland areas to produce a dense, well graded, stable base course for the bituminous concrete surfacing. The work of stabilization consisted of scarifying the graded gravel runways, removing oversize stone, adding the proper amount of soil, mixing the gravel and soil by means of cultivators, disk harrows, and plows, compacting with rollers, and shaping with motor graders and drags.

Control over the base stabilization in accordance with established requirements as to gradations, physical properties and densities was accomplished by coordinating the construction operations with the tests performed on the raw materials and the mixtures. This work was directed from a portable field laboratory located on the runways.

5 - Aaron, H., "Stabilized Base Experiment in Minnesota", Public Roads, 1944, Vol. 24, No. 2, pp. 33-46, 54.

(A)

Description of methods and results of test of various thickness of stabilized wearing course applied to heavy clay subgrade; description of subgrade soils, base course materials and construction methods.

Abercrombie, L. D., (see 191)

Abercrombie, W. F., (see 330)

6 - Aimont, E., "La Stabilisation des Terrains a grains fins par le Drainage en Profondeur", Technique des Travaux, 1949, Vol. 25, No. 9-10, pp. 297-314.

(H)

Stabilization of granular soils by deep drainage; principle of temporary suppercharge; placement of drains; method of depression; efficiency of Kjellman-Franki method.

7 - Alley, P. J., "Loess in Soil Cement Mixtures," Proc. N. Z. Instn. Engrs., 1948, Vol. 34, pp. 167-171.

(C)

An account of the examination of the properties of the loess deposits near Christchurch, New Zealand, to determine their suitability for use in soil-cement mixtures. Standard laboratory tests and tests on full-scale walls were used.

8 - American City, "How Pennsylvania Builds Soil-Cement Roads", American City, 1949, Vol. 64, pp. 94-95.

(C)

A description of the construction of a typical soil-cement road, as carried out by the Pennsylvania Department of Highways. A mix-in-place method was adopted.

9 - American City, "Peoria, Illinois Paves with Soil Cement", American City, June 1949, Vol. 64, No. 6, p. 88.

(C)

Gravel streets were salvaged by soil cement construction topped with asphalt surfacing, improvement costing $1.93 per sq. yd.; work procedure shown in photographs.

10 - American City, "Refuse Fill Stabilized for School Building Use", American City, 1948, Vol. 63, No. 5, pp. 108-109.

(A)

When school building in Elizabeth, N. J., built on municipal refuse dump, settled irregularly, soil was stabilized by Weber system; it uses pressure system of injecting sand & mortar compositions into deep muck & filled ground strata; procedure & equipment; machinery included Prehy pressure grout injectors, portable air compressor of 160 cfm. capacity and concrete mixer.

11 - American Road Builders Association, Annual Report of Soil-Cement Stabilization Committee, Washington: American Road Builders Association, 1948, Technical Bulletin 137, pp. 1-32.

(C)

This pamphlet contains a simple account, in the form of questions and answers, of soil-cement construction, covering the uses, materials, control methods and factors, methods of construction, methods of testing, equipment and performance.

12 - American Road Builders Association, Report of Committee on Calcium Chloride Soil Stabilization, Washington, D. C.: American Road Builders' Association, 1948, Bulletin No. 127, pp. 1-32.

(F)

This is a complete description of the procedure recommended for stabilizing by the use of calcium chloride, including preliminary preparation of subgrade, plant mixing and equipment used.

13 - American Road Builders Association, Report of Committee on Compaction of Soils,American Road Builders Association Technical Bulletin No. 120, Washington, D. C.; 1947, pp. 1-39.

(H)

Information on the most recent methods and equipment for soil compaction is given under the following heads: advances in compaction theory; compaction procedures; compaction specifications and contract inspection; compaction equipment.

14 - American Road Builders' Association, Report of Committee on Tar Stabilized Roads, Washington, D. C.: American Road Builders' Association, 1946, Bulletin No. 104, pp. 1-32.

(D)

This includes the results of a survey on tar-soil and tar-sand stabilized roads and specifications for the construction of these types of roads.

15 - American Road Builders' Association, Soil-Cement Stabilization, Report of Committee on Soil-Cement Stabilization, Bulletin No. 138, Washington, D. C.: American Road Builders' Association, 1948, pp. 1-20.
(C)

This report describes projects involving approximately 2,743,000 square yards of work in widely separated sections. The data received on 22 projects are also set up in tabular form.

16 - American Road Builders' Association, Soil-Cement Stabilization in Pennsylvania. Construction and Performance of Soil-Cement Paving in Alexandria, Louisiana, Bulletin No. 160, Report of Committee on Soil-Cement Stabilization, Washington, D. C.: American Road Builders' Association, 1949, pp. 1-12.
(C)

Various projects in the two states are described, including information on the kind of equipment used and methods of construction.

17 - American Road Builders' Association, Stabilization of Soil with Asphalt, Report of Committee on Stabilization of Soil with Asphalt, Bulletin No. 164, Washington, D. C.: American Road Builders' Association, 1949, pp. 1-36.
(D)

This information is the result of a committee study extending over a two-year period. It describes the various processes now in general use and the equipment needed for both construction and maintenance.

18 - American Road Builders' Association, Tar Soil Stabilized Base Courses, Report of Committee on Tar-Soil Stabilization, Bulletin No. 148, Washington, D. C.: American Road Builders' Association, 1948, pp. 1-8.
(D)

This contains a review of the conclusions included in an earlier report and additional information on tar stabilization work done by the U. S. Engineers.

19 - American Society of Civil Engineers, "Compaction of Cohesive Soils", Proceedings of American Society of Civil Engineers, 1950, Vol. 76, Separate No. 48, pp.1-9.
(H)

Intent of report presented is to broaden scope of compaction problem to its' four phases - laboratory practice, compaction of fills, compaction requirements as related to design, and performance of fills.

20 - Andrews, A. C. and Noble, G. G., "A Study of Bituminous-Soil Stabilization by Methods of Physical Chemictry", Proceedings Highway Research Board, 1949, Vol. 29, pp. 496-520.

(D)

The work described was carried out jointly by Kansas State College Engineering Experiment Station and the Kansas State Highway Commission. The research had two main objects: (1) To find ways of predicting the suitability of soils and/or bitumens for soil-bituminous stabilization. (2) To develop methods and/or treatment that would make bituminous stabilization practical with soils previously considered unsuitable. Six Kansas soils and three cut-back bitumens were studied, the following aspects being investigated: Hydration and dehydration of bitumens; contact angles between bitumen and soil in soil briquettes: the film-forming characteristics of bitumen, by means of the surface pressure balance; the particle charge on soil and bitumen, as determined by the migration of particles during electrophoresis; the effect of various additives on soil-water bitumen mixtures. The additives studied included silicon tetrachloride, hydrated lime and aluminium sulphate. Briquettes, 1 in. high and 1 in. diameter, were prepared and subjected, in both dry and saturated conditions, to compression tests. The investigations indicated that: (1) Bitumens do not spread easily on soil. (2) Bitumens spread more easily on acid than on other media. (3) The soils and bitumens are strongly influenced by variations of humidity as well as temperature. (5) Amines are effective in increasing the water-resisting properties of soil-water-bitumen systems, aniline hydrochloride having a particularly marked effect with a heavy clay. Ethyl silicate was more effective with dry than with wet soil. Silicon tetrachloride was effective with a heavy clay but was not effective as the amines in increasing the water-resisting properties of the soil-water-bitumen briquettes.

21 - Andrews, W. P., "Soil Cement Stabilization", Roads and Road Construction, 1950, Vol. 28, pp. 4-7, 36-38, 68-70.

(C)

These three articles deal respectively with (a) examples of roads in England in which soil-cement stabilization has been used, (b) soil testing, and (c) methods of constructing cement-stabilized roads.

22 - Arend, A. G., "Development in Solidifying Loose Soils", Civil Engineering (London) 1944, Vol. 39, No. 451, pp. 16-17.

(A)

General description of methods, equipment and results of soil solidification; process,in brief, comprises thrusting impregnating reagents through soil, rising pipes operated by compressed air lines; two different chemical solutions are used separately, one salt solution and other water glass or prepared solution of sodium silicate.

23 - Armstrong, C. F., "An Example of Soil-Cement Construction Development", Proceedings 2nd International Conference Soil Mechanics, 1948, Vol. 4, pp. 289-296.

(C)

This paper deals with mix-in-place soil-cement road construction in South England. It describes development work carried out by the Ministry of Transport during the period 1944-47 and includes soil survey data and remarks on the use of plant. It is concluded that with suitable equipment satisfactory results should be obtainable. For heavy clay and large gravel without soil binder, it would be necessary either to balance the grading by adding suitable material or to excavate and replace with suitable soil. The experiments described indicate that the use of soil-cement mixtures in Britain promises to provide an economical form of road construction.

24 - Armstrong, C. F., "The Use of Plant in Soil Stabilization", Institution of Civil Engineers, 1947, Road Paper No. 24, London, pp. 1-34.

(I)

The essential features of the plant-mix, travel-mix, and mix-in-place methods of soil stabilization are briefly reviewed and it is emphasized that whichever method is employed the items of equipment selected must be operated as an organized whole, the basic item being the soil mixer.

25 - Asghar, A. G. and Dhawan, C. L., "Effect of the Physico-Chemical Properties of soils on Road Performance", Journal Indian Roads Congress, 1948, Vol. 12, pp. 329-344.

(A,B)

This paper refers to the work of Rapp and Mizroch which showed that physical tests alone were not always adequate for indicating the suitability of soil-aggregate mixtures. It then presents the results of an investigation of the chemical properties of soil samples taken from roads of different quality in the Punjab, and shows how these properties are related to the suitability of the soils for making stabilized earth roads. It is shown that owing to the difference between American and Punjab conditions some of the requirements of the "Standard Specifications for Highway Materials" of the AASHO are not always applicable. Specifications for soils suitable in the Punjab are suggested.

26 - Astier, J., "Notes on the Stabilization of Soil with Bitumen on a Construction Site in Algeria", Rev. Gen. Routes, 1950, Vol. 20, pp. 39-41, 44-47.

(D)

The construction is described of a 13 km. stretch of road which forms part of RN 28 and completed the planned project of linking Magra with Barika. Details are given of preliminary investigations and tests carried out in the laboratory on natural soils, imported materials and bituminous mixes. The pavement design

was determined according to Filippi's bituminous mixes. Organization of work site and sequence of operations are described and observations are made on the difficulties encountered during construction. It is concluded that: (1) April, May and June are the most suitable months for carrying out soil stabilization with bitumen in this region. (2) Great care must be taken with the aggregate grading and to ensure that no excess of binder is left on the surface. (3) The stabilized layer should be allowed to harden before the surface dressing is spread. (4) The cut-back bitumen used should not be too fluid. (5) Constant supervision of surfacing leveling and removal of ruts caused by rollers is necessary. (6) The estimated cost of the finished road amounts to 350 frs. per square meter.

27 - Asturloa, U. M. and D'Alessio, J. T., "Estudio de la Estubilizacion de Suelos Con Tosca Calcinada", Ingenieria, (Buenos Aires) 1947, Vol. 51, No. 875, pp. 450-453.

(A)

Study of stabilization of soils with calcined calcareous tufa; results of studies and tests, using different proportions of tufa; cost of road construction by this method is less than when equal degree of stabilization is obtained with portland cement.

28 - Asturloa, U. M. and D'Alessio, J. T., "Estabilizacion de Suelos por Concreciones Calcareas (Toscas) Calcinadas", IV Congreso Panamericano de Carreteras Memoria, 1942, Vol. 1, pp. 703-733.

(A)

Stabilization of soils by calcined calcareous concretions.

29 - Baise, W. V., "Patching Pavements with Soil-Cement", Roads and Streets, 1944, Vol. 87, No. 2, pp. 56,58.

(C)

Soil-cement has been used since 1939 for local repairs on primary and secondary roads in North Carolina, especially where failure has been due to sub-grade weakness. This paper describes the method of patching pavements with soil-cement.

30 - Baise, W. V., "How We Whipped Sand and Water on the Outer Banks Job", Roads and Streets, 1949, Vol. 92, pp. 70, 72, 74, 76, 84.

(D)

An account of the difficulties encountered in constructing a road near Cape Hatteras, North Carolina. The surfacing consisted of a 5 in. thickness of bitumen-stabilized sand. Verges and ditches were built after the road surface was completed, because of the unstable nature of the sand and the severe climatic conditions.

Baker, R. F., (see 176)

Banchi, G., (see 282)

31 - Baptista, J. R., "Injeccoes Quimicas Nos Terrenos", Ordem Dos Engenheiros-Revista, 1948, Vol. 6, No. 59, pp. 553-565.

(F)

Chemical injection in soils; review of data published in foreign technical journals; in many processes described, silicate of soda is injected. Bibliography.

32 - Barber, E. S., "Electrical Stabilization of Soil" Roads & Streets, 1948, Vol. 91, No. 6, pp. 64-65.

(G)

Explanation of theory and practice in use of electricity for soil stabilization by heating, drainage and chemical hardening; when voltage is applied between two electrodes of soil water mixture, soil is attracted by anode and water by cathode; if cathode is impervious, moisture content nearby is increased by first flow of current; possibility of using this principle in driving steel piles through stiff clay layers.

Barber, E. S., (see 348)

33 - Barrett, Eugene V., "Stabilization with Cutback Asphalt of 42 Kilometers of the Natural Surface Soil of the Perija Highway in Venezuela", Proc. 2nd Int. Conf. on Soil Mech. and Found. Eng., 1948, Vol. V, pp. 251-256.

(D)

Test method; characteristics of RC_2 cutback asphalt; test results; recommendations; field stabilization; finished surface; maintenance of stabilized soil surface and present condition; conclusions.

34 - Barron, Reginald A., "Consolidation of Fine-Grained Soils by Drain Wells", Trans. ASCE, 1948, Vol. 113, pp. 718-754.

(H)

Drain wells have been used to accelerate the consolidation of fine-grained compressible soils subjected to new loads. Complete formulas for consolidation by vertical and radial flow to wells, for cases with or without peripheral smear and drain well resistance are presented in this paper. Because soils are not homogeneous, and because of incomplete knowledge of stress-strain consolidation characteristics of soils, these solutions should be regarded as approximate when applied to practical problems.

Barron, R. A., (see also 312)

35 - Baylard, E. M., "Performance Study of Calcium-Chloride-Treated Roads", Proceedings Highway Research Board, 1952, Vol. 31, pp. 316-348.

(F)

In 1938, 435 miles of gravel roads had been stabilized with calcium chloride by the Onondaga County Highway Department (New York State). At the present time, 325 miles have received a bituminous surfacing and 110 miles are still maintained as gravel surfaces. A study of the roads in Onondaga County showed that the loss of gravel from roads treated with calcium chloride was 23 cu. yd. per mile per year when the traffic volume ranged from 41 to 216 vehicles per day. It is estimated that the use of calcium chloride results in a saving of maintenance costs, as the cost of applying this material is more than offset by saving in cost of gravel replacement and blading operation.

Beatty, J. L., (see 454)

Becker, C. J., (see 39)

Beland, C. E., (see 161)

36 - Belcher, D. J., A Field Investigation of Low-Cost Stabilized Roads, Purdue University Engineering Experiment Station Research Series No. 81, Lafayette, Indiana 1941, (159 pages)

(A)

In conjunction with field and laboratory tests, experimental roads were constructed with crusher-run stone; gravel without admixture; soil cement; and gravel stabilized with calcium chloride, sodium chloride, tar, road-oil, and bituminous emulsions. The general conclusions are as follows: (1) Adequate compaction will prevent the entrance of dangerous quantities of water in most soils. (2) Admixtures act by waterproofing, by chemically uniting soil particles, or by minimizing moisture fluctuation. Bases built on the last principle are the most satisfactory. (3) The amount of admixture required increases with the amount of fine material present. (4) Compaction of soil-cement mixtures must be completed before setting. (5) With bituminous admixtures, moisture content should be kept low. (6) Stabilized bases should be given a light sealing-coat, applied as soon as possible in the case of soil-cement or bituminous admixtures of low cohesion.

37 - Belt, R. M., "Volcanic Clinkers Stabilize Fills on Hawaiian Highway", Civil Engineering, 1950, Vol. 20, pp. 30-31.

(A)

Constructional problems encountered while building the first 14 miles of the 40-mile Hamakua Coast Highway in Hawaii are discussed. The first attempts to drive the road across deep deposits of volcanic ash, in a region where the

average annual rainfall is 145 in., were unsuccessful because construction vehicles could not maneuver on the saturated soil of cuts and fills. The difficulty was overcome by placing alternate layers of volcanic clinker or lava of unstable soil.

38 - Benedict, H. W., "Here's Tip: New Cement-Treated Base Road-Mixed Method Used Between Sherwood Road and Sapp Creek", Calif. Highways & Public Works, 1950, Vol. 29, pp. 46-48.

(C)

About 8 miles of U.S.-101, in California, have been speedily resurfaced by the extensive use of machinery, some of which was constructed specially for the job. The surface of the old road was broken by scarifier teeth mounted on a tractor, and then crushed by running a tractor over it. A grader then windrowed this material,4 per cent of cement was added, and a road-mixer towing a water truck blended the mix. Compaction was carried out by two 12-ton three-wheeled rollers. The base was surface-dressed with bitumen emulsion and sand.

39 - Benson, J. R. and Becker, C. J., "Exploratory Research in Bituminous Soil Stabilization", Proc. of Association of Asphalt Paving Technologists,1942, Vol.13, pp. 120-168, (Discussion: pp. 168-181).

(D)

Research into the principles of soil stabilization with bituminous binders, and methods of designing and construction soil-bitumen mixtures, has led to proposals for two methods of stabilization with the most economical proportion of bituminous binder; (1) a waterproofing action resulting from the formation during mixing of a soil-water bitumen system, and (2) the alteration of soil properties, before mixing with bituminous binder, by physico-chemical reactions between the soil and added materials such as Portland cement, lime and salts of heavy metals. It is emphasized that the attainment of a mixture of soil and bitumen, commonly held to be a basic requisite of successful stabilization, may under certain conditions be the least desirable soil-bitumen relationship.

40 - Bernatzik, W., "Electro-Chemical Consolidation of the Ground", Final Report, Second Congress of the International Association for Bridge and Structural Engineering, (Berlin: W. Ernst & Son, 1939), pp. 819-924.

(G)

41 - Bernhard, R. K., "Static and Dynamic Compaction", Proceedings Highway Research Board, 1952, Vol. 31, pp. 563-591.

(H)

This paper describes an investigation on soil compaction as part of a more comprehensive study on "Dynamic Properties of Soils", sponsored by the New Jersey State Highway Department, the Bureau of Public Roads, and Rutgers University.

Methods to produce and measure compaction effects are discussed; laboratory and field experiments have been performed and static and dynamic compaction efficiencies compared. The results indicate that for certain soils, in particular soils used often as highway subbases, dynamic compaction can produce higher densities and reach deeper strata than static compaction.

42 - Berry, D. S., "Stability of Granular Mixtures", Proceedings A.S.T.M., 1935, Part 2, Vol. 35, pp. 491-507, (Discussion: pp. 508-510)

(A,H)

Investigation made as part of study by Michigan State Highway Department for developing rational method for design of surface and base courses for flexible type low-cost roads; description of testing machines for determinations of load carrying capacity, deformation under load, and shearing resistance; development of vibration method for controlling degree of compaction.

43 - Beskow, Gunnar, "Scandinavian Soil Frost Research of the Past Decade", Proceedings Highway Research Board, 1947, Vol. 27, pp. 372-383.

(A,F)

In the past decade (1937-1946), the principal advance in this field has been the results of the comprehensive Norwegian investigation on frost depth as a function of temperature conditions and material properties. The paper describes this work and contemporary Swedish research in frost action. Formulas are derived for a given "frost quantity" (freezing index in U.S.A.) by which frost depth may be calculated as a function of the soil material's heat conductivity, heat capacity and the freezing energy libration of its water content at freezing. The formulas may be used in homogeneous materials and where several strata of different materials are present. The effect of soil stabilizing chemicals (calcium chloride, water soluble resins, sulphite leach, etc.) on frost action is reported.

44 - Beskow, G., Rengmark, F., and Soveri, U., "Stabilization of Clay Gravel Road Surface with Resinous Materials", Engineering Journal (Canada), March 1953, Vol. 36, No. 3.

(F)

Using the wastes and by-products of the paper pulp industry, a substance was produced which gave promising results in the laboratory. The main ingredient in this substance is a resin, which is derived from sulphate raw soap by distillation, not by extraction, as are some American resins used for soil stabilization. The crystalline resin thus obtained is dissolved in sodium hydroxide and solution may be used so prepared; if still better results are desired, small amounts of sulphate liquor may be added; this addition causes the formation of a fine colloidal suspension. The product is a liquid, its concentration can be varied according to need, and it may be made on the job. Tests have proved that it is possible to make a surfacing of clay gravel of excellent stability

by means of resin. Some surfacings have shown a high stability during unfavorable weather conditions over a long period.

45 - Betty, Ben H., "Symposium on Applications of Granular Stabilization: Stabilization and Maintenance of Roads for Heavy Armored Traffic", Proceedings Highway Research Board, 1944, Vol. 24, pp. 478-481.

(B)

This is one of the four papers dealing with the application of the principles of granular stabilization to construction of surfaces and bases. This paper describes the successful use of 2-in. to 3-in. crushed stone to provide surfaces that would stand up under the pounding of tanks, tank destroyers and heavy trucks. In one case, gravel boulders up to 6-in. were incorporated in the road without difficulty.

46 - Better Roads, "Coordination Steps Up Soil-Cement", Better Roads, 1951, Vol. 21, pp. 25-26.

(C)

Approximately 11 miles of Mississippi Route 1 in Bolivar County were built during 1951 with a road-mixed, cement-stabilized earth and alluvial sand base and sealed with two applications of bituminous surface dressing. The mix contained 13 per cent of cement by volume and the compacted base was 6 in. thick and 21 ft. wide. The equipment and organization are described.

47 - Better Roads, "Sand Drains Installed at Marsh Crossing", Better Roads, 1949, Vol. 19, No. 6, p. 39.

(H)

Vertical drains totaling 157,000 lineal ft. placed to stabilize approach to new bridge carrying New Jersey Route 35 across Manasquan River Inlet; drains average in depth from 33.6 to 53.6 ft. installed by driving 18 inch diam pipe which encloses 15 inch diam pipe under pressure and expands to full 18 inch diam. of finished drain as pipe is withdrawn.

Biesenbach, W. J. (see 480)

48 - Birrell, K. S., "Laboratory Tests on Stabilization of New Zealand Soils with Portland Cement", New Zealand Journal of Science & Technology, (B Gen. Sec.) 1944, Vol. 26, No. 2, pp. 77-89.

(C)

Comprehensive survey has been made of principal soil types on New Zealand airfields for purpose of finding soils which were best suited for cement stabilization, 29 laboratory tests showed that soil or subsoil of 7 were suitable; corrections were sought between efficiency of cement-stabilizing process with respect to soils and certain physical properties which govern their classification into groups.

49 - Bishop, J. A., Granular Stabilization with Limerock, Fla. University Eng. & Indus, Experiment Station, Tech. Paper Series, 1950, Vol. 4, No. 12, 6 pages.
(B)

Increase in stability of soils by addition of natural or artificial material; limerock as stabilizing agent has been tested on basis of Florida bearing test and California bearing ratio; description of tests and results. From Florida Highways, July 1950.

Bishop, J. A. (see also 276)

50 - Blott, J. F. T., "The Structure of Clay in Relation to Road Construction", Journal Society of Chemical Industry, 1946, Vol. 65, pp. 113-118.
(A)

This is a discussion of the physical structure of clay particles and clay suspensions in relation to the behavior of subgrades and foundations in road construction. 31 references.

Borkov, B. S. (see 449)

51 - Bratt, A. V., "Asphalt Emulsion Stabilization on Cape Cod", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 289-291.
(D)

This paper describes the design and construction of an experimental project consisting of a section of asphalt emulsion stabilized road at Cape Cod, Mass. Laboratory stability tests were made with the Hubbard-Field Asphalt Stability Machine. Based on the results of stability and absorption tests, 3.5 to 4 per cent asphalt emulsion was used. Construction procedures consisted in applying the asphalt emulsion to the base material, harrowing and blading, and compaction. The mixture was allowed to set over night, bladed to shape and initial compaction obtained by means of a sheepsfoot roller. Final compaction was obtained by means of an 8 ton three-wheel roller after about 10 days.

52 - Brest, Alexander & Woodson, Dillard D., "Cement Stabilized Bases for Runways", The Military Engineer, 1944.
(C)

Breth, H. (see 139)

Briggs, G. F. (see 503)

53 - Brooke-Bradley, H. E., "Soil-Cement Roads in Worcestershire", Surveyor, London, 1952, Vol. 3 (3157), pp. 571-573.
(C)

A brief description is given of soil types which occur in Worcestershire. These range from sand and gravel to loam and several different kinds of clay. All

these soils have been successfully stabilized. Details are presented on the methods of stabilization adopted and experimental work undertaken. Examples quoted relate to cohesive soils, and a description is given of the reconstruction of an urban street carrying heavy industrial traffic; costs are worked out.

54 - Brooke - Bradley, H. E., "Stabilization of Soils", Structural Engineering, 1944, Vol. 22, No. 8, pp. 347-374.

(A)

Importance of stabilization factor in road design from point of view of British practice; practice in use of adhesives or binders to make soil forming roadbed permanently strong enough to distribute loads over wide area to make soil resistant to capillarity and to maintain permanent uniform moisture content; stabilization methods and tests and soil classification discussed. Bibliography.

Brooks, H. E. (see 318)

Brown, A. L. (see 330)

Brown, F. L. (see 330)

55 - Brown, V. J., "Intimate Mix Obtained in Oklahoma Bituminous Soil Stabilization", Roads & Streets, 1949, Vol. 92, No. 8, pp. 45-47.

(D)

Program of Highway Commission of Oklahoma to obtain low cost roads through bituminous soil stabilization; mixing machine cuts roadway to depth required to provide specified compacted thickness and thoroughly coated mixture; initial engineering; mixing and manipulation procedure; operation illustrated.

Browning, George, (see 334)

56 - Buchanan, S. J., "Military Application of Soil Stabilization", Proceedings of Conference on Soil Stabilization, M.I.T., 1952, pp. 292-296.

(A)

Methods of soil stabilization applicable to the difficult problems encountered in forward areas are summarized, in the order of their desirability, as follows: (a) mechanical methods, using natural or locally available materials. (b) physical methods, involving the use of materials that are normally available in forward areas for other purposes, thus involving only an increase of the quantities required and utilizing personnel and equipment already available. (c) physical methods involving materials that are not normally available in forward areas and that would significantly increase the logistics problem, but could be utilized with personnel and equipment already available. (d) chemical and electrical methods involving the use of new materials and/or new equipment and requiring new techniques, all of which are not normally available. It is concluded that for any method to be a success, it must be very simple or "surefire", so to speak.

Buchanan, S. J. (see also 160)

57 - Bureau Central d'Etudes pour les Equipements d'Outre-Mer: "Recommendations du Comité technique créé pour l'étude générale des routes économiques,(Recommendations of the Technical Committee created for the study of low-cost roads), Service des Routes, Paris, 1951. (In French)

(A)

The Central Bureau for the Study of the Development of Overseas Territories was created in February 1949, and is a body sponsored and subsidized by the French Government and a number of private firms. The present publication sets out the recommendations made by the Technical Committee to the Ministry for French Overseas Territories on the following subjects: Technical and Economic Concepts, Alignment, Expropriation and Procedure, The Road Formation, Earth Roads, Other Types of Roads, Macadam, Mechanically Stabilized Soil, Laterites, Soil Stabilized with Bituminous Materials, Soil Cement, Problems Relating to Bituminous Binders, Impregnation, Coated Materials, Surface Dressing, Selection of Binder, Organizing the Supply of Binders, Organization of Work Sites Concerned with the Spreading of Binders, Quarries, Roadside Amentities.

58 - Burggraf, F., "Field Tests and Their Application to the Design of Stabilized Soil Roads", Proceedings American Road Builders' Association, 1940, pp. 324-335.

(A)

This paper contains a description of a field testing apparatus which would give quantitative results on each of the components making up the road structure along with some typical data obtained during the construction and on finished projects in several states and a practical analysis of the results. The paper is divided into the following parts: (1) Description of Machine and Field Testing Technique, (2) Presentation and Discussion of Data, (3) Conclusions.

59 - Burggraf, Fred, "Stabilization's Place in Our Present Day Highway System", Proceedings American Road Builders' Association, 1941, Vol. 38, pp. 151-156.

(A)

Progress and Trends; Developments in Structural Design Formulas; Other Indications of Stabilization's Importance; The Future of Stabilization.

Burggraf, Fred, (see also 503)

60 - Burnside, W. H., "Test on Virginia Road of New Resinous Soil Stabilizer", Public Works, 1945, Vol. 76, No. 2, pp. 24-25.

(F)

Details of tests made during 1944 by State Highway Department on heavy clay road in Virginia; illustrations given.

61 - Bush, W. H., "Soil Stabilization by the Bitumen-Cement Process", Highway Bridges and Aerodromes, 1947, Vol. 13, No. 652, pp. i-ii, v, xii (supplement).

(C,D)

The fundamentals of soil stabilization are briefly discussed and recommendations are given for a method of stabilization involving the use of bitumen emulsion and cement. The recommended compacted thickness of the stabilized course varies from 1 to 1½ inch for footpaths to 4 inches for car parks, runways for light aircraft, secondary roads and base for concrete surfacings.

62 - Butler, S., "Why Alexandria, La. Uses Soil-Cement Streets", American City, 1949, Vol. 64, pp. 144-145.

(C)

Curbs and gutters are placed before the cement-stabilized base is prepared. Cement is applied by a belt spreader to the full width of the street and the sheepsfoot rollers followed by pneumatic-tired rollers. After being open to traffic for two weeks, the roads are surface-treated with pre-mixed asphalt which is spread by patrol graders and rolled with a steel-tired roller.

63 - Calcium Chloride Association, Soil-Aggregate Stabilization and the Use of Calcium Chloride for Military Roads and Airport Runways, Calcium Chloride Association Bulletin, No. 26, 1942, Detroit, (24 pages)

(B,F)

This booklet gives information mainly in the form of extracts from technical literature on the use of calcium chloride with graded soil mixture for stabilized bases and surfacings on roads and aerodromes.

64 - Calcium Chloride Association News, "Bases for Maryland Roads", Calcium Chloride Association News, 1949, Vol. 15, pp. 10.

(B,F)

Gravel bases are stabilized with calcium chloride and left unsurfaced for at least one winter to ensure good compaction by the action of traffic. In this way, base failures may be located and remedied before the permanent surfacing is constructed.

65 - Campen, W. H. and Smith, J. R.,"Some Physical Properties of Densified Soils", Proceedings Highway Research Board, 1942, Vol. 22, pp. 460-468.

(H)

This paper presents laboratory data to substantiate the belief of the authors that the stability of densified soil mixtures can be measured by the behavior of these mixtures when submitted to drying, freezing and capillary water. The samples examined by these tests include ten fine grained soils and six soil-aggregate mixtures. The tests reveal that: (1) All mixtures shrink on drying and the shrinkage increases as the optimum water content increases.(2) The fine

grained soils shrink on freezing and the shrinkage increases as the optimum water content increases whereas the soil-aggregate mixtures expand and the expansion increases as the ratio of water used at optimum to theoretical water required increases.(3) None of the soil samples absorbed water appreciably by capillarity if the air-void content at optimum moisture and maximum density did not exceed 3.5 per cent. None of the soil-aggregate mixtures absorbed water if the air void content did not exceed about 1.0 per cent.

66 - Cape, E. B., "Test Methods Used in the Design and Control of Soil-Bituminous Mixtures in Texas", Proceedings Association Asphalt Paving Technologists, 1940, Vol. 12, pp. 139-148, (Discussion: 149-151)

(D)

The modified bearing value test described based on the performance of early soil-bitumen roads in Texas is used to determine whether a given soil can be stabilized economically and the type and proportion of bituminous product to be used. The test shows the minimum percentage of bitumen necessary to waterproof the soil and the maximum percentage of bitumen necessary to waterproof the soil and the maximum beyond which mix is too fat: the proportion used should not be too near either extreme.

67 - Carey, W. C., "Soil Engineering Practices for Military Engineers", Military Engineer, 1944, Vol. 36, No. 222, pp. 120-126.

(A,I)

Discussion of classes of soil use, basic methods of stabilizing soil and equipment for construction and maintenance of soil stabilization.

Carl, R. (see 318)

68 - Carpenter, C. A. and Willis, E., "A Study of Sand-Clay-Gravel Materials for Base-Course Construction", Public Roads, 1939, Vol. 20, No. 1, pp. 1-12, 16-17.

(B)

Mixtures tested in circular track; additional compaction necessary for three sections of series; only one section of series 1 failed during traffic test; water elevation of $\frac{1}{2}$ inch proved severe test condition; new instrument used to take longitudinal profiles; satisfactory plastic materials had greatest compaction in test track; tests showed importance of controlling plasticity and grading; findings used in drafting specifications for soil and gravel base courses; conclusions.

Carpenter, C. A. (see also 512)

69 - Carpenter, G. Y., Base Stabilization on the Blue Ridge Parkway, Bulletin No. 157, Washington, D. C., American Road Builders' Association, 1949, (8 pages)

(B,F)

This is a description of base stabilization by the use of calcium chloride both as road mix and surface application. Methods and equipment are described.

Where previously crusher run stone was used without stabilization, the crushed stone is now stabilized by the addition of soil fines and calcium chloride.

70 - Carpenter, J. C., "Sand Drains Inserted Into Unstable, Water-filled Material Stabilized Muck in Puerto Rico", Engineering News Record, 1948, Vol. 141, pp. 52-54.

(H)

The most important road in Puerto Rico between San Juan and Point Borinquen has been extended by using vertical sand drains to stabilize a foundation soil of negligible shear strength and rich in organic matter. The methods employed closely followed procedure developed by the California Division of Highways with two major changes. The soft and waterlogged nature of the area necessitated the spreading of a blanket of tough clay to support construction equipment. Sand was used for the entire fill above this clay blanket. Provision was made for a 64 ft. wide road with a surfacing 51 ft. wide. Work was started in November 1942 and completed in August 1946.

71 - Carson, L. S. and Reid, Carl R., "Chemical Determination of Cement Content of Soil-Cement Mixtures from Cement Hardened Base", Proceedings Highway Research Board, 1941, Vol. 21, pp. 471-483.

(C)

After preliminary inquiry had shown that two basic methods had been used in determining cement content, it was decided to ask a number of laboratories to cooperate in testing standard samples by the two methods. Twenty-four laboratories participated in the investigation. The results obtained by the laboratories were remarkably uniform with both methods but it was felt that the test procedure recommended in the Committee report which is based upon determination of C_aO content in samples of the raw soil, cement and soil-cement mixture offers wider application in that it may be used with soils of higher lime content than are usually met.

72 - Carter, H. C., "Lime Stabilization in District Fourteen Texas Highway Department", American Road Builders Association Technical Bulletin No. 185, 1952, pp. 5-11.

(E)

Subgrade Problems; Mechanical Stabilization; Stabilization Costs; Methods of Mixing; Conclusions.

73 - Casagrande, L., "Die Elektrochemische Bodenverfestigung", Die Bautechnik, 1939, Vol. 17, pp. 228-230. (The Electro-chemical Soil-Stabilization)

(G)

74 Casagrande, L., "Electrical Stabilization in Earthwork and Foundation Engineering", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 84-100, (Discussions: pp. 101-106).

(G)

This paper reviews briefly the present knowledge of the electrical stabilization in earthwork and foundation work. The following topics were discussed: Electro-osmosis; some unsolved problems regarding electro-osmosis in compressible materials; description of a full-scale field test; suggestions for practical applications; electrochemical hardening. It was concluded that the electrical methods for stabilizing soils will hardly ever achieve the broad application of generally accepted construction procedures. The electrical methods will probably be used only occasionally where special conditions render conventional methods useless or excessively expensive.

75 - Casagrande, L., "Electro-osmosis", Proceedings Second International Conference Soil Mechanics & Foundation Engineering, 1948, Vol. 2, pp. 218-223.

(G)

A laboratory investigation of electro-osmosis in soils and the main results are summarized in this paper; theory, description of laboratory tests, discussion of the results. A more comprehensive publication on this subject is being prepared at the Building Research Station, Department of Scientific and Industrial Research, England.

76 - Casagrande, L., "Electro-osmosis in Soils", Géotechnique, June, 1949, Vol. 1, No. 3, pp. 159-177.

(G)

The present paper shows that from a practical point of view the electro-osmotic transport of water may be assumed to be constant for all soils. The possibility of diverting the flow of pore-water away from cuttings is discussed and illustrated by practical examples. An explanation is also offered for the favorable effect of electro-osmosis on the consolidation of soft soil deposits.

77 - Casagrande, L., "Electro-osmotic Stabilization of Soils", Journal Boston Society Civil Engineers, 1952, Vol. 39 (1), pp. 51-83.

(G)

A review is presented of the principles and practical applications of electro-osmosis with particular reference to the stabilization of natural and excavation slopes in fine-grained soils. The subject is discussed under the following headings: (1) Principles of electro-osmotic flow through capillaries, (2) Electro-osmotic effects upon compressible materials, (3) Description of practical applications.

78 - Casagrande, L., "Grossversuch zur Erhohung der Tragfahigkeit von schwebenden Pfahlgrundungen durch elektrochemische Behandlung", Die Bautechnik, 1937, Vol. 15, pp. 14-16.

(G)

The improvement of the bearing strength of the floating pile foundation by electro-chemical treatment is discussed.

79 - Casagrange, L., The Application of Electro-osmosis to Practical Problems in Foundations and Earthworks, Great Britain Department of Scientific and Industrial Research, Building Research Technical Paper No. 30, (London: His Majesty's Stationery Office, 1947).

(G)

80 - Catton, Miles D., "Basic Principles of Soil-Cement Mixtures and Exploratory Laboratory Results", Proceedings Highway Research Board, 1937, Vol. 17, Part II, pp. 7-23. (Discussions: pp. 24-31).

(C)

This paper reports the results of an exploratory investigation of soils and soil-cement mixtures. A direct correlation between the hardening influence of cement on soil-cement mixtures and soil characteristics has been found. It is concluded that a soil meeting the following requirements can be effectively hardened by the addition of a reasonable amount of cement: (1) The LL must be below 50. (2) The PI must be below 25. (3) The clay content must be below 35. (4) The percentage of solids at maximum density must be 60 or greater. (5) The soil must possess a "regular" moisture density curve.

81 - Catton, M. D. and Felt, E. J., "Effect of Soil and Calcium Admixtures on Soil-Cement Mixtures", Proceedings Highway Research Board, 1943, Vol. 23, pp. 497-529.

(C)

This report shows that some sandy surface soils which react poorly with cement, and therefore require high cement contents for hardening, can be improved to react in the normal manner by adding to the sand an admixture of clayey soil, or by adding a small quantity of calcium chloride. Compressive strength, wet-dry and freeze-thaw test data are given showing the effect of the soil and calcium chloride admixtures on a number of poorly reacting sandy soils. Data are also given showing the effect of calcium chloride upon normally well reacting soils.

82 - Catton, M. D., "Laboratory Investigation of Soil-Cement Mixtures for Subgrade Treatment in Kansas", Proceedings Highway Research Board, 1937, Vol. 17, Part II, pp. 92-97. (C)

This paper reports the investigations of soil-cement mixtures for subgrade treatment in Douglas County, Kansas. The problem involved is one of reducing volume changes in the soil enough to overcome pavement distortion due to moisture changes or moisture gradients. It was found that the use of cement contents around 5 per cent would produce a cement hardened soil for a time which would slowly change from a hardened cake condition to a granular condition in proportion to the severity of weather conditions.

83 - Catton, M. D., "Moisture Requirements for Soil-Cement Construction", Soil-Cement News, 1943, No. 12, Page 2.

(C)

Research on the permissible variation from optimum moisture content in soil-cement mixtures has shown that sandy and gravelly mixtures have about the same durability and strength when compacted at moisture contents slightly above or below the optimum; finer-grained soils give as good or better results when compacted at moisture contents above the optimum but inferior results at moisture contents below optimum.

84 - Catton, Miles D., "Research on the Physical Relations of Soil and Soil-Cement Mixtures", Proceedings Highway Research Board, 1940, Vol. 20, pp. 821-855.

(C)

The report presents the results of soil and soil-cement tests on 329 soils from 37 states which were performed in the Portland Cement Association soil-cement laboratory during the past five years. Included are the usual routine tests on soils and moisture-density, wet-dry, freeze-thaw and compressive strength determinations on soil-cement mixtures. The report points out that such factors as grain size, gradation, silt and clay content, density, optimum moisture, water holding capacity, surface area, organic content, void-cement ratio, hydrogen ion concentration, compressive strength, etc., contribute to an analysis of soil and soil-cement relations but they are so diverse and interrelated in character and influence that none of them have a constant, major, predominating influence. The facts show that some factor or influence of a chemical or physio-chemical nature, such as the mineral composition of the soil grain and its adsorbed ions, may play a predominate part in evaluating soil and soil-cement relations and research on these factors holds promise of contributing valuable information on these relations.

85 - Catton, M. D., "Soil-Cement: A Construction Material", Proceedings Conference on Soil Stabilization, M.I.T., 1952, pp. 26-58.

(C)

This article deals with the basic principles and designing methods of soil-cement mixtures. The developments of soil-cement and the performance of soil-cement roads are briefly discussed.

86 - Catton, Miles D., "Soil-Cement Mixtures for Roads - Review of 1937 Symposium", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 314-321.

(C)

This review briefly covers the laboratory which defines soil-cement mixtures and outlines the general construction procedures which the various state reports have shown to be successful. Discussions are presented under the following headings: (1) Basic Control Factors, (2) Construction, (3) Processing, and (4) Cost.

87 - Catton, M. D., "Soil-Cement Paving", Pacific Builders & Engineers, April 1947, Vol. 53, No. 4, pp. 82-83.

(C)

Data on soils used, volume of cement, density & moisture; description of equipment and protective covering.

88 - Catton, Miles D., "Some Wartime Soil-Cement Construction Experience", Proceedings Highway Research Board, 1944, Vol. 24, pp. 450-466.

(C)

A brief review of the highlights of the Army and Navy experiences with soil-cement construction during the war is presented. Details are given of construction procedures, equipment and accomplishments on some of the more important projects. Also, some of the unusual weather and subgrade conditions encountered on some jobs are described together with results obtained.

89 - Catton, M. D. and Felt, E. J., "Weight-in-Water Methods of Determining the Moisture Content of Soil-Cement Mixtures in the Field", Proceedings Highway Research Board, 1943, Vol. 23, pp. 487-494. (Discussions: pp. 494-497)

(C)

This report discusses two "weight-in-water" methods for determining field moisture content of soil-cement mixtures. The methods are based on the fundamentals that a sample of soil-cement when weighed in water weighs the same regardless of its moisture content. After the weights of the sample in air and in water are obtained, the specific gravity of the mixture is used to aid in the calculation of its dry weight and moisture content. The fact that cement is a powerful flocculating agent is instrumental in making possible the use of a pycnometer-syphon weight-in-water method applicable to soil-cement mixtures even though they are composed of fine textured soils.

90 - Cement and Concrete Association, Soil-Cement Roads and Pavements: Soil Identification and Classification of Field Testing Procedures for Soil-Cement Construction Based on American Practice, Cement and Concrete Association Bulletin D 30, London, 1943, (24 pages).

(C)

To make readily available to road engineers the information required for constructing durable and economical soil-cement surfacings, this memorandum presents in simple form the methods of soil identification and classification and the procedure for field tests on soil-cement mixtures that have been used successfully in the United States.

91 - Cement & Lime Manufacture, "Soil-Cement Paving", Cement & Lime Manufacture, 1943, Vol. 19, No. 9, pp. 139-140, 142.

(C)

Notes on first full scale experiment in stabilization of soil with cement using agricultural machinery recently carried out in Great Britain; occasion arose when it was desired to pave fairly level rectangular plowed field of about 4 acres for use as steel yard.

Chandrasekharan, E. C. (see 525)

92 - Chasten, F. N., "Soil-Cement Progress in Australia", Construction Review, 1952, Vol. 25 (4), pp. 17-24.

(C)

Soil-cement bases in Australia have proved to be as durable as most low-cost flexible bases of equal thickness when provided with a bituminous surfacing and to have better load-carrying capacity.. A brief illustrated account is given of construction methods and equipment, the kinds of soil treated and laboratory and field tests used in soil-cement construction.

93 - Chopra, S. K. and Patwardhan, N. K., "Investigations on the Use of Lime-sludge as Soil Stabilizer", Journal of Scientific Industrial Research, India, 1952, Vol. 11B, No. 10, pp. 434-437.

(E)

The suitability of lime-sludge, a waste product of sugar factories and tanneries, as a soil stabilizer has been investigated at the Central Building Research Institute, Roorkee. It was found that: (1) 8 to 10 per cent of lime-sludge mixed with 3 to 5 per cent of lime and 2.5 to 5.0 per cent of cement is suitable for stabilizing Roorkee soils. (2) Mixtures containing lime-sludge and sodium silicate are better than those made with lime-sludge only. (3) The stabilizing efficiencies of lime-sludge and lime appear to depend on their C_aO content. (4) Initial drying improves the compressive strength of specimens made with soils stabilized with lime-sludge or with lime. (5) Mixtures of lime-sludge and cement are suitable for stabilizing soils intended for moderate loads.

Choudhurg, A. N. Dutta (see 524)

94 - Civil Aeronautics Authority, U. S. Department of Commerce, Laboratory Study of Soil Stabilizing Effectiveness of Complex Salt of Abietic Acid, Technical Development Note No. 35, 1944, (26 pages).

(F)

Results obtained from laboratory in investigation of soil stabilizing properties of complex salt of abietic acid known commercially under trade name "Resin Stabilizer 321". This material, finely powdered, white resinous substances, is exceptionally light weighing only 16 pcf. and not being hygroscopic can be packed and stored without deterioration or loss of effectiveness.

95 - Clare, K. E., "Effect of Cetyl Pyridinium Bromide on the Water Absorption and Swelling of Soil", Nature, London, 1947, Vol. 160, pp. 828-829.

(F)

Experiments carried out at the Road Research Laboratory, Harmonsworth, England, showed that the addition of cetyl pyridinium bromide to a clay soil does not prevent the movement of water through the pore spaces of the soil but inhibits the adsorption of water by clay particles and hence the swelling of the latter presumably because of the adsorption of organic cations by the clay particles.

96 - Clare, K. E. and Sherwood, R. T., "Separation of the Organic Constituent of Black Liquor", Chem. Ind., 1950, No. 69, pp. 192-

(F)

A method of constructing road foundations at present in the development stage is to waterproof the soil by the addition of small quantities (1-2%) of certain resins. Since these resins are obtained chiefly from hard-currency areas, work at the Road Research Lab., Harmondsworth, England, has been directed towards finding substitute materials and in particular investigations have been made on the organic constituents of the alkaline black liquors obtained during paper pulp manufacture in England. Lignin has been prepared from esparto grass liquor by the addition of excess calcium chloride followed by acidification with hydrochloride acid and data are presented on the compositions of the precipitates and the concentrations of solutions, filtration times and precipitate weights in experiments to determine the optimum concentrations of the various constituents for obtaining the most rapid filtration.

97 - Clare, K. E., "Some Laboratory Experiments in the Waterproofing of Soils", Proceedings 2nd International Soil Mechanics Conference, 1948, Vol. 1, pp. 230-236.

(F)

This paper presents an account of experimental work carried out at the Road Research Laboratory, Harmondsworth, England. The efficacy of Vinsol-resin and a fuel oil containing paraffin wax in waterproofing a sandy loam was investigated by means of the Capillary Water Absorption Test. The samples for this test are prepared with a 10% air void content. The dry soil density and moisture content are determined from the results of preliminary compaction tests. Duplicate specimens (3 in. long, 2 in. diameter) are then made in split cylindrical molds. After three days storage in a humid atmosphere, the specimens are removed from the molds and the curved surfaces are coated with wax. The specimens are then weighed, stood in a closed tank in about 2 mm. of water and reweighed after 1, 3, 7, 14 and 28 days. Results which are shown graphically indicate that 1% of Vinsol resin or 3 per cent of the waxed fuel oil gives a maximum waterproofing effect with a sandy loam soil. Other experiments indicated that (1) natural resinous materials are effective in waterproofing acid but not alkaline soils, (2) alkaline soils can be waterproofed with sodium stearate or a resinous emulsion, (3) a Manila Copal resin is the most satisfactory of a number of

tropical resins tested, (4) Vinsol-resin may increase the frost resistance of chalk and (5) Vinsol-resin does not change the shear resistance or cohesion of a soil.

98 - Clare, K. E. and Sherwood, R. T., "The Determination of the Cement Content of Soil-Cement Mixtures", Journal of Applied Chemistry, 1951, Vol. 1, pp. 551-560.

(C)

Part I. Experience at the Road Research Laboratory, Harmondsworth, England is reported. A series of modified analyses indicated that with clay-cement it is advantageous to separate the acid extract containing calcium by centrifuging before precipitating the calcium as calcium oxalate. Reference is made to the possibility of measuring the cement content of soil-cement mixes by estimating the sulphate content especially with soils containing a large proportion of calcium carbonate substantially free from sulphate. Part II. Two rapid field methods are described. One is based on measurement of the pH of a suspension of soil-cement in a buffer solution and the other on the determination of the chloride content of the soil-cement; the second method is applicable when super-rapid-hardening cement is used.

99 - Clare, K. E. and Pollard, A. E., "The Relationship between Compressive Strength and Age for Soils Stabilized with Four Types of Cement", Mag. Concrete Res., (England), 1951, Vol. 8, pp. 57-64.

(C)

Mixtures of a sand, a silty clay and a clay with normal Portland rapid-hardening high alumina and super-rapid-hardening cements have been tested at the Road Research Laboratory, Harmondsworth, England, at ages ranging from a few minutes to 28 days; the results are summarized in graphs. To insure constant moisture contents, specimens were coated with paraffin wax immediately after molding and stored in sealed containers in a room maintained at 25° C. Organic matter in the sand not detectable by extraction with sodium hydroxide delayed the hardening of normal Portland and rapid-hardening cements seven days; this retardation was reduced to two days when lime was added with the cement and virtually eliminated when super-rapid-hardening cement which contains calcium chloride was used. Other experiments confirmed that small proportions of lime or calcium chloride, especially the latter, improve the early strength of mixtures containing organic matter. A statistical examination of compressive strength of samples cured by two different methods (in humid air and with a wax coating) showed that the coefficient of variation of the moisture contents of the specimens was substantially reduced when test samples were coated with wax. Two short appendices describe procedures for the compaction test and the unconfined compressive strength test for soil-cement mixtures.

)0 - Clare, K. E. and Packham, D. I., "The Stabilization of Soil with Resorcinol-Formaldehyde Resin for Road Construction", Journal of Applied Chemistry, 1952, Vol. 2 (8), pp. 456-463.

(F)

A study has been made at the Road Research Laboratory, Harmondsworth, of the strength and water-absorption characteristics of 3 soils when treated with resorcinol-formaldehyde resin and certain lower grade substitutes. Factors affecting the setting time of the resin have also been investigated. It was found that small proportions of resin increased the 7-day strength and reduced the water-absorption of the compacted soils and that the setting time of the resin was accelerated by the addition of hydrated lime and by increasing the temperature.

101 - Clare, K. E., "Waterproofing of Soil by Resinous Materials", Journal of Society of Chemical Industry, 1949, Vol. 68, No. 3, pp. 69-76.

(F)

Study made at Road Research Laboratory of method of waterproofing soils by addition of small quantities of two natural resinous materials, "Vinsol" resin and rosin; charts. Bibliography.

102 - Clauson, L. M., "Developments in Iowa Secondary Road Soil Stabilization", American Road Builders' Association Technical Bulletin No. 184, 1952, pp. 1-11.

(A,B)

Flexible Base; Soil-Aggregate Bases; Soil Binders; Road Maintenance Reduced; Treated Surfacing Materials; Maintenance Question; Judicious Blading.

103 - Clauson, L. M., "Secondary Road Surfacing Problems in Iowa", Proceedings Highway Research Board, 1949, Vol. 29, pp. 293-300.

(A)

The State of Iowa has about 79,000 miles of secondary roads which have to be maintained to provide access to farms. Supplies of good roadmaking material are limited and unevenly distributed, the whole of Iowa being covered by glacial drift and later wind-blown deposits. A brief account is given of the use of local materials in the construction of graded soil base courses and wearing surfaces.

104 - Clemmer, H. F., "Report of Committee on Granular Stabilized Roads", Proceedings Highway Research Board, 1944, Vol. 24, p. 478.

(B)

Four pages are presented dealing with the application of the principles of granular stabilization to construction of surface and bases. Each report introduces new and much needed information on the use of local materials.

105 - Clemmer, H. F., "Report of Committee on Soil Calcium Chloride Roads", Bulletin No. 14, Washington: Highway Research Board, Oct. 1948, pp. 18-19.

(F)

In controlled experiments, it was found that the addition of calcium chloride to soils resulted in greater shear strength, better moisture control as indicated by reduced moisture fluctuations, reduction of ravelling and pot-holing on unsurfaced roads and a reduction in the friability of non-cohesive or non-plastic soils.

106 - Clemmer, H. F., "Report of Committee on Soil Calcium Chloride Roads", Highway Research Abstracts, 1952, Vol. 22, No. 6, pp. 14-24.

(F)

The work of this Highway Research Board Committee since 1950 is reported. Results are presented of shear test on treated and untreated soils and information is given about the effect of moisture on the stability of soil roads, ravelling, friability, bond between bituminous wearing course and soil base course and durability and performance. In the section devoted to new projects, accounts are given of the construction of experimental roads in Minnesota and Kentucky, special consideration being given to densities and curing period. Future studies are briefly discussed.

Coleman, R. J. (see 375)

107 - Collier, B. T., "Emulsified Asphalt Stabilized Base Construction", Public Works, 1941, Vol. 72, No. 11, pp. 18-19.

(D)

Since 1939, bases stabilized with bitumen emulsion have been used with success in Mississippi. This paper describes briefly the construction of the emulsified asphalt stabilized bases.

108 - Concrete, "Pressure-Grouting With Cement-Loam Mixtures Restores Settled Buildings", Concrete, Vol. 50, 1942, No. 11, pp. 2-3.

(A,C)

Settlement of existing buildings occurred in large residential sections in St. Louis; success experienced with pressure grouting operations for correcting settlement in existing buildings; suggested application of same principles to stabilization of similar foundation soils prior to construction of new buildings; method of procedure described and illustrated.

109 - Construction Methods, "Chemical Injections Solidify Soil to Stomp Foundation Settlement", Construction Methods, 1945, Vol. 27, No. 12, pp. 78-79, 156, 158, 160, 162.

(F)

To stop settlement of heavy mill engine and crusher foundation resting on water logged, medium fine sand, pipes resembling well points are driven from working trench outside building into area below concrete mat and chemicals are injected under pressure through these pipes to form gel which hardens rapidly to transform soil into hard insoluble mass.

110 - Construction Methods, "Earth Roadbed Waterproofed by Stabilizing Agent of Treated Resin and Chemicals Mixed in Place as Dry Powder", Construction Methods, 1945, Vol. 27, No. 1, pp. 70-72.

(F)

Earth roadbed stabilization with water repellent mix of specially treated resin and other chemicals in form of dry powder known as "Stabinol" has been applied to ½ mile test section of 22-ftwide road near Farmville, Va.

111 - Construction Methods, "Powdered Admixture Waterproofs Shale Road in Pennsylvania Stabilization Test", Construction Methods, 1945, Vol. 27, No. 7, pp. 72-73, 160, 164, 166.

(F)

A half-mile test section of stabilized soil road has been constructed by the Penna. State Highway Department, the soil being waterproofed with "Stabinol" applied in the form of a powder at the rate of 6 lbs. per sq. yd. of 6-in. treated depth. "Stabinol" is usually effective with clayey or silty soils in which fine clay does not predominate but is not recommended for granular soils with small proportions of binder soil. On roads carrying more than very light traffic, a wearing course is recommended.

112 - Contractors' & Engineers' Monthly, "Asphalt Stabilizes Granular Road Base", Contractors' & Engineers' Monthly, 1951, Vol. 48, pp. 61-62.

(D)

Road improvements recently carried out on US-24 near Colby, Kansas included raising the roadbed above the level of the plain to relieve the snow clearance problem. A 7-in. bitumen stabilized base was laid in two 3½ in. courses and a surface dressing was applied.

113 - Contractors' & Engineers' Monthly, "City Dump stabilized to Carry Highway Fill", Contractors' & Engineers' Monthly, 1949, Vol. 46, p. 24.

(B,H)

A refuse dump which rested on unconsolidated organic silt and clay was compacted by a roller with pneumatic tired and oscillating wheels and a maximum weight of 50 tons. Preliminary tests were carried out to find the best method of using the roller. The average settlement was 1.5 ft. and the compacted layer appeared to be 4 ft. to 5 ft. thick. Depressions which developed in the surface were filled with sand and gravel before the rolling was completed.

114 - Contreras, L., "Stabilization of Soils for Roads", Rev. Caminos, 1945, Vol. 19, (½), pp. 41-46.

(A,F)

Fundamental principles of soil stabilization for the design of bases and surfacings for low-cost earth roads are briefly reviewed with particular reference

to conditions in Chile. Since the presence of mineral salts in soils permits the optimum moisture content to be maintained and the cohesive properties of the soil to be increased, earth roads have been constructed in northern areas of Chile by adding soil impregnated with chlorides or nitrates. A homogeneous, smooth and strong surfacing has resulted.

115 - Cooling, L. F., "The Physical Properties of Clay Soils and Some Aspects of Their Mechanical Behavior", Chemistry and Industry, 1936, pp. 25-31.

(A)

The subject is discussed in connection with problems concerned with foundations of roads and buildings.

116 - Corps of Engineers, U. S. Army, The Influence of Drain Wells on the Consolidation of Fine Grained Soils, (Providence: Corps of Engineers, U. S. Army), 1944.

(H)

117 - Couillaud, E., "Substitute Binders", Rev. Matér. Construction, (In French), 1951, No. 426, pp. 77-84.

(A,E)

An investigation has been carried out into the possibility of using local materials available in Algeria as substitutes for cement in the maintenance and construction of roads. The materials tried out were brick dust, fine clinker and pozzolana; they were mixed with different proportions of lime and sand. The results show that it is possible to determine the purpose for which each mixture is best suited but it is stressed that in practice heavy traffic loads must not be allowed to use surfacings made of these materials until they have had time to harden.

118 - County Surveyor of Offaly, England, "Reconstruction of Roads in County Offaly", Roads and Road Construction, 1949, Vol. 27, pp. 408-409.

(D)

In the reconstruction of roads in County Offaly, Eire, a macadam surfacing of 3 in. consolidated thickness is treated with a slurry of sandy clay, water and a stable emulsion covered with 1 in. screenings and rolled. The emulsion helps to waterproof the road and improves the adhesion of the subsequent surface dressing.

119 - Crum, R. W., "Soil-Aggregate Mixtures for Stability", Civil Engineering, 1944, Vol. 14, No. 6, pp. 247-250.

(B)

A review is given of current practice in the construction of soil-aggregate roads and runways and of control methods.

120 - Cuthbert, F. L., "Use of Calcium Chloride in Granular Stabilization of Roads", Highway Research Board, Research Report No. 2F, Washington, D. C., 1945, pp. 1-55.

(B,F)

A critical review of the literature dealing with the use of calcium chloride in granular stabilization. A classified and annotated bibliography of 194 references is appended.

121 - Curtis, W. D., "Soil Compaction Experiments Point Way Toward Stronger More Economical Subgrades", Civil Engineering, 1947, Vol. 17, No. 7, pp. 390-393, 438.

(H)

An account is given of experiments undertaken by the Engineering Experiment Station of Utah University to investigate methods of compaction control and possibilities of obtaining higher subgrade bearing capacities. Tests were undertaken on four soils containing 15 to 75 per cent of clay. Strength and densities were determined for a range of moisture contents and compactive efforts, AASHO compaction and density tests and CBR tests were also undertaken. Conclusions were drawn.

Dabney, G. W. (see 158)

D'Alessie, J. T. (see 27 and 28)

122 - Darwin, D. V., "Soil Cement Pavements", Commonwealth Engineer, 1942, Vol. 30, No. 3, pp. 53-55.

(C)

History of low cost pavements in Victoria; results of soil cement experiments carried out by County Roads Board; advantages and disadvantages of soil-cement pointed out; plant required.

123 - Davis, Frank L., "Soil-Cement Base, Wayne County, Iowa", Proceedings Highway Research Board, 1937, Vol. 17, Part II, pp. 78-83.

(C)

A section of 1.64 miles of soil-cement stabilization base was built in Wayne County, Iowa by the State Highway Commission during 1937. This article describes the construction procedures of this project under the following headings: (1) Mixing and Laying, (2) Curing, (3) Progress, (4) Costs, (5) The Finished Base. Recommendations for operations and equipment on soil-cement base stabilization are given at the end of the paper.

124 - Davidson, Donald T. & Glab, John E., "An Organic Compound as a Stabilizing Agent for Two Soil-Aggregate Mixtures", Proceedings Highway Research Board, 1949, Vol. 29, pp. 537-543.

(F)

A fatty acid amine acetate available in the U.S.A. in commercial quantities was investigated with respect to its value as a stabilizing agent, the experiments being carried out with two natural soils which had gradings suitable for base course materials and plastic indices greater than 3 and which contained clay minerals of the kaolinite type. The test procedure is described and results are presented in graphs and tables. It is concluded that more research is necessary before concrete recommendations can be made on the use of this substance as a stabilizing agent for highway subgrade and base course materials but the work so far indicates that it has considerable promise for improving the all-weather stability of soil-aggregate mixtures such as those used in the investigation.

125 - Davidson, Donald T., "Exploratory Evaluation of Some Organic Cations as Soil Stabilizing Agents", Proceedings Highway Research Board, 1949, Vol. 29, pp.531-537.

(F)

In the research for new soil stabilizing agents the effects of six organic cations on plastic limit, liquid limit, shrinkage limit, air-dry strength and rate of slaking of a highly plastic clay subsoil were studied. In all cases the plasticity index and shrinkage were reduced by the treatments. The air-dry strength was lowered in varying degree which was the only undesirable effect noted. With one exception, resistance to slaking was improved. It is concluded that large organic cations show promise as possible stabilizing agents for highly plastic fine-grained soils.

126 - Davidson, D. T., Large Organic Cations as Soil Stabilizing Agents, Iowa Engineering Experiment Station Bulletin No. 168, Ames: Iowa State College , 1949, (55 pages).

(F)

Relevant literature is briefly reviewed and a report is presented of a laboratory investigation on six cationic surface active agents and five plastic clays. The work carried out was of an exploratory nature but it indicated that large cations show considerable promise as soil stabilizing agents.

Davidson, D. T. (see also 227)

de Bruyn, C. N. A. (see 163)

Deibler, G. W. (see 551)

127 - Deklotz, L. A., "Effect of Varying the Quantity and Quality of the Soil Portion of Highway Aggregates on their Stability", Proceedings Highway Research Board, 1940, Vol. 20, pp. 787-797.

(B)

The combination of the PI and liquid limit as PI/LL x 100 for convenience designated as "D" was found useful to indicate the quality of soil. Three soils of different qualities were added to each of three similarly graded specimens of coarse material to produce a maximum density grading. Thirteen per cent passing the No. 40 sieve and 2 other gradings which differed only in that the per cents passing the No. 40 sieve were 23 and 33 per cent, respectively, were used. The stability of the none combinations was determined by the California bearing value test. These tests indicated that there is a definite relationship between the quantity D x soil per cent and the stability which should be of considerable value in the design of subgrades, base and surface courses. It also appears that the practice of rejecting aggregates on the basis of liquid limit and plasticity index tests without providing for consideration of the relative importance of the quantity of soil in the aggregate tested may often be uneconomical.

128 - Delord, R., "Study of Roads Having a Clay Binder", Travaux, 1943, Vol. 27, No. 118, pp. 141-146.

(B)

Owing to the lack of bituminous binders for repairing bituminous surfacings in France, a study has been made to enable satisfactory results to be obtained from the use of soil-aggregate mixtures. The subject is discussed under the following heads: cohesion of soils including the importance of the colloidal structure of certain components of clay; theory of construction of roads having a clay binder; and application of the theory to the temporary maintenance of bituminous surfacings.

Demers, G. (see 353)

129 - De Waal, F. I., "Soil Stabilization with Cut-back Bitumens and Tars", Roads & Road Construction, 1944, Vol. 22, No. 260, pp. 238-239.

(D)

Description of purpose, materials, tests and results of experiments; moisture content and type of binder studied; attempt to work out details of road construction in absence of hard stone or high quality gravel.

Dhawan, C. L. (see 25)

130 - Dicks, F., "Base of Soil-Cement", Rev. Caminos, 1945, Vol. 19, (5/6), pp.146-149.

(C)

The principles of constructing soil-cement bases for earth roads are briefly discussed with particular reference to the construction by the Chilean Roads Department of an experimental soil-cement base on the road between Concepcion and Coronel.

Dobson, A. F. (see 288)

131 - Dockery, W. D., "Lime Stabilization and Low Cost Road Construction", Roads and Streets, 1947, p. 93.

(E)

Success of lime in stabilizing local materials, particularly those having excessive clay content, is reported. Reduction in PI due to lime is reported. Construction methods and cost of treatment are given.

132 - Doran, J. S. and Wilson, L. H., "Better Testing Methods for Bitumen Emulsion-Sand Paving", Engineering News Record, 1943, Vol. 131, No. 21, p. 750.

(D)

A laboratory test developed on a particular job in South Carolina has proved valuable in determining the amount of bitumen emulsion required for mixing with local soil on the site to obtain maximum stability and density. With the soil in question, maximum stability and density were reached with 12 per cent of bitumen emulsion.

133 - Douglas, A. M. and Harvest, J., "A Mechanically Compacted Gravel Housing Estate Road", Journal of Institution of Municipal Engineers, 1949, Vol. 75, pp. 659-672.

(H)

A road on a housing estate in Stafford has been constructed by excavating the road bed to the required level placing curb foundations and curbs spreading a 9 in. depth of gravel ballast (1.5 in. down) with a bulldozer and rolling the material with a sheepsfoot roller and then with a wobbly-wheeled roller. The moisture content was adjusted to the Proctor optimum or preferably slightly below this value before compaction was begun. Where adjustment had been necessary, the distribution of moisture was improved by harrowing the loose material. The dry density of the compacted course was tested by the "post-hole" method, a chart being used to connect the density of wet and dry ballast with that of a standard sand used for comparison. A light sealing coat of bitumen emulsion and gravel failed to adhere satisfactorily and a 2 in. surfacing of densely-graded limestone 1.5 in. down, blended with precoated materials, was placed as soon afterwards as possible. Testing methods are described in some detail. Stress is laid on the need for adequate foundation drainage and of covering clay subgrades with a protective course preferably of material stabilized with bitumen emulsion or cement. The method is described as cheap, rapid and effective but it is suited only to gravel and sandy soil and the work must be done in the summer months.

134 - Downey, B. R., "Michigan Practice in Gravel Stabilization", Roads and Streets, 1943, Vol. 86, No. 6, pp. 57-59.

(B)

The Michigan practice in gravel stabilization is briefly described.

135 - Downey, B. R., Rowat, R. M., Ettinger, L. J.,(Arranged by Crum, R. W.), "Progress in Use of Sodium Chloride in Road Stabilization", Proceedings Highway Research Board, 1939, Vol. 19, pp. 559-562.

(F)

An interesting trend in the use of salt for stabilization in Canada was reported by Mr. Rowat. In 1936, the ratio of the quantity of salt used for surface treatment to that used for base stabilization was 4 to 1. In 1939 the ratio had changed to 1 to 14 and the total consumption had increased 15 times in the same period. The central mixing plant was the method preferred for preparation of the material. Salt was used at about 25 lbs. per cu. yd. and cost about 54¢ per cu. yd. including all cost items except gravel costs. Ettinger reports that a cost of $70.00 per mi. for salt for the first year is to be expected with cost of half that for subsequent years.

Downey described the experiments of the Maintenance Division of the Michigan State Highway Department with a type of shallow surface stabilization using a simple road mix procedure.

Downey, B. R. (see also 503)

Drake, W. B. (see 177)

136 - Duriez, "Note sur les nouvelles methodes pour augmenter la stabilité et l'imperméabilité des terrains", Annales des Ponts et Chaussées, 1949, Vol. 119, No. 2, pp. 289-295.

(A)

New method of increasing stability and impermeability of soils; referring to Swedish paper by F. R. Schultz abstracted in Highway Research Abstracts. Following methods are described; injections with bituminous emulsions, cement, water glass, electro-osmosis,electrochemical treatment and freezing.

Eckert, George W. (see 526)

137 - Ekblaw, G. E. and Grim, R. E., "Some Geological Relations Between the Constitution of Soil Materials and Highway Construction", Illinois State Geological Survey, 1936.

(A)

Engineering geology problems in Illinois relating to subgrade conditions and stabilized-soil roads. Surface materials, which are mostly glacial derivation are modified by weathering into typical soil profiles. Large proportion of these materials the clay minerals montmorillonite and sericitelike mineral (illite) whose properties including base-exchange capacity are markedly different. Consequently, materials' reactions under various conditions vary greatly and therefore identification of principal clay minerals and exchangeable base in any soil material is of prime importance before it is used in highway construction.

138 - Elleman, John H., "Calcium Chloride Surface Consolidated Roads", Proceedings Highway Research Board, 1940, Vol. 20, pp. 807-810, (Discussions:pp. 810-811).
(F)

This paper contains a description of the construction and maintenance methods necessary to obtain a surface consolidated road. The advantages of this type of surface consolidation are: (1) A variety of local surfacing materials which are available in most regions can be utilized, (2) Special technical knowledge is not required in the selection of these materials; selection being based on the individual roadman's experience, (3) The cost is low, and (4) This road type fits well into a stage construction program.

Elleman, John H. (see also 503)

139 - Endell, K., Koos, W., and Breth, H., "Zusammenhang zwischen kolloid-chemischen sowie bodenphysikalischen Kennziffern bindiger Böden und Frostwirkung" (The Relation Between Colloid Chemistry, the Physical Constants of Cohesive Soils and Frost Effects), Forschungsarbeiten aus dem Strassenwessen, 1939, Vol. 16, pp. 1-55.
(A)

Experiments made on clay minerals with controlled proportions of quartz and on natural soils. Relation between particle size distribution, Atterberg limits, absorption capacity, permeability and capillary pressure considered and conclusions drawn with regard to influence of these properties on frost danger.

140 - Endersby, V. A., "Fundamental Research in Bituminous Stabilization", Proceedings Highway Research Board, 1942, Vol. 22, pp. 442-459.
(D)

Information now available indicates a possibility of stepping up soil stabilization to a higher class of construction. A definite soil system exists which changes with the degree and method of mixing; the process passes through an optimum phase during mixing. The importance of water control is shown. There are vital differences in the phase aspects of different mixers. It is indicated that it is possible to improve soil stabilization with liquid oils several-fold by proper relation between oil and water content, phase mixing, proper curing, selection of stabilizer, selection of stabilizer content. For control test procedures: curing should be done in a manner approximating field conditions; exposure to water should be more severe than capillary methods; swell should be regarded as not proportional to loss of bearing power; for the evaluation of bearing power, both friction and cohesion must be taken into account.

141 - Engineering, "Pectosol-Cement Process for Soil Stabilization", Engineering, 1949, Vol. 168, No. 4360, p. 186.
(A,F)

Process for making roads cheaply and quickly in undeveloped territories overseas evolved by A. S. P. Chemical Co. makes use of certain vegetable materials normally wasted such as sisal "flesh", ground nut husks and palm kernel husks; laboratory tests gave satisfactory results with mixture of $1\frac{1}{2}$ parts cement to 100 parts soil and stabilizer together.

142 - Engineering News Record, "Base Stabilization Widely Used on N. Carolina Secondary Roads", Engineering News Record, 1948, Vol. 141, No. 2, pp. 128-130.

(B)

Paved surface on all of mileage being improved is made at least 18 ft. wide; base made 1 ft. wider then surfacing; 6 to 7 inches compacted thickness usually specified in stabilizing natural soil base with screening or sand; data on gradation of subgrade soils, mix of stabilizing material and soils and crushed stone and gravel used for surface treatment; notes on drainage structures and small bridges.

144 - Engineering News Record, "Electrical Stabilization of Soil", Engineering News Record, 1947, Vol. 38, No. 20, pp. 822-823.

(G)

Density and bearing capacity of clayey soils increase by electric current; electro-osmosis of water, substitution of aluminum for other replaceable bases and formation of Al and Fe gels are believed responsible for stabilization. Abstract prepared by U. S. Geological Survey from information in two Russian articles by B. A. Rzhanitzin, D. I. Solntzev and B. S. Borkov.

145 - Engineering News Record, "Jacksonville Builds Oyster-Shell Pavement", Engineering News Record, 1948, Vol. 140, pp. 434-435.

(A)

A description is given of the successful surfacing of streets in residential areas by (1) stabilizing the sand subgrade with calcareous dust, (2) compacting a 6 in. layer of oyster shells into a 3.5 in. base, and (3) completing with a surface dressing consisting of bitumen emulsion and slag followed by bitumen emulsion and sand.

146 - Engineering News Record, "Soil Waterproofed and Stabilized with New Type Resin Compound", Engineering News Record, 1944, Vol. 132, No. 11, p. 385.

(F)

A short account is given of the use in soil stabilization of "Stabinol", a proprietary resin compound similar to Vinsol resin. It is claimed that Stabinol can be used successfully in a wider range of soils than Vinsol but that since it has no binding qualities, it is most effective in soils containing at least 10 per cent of clay as a binder.

147 - Engineering News Record, "Vinsol Resin-A New Soil Stabilizer", Engineering News Record, 1942, Vol. 128, No. 19, pp. 777-781.

(F)

Laboratory and field studies extending over several years have led to the development of a satisfactory method of constructing stabilized soil bases with Vinsol resin and to a knowledge of the limitations in its use. Vinsol provides no binding power, but acts as a water repellent. It can be used satisfactorily with any soil that according to laboratory tests will not absorb more than 75 per cent of optimum moisture in 24 hours and that does not show appreciable slaking or swelling provided that the soil can be dried satisfactorily in the field and that the subgrade has sufficient load-bearing capacity - Vinsol should not therefore be used with either very sandy soils or heavy clays.

148 - Eno, F. H., Some Effects of Soil, Water and Climate Upon the Construction, Life and Maintenance of Highways, Ohio State University Engineering Experiment Station Bulletin No. 85, 1934, (137 pages).

(A)

Methods of testing soils with reference to highway construction; subgrade treatment beneath concrete pavements; subgrade treatment for traffic-bound roads; subdrainage of highways; treatment of bog holes; earth slips and their treatment; pavement displacement.

149 - Erlenbach, L., "Anwending der elektrochemischen Verfestigung auf schwimmende Pfahlgrundungen", Die Bautechnik, 1936, Vol. 14, pp. 257-259.

(G)

The application of electro-chemical stabilization to floating pile-foundations is discussed.

Ettinger, L. J. (see 135)

150 - Fallon, R. G., "Sand-Asphalt Mixed-In-Place Highway Construction", Roads and Streets, 1951, Vol. 94, pp. 78-80.

(D)

Mix-in-place methods have been used in reconstructing 4 miles of "oiled" roads in Hampstead, Long Island. Pulverizing mixers first broke up the existing material to a depth of 5 in., fines or sand were added as required and bitumen emulsion was applied by a distributor in 4 stages; in each traverse the distributor was closely followed by the mixers. The upper 3 in. of mixed material was bladed into a windrow for curing, the remainder being left to protect the subbase and carry traffic; in dry weather the material was ready for use by the following day, when it was spread in 1 in. layers by a blade grader and compacted. Irregularities were removed and surface dressing was applied. This type of surfacing has been found satisfactory both for residential streets and for roads carrying fairly heavy commercial traffic.

Farnsworth, George (see 330)

Fehrman, R. G. (see 531)

151 - Feld, J., "Soil Stabilization by Intrusion", Proceedings Conference on Soil Stabilization, M.I.T., 1952, pp. 297-298. (Discussion: pp. 299-302).

(A)

General methods of soil stabilization by intrusion is described. Preference is expressed for soil intrusion over chemical or cement injection for stabilizing soil strata to desired physical characteristics because there is less possibility of forming internal hard streaks which can support desired loadings for short time periods with later sudden failure. Adding soil grains in a restricted volume increases density and decreases voids where such decrease is desired. By proper choice of soil being added, the water content can be altered not only in volume but also in character; for instance, in silty clay layers, the addition of crushed rock dust will alter the moisture filaments and may even cause better and faster drainage.

152 - Fellows, C. E., "Some Experiments in Soil Stabilization", Journal of Institution of Municipal & County Engineers, 1946, Vol. 73, No. 5, pp. 217-221.

(A)

General discussion of principles involved in soil stabilization problems and description of various methods of stabilizing; data on tests made on road in England and discussion of results; description of apparatus used for Proctor consolidation test.

Felt, E. J. (see 81 and 89)

153 - Fischer, W. N. D., "Baltimore City Streets to Stay Smooth Because of Drained, Stabilized Subgrades", Highway Magazine, 1947, Vol. 38, No. 2, pp. 32-35.

(A)

Reports on revised paving methods and specifications; concrete base course for sheet asphalt, underdrain pipe and compacting subgrade soils.

154 - Forrer, J. J., "Effect of Base Compaction on Maintenance Cost", Proceedings Highway Research Board, 1939, Vol. 19, pp. 460-463.

(H)

Emphasis in this paper is placed on the importance of proper compaction of highway embankments and the necessity of a certain time passing before the complete stabilization of the materials can be accomplished. As the conditions under which embankments are placed can seldom be controlled to an ideal, uniform compaction cannot be secured by mechanical means alone. Time must be allowed for complete adjustment of the particles. Experience gained in maintenance work

indicates that at least one year's time should elapse before placing a high type costly pavement. During such time, a temporary surface such as gravel, crushed stone or cheap bituminous treatment should be applied.

Foster, C. R. (see 478)

155 - Frasch, D. W., "The Construction of Stabilized Gravel Roads and Runways in Finland", Flughafen, 1944, Vol. 12, No. 3, pp. 1-4.

(B)

In road construction in Finland, earthwork is kept to a minimum except on main roads in the North. Consequently, alignment is dictated largely by natural conditions and heavy gradients are common. Roads run along gravel ridges and where peat must be crossed, gravel is hauled from these ridges. Loam-or clay-stabilized gravel is used almost exclusively for surfacing. Grading limits for surfacing material specified by the Road and Waterways Department of the Finish Ministry of Transport are discussed. Mix-in-place is the most common procedure; moraine sand (containing clay and loam) is spread on the gravel and 0.5 per cent by weight of calcium chloride added. Mixing is usually effected by agricultural implements followed by handraking and blading. Plant-mixing is less frequently used; a mixing plant which can handle about 12 cu. yd. per hour is described. Surfacing is usually about 2.0 to 2.3 in. (5 to 6 cm.) thick and the proportion of loam varies from 8 to 15 per cent by weight. Optimum water content usually lies between 5 to 7 per cent. This surfacing lasts well and maintenance though requiring great care is simple. Moorland stretches are usually closed in early spring as the means have not been available to replace the subgrade soil by a material not liable to frost damage.

156 - Frederickson, F. C., "Base Construction Reviewed by Minnesota Materials and Research Division", Roads and Streets, 1952, Vol. 95 (8), pp. 38-43, 60-62.

(A,B)

Information is presented about the base construction adopted on 63 projects undertaken in 1951 by the Minnesota Department of Highways. Sand-gravel, gravel, soil stabilized gravel and crushed rock were used for the work according to local conditions.

157 - Freeborough, B. B., "Lime Treatment Permits Use of Substandard Flexible Base Materials", Public Works, 1947, Vol. 78, No. 6, pp. 17-18, 20.

(E)

The use of lime was revived in Texas in an effort to correct unsatisfactory materials in flexible bases. The stability of lime-treated plastic clay was increased. Cheap waste products from kilns can be used.

158 - Fuller, M. G. and Dabney, G. W., "Stabilizing Weak and Defective Bases with Hydrated Lime", Roads and Streets, 1952, Vol. 95, No. 3, pp. 64-69, 82.

(E)

Experiments carried out at Fort Sam Houston, Texas confirm that hydrated lime is a satisfactory and economical stabilized agent for plastic granular base material. The lime was added at a rate of 3 per cent by weight being incorporated in the base material by means of a pulverizing mixer. In the case of clay soils which were too plastic to be stabilized with cement because of the difficulties of mixing, adding hydrated lime before cement permitted satisfactory stabilization with cement.

159 - Gabriel, L. G., "Problem of Devising Tests for Soil Stabilization", Journal of Inst. Petroleum, 1945, Vol. 31, No. 261, pp. 353-355(Discussion pp. 360-361).

(D)

Brief outline of scope of studies undertaken by Soil Stabilization Panel of Standardization, Sub-Committee No. 7, Asphalt Bitumen; procedure adopted was to collect as many as possible of sets of tests already published in different countries; and then to determine origin of any difference.

160 - Gallaway, R. M. and Buchanan, S. J., Lime Stabilization of Clay Soil, Texas Engineering Experiment Station Bulletin No. 124, College Station, Texas, 1951, pp. v-51.

(E)

The relation between the plasticity index of a soil containing montmorillonite clay and its capacity for base exchange has been studied by experiments with artificial mixtures of montmorillonite and an inert silt. The effect of lime admixtures on Atterberg limits has been investigated for silt-montmorillonite mixtures and natural clay soils. It was found that at least 24 hours should be allowed to elapse between the addition of lime and the carrying out of tests. It is concluded that lime appears to be a suitable stabilizing agent for soils with a plasticity index greater than 20. The difficulties of obtaining thorough mixing of lime and clay soils is noted.

161 - Garnean, J. B. & Beland, C. E., "Studies of Soil-Aggregate Base Course Mixtures", Roads & Streets, 1942, Vol. 85, No. 6, pp. 56 & 58.

(B)

Effects of variable gradation, moisture content and admixtures upon strength and stability of soil aggregate base course mixtures are presented in tabular form.

162 - Gauntlett, H. D., "Problems of Soil Stabilization and the Scientific Control of Concrete for Road Works", Journal of Institution of Municipal & County Engineers, 1946, Vol. 72, No. 10, pp. 385-416.

(C)

A detailed account is given of the closely controlled construction of concrete and cement-stabilized hoggin roads and foundation slabs for pre-fabricated houses on a housing site at Luton. Methods of carrying out and interpreting tests on

aggregates, concrete and stabilized hoggin are described and a list is given of equipment for a field laboratory.

163 - Geuze, E. C., de Bruyn, W. A., and Joustra, K., "Results of Laboratory Investigations on the Electrical Treatment of Soils", Proceedings Second International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. III, pp. 153-157.

(G)

In order to investigate the effects of electrical treatment, it was necessary to develop a suitable technique for laboratory experiments and to test a range of soils from coarse to fat clay. This paper is a report of the results of laboratory investigations on the electrical treatment of soils. Results of tests on sandy soils showed that the properties of the soil were slightly or not influenced by the treatment. The opposite was encountered with all clay soils.

Gibbs, H. J. (see 531)

Glab, John E. (see 124)

Glasgow, Paul E. (see 330)

164 - Glover, V. L., "An Experimental Soil-Cement Road in Illinois", Proceedings Highway Research Board, 1937, Vol. 17, Part II, pp. 34-46.

(C)

This paper is a report on the experimental soil-cement road built near Rockford, Winnebago County, Illinois during September, 1936. Laboratory test results and construction methods are described. It is concluded that (1) Preliminary samples on which the job control data are to be based should not be taken until the grading operations have been completed. (2) Extreme care should be exercised in taking the samples on which the job control data are to be based. The locations at which the samples are taken should be carefully selected and a sufficient number of samples secured to represent satisfactorily the soil types and variations within these types. (3) The equipment for preparing the soil, mixing the cement, distributing and incorporating the water and compacting the mixture should be such that the actual time of processing will be reduced to the minimum. (4) Comprehensive field tests should be conducted during the progress of the job.

165 - Goldbeck, A. T., "Crushed Stone Stabilized Bases", Crushed Stone Journal, 1950, Vol. 25, pp. 17-20.

(B)

The construction and maintenance of traffic-bound base-courses containing crushed stone aggregate are described; the natural cementing properties of the aggregate are taken into consideration. Roads constructed by the methods described are usually intended to receive a bituminous surfacing after they have been open to traffic for a year or two.

166 - Golder, H. Q. and Ward, W. H., German Roads and Soil Stabilization, British Intelligence Objectives Sub-Committee Final Report, No. 917, London, H. M. Stationery Office, 1948, (71 pages).

(A)

This report presents the information obtained from an inspection made in August 1945 in the British and American Zones of Germany of research institutions and firms concerned with geotechnical processes and soil mechanics. The inspection formed part of an investigation of German progress in soil mechanics and road engineering.

167 - Goodman, Fred L., "Looking Ahead with Soil-Cement in Louisiana", American Road Builders Association Technical Bulletin No. 183, 1952, pp. 5-7.

(C)

The phenomenal acceptance of soil-cement streets and road construction in Louisiana from the beginning of post-war construction in Louisiana in 1945 through 1951 is evidenced by the 700 miles of 18 ft. roadway now in use. Commercial and publicly owned testing laboratories are now equipped to handle all phases of soil-cement design and control.

168 - Goodman, Louis J., A Laboratory and Field Study of the Effectiveness of Various Soil Additives for Erosion Control, Paper Presented at the 32nd Annual Meeting of the Highway Research Board, 1953, Washington. (30 pages).

(A,F)

This paper summarizes an extensive search for soil additives that can reduce the damaging effects of rainfall on steep slopes and thereby curb erosion. Described are laboratory testing procedures which were developed for the purpose of making hydro-mechanical studies of soil erosion and for evaluating the various soil additives studied. As a check on the laboratory work, field slopes have been set up in several sections of the country and observations on these have been quite encouraging. Although no entirely successful material was found during these investigations, one has proved to be very effective on certain soil types. Several other additives have shown good possibilities on one or two soil types. In order of their effectiveness based on current test data, these are:(1) Monsanto CRD-189,(2) Monsanto CRD-186, (3) Soil-Cement Aggregates,(4) Dupont Orchem DV-71,(5) Aerotil,(6) Dupont Elchem-1089. As a result of this study, two practical methods of application were evolved: (1) Spread additive on surface uniformly and wet down. (2) Rake in additive to a depth of $\frac{1}{2}$ inch and wet down.

Grace, H. (see 183 & 184)

169 - Graddy, J. M., "Columbus, Ga. Selects Soil-Cement Paving", American City, 1946, Vol. 61, pp. 100-101.

(C)

The use of soil stabilization with cement has resulted in the successful construction of low-cost surfacings for streets in Columbus, Ga. and in reducing maintenance costs. The base is stabilized to a depth of 6 in. by mix-in-place methods. The soils are blended with from 6 to 10 per cent of cement.

Graves, L. D. (see 554)

170 - Gray, J. E., "Traffic Bound Roads", Crushed Stone Journal, 1949, Vol. 24, pp. 10-13.

(B,H)

A brief account of the construction and maintenance methods used for roads on which the aggregate is compacted by the action of traffic. A bituminous surfacing can be applied when the compaction is complete.

171 - Grim, R. E., "Some Fundamental Factors Influencing the Properties of Soil Materials", Proceedings Second International Soil Mechanics Conference, 1948, Vol. III, pp. 8-12.

(A)

The molecular structure of clay minerals and the capacity of these minerals to adsorb oriented water molecules are discussed and related to the plasticity of clays. Some compounds, notably phosphates and the salts of magnesium and boron, are known to alter clay-bounding properties while small amounts of sodium, hydrogen and aluminum as exchangeable bases greatly alter certain plastic properties. A table is presented showing the effect of base exchange on the Atterberg limits of montmorillonite, illite, kaolinite and some natural mixtures. The influence of montmorillonite in clay mixtures depends on whether the components are present as discrete aggregate particles of the individual clay minerals or as very intimate interlayerings of one or a few unit layers of montmorillonite with several unit layers of the other clay minerals, the effect being much greater in the second case. Some organic molecules are adsorbed by clays to form gels and this may explain some unusual properties of certain soils.

Grim, R. E. (see also 137)

Haefeli, R. (see 424)

172 - Halton, J. E. and Holden, E. R., "Beach Sand Stabilization - Thermite Method", Technical Memorandum M-011, Naval Civil Engineering R. and E. Laboratory, 1950.

(A)

To solve the problem of crossing unstable beach areas, alternate layers of flux materials and thermite were placed and ignited to produce extremely high temperatures.

173 - Hanks, J. N., "Sand-Clay Mixtures for Shire Roads", Commonwealth Engineer, 1950, Vol. 38, pp. 54-57.

(B)

Tests carried out on samples of 4 available sands and 60 soils (classified into 10 types) from a district near Echuca, Australia, have shown that sand-clay mixtures are suitable for lightly trafficked roads both with and without a surface dressing. An additional thickness of 2 to 3 inches of fine crushed rock is recommended for heavily trafficked roads. Specifications of mixes for both types of surfacing are included.

Hannemann, W. (see 255)

Harvest, J. (see 133)

174 - Haswell, C. H., "Use of Graded Stone in Runway and Road Construction", Royal Engineers Journal, 1943, Vol. 57, pp. 97-103.

(B)

Due to heavy British consumption of cement for defense works, it was found necessary to apply local soil materials to runway and road projects; soil analysis and determined stabilization formulas at two sites are described.

175 - Hauser, E. A., "Silicic Chemistry in Highway Research", Proceedings Highway Research Board, 1947, Vol. 27, pp. 431-435.

(A)

Silicic chemistry is the name given to the colloidal chemistry of silicon compounds or the chemistry of siliceous matter characterized by large specific area. Attention is drawn to the importance of its application to the study of soil stabilization and surfacing programs.

Havelin, J. E. (see 325)

Havens, A. C. (see 396)

176 - Havens, James H., Young, James L. and Baker, R. F., "Separation, Fractionation and Mineralogy of Clay in Soils", Proceedings Highway Research Board, 1948, Vol. 28, pp. 469-480.

(A)

This paper described a working method for separation, fractionation and identification of colloid and near colloidal clay minerals in soils. Soils were first dispersed and separated by gravity sedimentation. Fractionation was accomplished by controlled supercentrifugation. The separated fractions were purified and then analyzed by X-ray diffraction. Computed size fractions were checked by shadow castings and lineal dimensions on electron micrographs. Results include identification of the mineral or minerals present and the properties of the natural sample from which the colloidal fractions were extracted. These methods furnish a basis for more extensive research relating the behavior of the clay minerals and their contributions to the properties of soils.

177 - Havens, J. H., Young, J. L. and Drake, W. B., "Some Chemical, Physical and Mineralogical Features of Soil Colloids", Proceedings Highway Research Board, 1949, Vol. 29, pp. 567-577.

(A)

The -1 micron portion of several diversified soils was separated by sedimentary fraction. Physical properties were evaluated on the -1 micron portion, the /1 micron portion and on the original -40 sample. The -1 micron portion was analysed for clay mineral identity by X-ray diffraction and analyzed chemically for associated materials such as the oxides of iron, aluminum, calcium and magnesium. These data present several possibilities and trends as to the interdependency of the involved variables. Other considerations have been devoted to the geologic origin of several samples and to various physio-chemical relationships.

178 - Heacock, R. C., "Barber-Greene Company's Experience and Observations on Soil Stabilization", Proceedings Conference on Soil Stabilization, M.I.T., 1952, pp. 207-213, (Discussions: pp. 214-216)

(I)

Barber-Greene mixers are designed for universal usage rather than limited localized applications. The heart of each mixing plant is the mixer itself capable of mixing tonnages up to 350 tons per hour. Material is fed into an apron feeder which conveys the materials below the lip of a calibrated measuring gate which continuously meters the amount of aggregate fed to the twin shaft continuous pugmill. As the material is mixed, it is propelled toward the end of the pugmill by the twin paddle shafts where it is discharged either into windrow or into trucks. The mixers are adaptable to either travel or central plant operation to either stabilization work or the mixing of the most demanding asphaltic concretes.

179 - Hearn, R. L., "Calcium Chloride Stabilized Roads Carry Heavy Traffic at Polymer", Engineers & Contractors Record, 1944, Vol. 57, No. 24, pp. 16-17.

(F)

Stabilized clay roads carry 17 ton mixers during construction operations; road specifications.

180 - Henderson, George H., "Some Principles Involved in Bituminous Macadam Construction", Proceedings Highway Research Board, 1926, Vol. 6, pp. 188-191.

(D)

In order to build a bituminous macadam road of lasting integrity and whose riding qualities will be excellent, attention must be given to each detail of construction from the bottom to the top. In all cases proper drainage should be provided while in localities where considerable frost action prevails, foundations must be provided through heavy retentive soil or the integrity of the pavement will be seriously threatened. It is conceded that a layer of granular

material directly beneath the pavement proper serves to break up capillarity and to lessen in a great measure the detrimental effect of frost action. The depth of foundation to be provided varies with the tightness of the soil encountered.

Henderson, H. G. (see 318)

181 - Henley, R. H., Sieland, H. J. and Holden, E. R., "Beach Soil Stabilization - Aniline - Furfural Method", Technical Report 001, Naval Engineering R. and E. Laboratory, 1950,

(F)

182 - Hennes, R. G., "How to Design Stabilized Soil Mixtures", Engineering News Record, 1943, Vol. 130, No. 20, pp. 761-762.

(B)

Description of method used by author which takes into account both plasticity and grading to greater extent than do ordinary empirical rules or charts.

183 - Henry, J. K. M. & Grace, H., "The Incorporation of Decomposed Granite in the Design and Construction of Pavements in Hongkong", Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. IV, pp. 190-196.

(A,C)

This paper briefly describes the design and construction of pavements for a projected airfield in Hongkong. It is concluded that the decomposed granite in Hongkong could be divided into two classes for purposes of stabilization. The type A soil presented no construction difficulties and stabilized satisfactorily with cement. The type B soil could be used to best advantage as fill or lower base course material compacted at its natural moisture content.

184 - Henry, J. K. M. & Grace, H., "The Investigation of Decomposed Granite in Hongkong for Use as a Stabilized Base Course Material", Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. III, pp. 187-192.

(A,C)

This paper summarizes the results of the investigation of the possibility of constructing stabilized base courses using decomposed granite of which large deposits occurred in the Colony: investigation of deposits; tests on physical properties; summary.

185 - Herzog, J. E., "Stabilized Crushed-Rock Surfaces", Better Roads, 1943, Vol. 13, No. 2, pp. 21-22.

(B)

Low cost processing of highways in Steele County, Minn. saves surfacing materials, produces smooth, hard and dust free roads.

186 - Hester, L. O., "Florida Road Stabilized with Local Materials", Construction Methods, 1948, Vol. 30, pp. 92-93.

(B)

A brief account is given of the construction of a 15-mile section of the new State Route 25 between Lake Placid and Sebring designed to avoid maintenance costs in the future. The natural soil was a porous loose sand incapable of supporting vegetation other than brush. The roadway area was stabilized 12 in. deep by the addition of local crushed limerock, earth or clay. The sections stabilized with earth and limerock respectively proved to be better than those stabilized with clay. Two 4-in. layers of limerock were placed as base course. The surfacing consisted of limerock mixed with bitumen in a continuous-mix plant spread and finished with paving machines. To prevent shoulder erosion and the blowing of sand over the pavement, the verges were covered with a blanket of mixed earth and sand and planted with Bermuda grass.

187 - Hicks, L. D., "Soil-Cement Base Course Methods in North Carolina", Roads and Streets, 1951, Vol. 94, pp. 45-49, 51.

(C)

Between 1946 and 1950, about 670 miles of 6 in. cement-stabilized earth base were constructed for roads in North Carolina. Details are given of the various methods of constructing these bases and their costs. The stabilized bases are provided with 1 in. bituminous wearing course.

188 - Hicks, L. D., "Soil-Cement Design in North Carolina", Proceedings Highway Research Board, 1942, Vol. 22, pp. 415-418, (Discussions: pp. 418-422).

(C)

The method of soil-cement design in North Carolina is described. The method of soil classification developed by the Bureau of Chemistry and Soils which groups soils according to their origin and development has been found to be an excellent means of identification of soils and its use in making soil surveys and taking samples not only prevents duplication of samples but allows the accumulation of data that can be used with confidence on future work thereby eliminating the necessity for repeated durability tests. Soil-cement mixtures must contain sufficient moisture to hydrate the cement or their strength and durability are impaired. A "working optimum" which is equal to the optimum moisture of the raw soil plus two is suggested for use in the field. The use of arbitrary values of maximum loss by durability tests for the determination of the cement requirement for the stabilization of soils in all sections of the country does not seem logical. In localities not subject to extremely low temperatures, it would seem that only sufficient cement is needed to render plastic soils non-plastic and to harden cohesionless soils.

189 - Hicks, L. D., "Soil Stabilization for Highways", Proceedings Conference on Soil Stabilization, M.I.T., 1952, pp. 217-231.

(A)

Methods of highway soil stabilization generally used in North Carolina are briefly described: Discussions are under the headings of (1) Mechanical Stabilization, (2) Portland Cement Stabilization, (3) Bituminous Stabilization and (4) Vinsol Resin Stabilization and (5) Other stabilization processes.

190 - Hicks, L. D., "Stabilizing Soils for Base Courses & Highway Surfacing", Engineering News Record, 1942, Vol. 128, No. 7, pp. 248-253.

(A)

Low cost surfacing for highways and airports now being provided by several methods of soil stabilization; earlier methods of improving stability of road surfaces by additions of sand, gravel or other soils have been put on scientific basis in recent years and now are supplemented by admixtures of cement, bituminous oils and deliquescent salts; experiments with vinsol resin are in progress; principles applied in major methods described.

191 - Hicks, L. D., Abercrombie, W. F. and Land, J. L., "Topsoil, Sand-Clay and Graded Mix Roads in Southeastern United States", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 184-194.

(B)

The design and construction of topsoil, sand-clay and graded mix roads in southeastern United States were presented and discussed at a symposium under the headings of: (1) Materials, (2) Construction and Control Methods.

192 - Hicks, L. D., "Use of Soil-Cement for Patching Pavements in North Carolina", Proceedings Highway Research Board, 1944, Vol. 24, pp. 445-450.

(C)

The use of mixtures of soil and portland cement for patching failures in pavements especially flexible pavement has proved to be a successful method of pavement repair. Satisfactory repair requires that the unstable subgrade soil be removed to some depth and replaced with more stable material which generally is granular soil. When properly done, this method is quite satisfactory but there are many instances where improper workmanship, inadequate design or the use of unsuitable materials result in a recurrence of the failure. The slab strength possessed by soil-cement mixtures when compacted and allowed to harden serves to reduce considerably the unit pressure applied to the subgrade by surface loads. This allows the removal of much less subgrade material and consequently reduces the cost where much depth of excavation is necessary.

Hicks, L. D. (see also 318)

Hicks, W. B. (see 474)

193 - Highway Research Board, "Compaction of Subgrade and Embankment", Wartime Road Problems, Report No. 11, 1945, pp. 1-25.

(H)

Densification by compaction is considered best method of improving supporting power of subgrades and embankments; moisture-density relations, types of soils for embankments, compaction control and compacting equipment discussed; technical details of fill construction practice in various states presented; appendix deals with classification of soils.

194 - Highway Research Board, "Granular Stabilized Roads", Wartime Road Problems, Bulletin No. 5, 1943, pp. 1-27.

(B)

Structure of roads and classification of materials for use; recommended practice for materials and mixtures; maintenance practices.

195 - Highway Research Board, Prevention of Moisture Loss in Soil-Cement with Bituminous Materials, Research Report No. 8-F, Washington, D. C.: National Research Council, Division of Engineering and Industrial Research, 1949,(34 pages).

(C)

Investigations were made in Illinois, Kansas, Nebraska and Arkansas into the efficacy of 4 bituminous binders as covers for preventing the evaporation of water from cement-stabilized earth roads. The test showed that films of such materials were satisfactory provided; the binder did not penetrate the surface. Penetration could be prevented by providing a suitable moisture condition in the surface of the area being treated. Details of the tests and the results obtained are given and some general conclusions are drawn.

196 - Highway Research Board, Progress Report of Project Committee on Stabilized Soil Road Surfaces, Highway Research Board, 1935,(38 pages).

(A)

The process of building stabilized soil road surfaces consists first in arranging the most stable combination of the available materials and second in providing for as great a degree of permanence of the stability as is possible by means of mechanical consolidation and the use of admixtures or waterproof coverings. This report includes the general theory of soil stabilization, the design essentials of stable soil mixtures, discussion of typical soil mixtures and the discussion of the best current practice in treatment with calcium chloride.

197 - Highway Research Board, Report of Committee on Compaction of Subgrades and Embankments; Bulletin No. 5, Washington, D. C., National Research Council, 1947,(23 pages).

(H)

This report presents mainly in tabular form the information obtained in reply to a questionnaire sent in 1946 to all the States of the U. S. A. regarding the procedure adopted in the compaction of embankment and subgrades.

198 - Highway Research Board, Report of Committee on Roadside Development, Washington, D. C.: National Research Council, Division of Engineering and Industrial Research mimeographed, 1952, (91 pages).

(A)

This report which was presented at the 31st Annual Meeting of the Highway Research Board held in 1952 includes the following papers: Stable shoulders: C. Nikoca. Information is presented on the costs of construction and maintenance of stabilized verges and some of the properties of mixtures of granular soil materials used in the construction of stabilized turf verges in humid areas are indicated. Studies with polyelectrolytes: preliminary field application for erosion control: L. E. Weeks and W. G. Colter. Progress Report on Use of Maleic Hydrazide for Grass Inhibition on Highway Areas: J. W. Zukel. Adaptation of Certain Herbaceous Materials for Highway Slope Control: W. L. Hottenstein. This paper is a condensed and paraphrased version of a thesis by J. P. Stanford. Progress Report on Grading and Planting Plans: N. M. Wells. Report of Mechanization of Roadside Operations: W. J. Garmhausen.

199 - Highway Research Board, Soil-Bituminous Roads, Current Road Problems, No. 12, Washington, D. C., National Research Council , 1946,(52 pages).

(D)

Depending upon the physical composition of the available soil material and the function of the bitumen incorporated, there are four types of bituminous soil stabilization in common use: (1) soil-bitumen; a waterproofed, cohesive soil system; (2) sand-bitumen; a system in which loose beach, dune, pit, or river sand is cemented together by bituminous material; (3) Waterproofed mechanical stabilization; a system in which a soil material possessing good gradation of particles from coarse to fine and having high potential density is waterproofed by the uniform distribution of very small amounts of bitumen; (4) Oiled earth; and earth road surface made water and abrasion resistant by the application of slow-or medium-curing road oils. These 4 types of construction form the subject of the present bulletin of this series, the purpose of which is to disseminate in practical form the best current information on those phases of highway work that are still developing.

200 - Highway Research Board, (Edited by R. W. Crum), "Soil Mechanics and Soil Stabilization", Proceedings Highway Research Board, Vol. 18, Part 2, 1938, pp.1-433.

(A)

Volume of thirty-two pages arranged under following headings: Soil Mechanics; Soil Stabilization; Soil-Aggregate Mixtures; Stabilization Methods; Subgrades; Frost Heaves; and Testing.

201 - Highway Research Board, Use of Soil-Cement Mixtures for Base Courses, Wartime Road Problems, Washington, D. C.: National Research Council , 1943,(30 pages).

(C)

In these recommendations, embracing the latest information on the materials and construction methods used for building soil-cement bases, the types of soil-cement construction described cover the incorporation of cement with subgrade soils, borrow soils, pit-run materials and combinations of these materials by mix-in-place, traveling and stationary plant-mix methods. Requirements are stated for cement, water and soil and recommended practice is outlined for carrying out soil surveys, sampling and soil analysis for determining the quantity of cement required for satisfactory hardening and for estimating the moisture-density relationship for soil-cement mixtures.

202 - Hirashima, K. B., "Highway Construction Problems Involving Plastic Volcanic Ash", Highway Research Board Bulletin No. 44, Washington, D. C. , 1951, pp. 1-10.

(A)

The peculiarities of certain highly plastic soils derived by the weathering of volcanic ash under conditions of continuous moisture along the eastern shores of the Island of Hawaii are discussed. The soils have a natural moisture content of about 200 per cent. The author discusses special methods which have been developed to facilitate construction with these soils. In particular, provision of layer of rocky material to provide positive traction for construction equipment during grading operations has proven beneficial.

203 - Hirsch, A. D., Stabilizing Earth Slopes Through Installation of Drains with Hydrauger Equipment, Presented at Western Association Highway Officials Meeting, Reno, Nevada, 1950.

(H)

204 - Hogentogler, C. A. and Willis, E. A., "Essential Considerations in the Stabilization of Soil", Transactions American Society of Civil Engineers, 1938, Vol.103, pp. 1163-1180, (Discussion: pp. 1184-1192).

(A)

Underlying principles involved in soil stabilization and possible means of its accomplishment discussed without any attempt to evaluate practical aspects or relative value of various methods. Particularly stressed is application of colloidal phenomena of absorption and base exchange as they effect particles of soil, sand, crushed rock, gravel, slag and so forth, coated with films of air, water, soluble chemical composition of aggregate and binders and ions on surfaces of solid particles.

205 - Hogentogler, C. A. and Terzaghi, K., "Interrelationship of Load, Road and Subgrade", Public Roads, 1929, Vol. 10, pp. 37-64.

(A)

Load distribution by various types of pavements; pavement characteristics; field investigations showing that subgrade variables influence pavement condition and the subgrade bearing properties depend on combined effect of cohesion and internal friction; precautionary measures for overcoming effects of undesirable subgrade support.

206 - Hogentogler, C. A., "Soil Stabilization in Highway Construction", Canadian Engineer, 1936, Vol. 71, No. 11, pp. 11, 43-46, 49-56.

(A)

Any air film around the soil particles must be removed and the moisture film thinned out to a high binding strength by changing the electrical fields surrounding the particles by the addition of chemicals.

207 - Hogentogler, C. A. and Willis, E. A., "Stabilized Soil Roads", Public Roads, 1936, Vol. 17, pp. 45-65.

(A)

Two general methods for accomplishing soil stabilization as follows: (1) by providing soil with coarse and fine materials of proportions and the character required to produce stability and possibly supplementing this by adding chemical admixtures to maintain stability thus produced; (2) by incorporating water-insoluble binders in fine-grained or poorly graded soils consolidating in particular manner to provide structural stability and covering bases thus produced with thin wearing courses to furnish resistance to abrasion.

208 - Hogentogler, C. A., Willis, E. A. and Wintermyer, A. M., "Subgrade Soil Constants, Their Significance and Their Application in Practice", Public Roads, 1931, Vol.12, pp. 89-108, 117-144.

(A)

Physical characteristics of subgrade soils which have important bearing on serviceability of road surfaces; influence exerted by condition in which soil exists and character of its constituents upon important subgrade soil properties; and degree to which subgrade soil constants disclose presence of important subgrade characteristics.

209 - Hogentogler, C. A. and Willis, E. A., "Subgrade Soil Testing Methods", Proceedings American Society Testing Materials, 1934, Part 2, Vol. 34, pp. 693-725; also 1935, Part 1, Vol. 35, pp. 940-982.

(A)

Based upon constituent materials, physical properties and performance, uniform subgrades tentatively classified in eight groups identified definite test limits and requiring different design features in roads laid thereon. Tentative methods of surveying and sampling soils for soils for use in place as subgrades for highways; tests for making mechanical analysis and determining subgrade soil constants.

210 - Hogentogler, C. A. Jr., "Essentials of Soil Compaction", Proceedings Highway Research Board, 1936, Vol. 16, pp. 309-316.

(H)

Discusses four stages of soil wetting, hydrating, lubrication, swelling and saturation; effect of chemical composition of soil particles and kind of absorbed ions.

Hogentogler, C. A. Jr. (see also 503)

Holden, E. R. (see 172, 181)

211 - Holmes, August, Roediger, J. C., Wirsig, H. D. and Snyder, R. C., "Factors Involved in Stabilizing Soils with Asphaltic Materials:, Proceedings Highway Research Board, 1943, Vol. 23, pp. 422-449, (Discussions: pp. 449-450).

(D)

This paper describes various observations made on the properties of soils during investigations conducted to obtain information which would assist in the design of soil-asphalt mixtures for structural use. The usual soil constants attempt to portray the behavior of the unconfined soil in the presence of water and give little information on the properties of soil in the highly compacted state in which it is employed in earth constructions. A series of constants have been developed which give this information and thus aid in the further characterization of soils from the standpoint of their practical manipulation. In soil design, the following principles should be taken into consideration: (a) the angle of failure and therefore, the angle of load distribution does not have a constant value of 45 degrees but decreases with increase in soil thickness approaching the limit of 0 degrees to the vertical; namely, simple shear; (b) the load-bearing capacity varies according to the 1.5 power of the thickness of the compacted soil; (c) the greater the number of layers used to build up a given thickness of the compacted soil, the greater the strength and the soil density; (d) tensile strength rather than shear strength is determinative for the load-bearing capacity of compacted soil at its point of failure.

212 - Housel, W. S., "Experimental Soil-Cement Stabilization at Cheboygan, Michigan", Proceedings Highway Research Board, 1937, Vol. 17, Part II, pp. 46-66.

(C)

This paper describes the experimental soil-cement stabilization of a section of the Shore Line Highway near Cheboygan, Michigan during the summer of 1936. Design and construction procedures are discussed under the following headings: (1) Preliminary soil survey and soil classification, (2) Laboratory investigations, (3) Field Control Tests. It is concluded that the experience on the Cheboygan cement stabilization project indicates some rather definite relations based on void characteristics of the soil which may be applied to the design of soil-cement mixtures.

213 - Housel, W. S., "Principles of Soil Stabilization", Civil Engineering, 1937, Vol. 7, No. 5, pp. 341-344.

(A)

In this article, fundamental aspects of soil stabilization particularly as applied to subgrades are discussed. Taking up in turn the properties of soil

mixtures, rational methods of proportioning and special stabilizing processes, the author reviews the present technique both in the field and the laboratory and points out that a number of important problems remain to be solved. Extensive investigations now under way may go far toward solution of these problems but local conditions will always control.

214 - Housel, W. S., "Report on an Investigation of Tests to Determine the Properties of Stabilized Soil Mixtures", 1941, Unpublished report, Engineering Research Institute, University of Michigan, pp. 1-86.

(A)

This is a report of investigations undertaken by the Civil Aeronautics Authority to determine the adequacy and applicability of tests that had been proposed to determine the acceptability of stabilized soil mixtures for use in the construction of airport runways. The soils selected for study were obtained from four airport projects which would provide a reasonable range of variation in soil characteristics. The report is divided into the following parts: (1) Introduction, (2) Preliminary tests, (3) Design of stabilized mixtures, (4) Summary of comparative tests, (5) Supplementary tests and (6) Conclusion.

215 - Hubendick, P. E., "The Economic Limits of Dust-Binding with Sulphite Lye", Svenska Vagforen. Tidskr., 1950, pp. 322-326, (In Swedish)

(F)

The economic advantages of using sulphite lye for the stabilization and dust-binding of earth-roads in Sweden are discussed. Formulas are given for working out the distances over which sulphite lye can be transported and used more cheaply than calcium chloride.

216 - Huber, O., "Earth Road Experiments in the Laboratory and on the Site", Strasse, 1942, Vol. 9, No. 23/24, pp. 233-237.

(A)

An account of laboratory and full-scale experiments carried out by the Road Construction Institute and the Soil Mechanics Institute of the Technische Hochschule, Munich, on behalf of the Inspector-General of German Roads (a) with a view to developing a laboratory method for testing the suitability of soil mixtures and (b) in investigating the stabilization of clay soils particularly of the loess-loam type. The wet and dry methods for stabilizing clay soil with sand are briefly described.

217 - Huffman, B. L., "Soil-Cement Paving - Entire Job Mechanically Performed", Western Construction News, 1948, Vol. 23, pp. 73-76.

(C)

A description of the methods used by the Washington State Highway Department in constructing a new 10-mile section of the Oakesdale-Tekoa soil-cement highway. A new type of cement spreader was developed which permitted the use of cement in bulk.

Hughes, William (see 334)

218 - Hurst, J., "Hetherington - Berner Stabilization Equipment", Proceedings Conference on Soil Stabilization, M.I.T., 1952, pp. 191-192.

(I)

This paper briefly describes the development and the use of the Hetherington-Berner Stabilization Equipment. The trade name of the unit is the Motorpaver. It is one unit self propelled combination proportioning, mixing and spreading unit for surfacing or stabilizing work. Normally, three men are required for operation. Although it is used principally for processing aggregate or various types of soil with bitumen, in a few instances other materials have been worked.

Hveem, F. N. (see 454)

219 - Imperial Chemical Industries Limited, London, Stabilized Roads, London: Imperial Chemical Industries Limited , pp. 1-20.

(F)

The use of calcium chloride in the construction and maintenance of stabilized roads is described.

220 - Indian Concrete Journal, "Soil-Cement Paving - Questions & Answers", Indian Concrete Journal, 1948, Vol. 22, No. 11, pp. 250-254.

(C)

Definition, characteristics, use and control of soil-cement; tests required and data on moisture content; surfacing of soil-cement.

221 - Inglis, F. R., "Quebec Tries Fast, Low-Cost Bituminous Stabilization", Roads and Engineering Construction, 1951, Vol. 89, pp. 81-82, 125.

(D)

In Quebec about 11 miles of secondary road between Hull and Maniwaki as well as sections of more heavily trafficked roads have been stabilized with bitumen by self-propelled rotary mixers. Gravel was spread on the carriageway to a depth of 3 inches bladed to shape by graders, sprayed with a bituminous binder and mixed in place immediately. At one stage, the two mixers zigzagged across the carriageway in order to obtain thorough cross-blending. Compaction was carried out with smooth-wheeled rollers.

222 - Institution of Petroleum, "Report on Test for Soil Stabilization", Journal of Institution of Petroleum, 1944, Vol. 30, No. 251, pp. 327-348.

(D,A)

Report constitutes first account of discussions and work of soil stabilization panel of Institution of Petroleum Standardization Committee; it will be supplemented from time to time by further reports indicating progress achieved; status

and terms of reference of panel; membership of panel - plan of work; definition of terms; interpretation of and comments on schedule of soil stabilization test methods; notes on individual tests; future program, methods of test.

223 - Institution of Petroleum,"Second Report on Tests for Soil Stabilization by Soil Stabilization Panel of Standardization Sub-Committee No. 7, Asphalt Bitumen", Journal of Institution of Petroleum, 1947, Vol. 33, No. 278, pp. 113-128.

(D)

Report on work accomplished since completion of first report, frost resistance of compacted mixes; stabilizer content of mixes; sampling and treatment of samples in field testing; standardization of procedures to obtain standard degree of compaction.

224 - Jackson, J. S., "Recent Development in Connection with Application of Soil Stabilization in Practice", Society of Chemical Industry - Journal, 1944, Vol.63, No. 6, pp. 161-165.

(A,D)

Principles of soil stabilization are discussed and process based on use of small percentage of waxy petroleum oil described and explained; large scale practical trial also described.

225 - James, R. L., "Road and Runway Construction in Soil Stabilized by Bitumen-Cement", Contractor's Record, 1944, Vol. 55, No. 33, pp. 1683-1688.

(D)

A method has been developed of stabilizing soil by the addition of cement and bitumen emulsion. Test results suggest that soil stabilized with cement and bitumen emulsion will conform more readily to inequalities in the subbase than soil stabilized with cement alone.

226 - James, R. L., "Soil Stabilization", Contractor's Record, 1945, Vol. 56, No. 51, pp. 2811-2812, 2815; 1946, Vol. 57, No. 1, pp. 16-18, 28; No. 2, pp. 69, 71, 91; No. 3, pp. 129-130, 137; No. 4, pp. 187-188; No. 5, pp. 251-253; No. 6, pp. 319-320; No. 7, pp. 387-388, No. 8, pp. 458-459; No. 9, 515-517; No. 10, pp. 585-587.

(A)

A serial article presenting a summary of soil stabilization practice intended mainly for engineers who have not specilized in the subject. Chapter headings: soil testing; roads and loads; mechanical stabilization; cement as a stabilizer; emulsified sand-asphalt pavement; bitumen-cement stabilization; wet sand process; water-repellant chemicals; drainage; surfacing the stabilized road.

227 - Johnson, A. L. and Davidson, D. T., "Clay Technology and its Application to Soil Stabilization", Proceedings Highway Research Board, 1947, Vol. 27, p. 418.

(A)

An account of the colloidal behavior of clay minerals and their base exchange and adsorption characteristics is presented. Thermal analysis of soil mixtures is discussed. The engineering properties of some synthesized soil mixtures have been studied and the results are reported.

Johnson, F. M. (see 419)

228 - Johnson, S. J., "Soil Stabilization of Building Foundations", Proceedings Conference on Soil Stabilization, M.I.T., 1952, pp. 241-254.

(A)

Soil stabilization of building foundations can be either a temporary or permanent nature. The most common method of temporary soil stabilization is control of the groundwater. Permanent methods of stabilizing building foundations include compaction of the foundation using heavy surface and subsurface compactors; excavation of undesirable foundation soil and replacement with satisfactory soil compacted in accordance with earth dam compaction techniques with the structure supported on the fill; prestressing the soil in advance of construction using temporary preload fills or temporary lowering of the groundwater level; grouting; and changing the properties of the foundation soil using electrochemical and chemical process. These various methods are briefly discussed in this article.

229 - Johnson, S. J. and Maxwell, A. A., "Subgrade Compaction Tests with Heavy Rollers", Proceedings 2nd International Conference on Soil Mechanics and Foundations Engineering, 1948, Vol. V, pp. 216-223.

(H)

The results of compaction tests on clayey sand, clayey silt and silty clay subgrade soils using a 40,000 lb. rubber tired wheel load and a 1100 psi. sheepsfoot roller have shown that deep compaction and high densities can be obtained in subgrades by surface compaction with heavy compaction equipment provided moisture conditions are favorable.

230 - Johnston, W. T., "Pressure Subsurface Grouting on the New York Central System West of Buffalo", Proceedings Second International Soil Mechanics Conference, 1948, Vol. 5, pp. 248-251.

(A)

An illustrated account of the methods used in stabilizing soft spots due to the pressure of pockets of clay in the roadbed of a railway.

231 - Johnson, A. M., "Laboratory Experiments with Lime-Soil Mixtures", Proceedings Highway Research Board, 1948, Vol. 28, pp. 496-507.

(E)

This paper reports the results of laboratory research conducted by the Engineering Experiment Station of Purdue University and sponsored by the National

Lime Association. Atterberg limits were run on 25 fine-grained soils. The plastic indexes of silty soils were increased slightly by additions of 2 and 5 per cent of hydrated lime but the PI's of clay soils were lowered appreciably by the lime additive. Proctor compaction curves were plotted for 11 of the fine-grained soils with 0, 2 and 5 per cent of lime. With but 2 exceptions, the addition of lime was accompanied by decreases in maximum density. Compaction curves were also plotted for five natural gravels to determine optimum moisture contents and CBR specimens were molded at or near this moisture content with 0, 2 and 5 per cent of lime. Additions of lime produced increased strength in most specimens. In most cases, the period of drying before wetting added to the strength at the time of testing if lime had been added to the soil.

232 - Johnson, A. M., "The Role of Calcium Chloride in Compaction of Some Granular Soils", Proceedings Highway Research Board, 1946, Vol. 26, pp. 594-601, (Discussions: pp. 601-602).

(B,F)

Results are reported for 90 compaction runs on six typical A-2 soils, one plastic and one friable from each of three states; Alabama, N. Carolina and Virginia. Runs were made using 0, 0.5, 1, 2 and 3 per cent of calcium chloride admixture. Compactive efforts used were 6-in. drop with the standard hammer, 12-in. drop with the standard hammer, and 18-in. drop with the 10-lb. hammer. The Proctor mold was used and plasticity needle readings were taken. The results indicated that a substantial saving in compactive effort required to obtain a specified density is effected by the addition of calcium chloride. For some soils, the maximum density obtained without admixture was reproduced with about 50 per cent of the compactive effort when 3 per cent of admixture was used. Penetration curves indicated a noticeable increase in workability with successive additions of the chemical.

233 - Jones, R. P., Asphalt-Soil Stabilization in Oklahoma, Bulletin No. 169, Washington, D.C.: American Road Builders' Association, 1950,(16 pages).

(D)

This is a description of methods used in asphalt-soil stabilization in Oklahoma including soil surveys and analyses, types of equipment used, manipulation, asphalt specifications, items, quantities and bid prices on base and surface construction.

234 - Jones, R. P., "Commercial Stabilization Equipment - Development of the P & H Single Pass Processing Method", Proceedings Conference on Soil Stabilization, M.I.T., 1952, pp. 185-190.

(I)

This article describes the P & H Single Pass Stabilizer which may be used for granular - cement and bituminous stabilization. The P & H Single Pass Stabilizer is a self-propelled, dual unit machine consisting of a power unit which is mounted

on tractor type crawler treads and a processing unit suspended from the rear of the power unit. It operates on a continuous principle performing in a single pass all of the necessary operations for complete in-place processing of road materials and leaving them in position for immediate compaction where aeration is not required. The entire unit is operated by one man with a helper on the ground to connect and disconnect liquid supply trucks.

235 - Joosten, H. and Vail, J., Chemical Document No. 598, 1937, Philadelphia Quartz Company Library.

(F)

236 - Journal of Institution of Highway Engineers, "Symposium on Soil Stabilization", Journal of Institution of Highway Engineers, 1952, Vol. 2 (6), pp. 8-19, Discussion: pp. 19-35.

(A)

The following papers were presented and discussed at a symposium organized by the Institution of Highway Engineers and held in London on December 7, 1951; Soil Stabilization with Bitumen: A. W. Jarman: Contractors' Record, 1951, Vol. 62 (50) pp. 23-25: Contractors' Journal,1951, Vol. 145 (3782), pp. 2324-2325. Consideration is given to scope, experience, principles, soil stabilization with bitumen and function and limitations of soil stabilization.
Soil Stabilization with Bitumen Emulsions: L. G. Gabriel: Contractors' Record, 1951, Vol. 62 (51), pp. 13-15, 28. A patent-protected process in which 5 to 10 per cent of cement or lime is added is briefly discussed and the problems encountered in soil stabilization with bitumen emulsion are dealt with.
Soil Stabilization with Cement: W. P. Andrews, Contractors' Record, 1952, Vol.63 (1), pp. 25-27, Contractors' Journal, 1952, Vol. 146 (3784), pp. 44-45. An outline is given of the principles involved and methods used in the construction of soil-cement roads.

Joustra, K. (see 163)

237 - Karpoff, K. P., Laboratory Tests Aid Study on the Stabilization of Fine-grained Soils by Electro-osmotic and Electro-chemical Methods, Paper Presented at the 32nd Annual Meeting, Highway Research Board, 1953.

(G)

The paper describes the exploratory study which was undertaken by the Bureau of Reclamation to develop the apparatus, equipment and procedure for measuring the changes induced in a soil by electro-osmotic and electro-chemical methods of stabilization. Investigations carried out by the Denver Laboratory show that a more stable soil is produced by electro-osmotic and electro-chemical methods from an originally unstable soil with an accompanying: 1) decrease in moisture content, 2) increase in density, 3) increase in cohesion, 4) increase in internal friction, 5) increase in penetration resistance, 6) change in base-exchange capacity, 7) change in permeability and 8) increased resistance to maceration in water. The author felt that realistic recommendation for the solution of soil

stabilization problems can be obtained by using the equipment used in this study for the solution of specific field problems.

238 - Kassel, F. L., "Soil Consolidation by Electrolysis", Civil Engineering, (London), 1946, Vol. 41, No. 479, pp. 187-188.

(G)

Brief description of method of treatment of clay soils by means of electrolytical consolidation; moisture content and compressibility considerably reduced. Bibliography.

Kellogg, F. H. (see 497)

Kelly, J. A., "Experimental Sand-Clay Base Course in North Carolina", Public Roads, 1947, Vol. 24, No. 12, pp. 299-306.

(B)

The purpose of the investigation was to study by construction and observation of an experimental road the effect of variations in PI on the service behavior of base courses composed of sand-clay mixtures; description of experimental road; description of soils; proportioning materials; construction methods; base course density; performance of experimental road; summary.

240 - Kemler, H., "The Construction of 'Clay Concrete' Roads", Génie Civil, 1947, Vol. 124, No. 6, pp. 105-106.

(B)

This article describes mechanical soil stabilization procedure as illustrated by French road construction experience in Tunisia. The method is recommended for the construction of bases and lightly trafficked roads in fairly dry districts. Mechanical stabilization may advantageously replace macadam construction where the necessary material is available near the site. Disadvantages are the need of a considerable amount of machinery and of personnel more skilled than is necessary for the construction of macadam roads: advantages are that it prevents the forcing of a clay subgrade up into the base or surfacing, it is more economical than macadam and it provides a smooth riding surface even at high speed.

241 - Kempf, C. and Walsh, W. J., "Soil-Cement Paving Jacking", Western Construction, 1952, Vol. 27, No.11, pp. 60-61.

(C)

Surface irregularities caused by the swelling of soil under the concrete surfacing of the Boulder-Denver turnpike have been removed by the injection of a slurry consisting of cement, water and a silty loam. The need for care in the rate of application of the mixture is stressed and it is recommended that it should normally be pumped through holes spaced about 6 ft. apart.

242 - Kenne, P., "Sand Wells Speed Marsh Crossing", Better Roads, 1947, No. 9, pp. 27-29.

(H)

An account is given of the construction by the Connecticut State Highway Department of vertical sand drains to hasten settlement and consolidation of a marshy foundation beneath the filling for the re-aligned U. S. No. 1 on its approach to the new Raymond E. Baldwin Bridge over the Connecticut River. The economic advantages of this method over those involving replacing the mud by stable material or displacing it by blasting are outlined.

243 - Khursale, N. V., "Soil Stabilized Roads", Journal of Institution of Engineers, (India), 1948, Vol. 29, pp. 86-96.

(A)

The present road system of Hyderabad is inadequate, as illustrated by the fact that on an average one mile of road serves 15.65 sq. miles as against 1 sq. mile in the United States and 0.5 sq. mile in the United Kingdom. Three current experiments in soil stabilization, two in the Punjab and one in Hyderabad, are described briefly. Mechanical soil stabilization is recommended as being cheap and satisfactory for most road construction in Hyderabad, but a stone surfacing should be provided where the traffic exceeds 400 tons per day.

King, Harry L. (see 450)

244 - Kjellman, W., "Accelerating Consolidation of Fine-Grained Soils by Means of Cardboard Wicks", Proceedings 2nd International Soil Mechanics Conference, 1948, Vol. 2, pp. 302-305.

(H)

The author refers to the work of O. J. Porter on vertical sand drains, and to the later work of H. J. McKeever. This paper describes a band-shaped cardboard drain used successfully for deep drainage in Sweden. The cardboard is unsized but impregnated with arsenic salt to resist bacterial attack and with melamine-resin to increase its strength in the wet state. The drain is about 3mm. thick and 100mm. wide, furnished with inner longitudinal channels. The author patented the drain and the method of driving it into the ground in 1939. The procedure for calculating the spacing of these drains is given, and the machine used in placing them is described. Results of a large-scale field test are presented.

245 - Kjellman, W., "Consolidation of Clay Soil by Means of Atmospheric Pressure", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 258-263, (Discussions: 264-274).

(H)

Vertical drains have frequently been used in recent years for accelerating the consolidation of clay soils. In most cases after the drains have been installed and the permanent earth fill have been placed, a surcharge is applied to the drained area and left to act on it during the consolidation process. It is then removed before the structure is erected. The main purposes of the temporary surcharge are (1) it brings the settlement to a standstill, which cannot be achieved otherwise, (2) it accelerates the settlement so that either the structure can be erected earlier, or else the drains can be placed more widely. The Royal Swedish Geotechnical Institute has worked out the following method of using the atmospheric pressure as a temporary surcharge: The drained area is covered with a filter and on top of it a tight membrane. Outside the filter the membrane is connected tightly to the soft clay, free from cracks and root channels, that underlies the dry crust. The suction-pipe of a pump is carried tightly through the membrane into the filter. When the pump starts working, the pore pressure decreases in the filter and the drains and, gradually, in the clay. In any horizontal plane the total normal pressure remains constant; therefore, the grain pressure increases as the pore pressure decreases. Thus the pump simply sucks the water out of the clay, which is forced to consolidate accordingly. It is stated that the new method has not yet been used in practice, but has been tried in some large-scale field tests on soft clay.

Klinger, Earl W. (see 416)

246 - Knight, J. A., "Calcium Chloride as a Compaction Aid in Gravel Base Construction", Roads and Bridges, 1947, Vol. 85, No. 10, pp. 90-93.

(F)

Knight, J. A. (see also 503)

247 - Knister, W. H., "Stable Road Bases as Built in the County of Essex", Roads and Bridges, 1949, Vol. 87, pp. 64-65, 98-101.

(A)

This paper presented before the Ontario Good Roads Association describes gravel stabilization as carried out in Essex County, Ontario. Limestone screenings, hydrated lime and calcium chloride have been used as stabilizing agents.

Koos, W. (see 139)

248 - Kraveth, F. F., "Soil Stabilization Methods", Military Engineers, 1952, Vol.44, (302), pp. 451-454.

(A)

The information presented at a symposium held at Cambridge, Mass., in June, 1952, and conducted by the M. I. T. is reported. This paper gives very briefly the general points of view held on methods which incorporate the use of lime, calcium chloride, sodium silicate, chrome-lignin, plasmofalt, calcium acrylate,

aniline-furfural, Portland cement, bituminous materials, electro-osmosis and consolidation by atmospheric pressure. Consideration is also given to altering the soil-water relations with chemicals and by compaction and vibration. Reference is made to stabilization equipment designed for granular soils.

249 - Krishna, S., "Treatment of Sand, Soil and Earth", Indian Patent 32035, Dec. 17, 1947.

(E)

The kernel of Tamarindus indicus is steamed to release pectin from the cell walls. The soft mass is dried and ground to 70 to 90 mesh. From 2-4 parts of the powder are taken and the requisite amount of water added to give a 4-10% mixture. To the mass so obtained is added 1-4% of slaked lime, either as a fine powder or as thick paste. From 94-97 parts of dry sand, soil, etc., are added, mixed and allowed to dry until compaction is possible. A drying temperature of more than 125 degrees is to be avoided.

250 - Krynine, D. P., "Some Comments on Earth Compaction", Highway Research Board Bulletin No. 42, 1951, pp. 14-20.

(H)

Compaction terminology is examined and revisions proposed. Examples of how to make a choice between the dry and the wet side of the optimum moisture content are given. The commonly used concept of the moisture content "by dry weight" is discussed with the conclusion that the use of this concept does not always indicate the moisture distribution in a subgrade. A British paper on experimental compaction is analyzed and the results of the analysis are illustrated graphically.

251 - Kucera, K., "Construction Costs Reduced by New Methods of Building Base Courses", Dopravni Technika (In Czech.), 1951, Vol. 1, pp. 27-28.

(A)

The construction of macadam and stabilized-soil base courses enables the engineer to make use of materials available locally and to lower construction costs. Maps of Czechoslovakia show the occurrence of various types of aggregate in the country and the purposes for which they are suitable.

252 - Kucera, K., "Stabilisovane vozovky jejich navrh a kontrola provadeni", Silnicni Obzor, 1950, Vol. 26, No. 7, pp. 97-102.

(A)

Soil stabilized surfacings, design and control of construction; nature and properties of stabilized soil; types of binder; classification of soils; design of pavement thickness and soil gradation; soil cement tests and controls; construction methods and economy of soil roads; bibliography.

253 - Kudryavstseva, M. M., "Compacting Earth", U. S. S. R. Patent 66750, 1946.
(E,G,H)

To loose earth is added 2-4% of ground slaked lime. The moisture content of the earth is brought to 17-25%. The earth is compacted; electrodes are placed on the surface and a direct current is passed.

254 - Kumutat, E., "Über die elektrochemische Bodenverfestigung nach dem Verfahren von L. Casagrande", Angewandte Chemie, 1940, Vol. 53, pp. 168-171.
(G)

The Casagrande's method of electro-chemical soil stabilization is discussed.

255 - Kuron, H and Hannemann, W., "Influence of Lime of the Mechanical Properties of Soil Colloids", Zeitschrift für Pflanzenernährung und Dungung, 1948, Vol. 40, pp. 200-206.
(E)

The resistance to shock of a soil varies widely. Generally, its magnitude is parallel with the soils adsorption capacity or colloidal content. A maximum resistance generally occurs when slaked lime is added to 75-100% of the soil adsorption capacity. Additional lime causes a decrease in resistance to shock corresponding to the known effect of excess calcium on the physical properties of the soil. The slope of the resistance curve with additional lime varies with the soil. It seems to be related closely to particle size and to the possibility of "bridge formation" between individual particles. The resistance curve exhibits a break or minimum at approximately 25% lime saturation. This coincides with a corresponding break in the titration of de-gummed soils with calcium hydroxide and indicates a correlation between chemical and mechancial properties of the soil.

Kushing, J. W. (see 274)

Kusliik, B. R. (see 483)

256 - Kyrieleis, W. and Sichardt, W., Grundwasserabsenkung bei Fundierungsarbeiten (Ground-water Lowering in Foundation Engineering), 2nd Edition, Berlin: Springer, 1931, (286 pages).
(H)

Methods of lowering ground-water as practiced in foundation work for docks, locks and similar structures in Europe; subject is treated theoretically and practically; well-point methods; equipment; illustration from recent practice.

257 - Laburn, R. J., "Soil-Cement Stabilization in South Africa", Roads and Road Construction, 1943, Vol. 21, No. 251, pp. 325-326.
(C)

A brief account is given of work carried out in the Civil Engineering Laboratories of the University of the Witwatersrand, Johannesburg, on soil-cement stabilization and on the roadmaking properties of some South African stones.

258 - Lacroix, M., "The Electrical Consolidation of Soils", Ann. Ponts Chauss., 1948, Vol 118, pp. 621-643.

(G)

A brief historical note on the development of electrical methods of soil treatment is followed by detailed reviews of (1) electro-chemical consolidation as developed in the U. S. S. R. (2) electro-osmotic methods used by L. Casagrande and others, and work recently carried out by G. Beskow at the Statens Wäginstitut, Sweden, on the effects of continuing electro-osmotic treatment to a point at which non-reversible changes occur in the soil and its absorptive capacity is permanently lowered to an appreciable extent. Practical examples of these methods are described. It is concluded that: (a) Under present conditions, electro-chemical methods demand too high a power consumption to be applicable to any but small jobs; they also involve comprehensive preliminary tests in the laboratory. (b) Electro-osmotic methods are specially suited to the consolidation of fine uniformly graded soils, though the cost of equipment is likely to restrict application to sites where cheaper methods are impractical.

259 - Lacy, D. L., "Bituminous Soil Stabilization in Kansas", Roads and Streets, 1952, Vol. 95, No. 12, pp. 72-76, 86.

(D)

The methods adopted and problems encountered in the construction of a 9.2-mile section of U. S. Highway 83 in south-west Kansas are described. The binder was added to windrowed soil and mixing was affected partly by a traveling plant mixer and partly by mix-in-place methods. The surface of the carriageway was raised about a foot above the surrounding ground level to improve drainage and aid snow removal. Notes of a general character are also presented on procedures used in the construction of soil-bituminous and sand-bituminous bases in the State of Kansas.

260 - Laerum, O. D., "Soil-Cement (Geobeton) as a Surfacing for Roads and Airfields in Norway", Dansk Vejtidsskr, (In Norwegian), 1951, Vol. 28, pp. 17-21, 44-46, 56-59, 101-109.

(C)

Danish and Norwegian experts have agreed to use the term "geobeton" as the standard translation of "soil-cement" or "cement-stabilized earth." It is hoped that the new term will become recognized throughout Scandinavia. The paper, which was read at the Danish College of Technology (Denmarks Tekniske Højskole), Copenhagen, surveys methods of earth stabilization with cement, which have recently been carried out in Norway, including some minor roads in Trondheim, a short section of main road in Oppdal, and an airfield in the south of Norway. Details are given of service behavior and costs. These

surfacings, which either were not surface-treated at all, or were left for over a year before being given a single-coat bituminous treatment, have not shown any evidence of frost-damage; they have also resisted wear and tear by vehicles equipped with snow-chains. An estimate is given of the limits of possible future development of this type of road and airfield surfacing in Norway.

261 - Laing, R., "Wyoming's First Soil-Cement Highway Job", Pacific Builder and Engineer, 1952, Vol. 58 (8), pp. 54-58, 108.

(C)

An illustrated account is given of the construction methods adopted in laying a base course of cement-stabilized scoria (burned clay and sand formed by burning of coal beds). Sandstone scoria break down to dust and clay scoria break down to flakes, and neither provides satisfactory base material unless stabilized by cement of a bituminous binder.

262 - Lambe, T. W., "Stabilization of Soils with Calcium Acrylate", Journal of Boston Society of Civil Engineers, 1951, Vol. 38 (2), pp. 127-154.

(F)

The various known methods of stabilizing soil are briefly reviewed and the methods developed by M. I. T., Soil Solidification Project, of stabilization with calcium acrylate is described and discussed. The treatment consists in adding calcium acrylate to the soil, then polymerizing the acrylate with an oxidizing catalyst and a reducing activator. The tensile and compressive strengths and the flexibility of the stabilized soil can be varied within wide limits by altering details of the treatment.

263 - Lambe, T. W., "Summary of the Conference on Soil Stabilization", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 303-311.

(A)

This is a review of the individual papers presented in the conference on Soil Stabilization at M. I. T. in 1952. The subject of soil stabilization is discussed under the headings of (1) Densification, (2) Electrical Stabilization, (3) Stabilization with Additives, (4) Chemical Stabilization, (5) Incorporation of Admixtures with Soil, (6) Application and Economics of Soil Stabilization, and (7) Needed Research.

Land, J. L. (see 191)

264 - Larson, Guy H., "Experimental Soil-Cement Road in Wisconsin", Proceeding Highway Research Board, 1937, Vol. 17, Part II, pp. 83-91.

(C)

The building of the experimental soil-cement road in Adams County, Wisconsin,

during the fall of 1936 and early summer of 1937 is reported by this article under the following headings: (1) Equipment, (2) Subbase, (3) Application of Cement, (4) Compacting and Finishing, (5) Preparation for Next Day's Work, (6) Protective Surfacing, (7) Test Results.

265 - Laws, W. D. and Page, J. B., Silicate of Soda as a Soil Stabilizing Agent, Highway Research Bulletin, No. 1, Washington, D. C.: 1946, (21 pages).
(F)

The investigation reported herein was not an attempt toward immediate development of a commerically feasible system of soil stabilization with silicate of soda, but rather an attempt to obtain fundamental information on which such a system might subsequently be based. The report is in two parts: experiments with clay minerals and experiments with soils. It is concluded that the use of silicate has great promise for certain types of soils but gives a negative response with other types.

266 - Leadarbrand, J. A. and Norling, L. T., Soil-Cement Test Data Correlation Affords Methods of Quickly Determining Cement Factors for Sandy Soils, Paper presented at the 32nd Annual Meeting of the Highway Research Board, 1953, pp. 1-27.
(C)

This paper presents and discusses the results of a correlation of soil and soil-cement laboratory data obtained by testing 2,229 sandy soils following ASTM or AASHO standard test procedures. By use of the correlation, methods of quickly determining cement factors were developed. The soils were placed into 3 groups, two of which are based on textural classification. The third group includes special or miscellaneous granular materials. The test methods involved are presented as step-by-step procedures and include the use of charts based on relationships between maximum density, combined silt and clay content and the cement requirement for adequately hardening the soil. Minimum compressive strengths also are required. The procedure requires considerably less laboratory work and time than is needed for making complete ASTM or AASHO soil-cement tests and, in addition, smaller soil samples can be used.

267 - Lenis, M. J., "Metodo de Diseno de Mezclas de Materiales para Estabilizacion de Suelos", Ingenieria y Arquitectura, 1942, Vol. 4, No. 43, pp. 23-24.
(B)

Method of design of mixtures of materials for stabilization of soils; illustrative examples; screen analysis of mixture of 4 materials; 3 materials, graphic solution of design problem.

Lerch, R. W. (see 376)

268 - Lesesne, S. D., Stabilization of Clay Roadbeds with Lime, National Lime Association Bulletin, 1940, Washington, D. C., (15 pages).

(E)

The bulletin described tests in Texas and Oklahoma as well as recommendations for the use of lime in soil.

269 - L'Heriteau, G., "Research on the Strength of Soil. The Stabilization of Soils", (Recherches sur la résistance du sol. La stabilisation des terrains), Institut Technique du Bâtiment et des Travaux Publics, Circulaire Série D, No. 10, 1945, Paris, p. 8.

(B)

Reports experiments on the graded soil method of stabilization.

270 - Li, Mo Chin, "Research on Soil Stabilization", Proceedings Highway Research Board, 1943, Vol. 23, pp. 413-422.

(A,C,E)

Owing to the necessity of improving the highways, the National Tsing Hua University has been cooperating since Dec., 1939, with the Bureau of Highways of the Ministry of Communications in carrying out an extensive highway research project in which soil stabilization is one of the most important problems. In dealing with the specific problems in accordance with the prevailing local conditions there are some differences which must be borne in mind. One of the main differences is to obtain immediately a serviceable surface course while the prevailing practice in the United States is to use a stabilized base course which, sooner or later, will be surfaced. Another difference is that use must be made of cheap, local stabilizing agents, such as burnt-clay, quicklime, cinders, tung-oil, etc. Research work on stabilization has been carried on under adverse conditions and be strictly limited to local materials. This paper reports some of the findings.

271 - Lianos, M., "Stabilization of Soils for Roads", Boletin de la Direccion de Caminos y Ferrocarriles (Lima), 1944, Vol. 2, No. 2, pp. 1-74.

(A)

A review of the present state of knowledge, based largely on United States literature.

Litehiser, R. R. (see 318, 540)

272 - Livingston, W., "Colonial Roads", Surveyor, 1950, London, Vol. 109, pp. 299-300, 319-320.

(A)

The review of the conditions and requirements of colonial road construction,

which refers mainly to Nigeria, the West Indies, and British Guiana, is supplemented by reference to analogous types of construction in the U. S. A. Short accounts are given of various types of low-cost road, including (a) "coconut" roads through low-lying coastal coconut plantations where the ground is saturated with brackish water; (b) "corduroy" roads, consisting of straight pieces of hardwood laid close together transversely across the track and covered with sand or gravel; (c) an elaboration of the foregoing, used in marshy ground, and consisting of fascines carrying longitudinal timbers which support a corduroy surface course; (d) gravel roads (other than those of laterite gravel); (e) stabilized laterite roads; (f) bridle roads in mountain forest country; (g) macadam; and (h) burnt-earth roads. The use and deterioration of bituminous binders under tropical conditions is discussed and the value of adequate records of service behavior of roads is emphasized. Recommendations are made with regard to surfacing methods, the preparation of the base, the production of aggregate and the use of premix material. Tar should not be used in surface courses under tropical conditions unless a protective coating of bitumen is provided at an early stage. Close-textured surfaces should be used; non-skid qualities should be achieved by the choice of suitable materials rather than by using an open-textured surface. Sand asphalt is considered to be the most satisfactory bituminous surfacing for tropical conditions.

273 - Logan, E. and Ross, A. E., "An Aspect of Soil Stabilization with Bituminous Emulsion", Royal Engineers' Journal, 1947, Vol. 61, pp. 250-254.

(D)

A study of the efficiency of the 'color test' used for determining the approximate amount of emulsion required.

274 - Looker, C. D., Spencer, W. T., Kushing, J. W., (Arranged by Allen, Harold), "Use of Sodium Chloride in Road Stabilization", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 257-274.

(F)

The following items were presented and discussed at a symposium on the use of sodium chloride in road stabilization: (1) Theory, (2) Design, (3) Construction, and (4) Maintenance.

275 - Loughborough, T. F., Miller, A. M., Schafer, N. F. and Tilley, A. C., (Arranged by Rapp, Paul), "Use of Tar in Base Stabilization", Proceedings Highway Research Board, 1939, Vol. 19, pp. 504-516.

(D)

In this symposium the use of tar in base construction was described by representatives of Indiana, Nebraska, Virgina and West Virginia State Highway Departments. Cost of the base stabilization was also reported.

276 - Lowance, F. E., McKennis. H. and Bishop, J. A., "Navy Requirements and Experi-

ences with Soil Stabilization", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 275-280.

(A)

This paper presents a summary of the methods of stabilizing soil in which the Navy Department has a specific interest, and more specifically, those methods which have been studied and exploited by the Research and Evaluation Laboratory of the Bureau of Yards and Docks at Port Hueneme, California. The requirements, for soil stabilization for combat operations are briefly discussed. Methods of stabilization studied by the Navy include the thermite process, the uses of gypsum, high early strength cement, calcium chloride, sodium silicate and aniline furfural. The problem of providing stabilized soil under conditions that will satisfy the requirements is far from being solved.

277 - Lowe, R., "Soil Stabilization Methods and Plant", Roads and Road Construction, 1945, Vol. 23, No. 267, pp. 79-82.

(I)

Grade preparation and pulverization, type of binding agent, mixing, leveling, compaction, aeration, and finishing.

Lumb, P. (see 328)

278 - MacLean, D. J. and Rolfe, D. W., "A Laboratory Investigation of Electrosmosis in Soils", Philosophical Magazine, 1947, Vol. 37, No. 275, pp. 863-873.

(G)

Experimental work carried out at the Road Research Laboratory showed that moisture movements were greater in sandy than in clay soils. For a given soil the amount of water expelled at the cathode was proportional to the quantity of electricity passed through the specimen, up to the point when the soil at the anode became too dry to act as a conductor. On the assumption that the moisture movement is due to ions carrying water molecules from the anode to the cathode, calculations showed in the case of one of the soils that the number of water molecules transported per ion was 88.

279 - MacLean, D. J., Robinson, P. J. and Webb, S. B., "An Investigation of the Stabilization of a Heavy Clay Soil with Cement for Road Base Construction", Roads and Road Construction, 1952, Vol. 30, (358), pp. 287-292.

(C)

The work described in this article was carried out as part of a joint investigation by the Road Research Laboratory, Harmondsworth, and the Military Engineering Experimental Establishment. The study of the problem comprised: 1. A laboratory investigation to determine the suitability of clay for treatment with cement. 2. A subsidiary laboratory investigation to ascertain whether addition to the cement of materials such as lime and resin gave better

results than cement used alone. 3. Tests on large-scale mixing machines. 4. The construction of experimental lengths of clay stabilized with cement, using the specification and equipment found to be the most satisfactory in the work already carried out. The soil used was a clay from Brockenhurst, Hampshire. It was found that heavy clay soil could be stabilized with about 15 per cent normal Portland cement and 2 per cent of hydrated lime; in practice it had every appearance of being a satisfactory road base material. Weather resistance was good, but behavior under traffic has to be confirmed by systematic traffic trials. Further work will necessary to establish whether these results apply to other heavy clay soils possessing mineral compositions which differ from those of the soil tried out. It was established that pottery-type mixer was the only type of mixing plant which gave satisfactory results. The present cost of a stabilized clay layer 12 inches thick is estimated to be about 12 cents per square yard, and this method of stabilization is only suitable on sites where the clay occurs in situ and where it is desired to avoid the cost of importing stable materials.

280 - MacLean, D. J. and Rolfe, D. W., "Soil Drainage by An Electrical Method", Civil Engineering, London, 1945, Vol. 40, No. 464, pp. 34-37.

(G)

The first part of the paper describes investigations made at the Road Research Laboratory, Harmondsworth, to study the physics of an electrical method for the drainage of soils. A linear relation exists between the quantity of electricity required to expel one gram of water and the "clay" content of the soil. The second part of the paper described two large-scale applications of electrical drainage which were tried out in Germany and reported by L. Casagrande.

MacLean, D. J. (see also 505)

281 - Maffei, A., "The Adsorption of Lime by Silica Gels", Gazzetta Chimica Italiana, 1936, Vol. 66, pp. 197-204.

(E)

The adsorption of calcium hydroxide from solution by silica gels was studied to ascertain whether the phenomenon is a chemical adsorption. During the first few hours only physical adsorption takes place. Later by its dispersing action on silica gel, calcium hydroxide slowly changes the physical structure of the gel and the nature and extent of its surface with the ultimate formation of monocalcium silicate. Both the adsorption and the chemical phenomena continue for long periods of time. A unimolecular adsorption layer was not found.

282 - Maffei, A. and Banchi, G., "The Displacement of Alkalis in Clays by the Action of Lime", Ann. chim. applicata, 1932, Vol. 22, pp. 93-98.

(E)

Clay was mixed with quicklime, water added to a stiff paste. Briquettes were formed and air-dried for 24 hours. These were then placed in water and pulverized and the total alkalis determined. Velocity of alkali displacement increased with an increase of lime.

283 - Mainfort, R. C., A Summary Report on Soil Stabilization by the Use of Chemical Admixtures, U. S. CAA Technical Development Report No. 136, Indianapolis, Indiana, 1951, (57 pages).

(C,E,F)

This report presents the results of laboratory and field tests on a wide range of soils. The most effective of the chemical admixtures for soil stabilization studied are said to have been Portland cement with certain resin mixtures, aniline-furfural resin with a catalyst. Bituminous materials were not effective with any of the soils tested but some were improved by the addition of small quantities of certain artificial resins. Sodium silicate, hydrated lime, powered slag, calcium chloride and resinous water-repellents were not effective when subjected to severe exposure in the field or the laboratory.

284 - Mainfort, R. C., Laboratory Study of Effectiveness of Various Chemicals as Soil Stabilizing Agents, Tech. Development Note No. 40, CAA, 1945, (20 pages).

(F)

Laboratory studies made to develop chemicals which, when mixed with natural soils, form integral material suitable for light paving; main effort of study was directed toward development of materials that could be made readily available in combat areas.

285 - Malvani, G., "Stabilized Soil Roads", Asfalti, Bitumi, Catrami, 1952, Vol. 21, (In Italian), pp. 16-21, 46-50, 73-75.

(A)

The principles involved in the stabilization of soils are discussed and descriptions are given of the mechanical, chemico-physical and chemical methods used in practice. In the section devoted to chemical methods, consideration is given to stabilization with cement, bituminous binders, sodium silicate and resins, and to thermal and electrochemical methods.

286 - Maner, A. W., "Curing of Soil-Cement Bases", Proceedings Highway Research Board, Vol. 31, 1952, pp. 540-558.

(C)

This paper describes field experiments conducted on a secondary road in Appomattox County, Virgina, to study the effect of various methods of curing soil-cement bases. The project extended over two general areas, the soils of which are derived from a granite gneiss (Appling Soil) and from Wissahickon schist (Cecil soil). Types of curing materials studied included moist earth, waterproof paper, calcium chloride, RC-2 asphalt, RTCB-6 tar, and AE-2 asphalt emulsion. Results of the investigation indicated that, if applied and maintained

properly, 5 of the 6 cover materials used in this experiment are satisfactory curing mediums for soil-cement bases. It was also concluded that the bituminous materials can also serve as a prime coat if the subsequent surface treatment is placed at or near the end of the curing period.

287 - Manigault, D. E. H., "Lime Stabilization", Roads and Streets, August, 1947, Vol. 90, No. 8, pp. 94-95.

(E)

Lime for low-cost roads is described. Laboratory results are presented and conclusions are discussed.

288 - Markwick, A. H. D. and Dobson, A. F., "Application of Electromosis to Soil Drainage", Engineering, 1947, Vol. 163, pp. 121-123.

(G)

The conclusions drawn from lab experiments at the Road Research Laboratory, England were as follows: (1) On passing an electric current through wet soil, the soil is dried out at the positive electrode (anode) and water is expelled from the soil at the negative electrode (cathode). (2) When large current densities are employed, considerable heating takes place at the anode. The temperature gradients thus produced increase the water movement caused by the electrosmosis effect alone. (3) The weight of water expelled at the cathode is proportional to the quantity of electricity (in coulombs) passed through the soil, until the soil dries out at the anode, after which the rate of expulsion of water rapidly decreased to zero. (4) The weight of water expelled for a given quantity of electricity passed through the soil is greatest for sandy soils and least for heavy clay soils. A linear relation exists between the quantity of electricity required to expel one gram of water and the "clay" content of the soil. (5) The weight of water expelled per coulomb is independent of the state of compaction above 95%. Below this relative compaction the weight lost per coulomb tends to become variable and lower, probably due to a breakdown in the continuity of the soil/water system. (6) The drying-out produced by electrosmosis occurs mainly at and near the anode or positive electrode. The moisture content of the soil at the negative electrode is not changed to any great extent, provided that the water liberated is drained away.

289 - Markwick, A. H. D., "Basic Principles of Soil Compaction and Their Application", Roads and Road Construction, 1944, Vol. 22, No. 264, pp. 359-360.

(H)

Main facts regarding soil compaction summarized; author points out that existing knowledge on many aspects of soil compaction is still limited. Extracts from paper before Institution of Civil Engineers.

290 - Markwick, A. H. D., "Recent Progress in Stabilized Base Construction", Highways,

Bridges, and Aerodromes, 1943, Vol. 10, No. 489, pp. 1, 3, 10.

(A)

In this brief review of progress in Great Britain in the construction of stabilized bases, principally for camp roads and aerodrome runways, examples are given of the successful use of each of the four stabilization processes - mechanical, bituminous, soil-cement, and water-proofing.

291 - Marshall, H., "A Typical Ohio Soil-Cement Project", American Road Builders' Association Technical Bulletin No. 172, Washington D. C.: ARBA, 1950, p. 16.

(C)

This report, sponsored by the Committee on Soil-Cement Stabilization of the ARBA, describes the construction by the most up-to-date methods of a 10 mile section of soil-cement road. Details are given of the standard procedures adopted in Ohio for making a preliminary investigation. These include: (1) the sampling of surfacing material on the existing carriageway, (2) the survey of materials (gravel, stone, etc.) available locally, and (3) the survey of soils, including the extent of each type. Construction methods, sequence of operations, and plant and machinery used are described.

292 - Martin, G. E., "Practical Questions and Answers on Tar Treated Gravel Roads", Roads and Streets, March 1950, Vol. 93, No. 3, pp. 94-97.

(D)

While judgement plays an important role in tar road work, there is a recommended way to perform every step. This article gives recommendations on this subject under the following headings: (1) design fundamentals, (2) maintenance suggestions, (3) suface treatment, (4) road mix method.

293 - Martin, George E., "Soil Stabilization with Tar", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 275-282.

(D)

By the proper use of tar, existing soils can be made water resistant and a relative improvement can be obtained in their bearing power. The construction methods are fairly standardized although improvement in mixing and consolidating machinery may be expected. In this paper the design and construction of tar-stabilized roads are briefly discussed.

294 - Massachusetts Institute of Technology, Soil Solidification Project, Final Report, Phase I, M. I. T., Cambridge, 1948, (253 pages).

(A)

In this report prepared by V. F. B. de Mellow, R. S. Hess and C. A. Sturenburg under the supervision of E. A. Hauser, J. B. Wilbur and D. W. Taylor, the

report is in three parts. Part 1 is an account of preliminary work undertaken with a view to determining the most promising types of agents for chemical soil solidification. The laboratory tests were qualitative rather than quantitative. Part II presents a review of literature (with full references) related to chemical soil solidification and stabilization and a discussion of fundamental concepts of colloid chemistry pertaining to soil solidification, based mainly on publications and lectures by E. A. Hauser. Part III is a bibliography of 734 references arranged chronologically under the headings: calcium chloride, sodium chloride, cement, bituminous, resins, sodium silicate, fundamental concepts of soil and clay properties, miscellaneous. An author index is included.

Maxwell, A. A. (see 229)

Maxwell, John Keith (see 184)

295 - McDowell, C., "Hydrated Lime for Stabilizing Roadway Materials", Roads and Streets, 1949, Vol. 92, pp. 81-82, 84.

(E)

Low-cost roads constructed more than $2\frac{1}{2}$ years ago by the Texas State Highway Department by stabilizing old gravel roads with lime and sealing with a bituminous wearing surface are still in good condition. Freezing-and-thawing tests and the behavior during the winter of lime-treated sections of roadways indicate that hydrated lime may improve the frost resistance of some subgrade materials. A triaxial compression test has been developed for testing lime-stabilized soils. It is suggested that many soils have pozzolanic properties which account for this successful utilization of hydrated lime in soil stabilization.

296 - McDowell, Chester and Moore, W. H., "Improvement of Highway Subgrades and Flexible Bases by the Use of Hydrated Lime", Proceedings Second International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. 5, pp. 260-267.

(E)

Many natural soils contain pozzolanic materials which react with lime solutions to form stable cementitious compounds. Physical tests are necessary to evaluate this property. Unconfined compressions tests and triaxial compression tests have been used for this purpose. The laboratory procedure is described and data are presented in tables and graphs. As a result of laboratory tests and field experience, it is concluded that (1) soil-lime stabilization is applicable for the improvement of certain subgrade and flexible base materials; (2) many natural soils are suited to lime stabilization; (3) proportioning, mixing, moisture content, degree of compaction and curing procedure are important and (4) application of a wearing surface is desirable.

McFadden, Gayle (see 479)

McKennis, F. E. (see 276)

297 - McKesson, C. L., "Bituminous Emulsion Stabilized Roads", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 283-288.

(D)

Mixtures can be satisfactorily designed by using the tests for capillary adsorption and stability. The amount of emulsion required varies in about direct proportion to the amount of fines present in the soil. The emulsion used must be one which is stable enough to withstand any degree of mixing with the finest of aggregates, some of which even contain electrolytes. The most important items are proper mixing, adequate compaction, thorough drying and proper surface protection.

298 - McKesson, C. L., "Emulsified Asphalt Treated Sub-base Under Cement Concrete Pavement", Proceedings Highway Research Board, 1944, Vol. 24, pp. 466-477.

(D)

In 1938 the cities of Oakland and Los Angeles, California, constructed projects of substantial size on which the subgrade of concrete pavement was made water-resistant by the incorporation of small quantity of emulsified asphalt (usually 3 per cent) admixed to a depth of 4 inches. After six years of service, these projects are remarkable in their freedom from cracks, lack of warping at joints and in no case is there evidence of vertical movement at joints. It appears that the reasons for the successful performance on these projects may be: (a) uniformity of moisture content in top and bottom of slab on a treated base due to the reduced rate at which moisture passes upward from the subgrade to the slab, (b) prevention of surface leakage from saturating the subgrade beneath and adjacent to joints and cracks with a resultant reduction in swelling or instability of the subgrade adjacent to joints and cracks, (c) more continuously uniform moisture content in the subgrade, particularly under and adjacent to cracks in the slab due to the retarded rate at which subgrade moisture can escape upward through cracks and joints when the subgrade is protected by an intervening moisture-resistant subbase, (d) relatively uniform support of the slab at and adjacent to cracks in both wet and dry weather, (e) added load supporting strength of the entire slab due to the increased bearing value of the treated subbase.

299 - McKesson, C. L., "Recent Developments in the Design and Construction of Soil-Emulsion Road Mixtures", Proceedings Highway Research Board, 1940, Vol. 20, pp. 856-864.

(D)

This paper briefly reviews the theory of the stabilization of soils with emulsified asphalts. The major part is devoted to a description of recent

improvements in field operations which insure the success of the work and greater speed of construction. These improvements are discussed under the following subjects: (1) proportions of soil and emulsified asphalt, (2) mixing soil and emulsified asphalt, (3) rolling, (4) drying, and (5) stabilization if sand with emulsified asphalt.

300 - McKesson, C. L., "Report of the Rio Vista, California, Subgrade Treatment Experiments", Proceedings Highway Research Board, 1925, Vol. 5, Part I, pp. 123-129.

(A,C,E)

This paper reports the subgrade treatment experiments on the Rio Vista Lateral between Denverton and Rio Vista. The treatment consisted of loosening and pulverizing the soil to a depth of 6 and 12 inches, after which various adulterants were mixed with the pulverized soil. The conclusions are (1) that the soil adulteration with cement or lime compounds is not an efficient or economical method of securing stability in heavy soils, (2) that the suitability of soil for subgrade purposes or of the merits of various methods of soil treatments can be determined by relatively simple laboratory tests and that expensive field tests can in some cases, at least, be avoided by first resorting to a properly conducted laboratory investigation, (3) that a sand or gravel layer is an efficient and economical method of minimizing damage to pavement resulting from swelling or shrinkage of the subsoil.

301 - McKesson, C. L. and Mohr, A. W., "Soil-Emulsified Asphalt and Sand-Emulsified Asphalt Pavement", Proceedings Highway Research Board, 1941, Vol. 21, pp. 506-514.

(D)

The suitability of sands for bituminous treatment was determined by the Florida Bearing Value Method and the efficiency of treatment was determined by a modification of the Florida Bearing Value Method in which the bearing value of emulsified asphalt-sand mixtures was determined using the sand from the project or blends of the sand and filler with varying quantities of emulsified asphalt tested at various temperatures. The results of these tests seem to justify the conclusion that sands are satisfactory for use if the Florida Bearing Value is greater than 25 lbs., when the sands are tested prior to mixing with emulsified asphalt, and also if the mixture shows a bearing value by the Modified Florida Test Method of more than 100 lbs. at 140° F. on test after emulsified asphalt is mixed with the sand. The data are believed to justify the conclusion that untreated sands which are below the minimum allowability can usually be made suitable for use by the addition of fine non-cohesive filler.

302 - McKesson, C. L., "Soil Stabilization with Emulsified Asphalt", Proceedings Highway Research Board, 1935, Vol. 15, pp. 357-391.

(D)

This paper presents the results of studies in soil stabilization over a period of years in a private laboratory and of construction practices growing out of these studies, not heretofore published. The paper is divided into Part I, in which theory is discussed; Part II, a description of tests and test methods; Part III, devoted to a discussion of design of stabilized mixes; Part IV, a relative efficiency of stabilizers; Part V, construction and construction practices with descriptions of some projects already constructed.

03 - McLeod, N. W., "Fundamental Principles of Mechanical Soil Stabilization", Engineering and Contract Record, 1944, Vol. 57, No. 5, pp. 13-15, 25.

(B)

Proper design and construction of mechanically stabilized base courses; data on costs; basic principles of construction which must be followed to insure success.

04 - McManus, L. N., "Soil Stabilization Principles", Roads and Bridges, 1946, Vol. 84, No. 11, pp. 74, 104, 106, 108.

(A)

Article is concerned with mechanically stabilized soils, that is, soils which owe their stability to properties and gradation of natural soils of which they are compounded with selection of ingredients, design of suitable products, handling, uses and inspection.

05 - McMaustland, E. J., "Lime in Dirt Roads", Proceedings National Lime Association, 1925, Vol. 7, pp. 12-14.

(E)

This article describes the possibilities of the lime treatment of road subgrades arising from research at the University of Missouri on a National Lime Association fellowship.

06 - McRae, J. L. and Rutledge, P. C., "Laboratory Kneading of Soil to Simulate Field Compaction", Proceedings Highway Research Board, 1952, Vol. 31, pp. 593-600.

(H)

The basic principles of soil compaction are discussed and the fundamental requirements for a satisfactory laboratory-compaction test are set forth. It is contended that the laboratory-compaction test should produce curves that duplicate the field-compaction curves. Field-compaction curves obtained in the investigations of the Waterways Experiment Station are used as criteria by which the efficiency of laboratory-compaction procedure is judged. Field curves obtained by the use of sheepsfoot roller and rubber-tired rollers are compared with laboratory curves obtained by static loading, impact loading (Proctor compaction), and "kneading static compaction". The kneading static compactor developed at Northwestern University for simulating more closely the action of field compaction equipment is described in detail. Data are

presented to show that the position of the optimum curve with respect to the zero air-voids curve is a function of the time increment that the foot pressure is maintained. It is shown that the kneading static compactor can be used to duplicate field compaction.

307 - Mechanization, "Stabilized Roads at Strip Mine", Mechanization, August, 1943, Vol. 7, No. 8, pp. 41-45.

(A)

Fidelity strip mine near DuQuoin, Perry County, Illinois, uses stabilized hard surface roads for its coal trucks between loading pits and preparation plant; road maintenance has been cut appreciably and wear of truck tires has been decreased; mechanically stabilized base road; hard surfacing; in quicker method of construction job material for preparation plant is substituted for combination of job; clay and water (or oil) for road base; road maintenance.

308 - Mehlburger, M. A., "How Booneville, Arkansas, Built Soil-Cement Streets", American City, 1951, Vol. 66, pp. 112-113.

(C)

The 8-mile street network of a small town in the United States was repaired in 1950 with a 6-inch course of cement-stabilized soil covered with a two-coat wearing course. Construction methods are described and the cost of the work is analyzed.

309 - Mehra, S. R., "Soil Stabilization with Soft Aggregates", Proceedings 2nd International Soil Mechanics Conference and Foundation Engineering, 1948, Vol. 4, pp. 462-467.

(A)

This paper describes the construction of a low-cost road in India. Broken brick was used for the coarser material as no suitable gravel was available. The proportions of coarse aggregate and graded soil were such as to give a thin protective layer of graded soil around each particle of coarse aggregate, so as to avoid mutual attrition of the soft brick particles under traffic. The base course was of graded soil and the wearing course of graded soil and graded brick aggregate, the total compacted thickness being from 6 to 7 inches. Sheepsfoot rollers were used for the base course and the wearing course was compacted with a 6-ton power roller. Experiments over 8 years have demonstrated that this type of construction produces an all-weather surface suitable for minor roads in rural areas. The surface wears almost uniformly and on light trafficked roads is expected to have a life of more than 6 years.

310 - Mehra, S. R. and Uppal, H. L., "Use of Stabilized Soil in Engineering Construction", Journal of the Indian Roads Congress, Vol. 14; 1949, pp. 293-310, Vol. 15; 1950, pp. 184-204, 320-335, Vol. 15; 1951, pp. 469-482.

(A)

A report is given to research carried out at the Soil Research Laboratory, Karnal, Pakistan. The following subjects were studied: the effect of the moisture content of a soil at the time of compaction on its structural stability; the resistance of cement-soil mixtures to the action of water; the compressive strength of cement-soil mixtures; the shrinkage of compacted soils; the thermal expansion and thermal conductivity of compacted soils. Results are presented by means of graphs and tables.

Meyers, W. F. (see 324)

311 - Michaels, A. S., "Altering Soil-Water Relationships by Chemical Means", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 59-67, (Discussions: pp. 78-79).

(A,F)

Nearly all problems associated with the use, manipulation, and treatment of soils arise from the effects upon soil properties of the presence (and occasionally, absence) of water; the role of water in soils; the probable nature of soil surfaces; surface reactions of soils in aqueous environment - aggregation and dispersions; the nature of soil water; method of altering soil-water relationships.

312 - Middlebrooks, T. A. and Barron, R. A., "Stabilization of Dam Foundations", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 255-257.

(A)

The stabilization of dam foundations may be divided into two general fields: stability and seepage. Interest in the field of foundation shearing strength exists when the embankment strength is greater than that of the foundation. When the weak foundation material is shallow and at the surface of the foundation, it is generally more economical to excavate and replace the weak material with a strong earth fill. If the weak material is too deep for economical excavation, either the embankment slopes should be flattened or the embankments should be built by stage construction. The second field of interest in dam foundation stabilization is that dealing with seepage. Wherever economically possible, complete cutoff of pervious deposits in foundations should be obtained. The most common methods are to excavate a trench and backfill it with compacted impervious fill, to use steel sheet piling, cement grouting, or by means of a long upstream impervious blanket. It is hoped that a successful means of soil grouting will be developed, since it must be less expensive than other means of reducing groundwater flow.

313 - Mikhal'chenko, V. A., "Composition of the Products of Adsorption of Lime by Silica", Journal of Applied Chemistry, (U. S. S. R.), 1946, Vol. 19, pp. 1364-1370.

(E)

Slaked lime was added to silica gel containing 94.61% water. The products

were analyzed to determine their composition and results are given in terms of the original CaO/SiO_2 ratios of the reactants.

Miller, A. M. (see 275)

Miller, Richard H. (see 322, 323)

314 - Miller, R. W., "Effect of Quality of Clay on Soil Mortars", Proceedings Highway Research Board, 1936, Vol. 16, pp. 317-321.

(B)

The results of compaction and swell tests indicate that the plasticity index limits of 4 to 12 as allowed in the present specifications for stabilized soil roads satisfactorily cover the range of conditions usually encountered in various localities. However, it appears that there is a specific maximum plasticity index that should not be exceeded depending on the quality of clay binder soil used. The tests also indicate that for each ratio of binder soil to fine sand or soil fines there is an optimum coarse sand content at which maximum density is obtained.

315 - Mills, W. H., "Cement-Soil Stabilization", Proceedings Highway Research Board, 1937, Vol. 17, Part I. pp. 513-519, (Discussions: p. 520),

(C)

This is a summary of a symposium on soil-cement stabilization presented at the seventeenth Annual Meeting, Highway Research Board, in 1937. Reports were submitted by the Portland Cement Association and the state highway departments of Illinois, Iowa, Michigan, Missouri, Wisconsin, and South Carolina. Based on the information presented in these reports, it is concluded that cement-soil mixtures give promise of real merit as a road construction material and that adequate preliminary laboratory investigation prior to construction and positive and accurate control during construction are essential.

316 - Mills, W. H., Jr., "Condition Survey of Soil-Cement Roads", Proceedings Highway Research Board, 1940, Vol. 20, pp. 812-820.

(C)

The subcommittee on the use of Portland Cement in soil stabilization circulated a questionnaire to all state highway departments designed to yield information on the design, construction, maintenance and serviceability of soil-cement base courses with bituminous wearing surfaces. Special attention was given to the following items: (1) Climatic Conditions; (2) Design of Roadway; (3) Construction Methods; (4) Types of Soil Treated; (5) Types of Subgrade Material; (6) Weather Conditions during Construction; (7) Type of Wearing Surface; (8) Condition of Wearing Surface; and (9) Traffic and Maintenance. This paper is a summary of the replies received from 46 states.

317 - Mills, W. H., Jr., "Conditions Survey of Soil-Cement Roads", Proceedings Highway Research Board, 1941, Vol. 21, pp. 484-492.

(C)

This paper contains a description of the construction and maintenance methods necessary to obtain a surface consolidated road. Under construction is included a description of the necessary operations when: (a) roads lack binder, (b) roads lack aggregate, (c) roads lack moisture, (d) new roads and (e) drainage and crown. Under maintenance types are described: spring maintenance, summer and fall maintenance, hand patching and treatment with calcium chloride. The advantages of this type of surface consolidation are: (1) A variety of local surfacing materials which available in most regions can be utilized; (2) Special technical knowledge is not required in the selection of these materials; selection being based on the individual roadman's experience; (3) The cost is low; and (4) This road type fits well into a stage construction program.

318 - Mills, W. H., Jr., Hicks, L. D., Vaughan, F. W., Litehiser, R. R., Wood, J. E., Reid, Carl R., Sampson, E. J., Brooks, H. E., and Henderson, H. G., "Progress in Soil-Cement Construction", Proceedings Highway Research Board, 1939, Vol. 19 pp. 517-558.

(C)

In this symposium representatives of six state highway departments presented the most interesting features of the use of soil-cement encountered in their practice. Reports are arranged under the following headings: (1) General Procedures, (2) Sampling, Soil Classification and Cement Requirements, (3) Moisture and Compaction Control and Determination of Cement Content, (4) Single Machine Methods and Control Operations, (5) Construction in the Hills of Maryland, (6) Concrete Pavement Subgrade, Design, Construction, Control, (7) Dispersion of Soils and Soil-Cement Mixes, (8) Cost Data.

319 - Mills, W. H., Jr., "Report of Committee on Stabilized Roads, Report of Subcommittee on Use of Portland Cement, Condition Survey of Soil-Cement Roads", Proceedings Highway Research Board, 1941, Vol. 21, pp. 482-492.

(C)

A more detailed analysis of the data given in the previous year's report has been made and is presented here to complete the survey. For easy reference the information is summarized in a series of tables.

320 - Mills, W. H., Jr., "South Carolina Investigation of Soil-Cement Mixtures", Proceedings Highway Research Board, 1937, Vol. 17, Part II, pp. 31-34.

(C)

The designing and constructing of soil-cement roads in South Carolina are described. The preliminary laboratory durability tests and the moisture density control

test used vary in some particulars from the procedure adopted by the Portland Cement Association. Definite standards have not been adopted. The work to date has shown that adequate preliminary field soil surveys and laboratory tests as well as thorough field control are essential to the successful construction of cement stabilized roads.

321 - Mills, W. H., Jr., "Status of Soil Stabilization in the United States", Proceedings Highway Research Board, 1939, Vol. 19, pp. 491-497.

(A)

This report is a summary of answers to a questionnaire sent to all state highway departments and covers work done since 1924. The types of stabilization are divided into 10 groups as follows: soil-aggregate, RC type cutback, MC type cutback, SC type cutback, calcium chloride, sodium chloride, lignin binder, emulsified asphalt, tar, and Portland cement. It is noted that the mileage of the soil-aggregate type greatly exceeds the total of all other types. In general, the various types are distributed throughout the country depending upon the soil conditions and the cost of the admixtures.

322 - Minnick, L. John and Miller, Richard H., "Lime-Fly-Ash-Soil Compositions in Highways", Proceedings Highway Research Board, 1952, Vol. 31, pp. 511-528.

(A,E)

Optimum proportions for the compositions are indicated by the use of compressive strength tests and by fundamental transverse frequency determinations. An investigation is also being made of a pulse velocity technique for evaluating the durability and field performance of the compositions. The soils studied were secured principally from New Jersey and Maryland. Results are given of a field project in New Jersey; specimens taken from this mixture have reached 2,400 p.s.i. Microphotographs have been made on this material and formation of a cementitious matrix is clearly in evidence.

323 - Minnick, L. J. and Miller, R. H., "Lime-Fly Ash Compositions for Use in Highway Construction", Proceedings Highway Research Board, 1950, Vol. 30, pp. 489-496, (Discussions: pp. 496-502).

(A,E)

The addition of fly ash and a small proportion of lime to an A-3 soil, slag, and crushed stone has been shown to provide mixtures which develop considerable compressive strength and reasonable resistance to both wetting-and-drying and freezing-and-thawing tests. These mixtures have given good performances during a year's test on an experimental section of road.

324 - Minnick, L. John and Meyers, W. F., Properties of Lime, Fly Ash, Soil Compositions Employed in Road Construction, Paper prepared for Presentation at the Annual Meeting of the Highway Research Board in 1953.

(A,E)

An evaluation of field projects in which lime and fly ash are used for the stabilization of several types of soil indicates that the resulting compositions are very satisfactory as road bases. The evaluation includes laboratory tests for unconfined compressive strength, wetting and drying, freezing and thawing, and pulse group velocity. The equipment used to measure pulse velocity is described in some detail. The velocity measurements are found to be beneficial in evaluating the strength and durability of the compositions and good correlation is found to exist between the different test series. The construction work utilizes the mixed-in-place method. Several types of surface treatment have been applied to the stabilized bases.

325 - Minnick, L. John and Havelin, J. E., Report to Committee on Lime Soil Stabilization, Washington, D. C.: American Road Builders' Association, 1950.

(E)

326 - Mitchell, A. J. "Soil Stabilization for Roads in Tanganyika Territory", Journal of Institution of Civil Engineers, 1945, Vol. 24, No. 6, p. 261.

(A)

Application of soil stabilization to roads has been tested; methods of soil analysis and stabilization used are described.

327 - Mizroch, J., "Determination of Cement Content of Soil-Cement Mixtures", Public Roads, 1943-1944, Vol. 23, No. 11, pp. 297-299.

(C)

In the method developed by the Division of Tests of the United States Public Roads Administration for determining the cement content of soil-cement mixtures, the samples of soil, soil-cement, and cement are treated with hydrochloric acid, the insoluble residue is filtered off and calcium is precipitated and determined in the filtrate.

Mizroch, J. (see also 380)

Mohr, A. W. (see 301)

328 - Monton, B. G. G. and Lumb, P., "Influence of Particle-Size on Bearing Capacity of Mechanically Stabilized Subgrades", Journal of Institution of Civil Engineers, 1951, Vol. 35, No. 3, pp. 206-210.

(B)

Report on investigations carried out in the Highway Engineering Laboratory of Imperial College of Science and Technology, London, to assess relative values of different groups of soil particles, graded in size, as stabilizing influence in artificially prepared soil mixtures; comparison of saturated and unsaturated C. B. R. tests.

Moore, W. H. (see 296)

329 - Morales, M. D., "Study of Stabilization with Nitrate Gravel from Maria Elena; Application to a Section of the Pan-American Highway", Revista de caminos, 1946, Vol. 20, pp. 65-88.

(B,F)

An account is given of laboratory tests on nitrate gravel obtained as residue from the local works, and of the uses of nitrate gravel in the construction of an experimental surfacing consisting of a base of local gravel and a 2.5 in. (6 cm.) wearing course of natural gravel, nitrate gravel, and sand. The problem of the amount of water required for adequate compaction is discussed.

330 - Moreland, J. E., Glasgow, Paul E., Brown, F. L., Farnsworth, George, Brown, A.L., Whitton, Rex M., and Abercrombie, W. F., (Arranged by Clemmer, H. F.),"Economics of Stabilization with Calcium Chloride", Proceedings Highway Research Board, 1939, Vol. 19, pp. 563-573.

(F)

The following subjects were presented and discussed at a symposium on the economics of stabilization with calcium chloride: (1) Economy of Calcium Chloride in Stabilized Base Construction (Subgrade, Compaction, Surface Stability of Bituminous Mats, Summary on Base Stabilization), (2) Economy of Calcium Chloride in Stabilized Surface Construction.

Moorman, R. B. B. (see 521)

331 - Morrison, I. F., "Mechanics of Soil Compaction and Stabilization", Roads and Bridges, 1945, Vol. 83, No. 5, pp. 62-63, 106-108.

(A)

How physical characteristics of soil particles and presence of moisture affect resistance to deformation by shearing stresses.

332 - Morrison, J. L., "Ocracoke's Beach Sand Roads", Public Works, New York, 1951, Vol. 82, pp. 42-43, 75.

(C)

The construction of a road on Ocracoke Island in the Outer Banks of North Carolina is described. The surfacing consists of beach sand stabilized with cement; the sand contains a high proportion of shells. Cement and sand were used in the proportion of approximately 1:3 by weight; no coarse aggregate was added. The materials were mixed in a concrete mixer, water being used at the rate of 7.8 gal. per bag of cement. No reinforcement and expansion joints were used.

333 - Morum, S. W. F., "The Construction of Low-Cost Roads in South-West Iran", Journal of Institution of Civil Engineers, 1942-1943, Vol. 19, No. 1, pp. 21-37.

(A)

The experimental construction described was carried out on a low-lying desert plain, the soil of which consists of silt, clay and fine sand in varying proportions, generally salty. Flood conditions are experienced during the four rainy winter months while for the rest of the year water is scarce and saline and the soil is dry and dusty. The surface courses consist of: (1) soil aggregate mixture having the optimum grading, (2) clay-bound gravel, (3) road-mix soil-cement, (4) bituminous stabilized soil, etc.

334 - Muir, Levi, Hughes, William and Browning, George, "Bituminous Stabilization Practices in the United States - Subgrade", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 306-313.

(D)

This paper describes the principles and practice of bituminous stabilization, including the information concerning stabilization practices of Missouri, California, Kentucky, Florida, Nebraska and South Carolina. Definite principles have been formulated as following: (1) The primary object of bituminous stabilization is waterproofing to prevent capillary action. (2) The secondary object of bituminous stabilization is increased stability of the aggregate through the natural cohesive qualities of the bitumen. (3) For emulsions water content should be about that required for the plastic limit for mixing and at the optimum for compaction. (4) Soap must be used very sparingly. (5) For SC and MC oils, water content should be about optimum for best results for both mixing and compacting. (6) All bituminous materials can be used successfully under the proper conditions. (7) Bituminous bases are too friable to stand the abrasive action of traffic and so must be surface treated. (8) Principal laboratory tests are for stability and adsorption. (9) Bitumen must be thoroughly mixed with the aggregate. (10) Drainage is of prime importance.

335 - Murdock, L. J. "Stabilized Roads - Performance and Maintenance", Surveyor, 1949, Vol. 108, No. 2973, p. 51.

(A)

Data on granular stabilized roads; cement stabilization and bituminous and other binders; results of tests and behavior under different weather conditions.

336 - Murdock, L. J., "The Possibilities and Limitations of Soil Stabilization in Road Construction", Journal of Institution of Highway Engineers, 1949, Vol. 1, pp. 7-34, (Discussions:pp. 34-47).

(A)

In this paper presented before the Institution of Highway Engineers the methods employed to stabilize soils for base course construction are described and the difficulties and limitations of each method discussed. In the course of a survey of the tests used, including methods for determining the thickness of stabilized construction, the author draws attention to the importance of grading, plasticity index and liquid limit in determining the suitability of

a soil for the various methods of stabilization. The important part which drainage plays in the success of a soil-stabilized base is stressed and the difficulties of carrying out construction during wet weather are described. Consideration is given to the factors which have to be taken into account in estimating the relative costs of different types of base course construction at a given site. It is recommended that traffic should be allowed to continue the compaction of a soil-stabilized base course for at least two months before any permanent wearing surface is laid down, so that any weak spots may be revealed and remedied. The performance of various kinds of road rollers in compacting stabilized soil is discussed.

337 - Murray, G. E., "Soil Stabilization by Chemical Means", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 107-116, (Discussion: pp. 117-121).
(F)

Methods of stabilizing soils can be divided into two classes - physical and chemical. Chemical methods of stabilization alter the inherent properties of soils and it is this ability that gives chemical stabilization its great promise. This paper briefly discusses: (1) the forces operating in a soil system and how they can be altered by the introduction of a stabilizing agent, (2) possible mechanisms through which the stabilizing agent can act to alter the soil properties, (3) the effect of both the soil composition and the stabilizer composition on the properties of stabilized soils, (4) methods of formation of stabilizing agent on the soil, (5) application of such concepts to present potential stabilization methods.

338 - Mylragenam, T., "Compaction of Soil", Civil Engineering, London, 1947, Vol. 42, No. 493, pp. 288-290.
(H)

Mechanics of compaction; compaction tests; effect of force of compaction and percentage of fine particles on optimum moisture and maximum density of soils; bibliography.

339 - National Lime Association, "Out of the Mud with Lime", National Lime Association Bulletin 317, 1926.
(E)

This paper describes the use of lime in the prevention of muddy roads as a result of University of Missouri research.

340 - Nelson, B., "Freeway Job near Riverside, California, Features Mixing Cement-Treated Base in Place", Western Construction, 1950, Vol. 25, pp. 83-84.
(C)

In the construction of the base course, two windrows of borrow material were placed on the formation and cement spread in a trench in each windrow.

Road-mix machines covered about 5,300 linear ft. per day. Pneumatic-tired rollers were used for compacting the mix, which was spread by motor graders. A bituminous emulsion curing seal was applied as soon as possible after spreading and compaction. The cement-stabilized base was designed to have a compressive strength of at least 650 p.s.i. and the proportioning was carefully controlled.

341 - Newland, R. P., "Four-Year-Old Soil-Cement Proves It Can Take It", Pacific Builders and Engineers, 1942, Vol. 48, No. 11, pp. 42-43.

(C)

Washington's experimental section, laid in 1938, is in excellent condition today despite locality having been especially chosen for its severe frost conditions and moisture capillarity.

Noble, G. G. (see 20)

Norling, L. T. (see 266)

342 - Oldham, R. L., "Reconstruction of Lubbock, Texas Airport with Soil-Cement", American Road Builders' Association Technical Bulletin No. 183, 1952, pp. 8-11.

(C)

The reconstruction of the airport is described under the headings (1) Plans and Specifications and (2) Preparing Caliche Bases.

343 - Oldham, R. L., "Soil-Cement Base: Rehabilitation at Lubbock Municipal Airport", Roads and Streets, 1951, Vol. 94, pp. 42-44, 58.

(C)

The runways of the Lubbock Municipal Airport, Texas, were originally surfaced with three bituminous penetration courses on an 8-inch base of local material. During the war heavy service aircraft damaged the runways and to reconstruct these for civilian use it was decided in 1950 to provide 8-in. or 6-in. cement-stabilized base carrying 4-course or 3-course bituminous penetration surfacing respectively. The existing bituminous surfacing was removed and the existing base graded and compacted with a pneumatic-tired roller. The procedure adopted for the cement-stabilization of the base is described. The runways were treated in sections 600 ft. long and 75 ft. wide, with turning strips about 50 ft. wide between the ends of adjacent sections, the intermediate strips obviated the passage of construction machines over the freshly treated areas. The turning strips were stabilized by machinery working at right angles to the runway axis. The cement-stabilized base was cured under a coating of rapid-curing cut-back bitumen, which was also to serve as a priming coat for the bituminous surfacing; since the latter was not to be applied until the following spring, a dressing of crushed stone was provided to render the surface non-skid. Control methods included periodical tests of density,

moisture content, depth of cut and surface level. Proctor compaction tests were made twice daily; the results were compared with those of "sand-cone" tests on the finished base in the same positions.

344 - Olpinski, K., "A Review of Existing Knowledge of Soil-Cement Construction", Biuletyn Budownictwa Lotniczego, 1945, No. 6, pp. 24-45.

(C)

Published information on the method of stabilizing with cement is summarized and reviewed in the light of experience at the Road Research Laboratory, Harmondsworth.

345 - Olpinski, K., "Soils and Their Properties", Biuletyn Budownictwa Lotniczego, 1945, No. 7, pp. 69-98.

(A)

The importance is stressed of carrying out a thorough soil survey before undertaking any major road construction, and a brief account is given of soil classification systems and the main classification tests. The subject is treated under the following heads: (1) the problem of soils in road construction, (2) physical and mechanical properties of soil, (3) soil tests, (4) earth roads, (5) soil stabilization, (6) frost action in soils and how to prevent it.

346 - Oommen, G., "Colcrete - A Low-Cost Method of Constructing Concrete Roads", Indian Concrete Journal, 1950, Vol. 24, pp. 2-4.

(A)

A description is given of the laying, in 1949, of a mile of experimental "colcrete" surfacing on the Main Central Road near Kottayan in the United States of Travancore and Cochin. "Colcrete" is prepared by pouring "colgrout" into the interstics of the coarse aggregate which is alrady spread on the road, and then rolling the road to obtain compaction of the aggregate and distribution of grouting material. "Colcrete" is prepared by mixing cement, sand and water in a special mill which produces a stable colloidal grout that will not mix with water. This method of constructing concrete surfacing is said to be less expensive than orthodox methods because it permits of greater speed in laying; there is a large saving in labor and plant, less cement is used without sacrifice of strength, and the work is not affected by rain.

Packham, D. I. (see 100)

Page, J. B. (see 265)

347 - Pagni, R., "Cement Soil Stabilization", Revue Générale des routes et de la circulation routière, 1950, Vol. 20, pp. 51-63.

(C)

This paper, which surveys the problems encountered in the stabilization of soil with cement, is presented in two sections. Part I consists of descriptions of laboratory investigations with special reference to tests for determining the properties and suitability of cement and cement mixes. Part II deals with operations on the site.

348 - Palmer, A. A. and Barber, E. S., "The Theory of Soil Consolidation and Testing of Foundation Soils", Public Roads, 1937, Vol. 18, pp. 1-23.

(H)

Description of original apparatus and method for compression tests of soils; practical method of estimating part of total settlement of soil caused by loss of water forced vertically out of saturated compressible soil strata; application of theory to soil consolidation; development of theory of soil consolidation.

349 - Patel, O. H., "Stabilization of Gumbotil Soil for Highway Use", Journal of Indian Roads Congress, 1950, Vol. 15, pp. 336-356.

(C,E,F)

A report is given of a study of gumbotil soil, a highly plastic American soil somewhat similar to Indian black cotton soil. Gumbotil soil undergoes great volume changes and loss of stability with absorption of water; it contains clay materials which appear to belong to the montmorillonite group. The properties of the untreated soil were determined in the laboratory and the effects of adding small quantities of certain stabilizing agents (lime, cement, calcium chloride, barium hydroxide and fine and coarse aggregate) were then studied. The results, which are presented by means of tables, showed that lime produced the greatest improvement, cement gave some improvement, and other materials were of little value. It is considered that more research is needed into the advantages of using lime for the stabilization of plastic clays.

Patel, O. H. (see also 451)

350 - Patillo, J., "Calculations for Stabilized Mixtures", Revista de Caminos, 1946, Vol. 20, pp. 178-192.

(B)

The standard Proctor laboratory test for determining the compaction and density of a soil is briefly discussed. Specifications of the Chilian Roads Department are given for the construction of the following types of stabilized bases and wearing courses: (a) clay and sand, (b) gravel and medium crushed stone, (c) gravel and coarse crushed stone. Two mathematical formulas are presented for calculating the percentage of weight of the binder in stabilized mixture, based on (1) the grading and (2) the P.I. of the materials.

Patwardhan, N. K. (see 93)

351 - Philippe, R. R., "Field Compaction", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 162-166, (Discussions: pp. 167-168).

(H)

The mechanical compaction of soils is a developed technique which is a very useful and economical tool in the hands of an experienced engineer. Cohesionless soils respond well to densification by proper vibration but respond to a lesser, but often satisfactory, degree to the action of rolling equipment. Cohesive soils, on the other hand, generally respond well to proper rolling treatment but do not respond to existing vibration methods, although some investigators believe that they could be made to do so. This paper discusses the methods and equipments used in field compaction. Results of field compaction studies by Waterway Experiment Station are also outlined.

352 - Phillips, N. "Soil-Cement Road Construction, with Particular Reference to Mix-in-Place Methods", Journal of the Institution of Municipal Engineers, 1950, Vol. 77, pp. 281-297.

(C,I)

The principles of soil-cement stabilization are explained with a detailed account of the mix-in-place methods and equipment used on a housing estate in Middlesex. The success of the method, which is considered the most suitable to this type of work, depends primarily on the engineer's use of plant and his intelligent adaption of methods to the type of soil encountered. Recommendations are made on soil sampling and testing, mixing methods, control on the site, and plant required for the respective stages of construction. Graphs connect (a) rate of spread of cement with soil density and area covered, (b) density of soil with water added in each traverse, rate of application of water, and conditions influencing the latter factor.

353 - Piette, G. and Demers, G., "Lignin Extract as Stabilizing Agent for Road Foundations", Roads and Bridges, 1945, Vol. 83, No. 9, pp. 70-73, 114-116, 118.

(F)

Report of tests to obtain absolute values of bearing capacity of raw gravel, stabilized gravel, and stabilized gravel treated with lignin extract.

354 - Piette, P., "Improved Soil Stabilization", Engineering Journal, 1944, Vol. 27, No. 7, pp. 413-416.

(A)

Research Bureau of Quebec Highway Department has tried to obtain conclusive results on subjects of improved soil stabilization, defined as process of supplying granular soil with such cohesive materials as will develop maximum efficiency under all circumstances. Before Engineering Institute of Canada.

355 - Poblete, L. C., "Use of Gravel from Nitrate Works for the Stabilization of Bases and Wearing Courses", Revista de Caminos, 1946, Vol. 20, pp. 56-64.
(B,F)

Gravel obtained as residue from the local nitrate works has been used for the construction of bases and wearing courses of low-cost earth roads in Chile. The sodium nitrate content and residue of magnesium salts increase the stabilizing powers of the soil by retaining moisture and produce a surfacing similar in hardness to that of concrete. The properties of the nitrate, the grading of the nitrate aggregate, and the methods of construction employed are briefly described.

Pollard, A. E. (see 99)

356 - Portland Cement Association, Essentials of Soil-Cement Testing and Construction, 1944, Chicago, Portland Cement Association, (21 pages).
(C)

This booklet gives a general description of the methods and problems of soil-cement construction, covering the selection of soil, determination of water and cement contents, testing and construction procedure, and estimation of the required thickness of surfacing. For actual jobs, reference is recommended to other publications of the Portland Cement Association.

357 - Portland Cement Association, "Pavement Maintenance Practices and Uses for Soil-Cement at Army and Navy Facilities", Soil-Cement Information No. SCB 7, 1943, Chicago, Portland Cement Association, pp. 1-8.
(C)

This information sheet summarizes the methods for surfacing and repairing with soil-cement light-traffic roads, runways, taxiways, and parking areas for cars and airplanes that have given the most practical and economical results in military establishments.

358 - Portland Cement Association, Soil-Cement Roads Construction Handbook, 1949, Chicago, Portland Cement Association, (93 pages).
(C)

(1) Establishing soil profiles and resuming of laboratory tests; (2) Details of soil-cement road construction, including equipment; (3) Details of soil-cement paving for streets; (4) Soil-cement for airport paving; (5) Other paving uses of soil-cement mixtures; (6) Maintenance suggestions for soil-cement roads; (7) Field control.

359 - Portland Cement Association, "Suggestions for Emergency Soil-Cement Testing and Construction", For Emergency Overseas Military Use Only, Soil-Cement Information No. SCB 5, 1943, Chicago, Portland Cement Association, pp. 1-4.
(C)

Suggestions are given for the testing and construction of soil-cement under emergency military conditions when the standard procedure cannot be used for lack of time and facilities. The manual of the "Portland Cement Association Soil-Cement Mixtures: Laboratory Handbook" should be used for reference.

360 - Portland Cement Association, "Wartime Salvaging, Maintaining and Widening Old Roads and Streets with Soil-Cement", Soil-Cement Information No. SCB 6, 1943, Chicago, Portland Cement Association.

(C)

Instructions, based on field experience, are given for the economical and satisfactory maintenance of low-cost roads with or without a bituminous surfacing by the soil-cement stabilization process.

361 - Porter, H. C., "Effect of Moisture on Compacted Soils Revealed by Laboratory Tests", Engineering News Record, 1945, Vol. 135, No. 8, pp. 245-249.

(H)

Results of tests on compacted clay soils under varying conditions of initial moisture content, degree of compaction, and various stages of subsequent moisture content, including saturation.

362 - Porter, H. C., "Tests of Compacted Clay Soils Provide Highway Design Guides", Engineering News Record, 1945, Vol. 135, No. 22, pp. 726-728.

(H)

Tests show that there are definite limits to reduction of water content and increase in compactive force beyond which compressive strength of clay soils does not increase but instead positively decreases; use of laboratory tests of actual project soils for roadway design described.

363 - Pospisil, F., "Strojni provadeni stabilisovanych vozoveh", Silnicni Obzor, Vol. 26, No. 5,6, May, 1950, pp. 71-74, June, 1950, pp. 85-90.

(B)

Mechanical construction of stabilized soil road surfacings; influence of subgrade on durability of pavement - new methods of construction of bases and surfaces and their economy; development of soil stabilization in the United States; agricultural and other special equipment and machinery; description of soil cement pavement on full scale experimental road section in Ratiskovice, Czechoslovakia.

364 - Preece, Edmund F., "Geotechnics and Geotechnical Research", Proceedings Highway Research Board, 1947, Vol. 27, pp. 384-417.

(A,G)

The term geotechnics covers the application of the principles of mechanics,

physical chemistry, physics and mineralogy to problems associated with soils. This paper outlines some fundamental conceptions of physical chemistry and explains the behavior of various types of clay in terms of physical chemistry. Recent work on electro-osmosis consolidation is reviewed. Special apparatus not usually found in a soils laboratory is described.

365 - Proctor, Carlton S., "Cap Grouting to Stabilize Foundations on Cavernous Limestone", Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, Rotterdam, Holland, 1948, pp. 302-308.

(A)

This paper describes the cap grouting to stabilize foundation on cavernous limestone at the American Bemberg Rayon Plant in Elizabethton, Tennessee. It is concluded that foundation conditions in soluble limestone areas should be thoroughly investigated. Where structures are founded on unstable overburden, susceptible to reveling or erosion into underground cavitation, cap grouting may in many instances be the only economical corrective procedure.

366 - Proctor, R. R., "Fundamental Principles of Soil Compaction", Engineering News Research, Vol. 111, August 31, 1933, pp. 245-248, September 7, 1933, pp. 286-289, September 21, 1933, pp. 348-351, September 28, 1933, pp. 372-376.

(H)

Los Angeles' method for controlling compaction of soils; laboratory and field tests for determining suitability of available soils; data for design of dam; moisture effect on compacted density; saturated plasticity; rolled-earth dams; air-void and dry weight curves; needle determinations of moisture content and compaction; consolidation and percolation tests; swelling and bearing power; bearing power of saturated soils; experience with sheepsfoot rollers; field and laboratory tests of compacted fill.

367 - Proctor, R. R., "Laboratory Soil Compaction Methods, Penetration Resistance Measurements, and the Indicated Saturated Penetration Resistance", Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. 5, pp. 242-247.

(H)

The methods for laboratory soil compaction developed and presented by the author in 1930-33 are still in use. However, published literature regarding the use of these methods by other organizations describes procedures that fall short of the objective intended in 1933, particularly in the use of 90% and 95% of the many "optima" soil dry weights secured by various combinations of a 12 in. or 18 in. drop of $5\frac{1}{2}$ or 10 lb. tampers on 1 in. or 2 in. soil layers in compaction cylinders of 1/20 or 1/30 cu. ft. capacity, rather than the use of the penetration resistance of soils when saturated as the standard for evaluating the measured density of natural or compacted soils. A new method for showing soil compaction results involving the compactive effort is submitted for consideration.

368 - Proctor, R. R., "Relationship between Foot Pounds per Cubic Foot of Compactive Effort to Soil Density and Subsequent Consolidation Under Various Loadings", Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. 5, pp. 223-227.

(H)

This paper presents the results secured by compacting two soils, one very sandy and the other very clayey, over a wide range of laboratory compactive efforts, together with a discussion of the relationship between the compactive effort, the maximum soil dry weight secured and the corresponding indicated saturated penetration resistance. The relationship between the consolidation of about 900 soil test specimens and the indicated saturated penetration resistance of the specimens as compacted is shown, together with relationship between the compactive effort, compacted soil dry weight, and anticipated settlement under similar loadings of four compacted soils ranging from sand to clay.

369 - Proctor, R. R., "The Preparation of Subgrades of Compacted Soils for Paving or Structures", Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. 5, pp. 201-205.

(H)

The almost universal practice of preparing subgrades for paving or structures by compacting with a sheepsfoot roller until the top of the loose surface of the fill is at approximate subgrade elevation, and then completing the compaction by the use of one of many types of flat rollers to prepare the final subgrade includes two fundamental errors. First, the full compactive effort of the sheepsfoot roller is not secured closer than 10 inches to the fill surface and the flat rollers cannot compact this top 10 inches of the fill to as high a density as can the sheepsfoot roller and thus a layer of potential mud or near mud is left to serve as the foundation for the paving or structure. Second, the weight of the roller causes consolidation, not compaction, of the soil at a distance from 1 to 4 ft. from the loose surface of the fill. The paper points out possible ways and means of eliminating the foregoing errors in the preparation of subgrades.

370 - Proctor, R. R., "The Relationship between the Foot Pounds per Cubic Foot of Compactive Effort Expended in the Laboratory Compaction of Soils and the Required Compactive Efforts to Secure Similar Results with Sheepsfoot Rollers", Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. 5, pp. 231-234.

(H)

There are presented herein the results of tests to determine the laboratory compactive efforts required to duplicate the actual construction results secured during the construction of six major dams in Southern California, together with a comparison of these compactive efforts with the construction compactive efforts as calculated by multiplying the known or estimated drawbar

pulls by the number of roller trips over each foot of depth of compacted soil and dividing the product by the roller width.

371 - Prugh, B. J., "Sand Drains Reversed by Wellpoint System", Engineering News Record, 1952, Vol. 148, pp. 34-35.

(H)

Unstable material consisting of blue clay, black mud and some sand, which had been wasted hydraulically during reclamation of adjoining land, has been stabilized by installing sand drains and pumping water from the underlying stratum of sand. A well-point system, installed round the perimeter of the fill area, removed the downflow water.

372 - Quinn, M., "Base Stabilization with Soil as Stabilizing Agent", Public Works, 1942, Vol. 73, No. 6, pp. 13-14.

(B)

How Clay County, Kansas, improved 20 miles of road using crushed stone, sand and clay for base, followed later by bituminous armor coat.

373 - Quirk, W. H., "Connecticut Tests Material for Erosion Control", Contractors' and Engineers' Monthly, 1952, Vol. 49, pp. 12-14.

(A,F)

Krilium (a soluble synthetic polyelectrolyte) has been tested by the Connecticut State Highway Department, in a 30-acre grass seeding project at Bradley Field, an airfield near Hartford, Connecticut. Cut slopes and other areas on sandy soil were sprayed with fertilizer and grass seed. Some areas were mulched with hay and sections of these were then treated with Krilium; other areas were treated with Krilium alone. In each case, when lightly sprayed with water the Krilium formed a protective, but pervious, film and enabled the grass to take root and stabilize the soil. The best degree of erosion control was achieved when the Krilium was spread by hand at a rate of 1 lb. per 100 sq. ft. It is said that, as far as is known, the substance has no deleterious effect on the seeds; experiments on this aspect of the problem are still being carried out.

374 - Raedschelders, H. M., "Overzicht wan de huidige stand betreffende het probleem der Grondverdichting", Technisch-Wetenschappelijk Tijdschrift, 1950, Vol. 19, No. 3, pp. 49-56.

(H)

Review of present developments of soil compaction methods for soil compaction; comparison of laboratory tests and field tests; where control of density and moisture content is necessary; illustrated description of compaction equipment and its application to various types of soil.

375 - Rahn, G. A., Woodring, P. W., and Coleman, R. J., "Design and Control of Soil-Aggregate Road Mixtures by Means of the Metal Hydrometer", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 201-205.

(B)

The metal hydrometer method is suitable for use in the field to determine the grading and proportions of the soil mix. It reduces the work to be done at the laboratory and at the same time partially moves the design and control of soil-aggregate mixes into the field. In using the metal hydrometer method, however, the field is still dependent upon the laboratory for the plasticity index values of all binder soils used.

376 - Rahn, G. A. and Lerch, R. W., "Design of Soil Aggregate Mixtures in Pennsylvania", Proceedings Highway Research Board, 1938, Vol. 18, Part II, p. 195.

(B)

Pennsylvania's efforts in the field of low-cost roads have been confined almost entirely to the application, development, and simplification of the soil-aggregate type. This paper briefly describes the specified materials for soil-aggregate mixtures and the performance of the stabilized roads.

377 - Rahn, George A., "Materials and Design of Stabilized Soil Road Mixtures", Proceedings Highway Research Board, 1937, Vol. 17, Part I., pp. 497-502.

(B)

Five designs for mixtures of materials found in Pennsylvania based upon cohesion, internal friction and gradation as developed by the researches of the Bureau of Public Roads are presented. These mixtures range from fine combinations of soil with sand or screenings to coarser mixtures of properly stabilized soil with graded coarse aggregate. Provision is also made for two course work. It is recommended that the shoulders be stabilized with the same mixtures as the traveled way and that field control of construction be accomplished through frequent analysis of samples, methods for which are given. The soil-mortar gradation is the heart of the stabilized soil road and in all cases should be of the right composition. Coarse graded materials are added where practicable but in all cases whether the best coarse material is available or not, the voids in the coarse material should be filled with properly composed soil mortar.

378 - Ramirez, M., "Construction of Stabilized Surfacings", Revista de Caminos, 1945, Vol. 19, pp. 339-346.

(A)

A summary is given of specifications prepared by the Laboratory and Research Section of the Chilean Roads Department for stabilized earth roads. These roads, consisting of graded aggregate, clay binder, inert material and water have given satisfactory results: they are durable, even, and free from excessive dust in the dry season and from mud in the wet season.

379 - Rankin, E. S.,"Low-Cost Bituminous Surfaces Serve Increasing Traffic", Better Roads, 1951, Vol. 21, pp. 33-35.

(D)

The construction and maintenance of low-cost surfacings are described; these are in an area of sandy soil in north-central Minnesota where there is fairly heavy holiday traffic. The material in place on the road was road-mixed with slow-curing bitumen by motor-graders. The procedure adopted for the repair of places damaged by frost is explained.

380 - Rapp, P. and Mizroch, J., "Effect of Chemical Properties of Soil Fines on the Performance of Soil-Aggregate Mixtures", Public Roads, 1940, Vol. 21, No. 10, pp. 193-198.

(A)

This paper indicates the information that may be derived from a study of the chemical properties of the soil fines which, together with the knowledge of physical properties, provides a more adequate basis for determining suitability than do physical properties alone. Chemical properties of soils dependent on clay minerals present; silica-sesquioxide ratio investigated; base exchange related to surface course performance; summary.

381 - Rappleyea, G. W., "Stabilization of Beach Sand", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 286-290.

(A,F)

Research on the stabilization of beach sand with Plasmofalt, sponsored by the United States Marines Corps, is described. The Plasmofalt is a polymerized asphalt fuel oil powdered molasses composition developed in the Tropical Agricultural Research Laboratory at Southport, North Carolina. In the production of Plasmofalt, the aldehydes in the sugars of a completely dehydrated molasses have, by means of high temperature in the presence of a suitable catalyst, been polynerized and condensed with the phenols of the asphalt base of a heavy fuel oil; and the molasses carbohydrates are converted into asphaltic hydrocarbons, thereby converting the soft soluble molasses and fuel oil into a hard insoluble resinoidal plastic material with many of the characteristics of both a natural asphalt and a synthetic resin or a natural asphalt containing a high percentage of synthetic resin. During the experiment one 55-gallon drum of Plasmofalt when sent ashore and there mixed with 10 barrels of bunker C fuel oil withdrawn from the ships' bunkers and heated to 450 degrees F. for half an hour would produce two tons of Plasmofalt. It was reported that the treated beach sand had a hardness sufficient to take traffic within three hours after compaction. By sprinkling the newly laid pavement with sea water, the hardness was tripled. The sand would permit trucks to stand on the pavement without damage or tire indentation within one hour after the pavement was laid.

382 - Rauterberg, E., "The Physico-Chemical Effect of Lime on the Soil", Fortschritte der landwirtschaft, 1931, Vol. 6, pp. 680-686.

(E)

The reactions of lime in the soil are discussed with particular reference to base exchange.

383 - Reagel, F. V., "Asphaltic Binder Stabilized Roads", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 292-298.

(D)

Three general types of asphaltic binder stabilized roads have been constructed in Missouri: (1) Machine Mix Method, (2) Suboiling Method, and (3) Road Mix Method. This paper described briefly these procedures.

384 - Reagel, F. V., "Soil-Cement Stabilization in Missouri", Proceedings Highway Research Board, 1937, Vol. 17, Part II, pp. 66-78.

(C)

This paper is a report on the construction of several test sections of soil-cement roads in Missouri in 1936. Construction methods and equipment used are described in detail for each project. The average cost is approximately $2\frac{1}{2}$ cents per square yard for each percentage of cement used. It is believed that the costs are reasonable and in the range of what one can expect to pay for a reliable base in the low cost program.

385 - Reagel, F. V., "Soil Studies Applied to Highway Problems", Civil Engineering, 1941, Vol. 11, pp. 35-37.

(A)

Factors such as chemical properties, capillarity, thickness of moisture film, binders, etc., are discussed in their application to soil stabilization problems.

386 - Reagel, F. V. and Schappler, R. C., "Use of Cutbacks and Road Oils in Soil Stabilization", Proceedings Highway Research Board, 1936, Vol. 16, pp. 359-368.

(D)

The problem under consideration is the improvement of earth, crushed stone, and worn-out gravel roads of little thickness to give dustless safe survice at a reasonable annual cost. The solution lies in working in the direction of water-proofed bases plus relatively thin renewable cover coats. From the bituminous angle, the question arises as to whether enough oil can be added to a sufficient thickness to waterproof durably without causing a plastic condition and thereby losing the inherent stability of the soil and whether, if this is not possible, the plasticity so produced can be overcome by addition of an economical amount of friction material. Any treatment which keeps the moisture content of a soil system below the plastic limit will in general improve the system. Bituminous material tends to do these two things. A certain amount of water, however, is necessary for a good oiling job and the cohesive strength of the soil system is a function both of the water films

and the oil films. Laboratory experiments on soil-oil specimens have shown that water absorptions decrease with increasing bitumen content and that an optimum bitumen range demonstrated by stability measurements is roughly 6 to 10 per cent based on soil fines. Two major construction projects were undertaken in Missouri, one utilizing the subsurface method of introducing the soil and afterwards, as a check, the mixing method. These roads are now under observation; and although present indications are listed in this article, the subject is a current research and conclusions may not be final.

387 - Recketts, W. C., "Tar Soil Stabilized Base Courses", Roads and Streets, 1948, Vol. 91, No. 10, pp. 77-79, 102.

(A)

Classification of tar soil stabilized bases recommended by A.R.B.A.; Those constructed with sandy soils give satisfactory service whereas soils containing high percentages of clay require more maintenance; Description of tests made to determine bitumen content.

388 - Reid, Carl F., "Report of Committee on Soil-Cement Roads", Bulletin No. 14, Highway Research Board, 1948, pp. 12-17.

(C)

This report reviews the maintenance costs and conditions in service of soil-cement roads as inspected and reported to the committee by the several states. The construction details, age, traffic and present condition of the soil-cement base of these projects provide a complete history.

Reid, Carl R. (see also 71)

389 - Reinhold, F., "Soil-Cement Roads for Housing Estates", Strassen und Tiefbau, 1950, Vol. 4, pp. 117-126.

(C)

The construction is described of soil-cement roads for a housing estate in Leipzig in 1944. The soil tests which were carried out by the Technische Hochschule, Darmstadt, are enumerated and the results obtained are discussed. Descriptions are given of the mix proportions of materials used and illustrations of construction methods are presented. Consideration is also given to curing and service behavior. The soil-cement surfacings compare favorably with a water-bound macadam surfacing laid at about the same time.

390 - Remenieras, G., "Application de l'électroosmose á l'exécution de certanis travaux en terrains aquifères", Houille Blanche, 1949, Vol. 4, No. Special A, pp. 393-404.

(G)

Application of electro-osmosis to certain works on water bearing soils; review

of studies by W. Schaad and R. Haefeli of electro-osmotic actions produced by passing D.C. current through fine grained soils situated below water table; examples of large-scale application; theory of Helmholtz-Perrin, diagrams.

Rengmark, F. (see 44)

391 - Rentsch, B., "Compaction of Cement-Stabilized Soil Surfacings", Teer und bitumen, 1942, Vol. 40, No. 1, pp. 4-8.

(C,H)

The principal methods of compacting cement-stabilized surfacings are reviewed in detail. Rollers, which have so far been chiefly used, cause "pushing" of the mix and surface cracking especially if heavy three-wheeled rollers are used. Good preliminary compaction is obtained with pneumatic-tired rollers mounted in two staggered rows behind a traveling mixer. Owing to the successful development of combined mixing and compacting machines the use of hand-guided vibrators has hitherto been restricted, although they are as satisfactory for soil-cement as for concrete. For fine-grained or cohesive soils, tamping is the only satisfactory method but the design of suitable units presents difficulties.

392 - Rentsch, B., "Methods and Objects of Bituminous Soil Stabilization", Asphalt und teer, strassenbautechnik, 1944, Vol. 44, pp. 4-7.

(D)

The probable place of bituminous stabilization in post-war construction is reviewed with special reference to conditions in Germany and Eastern Europe; and the method of construction is discussed with regard to correct grading of the soil-aggregate mixture, the function of the bituminous binder, the types and proportions of binder that may be used, plant and machinery required, and efficient organization and co-ordination of all operations.

393 - Revista, Colegio de Ingenieros de Venezuela, "Estabilizacion de Suelos Usundo Asfaltos Cutback Como Aglutinantes, Colegio de Ingenieros de Venezuela - Revista, 1942, Vol. 20, No. 143, pp. 250-260.

(D)

Soil stabilization using cutback asphalts as binders; specifications proposed for stabilized base. Data supplied by engineering division of Standard Oil Company of New Jersey and affiliates.

394 - Revista, Sociedad Cubana de Intenieros, "Investigaciones Sobre Estabilizacion de Suelos con Cal Hidratada", Sociedad Cubana de Intenieros - Revista, 1949, Vol. 48, No. 1, pp. 297-331.

(E)

Investigation on stabilization of soils with slaked lime.

395 - Reynolds, J. H., "Traffic Tests of Soil-Cement Lanes", American Road Builders' Association Technical Bulletin, No. 187, 1952, pp. 5-10.

(C)

This paper reports the traffic tests on soil-cement surfaces in an effort to investigate any new development in the application and technique of soil-cement stabilization. Field tests were conducted to determine the wheel load carrying capacity and life expectancy of two types of cement-stabilized soil placed on subgrades of two strengths for sections for two depths with a varying cement factor. From the results of these tests it appears that soil-cement surfaces are capable of supporting limited amounts of wheel loads of significant magnitude on even low strength subgrades, provided that recommended procedures are closely adhered to and that proper curing is effected.

396 - Rhodes, E. O. and Havens, A. C., "Soil-Stabilization with Coal Tar", Proceedings Highway Research Board, 1936, Vol. 16, pp. 350-358.

(D)

As the result of three soil stabilization experiments conducted in South Carolina in 1935, much practical information about the use of coal tar as a stabilizing agent has been required. Two general methods were tried. In one a suitable oil or low viscosity tar was first mixed with the dry soil and then a more viscous tar binder was incorporated with the mixture. In the other method water was first added to the soil to soften lumps and otherwise prepare the soil for the addition of a viscous tar binder. The experience indicated that the latter, called the wet method, gave the better results. The report described four other projects in Georgia, North Carolina, and South Carolina on which the experience gained in the three experimental projects was utilized. In general procedure was as follows: scarification of surface; addition of water to increase the moisture content 2 or 3 per cent above that required for maximum density; addition of coal tar as determined by laboratory tests, drying to slightly below moisture content for maximum densification, compaction, surface application of tar, and cover aggregate. The laboratory methods and special shear test apparatus used in acquiring information about the soil are described and discussed.

397 - Riedel, C. M., "Chemical Soil Solidification and Chemical Sealing of Leaking Concrete", Journal of American Water Works Association, 1945, Vol. 37, No. 9, pp. 849-862.

(F)

Both processes are explained and usefulness for water works structures outlined.

398 - Riedel, C. Martin, "Chemical Soil Solidification Work in Construction and Emergencies", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 68-77, (Discussions: pp. 78-80).

(F)

Soil solidification by consecutive injections of modified sodium silicate and calcium salt solution into loose sub-soil to agglomerate it and make it safe for heavy foundations, to stop settlements, to block inflow of water into leaky tunnels and building pits is discussed. The use of the process is, however, definitely limited to sandy soil, gravel, and all kinds of slag. Any natural material as clay, silt or finest sand beyond the 200 mesh limit is generally unsuitable for solidification work.

399 - Riedel, C. M., "Latest Development in Soil Solidification", Midwest Engineer, 1949, Vol. 1, No. 6, pp. 6-8.

(F)

Process consists of consecutive injection of two aqueous solutions; chemical I, a special silicate of soda solution, must be followed by chemical II, either gas or strong calcium chloride solution; hardness to be expected from solidified natural sandy layers varies between 250 p.s.i. and 1,100 p.s.i.; examples of applications.

400 - Ritter, L. J., "Coguina Asphalt Streets in Florida", American Highways, 1952, Vol. 31 (2), pp. 14-15, 25-27.

(D)

Coquina, an unconsolidated mixture of coquina shells and sand, has been successfully used in bituminous stabilization processes for the construction of streets in Jacksonville, Florida. Two test sections have been laid using coquina and a rapid curing binder, after the application of which the mixture was manipulated by blade grader and pulvi-mixer. The surfacings were then rolled with a pneumatic-tired roller weighing between 3,000 and 4,000 lbs. The test sections carry moderately heavy traffic and are said to be behaving well, although the sufacing layer which is 4 in. thick is thinner than originally planned. Estimated cost of total pavement including subgrade and wearing course is said to be about 70 cents per sq. yd.

401 - Roads and Bridges, "Granular Stabilization", Roads and Bridges, 1947, Vol. 85, No. 7, pp. 53, 82-85.

(B,F)

Calcium chloride provides necessary moisture control before bituminous cover is placed; simple plasticity tests.

402 - Roads and Bridges, "Wartime Importance of Granular Stabilized Roads", Roads and Bridges", 1943, Vol. 81, No. 6, pp. 26-30, 56, 58, 60, 62, No. 7, pp. 33-34, 154-156.

(B)

Recommendations for their design, construction and maintenance; selecting and combining materials for road stabilization.

403 - Roads and Streets, "Asphalt-Soil Stabilization in Oklahoma", Roads and Streets, Vol. 93, No. 6, 1950, pp. 65-66, 68, 70, 72, 74, 76-77.

(D)

Soil asphalt as mixture of relatively fine grained soils and asphalt which does not come within limitations for sand asphalt; typical project described and illustrated.

404 - Roads and Streets, "Compaction - How States Specify It Today", Roads and Streets, 1947, Vol. 90, No. 4, pp. 55-59, 62-63.

(H)

Tabulated data gathered by state highway departments on embankment compaction methods and requirements; costs and organization data included.

405 - Roads and Streets, "Fifteen Years of Development in Soil-Cement Methods", Roads and Streets, 1950, Vol. 93, No. 3, pp. 54-56.

(C)

Illustrated discussion of progress in soil cement methods showing changes in construction equipment from fifteen years ago; new and better mixing and spreading equipment shown.

406 - Roads and Streets, "Lime Used in An Airfield Base", Roads and Streets, 1948, Vol. 91, No. 1, pp. 96, 107.

(E)

The use of 2 per cent of hydrated lime for reduction in the plasticity index in stabilizing the base at Chase Field, Texas, is described.

407 - Roads and Streets, "Old Caliche Road Rebuilt with Soil-Cement", Roads and Streets, 1945, Vol. 88, No. 1, p. 92.

(C)

On sections of old caliche roads in Texas asphalt was broken up and bladed off, base was then wet and scarified, cement added and surface compacted; road was then resurfaced with asphalt; method was found satisfactory in field tests.

408 - Roads and Streets, "Simple Method of Preventing Spring Breakup of Roads", Roads and Streets, 1944, Vol. 87, No. 10, p. 81.

(F)

Impregnating soil with calcium chloride prevents formation of ice layers.

409 - Roads and Streets, "Soil-Cement - Typical 'Specs.'", Roads and Streets, 1945, Vol. 88, No. 10, pp. 89-90, 92, 94-95.

(C)

Standard specifications of Alabama State Highway Department relating to soil-cement base course.

410 - Robertson, L, "Soil Stabilization by Mix-In Place Method", Journal of Institution of Municipal Engineers, 1947, Vol. 74, No. 3, pp. 149-162.

(I)

Notes on roads constructed at Dartford, Kent; Soil Survey and tests; Stabilization procedures and equipment; Strength tests; Bibliography.

411 - Robertson, R. E., "Stabilized Gravel Methods", Roads and Streets, 1946, Vol. 89, No. 7, pp. 91-93.

(B)

Clay and, more recently, crushed stone have been used in Cerro Gordo County, Iowa, to build up nearly 100 per cent surfaced country road system on limited budget; data on procedure and costs.

412 - Robinson, P. J. M., "British Studies on the Incorporation of Admixtures with Soil", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 175-182, (Discussions: pp. 183-184).

(A,I)

This article describes the research for improving the mixing performance of standard items of plant such as concrete mixers and bitumen mixers. (1) Application of measurement of efficiency, (2) application of results of trial, (3) field performance with applied results, (4) requirement of increased efficiency, (5) variations of strength, and (6) energy in mixing of mixtures are discussed. The paper only describes work in progress at the present time and is not by any means conclusive.

Robinson, P. J. (see also 279)

413 - Robinson, W. P., Practical Soil Stabilization, 1948, London, George Newnes, Limited, (101 pages). (A)

This book gives information concerning the practical application of soil stabilization methods in the construction and maintenance of roads. The subject matter covers the nature and properties of soils suitable for stabilization, and the tests used for determining the suitability of a soil, the user of stabilized soil, the methods and materials employed, the procedure adopted in preparing the site and in mixing, spreading, compacting, and surfacing, and practical hints for insuring successful results. The type of equipment required for each process is fully described.

414 - Rodes, V. H., "Incorporation of Admixtures with Soil", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 169-173.

(I)

The incorporation of admixtures in soil involves 3 primary ingredients: the soil, the water, and the additive. The uniformity of the distribution of the additive and the molding of the soil-water-additive system into the desired shape are general problems involved in the stabilizing process. Successful incorporation will be achieved only by full utilization of all the potentials of materials, equipment, and techniques now under development.

415 - Rodgers, E. C. "Soil-Cement Base Construction", Roads and Streets, 1951, Vol. 94, pp. 39-41.

(C)

The use of cement-stabilized soil base course on primary roads in Madison County, Tennessee, began in 1947, and has been continued because: (1) the necessary equipment has been available; (2) road stone or gravel do not occur locally; (3) the stabilized base resists weather conditions better than other types of base used locally; (4) the base is strong enough to resist the agricultural or industrial traffic carried by the county roads. Standard width of 26 ft. for formation and 18 ft. for carriageway have been adopted. Equipment and methods are described; special provision is made to prevent losses in unloading bulk cement. The stabilized bases eventually receive a single or double surface dressing or a mixed-in-place bituminous wearing course.

416 - Roediger, J. C. and Klinger, Earl W., "Soil Stabilization Using Asphalt Cut-backs as Binders", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 299-305.

(D)

This paper gives briefly a method of design and a recommended procedure for road construction using soils and asphalt cut-backs or soils, aggregates and asphalt cut-backs to produce suitable bases for pavement structures. It is stated that enough adequate information is available on the field performance of pavement structures designed with the Hubbard-Field apparatus and procedure to justify its adoption for immediate use in connection with soil-asphalt mixtures. Recommended construction procedures include scarifying, distributing and blotting, mixing and windrowing, spreading, leveling, and initial compaction, final finishing and final compaction, application of the blotter treatment, and application of the surface course.

Roediger, J. C. (see also 211)

417 - Rohrer, S. L., "Tioga Pass, Cement-Treated Base Successful at 10,000 Feet Elevation", California Highways and Public Works, 1950, Vol. 29, pp. 3-7.

(C)

An account is given of the reconstruction of $2\frac{1}{2}$ miles of a graded earth road after the failure of a light bituminous surfacing. The road, which crosses the Sierra Nevada, was scarified, and the base stabilized by the addition of

coarse material and cement, mixing being effected by a traveling mixer. After grading and rolling, bitumen emulsion was applied and the road was sanded. A 3 inch surfacing of bituminous road-mix material was laid in two courses after the winter, nearly a year later. The road has since suffered very little damage from winter conditions or from snow-moving equipment.

Rolfe, D. W. (see 278, 280)

418 - Rosenqvist, I. T., "Electro-Dialytic Experiments at Åsrum Lake, Vestfold, Norway", Meddelelser fra Vegdirektren, (In Norwegian), 1948, pp. 21-23.

(F,G)

In the field experiment in south-east Norway approximately 2½ cu. yd. of unstable clay soil were stabilized by the addition of about 90 lbs. of salt by means of electrolysis. Four perforated iron-tube electrodes, 2½ in. diameter, were driven into the clay at the corners of a meter square and filled with salt over which about ½ gal. of water was subsequently poured. About 50 kw. of direct current were applied over a period of 42 hours, salt and water being added from time to time as required. The bearing capacity and shear strength of the clay were increased very considerably.

Ross, A. E. (see 273)

419 - Rossi, F. J. and Johnson, F. M., "Cement-Stabilized Base Course Replaces Untreated Rock - Street Surfacing Cost Reduced 38 Per Cent", Western Construction News, Vol. 26, 1951, pp. 79-80.

(C)

Sandy loam, stabilized to a depth of 6 in. by the addition of 7 per cent cement, is used to provide the base course of residential streets in Modesto, California. A bituminous prim coat is applied immediately after the compaction of the base and 2-in. plant-mixed bituminous wearing course is laid the following day.

420 - Rowat, R. M., "Control of Frost Heave", Proceedings Highway Research Board, 1939, Vol. 19, pp. 464-466.

(F)

This paper described the use of salt in the prevention of frost heave on railroad tracks. Frost heave will not take place if the soil water in a susceptible area does not freeze. When salt dissolves in the water the freezing point is lowered. As it is possible to determine the amount of salt required to lower the freezing point to any desired level, it is only necessary to know the minimum temperatures to be guarded against. The paper suggests the use of salt as an admixture in subbase courses of highways as a frost control measure with no particular reference to stabilization.

Rowat, R. M. (see also 135)

421 - Russell, I. E., "Wyoming Uses Scoria Waste for Cement-Stabilized Base", Western Construction News, 1942, Vol. 27, pp. 60-62, 138.

(C)

Shortage of suitable local material for the construction of a gravel base led to the use of waste material from scoria used for ballast in railroad construction. On a 10-mile project, a 6-inch thickness of this material, stabilized with 7 per cent of Portland cement, was used instead of an 8-inch thickness of gravel. Scoria and cement were mixed in windrows, spread with a motor grader and compacted by a sheepsfoot roller. After shaping and rolling with a pneumatic-tired roller, the base was sprayed with cut-back bitumen. A plant-mix bituminous surfacing containing gravel aggregate was provided.

Rutledge, P. C. (see 306)

422 - Rzhanitzin, B. A., "Electro-chemical Stabilization of Clayey Ground", Reports of the Academy of Sciences of the U.S.S.R., (Akademiya Nauk S.S.S.R.), 1941, Vol. 1, pp. 55-56.

(G)

The results of field experiments indicate that passage of an electric current through an otherwise undisturbed soil mass increases significantly the density and bearing capacity of clayey soils. Clays so treated withstood immersion in water for 2.5 years without apparent loosening and swelling in gelation was diminished. Marked differences were observed in the behavior of different clays. Increase in density begins round the anode, the density near the cathode at first decreasing and then increasing. The region midway between the electros is the last to become stabilized. The treatment is accompanied by partial drying of the soil; moisture content in one case was reduced from 53 to 20 per cent. The method is applicable to deep excavations in unstable wet clay and to the rapid stabilization of bridge foundations. Maximum stabilization was observed at about 1.25 Wh. per sq. cm. of electrode; further application of current caused excessive compaction of the ground and loosening of the supports. Stabilization of clays of low exchange capacity was assisted by addition of electrolytes (sodium or calcium chloride).

423 - Saad, Michel A., "Expedient Methods for Stabilizing Swamps", Proceedings Highway Research Board, 1950, Vol. 30, pp. 508-515.

(A)

Porous vertical drains appear to hold the greatest promise for stabilization of swamps for road construction. Vertical drains shorten the setting time and minimize differential settling. Laboratory experiments are described using porous concrete piles (porous-walled pipe) in place of the usual sand drains. The concrete piles are easier to install and are unaffected by shearing stresses which may develop. They appear to plug less easily also. In the experiments the concrete piles were up to 29 per cent more efficient

as drains than the sand columns. An economic analysis shows that the concrete piles are approximately 30 per cent less expensive than sand drains, without considering the increased efficiency. It is concluded that on the basis of the laboratory tests, full-scale field trials of the porous concrete drains seems justified.

Sampson, E. J. (see 318)

424 - Schaad, W. and Haefeli, R., "Elektrokinetische Erscheinungen und ihre Anwendung in der Bodenmechanik", Schweizerische Bauzeitung, 1947, Vol. 65, pp. 16-18.
(G)

Schafer, N. F. (see 275)

425 - Schappler, R. C., "Graded Mix Roads in Missouri", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 196-200.
(B)

The construction of "graded mix" type roads in Missouri during 1937-1938 was confined to providing bases for thin bituminous wearing course treatments. The availability of materials for such mixes was the determining factor for employing this type of construction in particular localities. The materials included local crushed limestone, chert gravel, and chert mine tailings. There has been no opportunity to use plant mixed materials. A fairly standardized method for the purpose has developed.

Schappler, R. C. (see also 386)

426 - Schütz, F., "New Methods of Increasing the Stability and Tightness of Earth", Svenska Vägföreningen, Stockholm Tidskrift, 1947, Vol. 34, pp. 72-82.
(A)

The paper deals with methods used to strengthen foundation soils for structures. The following methods are fully described: injection with bitumen emulsions, cement or water glass; electro-osmosis or electro-chemical treatment; freezing.

427 - Scoggin, B. I., "Soil Stabilization with Emulsified Asphalt in the Mid-Continent Area", Proceedings Highway Research Board, 1939, Vol. 19, pp. 498-503.
(D)

Stabilization with emulsified asphalt in Texas, Oklahoma, Iowa, and Nebraska is described. The author expresses the opinion that while high density in the finished construction is commendable, the obtaining of this is often an expensive luxury. The chief reason for the use of bituminous material in stabilization is to make the resultant mixture more resistant to the effects of moisture. No failures have been noted in the projects that were compacted while below the optimum moisture content.

428 - Seaman, H. J., "Mechanical Stabilization and the Processing of Stabilized Soils", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 193-197.

(I)

Three types of the Seaman Pulvi-Mixer are briefly described. Essential working parts of the Pulvi-Mixer are (1) the rotor assembly and (2) the hood or mixing chamber. The mixers are of relatively light weight. They may be used in full operation, subgrade treatment, soil stabilization, etc.

429 - Searle, A. N., Limestone and Its Products, 1935, London, Earnest Benn, Ltd., pp. 588-592. (E)

The use of lime in subgrade soil treatment of roads is covered.

430 - Sharpensteen, J. T., "The Economic Value of Using Calcium Chloride in the Stabilization of Gravel Roads", American Road Builders' Association Technical Bulletin No. 188, 1952, pp. 3-9.

(F)

The economic value of using calcium chloride to stabilize gravel roads has been effectively demonstrated during the last three years in Genesee County, Michigan. The subject is discussed under the following heads: High Traffic Count, Smooth Wearing Surface, Grading After Rains, Important Benefits.

431 - Shaw, J. A., "Stabilization in Practice", Roads and Road Construction, 1947, Vol. 25, No. 290, pp. 45-50.

(D)

An account of the stabilization of gravel roads with bitumen emulsion with particular reference to the 8.5 mile Invergarry-Cluanie Road.

432 - Shelburne, Tilton E., "Virginia's Experience with Soil Cement", American Road Builders' Association Technical Bulletin No. 156, 1949, pp. 1-16.

(C)

Fifty-eight miles of soil-cement highways have been built in various parts of Virginia. The report describes the methods and equipment used and the performance rating of the surfacing.

433 - Sherman, W. A., "Use of Sulphite Waste Liquor as Road Binder", Pacific Road Builder and Engineering Review, No. 76, 1951, p. 46, No. 77, 1951, p. 32.

(F)

The economic and practical advantages are stressed of using sulphite waste liquor produced in pulp making for the stabilization of low-cost earth roads and for dust-binding. In Wisconsin, 3000 gal. trailer tanks fitted with wide-nozzled spray-bars are being used to transport and spread the liquor; and it

is expected that this type of stabilization will be adopted on an increasing scale in those parts of the United States which have access to the waste products of paper mills since in certain circumstances the material is cheaper to use than calcium chloride.

Sherwood, R. T. (see 96, 98)

Sichardt, W. (see 256)

Sieland, H. J. (see 181)

434 - Sinacori, M. N., "Compaction of Unstable Material with Heavy Pneumatic Tired Roller", Highway Research Board Bulletin No. 42, 1951, pp. 1-13.
(H)

This paper is a report of the investigation on the use of a heavy pneumatic-tired roller to compact a refuse fill from its surface. It was found that such a roller rolled over the area a sufficient number of times would furnish a compacted crust of specified thickness to support a light fill and permit the construction of an adequate pavement.

435 - Sisto, E., "Establizacion de Suelos", Rutas, 1948, Vol. 7, No. 59, pp. 3-40.
(A)

Stabilization of soils; notes based on study trip to United States in 1943.

436 - Sisto, E.,"Estabilizacion de Suelos con Grasasde Origen Animal o Vegetal y Soluciones de Caseina", Revista de Ingenieria, 1949, Vol. 43, No. 497, pp. 467-476.
(F)

Stabilization of soils with greases of animal or vegetable origin and solutions of casein.

437 - Slate, F. O., "Use of Calcium Chloride in Subgrade Soils for Frost Prevention", Proceedings Highway Research Board, 1942, Vol. 22, pp. 422-441.
(F)

In order to investigate the effects of calcium chloride on the formation of ice lenses in subgrade soils, field and laboratory studies were made on the migration of this salt through soil and laboratory experiments of the effect of calcium chloride on frost heaving were made. It was found that calcium chloride will diffuse through the subgrade when applied through pockets, and information was secured on the soil and application factors governing the spacing to the pockets to secure uniform distribution of the salt. The rate of migration was also found to be faster with higher ground water levels

supplying water to the migration zone. It was also noted that movement of water through silt will carry the salt with it. In laboratory tests of heaving of soil specimens due to freezing of capillary water, it was found that 2 per cent of calcium chloride protected the specimens from damaging frost heave.

438 - Slesser, Charles, "Movement of Calcium Chloride and Sodium Chloride in Soil", Proceedings Highway Research Board, 1943, Vol. 23, pp. 460-468, (Discussions: pp. 468-469).

(F)

This report treats of the movement of such water-soluble, inorganic compounds as calcium chloride and sodium chloride in soil and the reduction of frost heave by the use of these chemicals as admixtures with the soil. Important variables affecting the movement of water-soluble chemicals in soil and hence their permancence included: (1) evaporation, (2) soil texture, (3) percolating water, (4) soil cover, and (5) temperature when high enough or low enough to effect a change of phase of the water. Relative to base-exchange phenomena, the calcium and sodium cations were more persistent in fine-grained soil than the chloride anion. In general increased effectiveness in reducing heaving in soil resulted from increase in the amount of calcium chloride or sodium chloride added up to a certain percentage of chemical above which no heaving took place. In a coarse-textured soil heaving was greatly reduced by an admixture of only .33 per cent of either chemical. One or two per cent of either chemical was effective in reducing heaving in a silt which had heaved badly both in the field and in the laboratory.

439 - Slesser, C., "The Migration and Effect on Frost Heave of Calcium Chloride and Sodium Chloride in Soil", Purdue University, Engineering Experiment Station, Research Series No. 89, 1943, pp. 1-168.

(F)

This report describes the field and laboratory studies carried out (a) to trace the movement of calcium chloride and sodium chloride in various soils and to estimate its causes and (b) to determine the practicability of treating subgrades with these chemicals to reduce or eliminate frost heave. It was found that calcium chloride and sodium chloride migrate differently under similar conditions of exposure. Also, calcium and sodium cations are more persistent in fine-grained soil than the chloride anion. In general, increases in the amount of chemical admixture, up to the critical chemical content above which no heaving occurs, are increasingly effective in reducing frost heaving.

440 - Smith, Arthur R., "Placing, Spreading, and Finishing Stabilized Road Materials", Proceedings Highway Research Board, 1936, Vol. 16, pp. 380-384.

(I)

The blade grader is the most commonly used equipment for grading and spreading and most road mix operations can be performed with this machine. The amount

of manipulation depends on the design of the mix and the ease with which water is incorporated in it. Spreader boxes, high type asphaltic pavers, and even dumping trucks have been utilized. Compaction was superior with the sheepsfoot roller; but since this is a tamping roller, flat wheeled rollers or truck rollers are required for finishing. In placing materials for maintenance operations plant mixes are gaining in popularity, a 3 to 4-in. layer being placed on the old roadway. Scarification of the base proves satisfactory in certain instances. Finishing methods depend to some extent on the type of compaction, and proper moisture content is also necessary for the success of this operation. An important factor in this stage of the construction is the provision of an adequate A type crown which slopes uniformly from center to side and without which excessive potholing is likely to develop. If the stabilized course is intended as a base for bituminous surface, the seasoning period should extend until a mosaic of aggregate appears at the surface; but if the material is retained as a surface, operations need be less exacting and finishing can be considered as maintenance.

441 - Smith, J. C., "The Chrome-Lignin Process and Ion Exchange Studies", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 81-83.

(F)

The paper describes the investigations made at Cornell on the Chrome-Lignin process for chemical treatment of soil. It was found that the Chrome-Lignin chemicals, in fairly small amounts, give to compacted soils considerable compressive strength and shear resistance, as well as resistance to impact. They also impart a high degree of impermeability to water. When applied in field operation, the process, however, was not promising. Especially troublesome were the poor mixing of chemicals and soil, and the development of shrinkage cracks due to inadequate compaction. Recent considerations have led to the concept of briquetting stabilized soil for expedient military use.

Smith, J. R. (see 65)

442 - Smith, V. B., "Army, Navy Release New Data on Chemical Soil-Stabilization", Engineering News Record, 1950, Vol. 144, pp. 23-24.

(F)

Full-scale experiments on the stabilization of sand soils have been conducted under the direction of H. F. Winterkorn on behalf of the U. S. Navy, Bureau of Yards and Docks. The stabilizing agents are furfural resin and aniline which react in the presence of a suitable catalyst. Small-scale tests on a sand-clay have been carried out by the U. S. Army Corps of Engineers in collaboration with the M. I. T., the stabilizing agent being calcium acrylate in the presence of sodium thiosulphate and ammonium persulphate. Both methods provide a stable surfacing in a few hours.

443 - Smith, V. R., "Compaction Machine Prepares Soil Samples for Stability Test", Engineering News Record, 1944, Vol. 132, No. 6, p. 183.

(H)

Method of operation of mechanical compactor used for preparation of stability test specimens.

444 - Smith, V. B., "Tomorrow's Construction Machines", Engineering News Record, 1947, Vol. 138, No. 8, pp. 305-310.

(I)

A review of present tendencies in the design of construction machinery in the U. S. A. indicates that most of the new models contain improvements on existing designs rather than radical innovation. A general trend is noted towards the use of larger and higher-powered equipment. Accounts are given of the developments in earth-moving machinery, excavators, belt-conveyors, lorries, and plant and machinery for concrete and bituminous construction and soil stabilization.

445 - Smith, W. H., "Stabilizing Texas Roads with Lime", Better Roads, 1948, Vol. 18, No. 5, pp. 5, 23-24, 38.

(E)

This article describes field experiments conducted by the Texas Highway Department. Laboratory data give a bearing stress of untreated soil of 75 p.s.i. After lime treatment and seven days moist curing the bearing stress was 120-487 p.s.i.

Snyder, R. C. (see 211)

446 - Sokoloff, V. P., "Electrical Stabilization of Soil", Engineering News Record, 1947, Vol. 133, No. 20, pp. 822-823.

(G)

Abstracts are presented of the two main papers given at a conference on Stabilization of Soil and Rock under the auspices of the Academy of Sciences of the U.S.S.R. and published by the Academy in Reports, 1941, Vol. 1.

447 - Sokolov, V. A., "The Effect of the Addition of Lime on the Consistency of the Clay Mass", Keramika, 1939, No. 11-12, pp. 18-23, Khimicheskiĭ Referativnyĭ Zhurnal, 1940, No. 7, p. 81.

(E)

Addition of 0.5% lime to a clay mass of the usual moisture content has the same effect as the addition of 20% of the clay powder containing 1.5% water and the addition of 1% lime has the same effect as the addition of 30% of the dry clay.

448 - Sokolovshii, A. N., "New, Practical Applications of Results of Investigations of Soil Colloids in Agriculture and Construction Work", Transactions, VI Mendeleev Congress of Theoretical Applied Chemistry, 1932, Vol. 2, Part 2, pp. 87-92.

(A,E)

Calcium plays the part of a fundamental coagulating and cementing agent in soils. If it is removed and substituted by univalent cations, peptization of humus and clay begins. The cementing action is maintained by dehydration of soil colloids.

449 - Solntzev, D. I. and Borkov, B. S., "Electro-Chemical Stabilization of Clay Ground to Control Heaving in Railway Transport", Reports of the Academy of Sciences of the U.S.S.R., (Akademiya Nauk S.S.S.R.), 1941, Vol. 1, pp. 67-79.

(G)

Plasticity, shrinkage, expansion, and frost heaving were minimized in several types of clay by passage of an electric current. Previous addition of calcium chloride renders the treatment more effective; sodium chloride, however, causes swelling and decreases the bearing power near the cathode. For field work, a d. c. generator developing 20-30 kw. at 120-140 volts is recommended. Copper cathodes and iron or aluminium anodes may be used. Laboratory tests showed that electrical treatment resulted in loss of moisture amounting to about 40 per cent, a marked decrease in liquid limit and plasticity index values, and a noticeable increase in bearing capacity near the electrodes. Ground temperature was slightly increased by current densities above 2.3 miliamperes/sq. cm. Frost heaving is reduced as a result of the impeding effect of the electrical treatment on the migration of moisture in frozen ground.

Soveri, U. (see 44)

450 - Spangler, M. G. and King, Harry L., "Electrical Hardening of Clays Adjacent to Aluminum Friction Piles", Proceedings Highway Research Board, 1949, Vol. 29, pp. 589-599.

(G)

The paper reports the results of a small scale laboratory study directed toward the determination of certain facts relative to the Casagrande method of electro-chemical stabilization of soils in the vicinity of aluminum or aluminum sheathed friction piles. Piles of aluminum alloy rods were driven in various soils contained in waterproof boxes. After the piles were driven, initial bearing capacity of each of the piles was determined. Then a direct current of electricity was passed from one pile of a pair to the other and amount of current and the voltage were measured. During the period of electrical treatment, measurements of the bearing capacities of the piles were made at frequent intervals. It was found that the bearing capacity in all cases

increased to a maximum value as treatment progressed and that further treatment beyond this optimum amount caused a marked decline in bearing capacity. The optimum treatment was greater for the negative electrode piles than for the positive electrode piles. After the piles were pulled from the soil, it was also found that the soil adjacent to the piles was impregnated with a substance which appeared to cement the soil grains together and which probably accounted for the increase in bearing capacity of the piles.

451 - Spangler, M. G. and Patel, O. H., "Modification of a Gumbotil Soil by Lime and Portland Cement Admixtures", Proceedings Highway Research Board, 1949, Vol. 29, pp. 561-566.

(C,E)

A laboratory study is reported. The soil was a heavy, sticky, gumbo soil which is rather frequently encountered in highway construction in southwest Iowa; it is highly weathered montmorillonitic material of the A-7-6 type. The investigation showed that both lime and Portland cement admixtures improved the engineering properties of this soil, lime being the more effective.

Spencer, W. T. (see 274)

452 - Spronck, R., "Application, Control and Stabilization of Soils, Study of the Influence of Compaction and Moisture", Université de Liége, Cours de Construction du Génie Civil No. 52, 1945, pp. 1-16.

(A,H)

A study was made of the influence of earth fills and moisture of stabilization of soils used for embankments and roads. The mechanical properties of soils with given moisture contents are analyzed. A new representation of variation of soil structure is given. A description of soils stabilized by means of lime, cement, mineral oils, bitumen, etc., is presented.

453 - Spronck, R., "Mise en oeurve, controle et stabilisation des matériaux terreux", Revue Universelle des Mines, 1945, Vol. 88, No. 6, pp. 197-208.

(A)

Preparation, control and stabilization of soils; study of influence of earth fills and moisture of stabilization of soils used for embankments and roads; mechanical properties of soils with given moisture contents; soils stabilized by means of lime, cement, calcium, iron chloride, mineral oils, bitumen, vegetable fibers, etc.; bibliography.

454 - Stanton, T. E., Hveem, F. N. and Beatty, J. L., "Progress Report on California Experience With Cement-Treated Bases", Proceedings Highway Research Board, 1943, Vol. 23, pp. 279-295.

(C)

Since 1939, the California Division of Highways has built about 123 miles of base, mainly for improvement of first-class roads, by mixing cement with granular materials and compacting on the subgrade by rolling or tamping. Design and construction methods and the behavior of the stabilized roads are described.

455 - Stanton, T. E., "Sand Drains", California Highways and Public Works, 1948, Vol. 27, No. 3-4, pp. 6-9, 38-40.

(H)

Illustrated data on vertical sand drains constructed for foundation consolidation and accelerating settlement of embankments; methods of drain construction with use of rotary drill, rotary jet, driven and jetted mandrel; specifications issued by California Division of Highways concerning sand drains and sand fill material; illustrated description of pore pressure apparatus.

456 - Stanton, T. E., "The Hydrauger Method - California Experience in Stabilizing Earth Slopes through Installation of Horizontal Drains", California Highways and Public Works, 1948.

(H)

This paper describes the methods of stabilizing landslides through sub-drainage by installation of perforated metal pipe drains in horizontal or slightly inclined holes. "Hydrauger" equipment is adopted for drilling the holes. In general, the tentative locations, length, and required number of drains are determined by a preliminary investigation consisting of vertical test borings and a geological survey. The final locations and lengths of drains are determined by conditions encountered during installation.

457 - Stanton, T. E., "Vertical Sand Drains for Supporting Embankments Over Marshes", Public Works, 1948, Vol. 79, No. 5, pp. 19, 32.

(H)

Sand drains employed by California Division of Highways where embankments have to be built over marshy land consist of 18-to-24-ft. sand filled vertical drains spaced approximately 10 ft. centers; drains are constructed by rotary drill, rotary jet, driven mandrel, and jetted mandrel of double wall of closed end types; average cost of completed drain is approximately $1 per lineal ft.

458 - Statens Väginstitut, Specifications for Gravel Roads, (Arbetsbeskrivning för byggnad och underhåll as slitlager av grus), Meddelande 64, 1942, (18 pages).

(B)

This specification describes the procedure adopted in Sweden for stabilizing gravel roads. The theory underlying graded-soil construction is outlined and limits are shown within which the gradings of composite mixtures should lie. Directions are given for sampling and testing the component materials.

459 - Stewart, Leroy C., "Design and Operation of Plants for Producing Stabilized Soil-Bound Road Materials", Proceedings Highway Research Board, 1936, Vol. 16, pp. 369-379.

(I)

Because it allows for economy in the use of maintenance equipment, saving in time, and more uniform composition of product, plant-produced stabilized mixtures are favorably considered by the highway engineers. Producers are likewise in favor of central plant-mixing because it often makes possible the operation of accumulated aggregates and sand or clay wastes. Although the operations of the plant may vary with local conditions, its essential functions are thorough mixing of the ingredients and covering of the aggregate particles with the binder-soil to which moisture-retaining chemicals are added. The simplest method of proportioning the materials is by picking them up with power shovel or clam shell bucket and placing them in a hopper after which they are mixed in a pug mill or some other mixing device into which the chemical admixture is fed. Preliminary treatment of the binder soil is often advisable, however, to make it coat the coarser aggregate particles more thoroughly during mixing. "This may be accomplished by a vibrating screen or by pug mills when the binder soil is a friable sand clay and by a clay disintegrator when it is a tough and plastic clay. The amount of water used in the mixing operation depends on the moisture in the binder and in the aggregate and also of the method of laying down the material on the road. Sieve analysis of the various materials and plasticity index determinations of the binder soil are all that are required to calculate proportions of ingredients necessary to produce a road material which will comply with the usual specifications. Cost will depend on local conditions."

460 - Stokstad, Olaf L., "Stabilization of Soil Bases", American Road Builders' Association Bulletin No. 149, 1948, pp. 1-8.

(A)

Michigan State Highway Department built test roads for purpose of studying suitability of various stabilized bases and influence of climate and soil groups on stabilization techniques; glacial deposits of sand and gravel provide Michigan with excellent base and subbase material. Before American Road Builders' Association.

461 - Stone, T. B., "Wet Weather Problems for Placing Cement-Treated Base in Washington", Western Construction, 1951, Vol. 26, pp. 77-78.

(C)

About 6 $\frac{1}{4}$ miles of Washington State Highway No. 14, between Purdy and Pt. Fosdick, were provided with a cement-stabilized base of borrow material surfaced with a plant-mixed asphalt wearing course laid by a paver. Details are given of the design and construction of the project which was carried out during a rainy period; a drier was used to remove excess moisture from stockpiled borrow material.

62 - Stover, C. M. "County Roads Stabilized with Asphalt", Public Works, 1949, Vol. 80, pp. 38-39.

(D)

This article describes the methods used in constructing bituminous stabilized roads from the light, sandy or gravelly soil of Oceana County, Michigan.

63 - Strahan, C. M., "Sand-Clay Road Investigations", Proceedings Highway Research Board, 1924, Vol. 4, pp. 40-41.

(B)

Road soils and other pavements made by the formation of slabs from loose aggregates owe much of their durability and traffic service to mass action and internal physical bond. Effort has been made to devise a means of studying this action in some of its phases in the laboratory and in the field. After considerable disappointment with trial apparatus, an appliance has been devised. A brief description of the disc shear apparatus and the developed test is given.

64 - Strahan, C. M., "Semi-Gravel, Top-Soil and Sand-Clay Road Materials", Proceedings Highway Research Board, 1927, Vol. 7, Part I, pp. 131-141.

(B)

This report comprises in itself a resume of the previously published work concerning the research on semi-gravel, top-soil and sand-clay road materials most of which has emanated from the staff of the University of Georgia road laboratory. Despite the many variables involved, knowledge and methods now available enable the engineer to secure very substantial road service from these road-soil slabs at a remarkably low cost. There remains, however, a large margin of improvement in their use yet to be made. Better results in service and durability can be reached mainly along the following lines: (1) greater care by the contractor and by the resident engineer in all the details which affect uniformity of composition and intimate mixing before consolidation, (2) improved types of machines for quickly and more uniformily packing the loose material from the bottom upwards, (3) the abundant use of water during the consolidation stage, either by taking advantage of rains and scarifying or puddling the new bed before its final pack is permitted, or by the most liberal use of sprinkling carts which circumstances and finances permit, (4) a more intelligent appreciation and specific knowledge on the part of both engineers and contractors of the possibilities attainable.

65 - Surveyor, "Cement Stabilized Soil Paving", Surveyor, 1943, Vol. 102, No. 2690, pp. 339-340.

(C)

Description of first full scale test carried out in Great Britain using cement stabilized soil paving on area of approximately 4 acres.

66 - Taylor, D. W., "Slope Stabilization", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 139-145, (Discussion: pp. 146-147).

(A)

Slope protection and internal drainage are very briefly discussed in this paper. Slope protection methods include: (1) riprap for upstream slopes, (2) filters below riprap, (3) reinforced concrete revetments, and (4) protection of downstream slopes. Two examples of internal drainage are discussed: (1) the underdrained earth dam with a layer of coarse material placed below a portion of the downstream section to reduce water pressures in the surrounding soil and (2) the use of horizontal drains for stabilizing natural slopes or slopes of cuts.

Terzaghi, K. (see 206)

67 - Thompson, N., "Soil Stabilization", Texas University Journal of Architecture, Engineering and Industry, 1942, Vol. 5, No. 1, pp. 22-27.

(A)

Use of soils as construction material and as foundation for structures; why soils need stabilizing; discussion of various methods used for soil stabilization.

68 - Thorpe, J. T., "Construction of Crushed Rock Highway Pavements", Highways and Bridges, 1951, Vol. 17, p. 882.

(B)

In a paper read at a conference convened by the Victoria County Road Board in Melbourne ideal conditions for the construction of crushed rock surfacings are reviewed. They include a well-consolidated subgrade, suitable grading and moisture content of the crushed material, frequent leveling and watering of the surface during the consolidation period, compaction in layers preferably less than $4\frac{1}{2}$ in. thick before compaction, and use of suitable compaction equipment. Possible difficulties at each stage of construction are reviewed.

69 - Thuilleaux, M., "An Interesting Belgian Realization of Clay Concrete", Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. 5, pp. 256-259.

(B)

This paper, presented in the name of the Societe Solvay, is an account of an experimental clay concrete road constructed in the city of Athus, near the borders of Luxembourg and France. Crushed slag was used for the coarse aggregate, the finer material being a mixture of slag, slag dust and clayey sand. Mixing was carried out in a small concrete mixer and calcium chloride was added as a stabilizing agent. The stabilized mixture was spread about 7 cm. thick before consolidation, which was carried out with pneumatic-tired lorries followed by three passes of 14-ton 3-wheeled roller.

470 - Thuilleaux, M., "Clay Concrete - Rapid Determination in the Field of the Proportion of Mixing Water to be Added to the Moist Materials", Revue générale des routes et des aérodromes, 1948, Vol. 18, pp. 25-26.

(B)

The numerous weighing operations and drying tests required by the Proctor method of determining optimum moisture content are obviated by the suggested method. This consists in making up, from the various materials at their natural moisture content, a number of 2 kg. samples of the stabilized (clay-gravel-sand-calcium chloride) mixture to be used. One sample is thoroughly mixed with an arbitrarily chosen proportion of water, well below the probable optimum moisture content, and compacted in the Proctor mould, the diminution in volume being recorded. This process is repeated with successive additions of water, increasing by about 1% of the total weight of the original sample, until the optimum moisture content is reached or slightly exceeded. Any excess is easily detected by (a) shiny appearance of the compressed sample or actual exudation from it; (b) adhesion of the mixture to the compression plate; (c) the change in the mechanical resistance offered to compression. The field results should subsequently be corrected with those of laboratory tests.

471 - Thuilleaux, M., "The Use of Clay Binders in Base and Wearing Courses", Silicates industriels, (Brussels), 1949, Vol. 14, pp. 177-184.

(B)

Recommendations are made for the use of clay as a binder in road construction and Belgian and French experiences are discussed. The article is concerned with: the constituents of clay-concrete, in which the aggregate particles should not exceed 25 mm. in diameter; the effect of adding calcium chloride to argillaceous materials; mixing, placing, maintenance methods; purposes for which clay-concrete is suitable; precautions to be taken in the selection of materials; and mixtures of sand-clay and calcium chloride as binders for waterbound macadam surfacings. A brief description is given of the use of clay-concrete for the construction of cycle tracks in Tournai, Belgium.

Tilley, A. C. (see 275)

472 - Touhey, B., "Cement-Treated Road Base Built in Arizona", Engineering News Record, 1945, Vol. 134, No. 2, pp. 36-38.

(C)

Traveling-mix methods of applying cement to road base were used in Arizona last year as an experiment in low-cost road construction; method of construction described; diagrammatic outline of methods followed in processing cement stabilized pavement base and shoulders.

473 - Tournaire, R., "Electronic Chemistry and the Latest Developments in Road Engineering", Chimie et industrie, (In French), 1951, Vol. 65 (2), pp. 179-185, (3), pp. 348-355.

(A)

Descriptions are given of various modern methods of building roads and special reference is made to the part played by developments in chemistry in improving road engineering. Consideration is given to tar and its properties, petroleum bitumens, other types of bituminous binders, adhesiveness, modern theories concerning colloids, binders containing admixtures of rubber, fillers, bitumen emulsions, tar emulsions, and soil stabilization.

474 - Travers, Ray B. and Hicks, W. B., "Gravel Type Stabilized Surfaces for Secondary Roads", Proceedings Highway Research Board, 1933, Vol. 13, Part I, pp. 228-243.
(C)

Low cost stabilized gravel type surfaces have been developed as one approach to the problem of improvement of secondary roads. The process described in this paper consists in building on a graded road a surface course of a mixture of coarse aggregate, fine aggregate, silt and clay, proportioned for maximum stability according to the latest methods, and treated with a deliquescent salt to preserve the stability and keep down the dust by maintaining it in a damp condition. The report discusses specifications for materials and mixtures and describes the methods used on 300 miles of roads on Onondaga County, New York.

475 - Tribble, J. F., "Mechanics of Calcium Chloride Treatment", Proceedings Highway Research Board, 1944, Vol. 24, pp. 492-497.
(F)

The principles of behavior of base course materials into which calcium chloride has been mixed are based upon the presumption that these mixtures possess satisfactory mechanical gradation with enough fines to assure slight cohesive and capillary action. These features are generally provided by base course requirements. The experience in Alabama has demonstrated that calcium chloride performs one or all of the following beneficial functions: (1) reduces water requirement, (2) less rolling necessary, results better, (3) makes the base stronger and tougher, (4) accelerates seasoning processes, (5) extends some benefits to both courses, and (6) affords freeze protection.

476 - Tribble, J. F., "Tar Base Stabilization as Practiced on Recent Alabama Project", Roads and Streets, 1945, Vol. 88, No. 12, pp. 94-96, 99.
(D)

A tar-stabilized base of 6-in. minimum compacted thickness has been provided by the Alabama State Highway Department over a 22-ft. width of a 21-mile section of main road in a region where roadstone is scarce. The amount of tar used in the mix generally ranged from 2.4 to 2.6 gal./sq. yd. according to the grading of the material, but on two short sections higher rates of application were used experimentally.

477 - Tschebotarioff, G. P., "Vibratory and Impact Methods for Compaction of Soils", Roads and Bridges, 1946, Vol. 84, No. 12, pp. 65-66, 90-94.

(H)

Discussion based on experimental data obtained at Princeton University Soil Mechanics Laboratory for United States Civil Aeronautics Authority; studies primarily concerned with effects of vibrations on bearing properties of soils; some findings serve to formulate, as author's personal opinion, conclusions concerning advisable principles of design and use of vibratory equipment for compaction of different types of soils; before American Road Builders' Association.

478 - Turnbull, W. J. and Foster, C. R., "Bituminous Stabilization", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 122-126, (Discussions: pp. 127-137).

(D)

This paper gives brief descriptions of the methods and use of bituminous stabilization in the United States. General conclusions are: (1) Cohesionless sands can be stabilized with bitumen to make satisfactory base courses and emergency wearing courses. Where a high performance base is being produced, hot-mix construction is favored because closer control can be obtained. At certain locations in the United States such treatment has been economical. (2) Bituminous stabilization is a useful tool in creating a "working floor" in a cohesionless sand subgrade. (3) The use of emulsions and cut-backs in stabilization requires "drying weather" which must be considered where the time element is important. (4) The improvement of fine-grained subgrades by bituminous stabilization is not generally economical. (5) Bituminous stabilization can be used to provide satisfactory emergency roadways and landing facilities in the theaters of operations where soil conditions are favorable although the quantities of material and curing time may not meet presently stated Army requirements.

479 - Turnbull, W. J. and McFadden, Gayle, "Field Compaction Tests", Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. V, pp. 235-239.

(H)

This paper presents the results of field compaction tests of a clayey sand and a silty clay. In interpreting the test data presented herein the reader is cautioned that they apply to particular test conditions and that the results for other test conditions might be different since the results obtained for any roller depend not only upon the characteristics of the roller itself but also upon the test conditions which include types of soil, water content, number of passes, thickness of lift, and many other factors.

Uppal, H. L. (see 310)

Vail, James (see 235)

480 - Van der Lingen, G. W. B. and Biesenbach, W. J., "Investigations on the Heat Treatment of Subsoils and Gravels", The South African Industrial Chemist, 1949, Vol. 4, pp. 70-74.

(A)

Laboratory tests have been carried out to determine the effect of heat treatment on two exceptionally poor black clays, a poor weathered dolerits and a composite laterite having a somewhat high content of clay. The methods used are described. Small samples, $\frac{1}{2}$ in. thick, were heated for various times up to one hour and at various temperatures up to 800° C. The grading of the materials tested, the plasticity index and the linear shrinkage were determined before heat treatment, after heating and after subsequent vigorous boiling. Results obtained are discussed and presented in tabular form. It is considered that (a) the investigations provide a useful guide to the efficiency of heat treatment and (b) this method of soil stabilization would only in certain instances be used in preference to other methods.

Vaughan, F. W. (see 318)

481 - Vey, E., "The Mechanics of Soil Consolidation by Electro-Osmosis", Proceedings Highway Research Board, 1949, Vol. 29, pp. 578-589.

(G)

This paper discusses the mechanics of electro-osmosis and reviews the derivations which led to the quantitative expressions for hydrostatic pressure in terms of the physical, mechanical and electrical quantities. The electro-osmosis action when an EMF is applied to a fine-grained clay is described and the physical limitations in its effectiveness are also discussed. A method for determining experimentally the actual pressure head for a particular soil sample subjected to an EMF is presented as well as the variation in this pressure head with decreasing voids ratio. The experimental curve is compared with the theoretical equation for electro-osmotic pressure head. The degree and rate of consolidation of a fine-grained soil are shown to be both greatly increased by electro-osmosis. It is further shown that the electro-osmotic pressure can be presented very simply as an increased consolidation load in the consolidation theory. Finally, consolidation test results under a relatively large EMF and again without an applied EMF are given and the log time-settlement curves for both are compared with the theoretical curve. Load-settlement curves with and without the applied EMF are also compared.

482 - Visser, W. C., "Lime Status and Soil Structure", Landbouwkundig Tijdschrift, 1942, Vol. 54, pp. 791-796.

(E)

Further experiments indicated that liming increases the water content of the soil but at the same time gives a denser structure, the increased water capacity of calcium clay relative to that of hydrogen clay as well as the closer packing of the particles. Liming also reduces the content of large pores in the soil.

483 - Volkov, M. I. and Kusliik, B. R., "Influence of Additions of Lime and Cement on Road-Building Properties of Clay Soils", Journal of Katkhov Highway Institute, 1935, Vol. 1, pp. 90-99.

(C,E)

The addition of 4% slaked lime rendered soil less permeable, increased its bearing power, and prevented drying shrinkage. Cements were not effective.

Walsh, W. J. (see 241)

Ward, W. H. (see 166)

484 - Warren, D. S., "Soil Stabilization by Direct Labour at Dartford", Journal of the Institution of Municipal Engineers, 1949, Vol. 75, pp. 517-533.

(A)

The work described was carried out in 1947 on a site adjacent to that of similar work in the previous year and with similar equipment. Special difficulty, however, was presented by the variations in the character of the soil; top soil, chalk and gravel predominated but there were occasional pockets of sand and clay which sustained frost damage even after stabilization. Methods, quantities and equipment are described; and an appendix is included giving details of costs.

485 - Waterway Experiment Station, "Compaction Studies on Clayey Sands", U. S. Army Corps Engineers, Technical Memo No. 3-271 Soil Compaction Investigation Report No. 1, 1949, pp. 1-42.

(H)

Determination of stress and strain characteristics of soils compacted in field and of feasibility of utilization of field equipment to obtain greater compaction than is now generally required in fills; description of field and laboratory tests and equipment used for compaction.

486 - Waterway Experiment Station, U. S. Army, "Compaction Studies on Sand Subgrade", Technical Memo No. 3-271 Soil Compaction Investigation Report No. 3, 1949, pp. 1-22.

(H)

Determination of the effectiveness of heavy equipment such as tractors, Tournapulls, and the like, in obtaining compaction of free-draining sand subgrades which would meet the requirements specified by the Office of Chief of

Engineers, U. S. Army; description of investigation methods and results.

487 - Waterway Experiment Station, U. S. Army, "Compaction Studies on Silty Clay", Technical Memo No. 3-271 Soil Compaction Investigation Report No. 2, 1949, pp. 1-49.

(H)

This report presents the results of a combined field and laboratory study on the compaction and stress-strain characteristics of a lean silty clay. The general purposes of this investigation were to obtain information as to the effectiveness of rubber-tired and sheepsfoot roller equipment in compacting silty clay to a high density economically and to compare this information with laboratory compaction data. Conclusions were drawn based on the data presented.

488 - Waterway Experiment Station, U. S. Army, "Field Penetration Tests for Selection of Sheepsfoot Rollers", Technical Memo N 3-333, 1951, pp. 1-22.

(H)

Investigation to determine relationship between area, contact pressure, depth of penetration, and rate of penetration of model foot of sheepsfoot rollers; investigation was conducted at Grenada Dam, Mississippi; description of equipment and test procedure; effect of foot size and water content; penetration resistance versus roller behavior.

489 - Waterway Experiment Station, U. S. Army, "Miscellaneous Laboratory Tests", Soil Compaction Investigation Report No. 5, Technical Memo. No. 3-271, 1950, pp. 1-37.

(H)

Purpose of studies was to investigate effect of certain variables on standard procedures for preparation of laboratory specimens for C. B. R. test and to develop suitable standard compaction test for cohesionless materials; description of tests; results and conclusions.

490 - Waterway Experiment Station, U. S. Army, "Resinous Water Repellents for Soils", Technical Memo No. 217-1, 1946, pp. 1-31.

(F)

The interim results are reported of investigations to determine the suitability of various types of resinous water repellents for military construction. Preliminary laboratory tests were carried out on 14 soil types with 2 water repellents, using capillary rise tests, and full submersion followed by unconfined compression tests. Treatment was considered satisfactory if (a) it limited to 75% of the optimum moisture content the water absorbed after 24 hours by capillary action in test specimens previously dried to 55% of the optimum moisture content and (b) after full submersion for 24 hours similar specimens had an unconfined compressive strength equal to that of unsoaked

test specimens of untreated soil. Traffic tests after wet and dry periods were then carried out on field sections constructed from 5 soils ranging from sandy silts to silty clays, selected as a result of the preliminary tests. Additional laboratory and field research included wetting and drying tests, freezing and thawing tests, tests of further water repellents, the effect of pH values, the effect of the hardness of the mixing water, and the study of soils compacted to high density at a low moisture content. The results are discussed and conclusions are drawn.

491 - Waterway Experiment Station, U. S. Army Corps of Engineers, Slope Protection for Earth Dams, Vicksburg, Mississippi, 1949.

(A)

492 - Waterway Experiment Station, U. S. Army, "Subgrade Compaction Studies", Technical Memo No. 3-271 (Soil Compaction Investigation Report No. 4), 1950, pp. 1-22.

(H)

Results of field compaction tests performed on natural and constructed subgrades to determine feasibility of using 1,100 p.s.i. sheepsfoot roller and 40,000 lb. wheel load for producing deep compaction and high densities in natural and constructed cohesive soil subgrades, and effect of various numbers of passes of rollers.

493 - Watkins, C. L., "Ten Years of Soil-Cement Paving", American City, 1949, Vol. 64, pp. 114-115.

(C)

Soil-cement stabilization has been used with success in Alexandria, Virginia. The soils are loams of various kinds and are mixed in place with from 10 to 12 per cent of cement. The streets are given a bituminous plant-mix surfacing.

494 - Watson, John D., "The Unconfined Compressive Strength of Soil-Cement Mixtures", Proceedings Highway Research Board, 1941, Vol. 21, pp. 493-500, (Discussions: pp. 501-505).

(C)

To a sandy loam, a sandy clay loam, and a clay loam was added 5, 7, 9, and 11 per cent cement by dry weight. The optimum moisture content of each mixture was determined. From each mixture cylinders, 4 in. high and 2 in. in diameter, were compacted with moisture content below, at, and above optimum. After curing for 28 days in a moist closet these cylinders were loaded to failure in unconfined compression in a constant-strain type of testing machine. One additional series of tests was performed on cylinders compacted at optimum moisture from each soil type with 15 per cent cement. From the results of these tests, it was concluded that both the quantity of cement and the density

of the mixture are major factors effecting the compressive strength of the mixture. Also, cycles of wetting and drying produced an increase in the compressive strength of mixtures of sandy loam and of some clay loam mixtures, while cycles of freezing and thawing produced some decrease in the compressive strength in all cylinders.

495 - Weathers, H. C., "Sand-Bituminous Stabilization", Proceedings Highway Research Board, 1937, Vol. 17, Part I, pp. 521-530.

(D)

Stabilization of sandy soil has been accomplished by the addition of bituminous material, in proper quantity, to existing road material. This is mixed uniformly in place with harrows and graders or a traveling plant mixer and then compacted with rollers. Stability tests on the sand are made prior to addition of bituminous material, and if necessary the stability is increased by the addition of other fine aggregate, pulverized limestone or similar material having greater stability. The bituminous material used has been cut-back asphalt and tar. The results obtained have been entirely satisfactory. About 314 miles of this type of road are carrying traffic with a very low maintenance cost.

496 - Webb, S. B., "Soil Stabilization Tests Used in Great Britain", Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. 4, pp. 296-301.

(A)

This paper was prepared at the Road Research Laboratory, Harmondsworth, England. A discussion of the validity of the crushing tests for soil-cement precedes a description of the test procedure. The Rapid Water Absorption test and the Capillary Water Absorption test, both developed at the Road Research Laboratory, are described. These tests were designed to determine the suitability of soils for stabilization and to check the quality of field processing. From a consideration of results obtained with these tests in the construction of an experimental road stabilized with Vinsol resin, it is concluded that the tests correlated quite well with the subsequent performance of the road and that suitable acceptance criteria for stabilization with water-proofing materials are available from the results of the two absorption tests.

Webb, S. B. (see also 279)

497 - Webster, F. W. and Kellogg, F. H., "Granular Stabilized Base Construction of Access and Relocation Roads by the Tennessee Valley Authority", Proceedings Highway Research Board, 1944, Vol. 24, pp. 483-492.

(B)

The experience of the Tennessee Valley Authority in the construction of granular stabilized base course is described in this paper. Design and construction

methods are discussed under the following headings: (1) Design, (2) Subgrade, (3) Drainage, (4) Selection and Admixture of Subgrade Materials, (5) Compaction of Subgrade, (6) Construction of Stabilized Bases, and (7) Performance.

498 - West, F., "Cement Stabilized Soil Road Pavement at Warracknabeal", Commonwealth Engineer, 1942, Vol. 30, No. 3, pp. 56-59.

(C)

In May, 1941, Victorian County Roads Board constructed 2 short sections of road pavement on Henty Highway, 4 miles south of Warracknabeal, by soil cement stabilization process; notes on design, plant, construction technique, behavior under traffic, bituminous surface treatment, and record of laboratory tests.

499 - Western Construction News, "Cement-Treated Base in California", Western Construction News, 1950, Vol. 25, No. 2, pp. 67-71.

(C)

Development of use of Portland cement for treatment of road materials; cement content was gradually reduced from 6% to 8% to half that amount since fewer cracks occurred over weaker bases; outline of present practice; cost data; record of "soil-cement" used in West since 1940.

500 - Western Construction News, "Injected Fluid Stops Running Sand", Western Construction News, 1948, Vol. 23, No. 9, pp. 89,101.

(F)

Free running sand in cable tunnel of Pacific Telephone and Telegraph Company, San Francisco, was solidified by pumping dilute solution of chemicals at 200 p.s.i. gage pressure to face of tunnel; treatment gave sand compressive strength up to 100 p.s.i.

501 - Western Construction News, "Latest Equipment Speeds Cement-Treated Base Job", Western Construction News, 1951, Vol. 26, pp. 87-88.

(I)

The mechanized methods adopted for cement-stabilization on about 6 miles of a 4-lane dual-carriageway road near Livermore, California, are described. The foundation of the carriageway consists of a 16-in. layer of imported gravel, the upper 4 in. of which is cement-stabilized.

502 - Whitehurst, E. A. and Yoder, E. J., "Durability Tests on Lime-Stabilized Soils", Proceedings Highway Research Board, 1952, Vol. 31, pp. 529-540.

(E)

In the study reported three soils were tested with additions of 0, 2, 5, and 10 per cent lime. The specimens which underwent freezing and thawing were tested at the end of each cycle with the soniscope rather than by brushing.

The characteristic measured by the soniscope is the velocity of pulse propagation through the test specimen, which is a measure of rigidity, dynamic modulus of elasticity, etc. Results in these tests were most satisfactory. Results of the investigation include: (1) two per cent lime is insufficient to affect appreciably the performance of the soil tested; (2) five per cent lime, or more, significantly increased both strength and durability of these soils; (3) increased length of curing before testing was, in general, beneficial; (4) of the soils tested the greatest benefits of adding lime were derived by the river terrace gravel and the least by the Wisconsin drift soil; (5) the dynamic test employed seems to be quite adequate as a measure of progressive deterioration and merits further consideration.

Whitton, Rex M. (see 330)

503 - Wilford, H. D., Downey, B. R., Briggs, G. F., Hogentogler, C. A., Jr., Knight, J. A., Elleman, John and Burggraf, Fred, "Use of Calcium Chloride in Road Stabilization", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 209-256.

(F)

The following items were presented and discussed at a symposium on the use of calcium chloride in road stabilization: (1) Calcium Chloride, (2) Principles of Stabilization, (3) Mixture Design Specifications, (4) Computing Quantities, (5) Properties of Calcium Chloride and Their Functions in Road Stabilization, (6) Calcium Chloride Stabilization Types, (7) Surface Consolidation by Maintenance Methods, (8) Construction of Designed Stabilized Roads, (9) Construction Costs, (10) Maintenance, (11) Utility of Calcium Chloride Roads as Future Bases, (12) Research, (13) References.

504 - Williams, F. H. P., "Compaction of Soils", Journal of Institution of Civil Engineers, 1949, Vol. 33, No. 2, pp. 73-99, (Discussion: Oct., 1950, pp. 333-340).

(H)

Laboratory tests used to determine compaction characteristics are described and factors affecting their results are discussed, results of full-scale investigations of compaction of 5 British soils by smooth wheel, pneumatic tired and sheepsfoot rollers, frog rammer, and vibrating plant.

505 - Williams, F. H. P. and MacLean, D. J., "Compaction of Soil - Study of Performance of Plant", Great Britain Department of Science and Industrial Research - Road Research Laboratory Technical Paper No. 17, 1950, pp. 1-46.

(H)

Investigations undertaken to find out how compaction affects inherent properties of soil, to determine best ways of using existing types of compaction machines, effect of moisture on density of soil.

506 - Williams, T. D., "The Use of Calcium Chloride in Crushed Stone Stabilized Bases", American Road Builders' Association, Bulletin No. 171, 1950, pp. 1-12.
(F)

A description of methods used in the design and construction of low cost roads in Knoxville, Tennessee, by the use of local materials and calcium chloride in base construction.

507 - Williamson, A. O., "Soil Compaction and Use of Tampers", Journal of Institute of Engineers, 1947, Vol. 90, No. 6, pp. 24-25.
(H)

Principles applicable to compaction of soils in runway and road construction; selection of proper soils and description of compaction methods and giant tamper.

508 - Willis, E. A., "A Study of Coarse-Graded Base-Course Materials", Public Roads, 1946, Vol. 24, No. 9, pp. 239-243.
(B)

This report describes investigations of granular materials for surface and base-course construction. The purpose of this investigation was to study the effect of variations in PI on the stability of base-course mixtures having essentially the same grading and all with less than 40 per cent passing the No. 10 sieve. The paper is divided into the following heads: (1) Traffic Tests Made on Outdoor Circular Track, (2) Testing with Concentrated Traffic, (3) Bases with High PI Inferior, (4) Plasticity Index is a Guide to Performance.

509 - Willis, E. A., "Design Requirements for Graded Mixtures Suitable for Road Surfaces and Base Courses", Proceedings Highway Research Board, 1938, Vol. 18, Part II, pp. 206-208.
(B)

The first requisite of a graded soil type surface is stability; that is, it must support the superimposed loads without detrimental deformation. Second, it must withstand the abrasive action of the traffic. Third, it should shed a large portion of the rain which falls on the surface since a large amount of water penetrating the surface might cause loss of stability in the wearing course or softening of the subgrade. Finally, it should possess capillary properties in amount sufficient to replace the moisture lost by surface evaporation and thus maintain the desirable damp condition in which the particles are bound together by thin moisture films.

510 - Willis, E. A., "Metodos Practicos Para La Estabilizacion de Suelos", IV Congreso Panamericano de Carreteras - Memoria, 1942, Vol. 2, pp. 93-114.
(A,B)

Practical methods of soil stabilization; object is to produce pavement resistant to load, resistant to wear, and resistant to weathering within required limits; stabilization by securing suitable grain size relationship of soil particles; stabilization by use of binders; responsibilities of soil engineer.

511 - Willis, E. A., "Report of Subcommittee on Design of Natural Soil Mixtures and Effect of Admixtures of Commerical Products such as Crushed Stone, Gravel and Slag", Proceedings Highway Research Board, 1941, Vol. 21, pp. 549-551, (Discussions: pp. 552-555).

(B)

This paper is a summarized report of published information pertaining to the design of graded soil mixtures. The following items are suggested for research: (1) the influence of prevailing climatic and topographic conditions on specifications for stabilized mixtures, (2) investigation of local materials possessing properties peculiar to themselves in order to determine their suitability for use in base and surface course construction, such material include shales, mine and quarry wastes and the like.

512 - Willis, E. A. and Carpenter, C. A., "Studies of Water-Retentive Chemicals as Admixtures with Non-Plastic Road-Building Materials", Public Roads, 1939, Vol. 20, No. 9, pp. 173-187.

(F)

This report describes investigations using the outdoor circular track to determine the effect of the water-retentive chemicals, calcium chloride and sodium chloride, on non-plastic granular mixtures under controlled traffic and moisture conditions both before and after the application of a thin bituminous surface treatment. Various aggregates and admixtures used in test sections; weather conditions varied considerably during test; traffic tests continued after bituminous surface applied; all mixtures in track 2 proved satisfactory as base course; sprinkling aided in surface maintenance of granular mixtures; summary.

Willis, E. A. (see also 68, 204, 208, 209, 210)

513 - Wilson, G., "Improvement of the Mechanical Properties of the Soil", General Report, Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. 7, pp. 142-144.

(A)

This report reviews the salient points of the papers presented in Section IX of the conference. These dealt with (1) mass stabilization by grouting, (2) electrical osmosis, (3) stabilization of subgrades, (4) material for earth dams, (5) accelerated consolidation by vertical drains, and (6) compaction of soils.

514 - Wilson, M. D., "Akron's Soil Stabilization Program", American City, 1946, Vol. 61, No. 8, pp. 77-78, 123.

(A)

Illustrated report on soil stabilization both for street improvement and airport runway construction at Akron, Ohio; data on construction, equipment, and costs.

515 - Wilson, S. D. "Effect of Compaction on Soil Properties", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 148-158, (Discussion: pp. 159-161).

(H)

This paper evaluates the effect of compaction on the strength, stress-deformation permeability and compressibility characteristics of fine-grained cohesive soils. Based on the findings from experimental studies, it was suggested that highway embankments and similar structures consisting of cohesive soils would best be compacted somewhat on the dry side of optimum in order to achieve high strength and resistance to deformation and low volume compressibility.

516 - Wilson, S. D., "Small Soil Compaction Apparatus Duplicates Field Results Closely", Engineering News Record, 1950, Vol. 145, No. 18, pp. 34-36.

(H)

Illustrated description of soil compaction apparatus used in course in soil testing at Harvard University; inexperienced operator can obtain data for two complete moisture-density curves in one afternoon.

Wilson, L. H. (see 132)

517 - Wilun, Z., "Report on the Construction of Experimental Cement-Stabilized Soil Surfacings", (Sprawozdanie z wykonania odcinka doswiadczalnego nawierzchni gruntowej stabilizowanej cementem), Instytut Techniki Budowlenej, Nr. 66, (in Polish), 1950.

(C)

518 - Winkel, E., "How We Built Low-Cost Stabilized Road", Public Works, 1948, Vol. 79, No. 8, pp. 23-24.

(A)

Report on road in Osceola County, Iowa, built in 1941 and surfaced with 1,200 cu. yd. of gravel per mile; stabilization performed in 1945 by rolling gravel and clay; black top surface was placed in 1946 at total cost of $5,105 per mile.

519 - Winterkorn, Hans F., "A Fundamental Approach to the Stabilization of Cohesive Soils", Proceedings Highway Research Board, 1948, Vol. 28, pp. 415-422.

(A)

Structural, physico-chemical, and bacteriological factors entering into the problem of successfully and practically stabilizing cohesive soils are discussed and ways are shown by which soil stabilization can be extended to cover heavy soil types which at the present time are outside the realm of recommended practice for soil-bitumen and soil-cement.

520 - Winterkorn, H. F., "A Laboratory Study of the Soil Stabilizing Effectiveness of Artificial Resins with Special Emphasis on the Aniline-Furfural Resins", Technical Development No. 43, Civil Aeronautics Authority, U. S. Department of Commerce, 1947, pp. 1-45.

(F)

This report presents the data obtained from a laboratory investigation of the soil stabilizing properties of numerous artificial resins. Because of their outstanding effectiveness, the resins formed by the reaction of aniline and furfural were given special attention. A discussion of the history and structure of aniline-furfural resins and the results of a series of experiments concerning the catalyzation of these materials are given in the appendixes.

521 - Winterkorn, H. F. and Moorman, R. B. B., "A Study of Changes in Physical Properties of Putman Soil Induced by Ionic Substitution", Proceedings Highway Research Board, 1941, Vol. 21, pp. 415-434.

(A,F)

The paper presents the effect of chemical factors on the mechanical stability of a Putnam clay soil. Through chemical treatment and the medium of base exchange this soil was altered to produce homoionic soils whose bases were (1) sodium, (2) potassium, (3) magnesium, (4) calcium and (5) aluminum. These modified soils along with the natural soil were tested, by standard procedures, to determine (1) specific gravity, (2) size composition, (3) Atterberg limits, (4) shrinkage factors, etc. The relationship between the physico-chemical and the mechanical properties of the different soil systems are discussed.

522 - Winterkorn, H. F., "Final Report on Beach Sand Stabilization Research", Contract NOy-15087, 15 November 1947 to 15 November 1949.

(F)

523 - Winterkorn, H. F., "Fundamental Similarities Between Electro-osmosis and Thermo-osmosis Phenomena", Proceedings Highway Research Board, 1947, Vol. 27, p. 443.

(G)

A new theory is presented for thermo-osmotic flow in soils, which is based on the original film flow concept of Bouyoucos, and on the experimentally observed fact that the water-affinity of soil decreases with increasing temperature. This theory is also reduced to a form which is directly useful in the hand of

the engineer. Evidence is presented that there exists a close fundamental relationship between electro- and thermo-osmotic phenomena and that therma waves penetrating into the soil are accompanied by electrical waves. The general importance of this phenomenon is indicated.

524 - Winterkorn, H. F. and Choudhury, A. N. Dutta, "Importance of Volume Relationship in Soil Stabilization", Proceedings Highway Research Board, 1949, Vol. 29, pp. 553-560.

(A)

Attention is drawn to factors which determine the rate at which water penetrates soil and which, therefore, influences the rate of deterioration of a stabilized soil in normal climatic conditions. General formulas are presented for the rate of penetration of capillary water and the validity of the formulas is examined in the light of results of slaking experiments on clay and sand-clay systems. The importance of the relative volumes of the various soil components is demonstrated by reference to experiments on the stabilization of three synthetic soils which consisted of illite, kaolinite and montmorillonite respectively mixed with sand and ground feldspar. The influence of temperature on water attack is discussed.

525 - Winterkorn, Hans F. and Chandrasekharan, E. C., "Laterite Soils and Their Stabilization", Highway Research Board Bulletin No. 44, 1951, pp. 10-29.

(A)

The origin, occurance, and correct identification of laterite rock and soil are discussed. The peculiar properties of laterite soils are outlined and suggested methods of dealing with them are indicated. Results are reported of experimental studies with special attention to stabilization. Portland cement gave best results in some cases and aniline-furfural in others. The paper includes a map of the distribution of laterite and lateritic soils in the world and a number of tables of the characteristics of the soils and the results of stabilization experiments and tests.

526 - Winterkorn, Hans F. and Eckert, George W., "Physico-Chemical Factors of Importance in Bituminous Soil Stabilization", Proceedings of the Association of Asphalt Paving Technologists, 1940, Vol. 27, pp. 204-257.

(D)

This is a report of the investigation undertaken for the purpose of demonstrating and analyzing physico-chemical factors of importance in the bituminous stabilization of cohesive soils. The experimental work included: (1) a study of 6 soils varying in mechanical composition, chemical character, pedological development, type and amount of exchangeable bases, (2) a study of 18 asphaltic bitumens varying in origin and processing and in physical and chemical characteristics, (3) an investigation of the behavior toward water of soil-bitumen systems consisting of all possible variations of the soils studied,

which in most cases were available in 9 ionic modifications, with the bituminous materials previously identified by laboratory tests.

527 - Winterkorn, Hans F., "Physico-Chemical Testing of Soils and Application of the Results in Practice", Proceedings Highway Research Board, 1940, Vol. 20, pp. 798-806.

(A)

The mechanics of systems composed of granular constituents, liquid and gas phases, are dependent to a great extent upon the mechanical and chemical character of their internal surfaces. The electro-static concept of chemical linkage and other attraction forces permits the formulation of simple theories concerning water affinity of soil particles and friction and cohesion of soil systems which are in general agreement with experimentally obtained data. The theory indicates the directions in which soil properties can be changed by physico-chemically active admixtures such as soluble salts, bituminous materials and Portland cement. Besides offering help for the explanation and correlation of phenomena which were hitherto thought contradictory, the theoretical concept and the accumulated experimental results may serve as valuable guides in the future development of soil stabilization.

528 - Winterkorn, H. F., "Principles and Practice of Soil Stabilization", Colloid Chemistry, 1946, Vol. 6, pp. 459-492.

(A)

The following topics are discussed: source of soil knowledge, classification of soils, soil stability, destructive climatic action, mechanism of water attack, condition of water in porous systems, frost heaving, ice lenses, methods of soil stabilization, construction methods, stabilization by injections, etc. Many curves and tables are given.

529 - Winterkorn, Hans F., "Soil Stabilization", Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering, 1948, Vol. V, pp. 209-215.

(A)

A condensed survey is presented of the theoretical and practical features of soil stabilization. This survey shows the great aid which applied soil stabilization can receive by taking cognizance of the scientific facts and theories already available. The wide dispersion of this basic knowledge in a number of different pure and applied sciences makes it into a science of soil stabilization, which can make this knowledge more easily available, which can serve as a dependable guide to the practitioner, and which can organize, systematize, and preserve the intuitive inventions and discoveries of the art.

530 - Winterkorn, H. F., "Soil Stabilization by Use of Rosin", United States Civil Aeronautics Authority Technical Development Note No. 34, 1946, pp. 1-22.

(F)

Laboratory tests were made with wood rosin either as such or with wood rosin which had been partially or completely neutralized with sodium, potassium, or ammonium hydroxide; also, soil stabilizing power of insoluble rosinates formed from alkali rosin despersions by addition of salts of bi- and tri-valent metals was investigated.

531 - Winterkorn, H. F., Gibbs, H. J., and Fehrman, R. G., "Surface Chemical Factors in Importance in the Hardening of Soils by Means of Portland Cement", Proceedings Highway Research Board, 1942, Vol. 22, pp. 385-415.

(C)

Standard soil-cement and compression tests were employed to obtain data on the influence of exchangeable cations, physical soil constants, density of the soil-cement systems, and moisture content of the soil-cement systems at time of compaction. The results show: (a) that the surface-chemical along with other physical factors influence the hardening of clay soils with Portland cement, (b) that ionic treatment can improve the hardening action, (c) that the difference between the optimum moisture content and shrinkage limit of inorganic clay soils is a measure of its susceptibility to stabilization, (d) that the water affinity and the accessibility of the internal surface of the soil-cement system controls its behavior in the wet-dry tests, (e) that the permeability of the system and the amount of pore space filled with unadsorbed water determines its behavior in the freezing and thawing test, and (f) that organic matter of an acid nature affects the soil-cement system adversely.

532 - Winterkorn, H. F., "Surface-Chemical Factors Influencing the Engineering Properties of Soils", Proceedings Highway Research Board, 1936, Vol. 16, pp. 293-301.

(A)

Results of experimental study of influence of various exchange ions on engineering properties of soil, showing that physical character of natural soils, especially as pertaining to stability at varying moisture contents, can be changed to great extent by change of adsorbed ions.

Wintermyer, A. M. (see 209)

Wirsig, H. D. (see 211)

533 - Wood, C. W., "Soil Stabilization with Wood Roadmixers and Allied Equipment", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 198-206.

(I)

The development and the use of the wood Roadmixers are briefly described. They are built in three sizes to satisfy the needs of the large, the medium, and the small jobs. The mixers do not mix the material on the ground but

pick it from the ground, losing none of the expensive binders on the subgrade, and mix it thoroughly in a drum. The mixers are simple in design and sturdily built.

534 - Wood, J. Eldridge, "An Example of Gravel Base Construction in Maryland Under Heavy Traffic Conditions", Proceedings Highway Research Board, 1944, Vol. 24, pp. 481-483.

(B,F)

This paper describes gravel base construction in Maryland under heavy traffic conditions during the war. Calcium chloride was applied to the gravel base. It was found that a dense, tight and hard surface could be secured even through the dry summer months with frequent relatively heavy applications of calcium chloride and that this would provide a compacted and glossy surface. The roadway finally developed into an excellent stabilized base.

Wood, J. E. (see also 318)

535 - Woodring, P. W., "Requirements and Experiments in Expeditious Military Soil Solidification", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 281-285.

(A,F)

The prime objective of the investigations on soil stabilization by the Army is the conversion of normally unstable off-road soils to weather resistant surfaces useful as roads and airfields. The best approach to a solution is to attempt the development of a chemical-bond between soil particles which would utilize the natural attraction of soil particles for ions, which in turn could be connected by another added chemical. This method would utilize ion exchange reactions and polymeration of the added chemical to build a chain of molecules which would merely connect, and not coat the particles, to develop a coherent chemical-soil mixture. The calcium acrylate and calcium-ligno-sulfonate, or lignin, are quite promising to meet the objective in the laboratory study. However, it appears to be impossible to achieve a product in the field closely resembling the laboratory proved material.

Woodring, P. W. (see also 375)

536 - Woods, H. W., Jr., "Lime in Earth Roads", Proceedings National Lime Association Convention, 1926, Vol. 8, pp. 57-58.

(E)

The use of lime in treating earth roads is described.

537 - Woods, K. B., "Engineering and Construction Control of Embankments and Bases", Proceedings of American Road Builders' Association, 1941, pp. 108-114.

(H)

This paper emphasizes the importance of density control by showing the relationship that exists between density, maximum moisture content that the soil may attain, and stability. It is divided into the following heads: Moisture Content; Typical Computations; Density of Stabilized Bases; Embankment Compaction; Compaction of Bases; Some Observations in the Field; Compaction by Traffic; Specifications and Construction Control; Laboratory Tests of Typical Materials; Summary.

538 - Woods, K. B., First Progress Report Covering Durability Tests on Lime Stabilized Soil, Paper presented at 48th Annual Convention of the National Lime Association, 1950.

(E)

Freezing and thawing and wetting and drying tests were performed on a silty clay and a sandy soil which had been stabilized with varying amounts of lime. Lime by itself did not better the durability of the fine grained soil, but lime-bitumen admixtures helped appreciably. With the sandy soil lime alone was almost as effective as lime plus bitumen.

539 - Woods, K. B., Lime as an Admixture for Bases and Subgrades, Paper presented at 31st Annual Convention of the National Lime Association, 1949.

(E)

This paper reports on research being conducted at Purdue University on the addition of lime for subgrade stabilization.

540 - Woods, K. B. and Litehiser, R. R., "Soil Mechanics Applied to Highway Engineering in Ohio", Ohio State University Engineering Experiment Station Bulletin No. 99, 1938, pp. 1-5.

(A)

Laboratory and field investigation procedure of modern highway department soil testing laboratory is described. All usual physical characteristic tests described. Embankment specifications, methods of field control, and making of soil profile; subgrade treatment for various types of soils; field and laboratory studies of poor foundations; investigation and treatment of landslides and peat bogs; description of low cost road design and construction; highly practical development of family of curves for embankment construction control.

541 - Woods, K. B., "Soil Stabilization Research at Purdue University", Proceedings of American Road Builders' Association, 1940, pp. 336-350.

(A)

The paper briefly covers the so-called soil stabilization studies of the Joint Highway Research Project including in particular the 2 test roads constructed in 1937 and 1938. The design and construction procedure, observations, and some of the results obtained on these test roads are given. In

addition, some of the laboratory studies already completed and those recently inaugurated on soil and soil mixtures are included.

542 - Woods, K. B. and Yoder, E. J., "Stabilization with Soil, Lime, or Calcium Chloride as an Admixture", Proceedings Conference on Soil Stabilization, M. I. T., 1952, pp. 3-25.

(E,F)

This paper discusses mechanical stabilization and stabilization with lime or calcium chloride as admixtures. Included is historical development of the three stabilization techniques together with some of the fundamental aspects of obtaining satisfactorily-processed materials. The importance of gradation, density, and moisture control during compaction are emphasized. The paper includes a selected bibliography.

Woods, K. B. (see also 546)

Woodson, Dillard D. (see 52)

543 - Wooltorton, F. L. D., "Relation Between the Plastic Index and the Percentage of Fines in Granular Soil Stabilization", Proceedings Highway Research Board, 1947, Vol. 27, pp. 479-490.

(B)

The writer observes that specifications for granular stabilization usually give maximum permissible values for the plastic index of the fraction passing the No. 40 sieve, but give no logical reasons for this limitation. A formula is needed to cover general rather than local conditions. A study of methods used by various engineers suggests a relationship of the kind: (plasticity index) x (percentage passing No. 40 sieve) = C, where C is either a constant or the difference between a constant and a function of the percentage of soil fines.

544 - World Construction, "Dahomey: Scene of Modern Soil Stabilization Methods", World Construction, 1951, Vol. 4, pp. 16-17.

(D)

A 25-mile section of the new coastal main road in West Africa, from Accra to Lagos, is being built east from Porto Novo, the capital of Dahomey, to the Nigerian frontier. Since there are no suitable supplies of local stone or sand, the soil (known as terre de barre) is being stabilized with cut-back bitumen. The construction methods adopted and the machinery used are described.

545 - Worth, W. J., "Earth-filled Macadam for Use in Suburbs", Better Roads, 1952, Vol. 22 (9), pp. 33-44.

(B)

Methods developed in Wayne County, Michigan, for the construction of serviceable and relatively cheap roads are described. After the installation of a drainage system, the existing gravel surfacing is removed and the materials are placed on the sides of the road, to be used later for the new verges. Two compacted 4 in. layers of coarse slag aggregate are laid on the subgrade, and the voids are filled with the trenched out sub-soil material. If the natural subsoil is too plastic, suitable other material is mixed with it. A bituminous surface treatment about 4 in. thick is laid a year after construction. The Wayne County Road Commission has so far constructed 150 miles of this type of road at the rate of 30 miles a year, and the results obtained are considered to be very satisfactory.

546 - Yoder, E. J. and Woods, K. B., "Compaction and Strength Characteristics of Soil Aggregate Mixtures", Proceedings Highway Research Board, 1946, Vol. 26, pp. 511-520.

(B,H)

A series of compaction and strength tests were performed on four soil-aggregate mixtures to determine their compaction and wet strength characteristics under varying soil contents. On the basis of the test data, it was indicated that, for a given gradation of an aggregate, there is an optimum soil content at which maximum densities are attained. The optimum soil content where strengths are concerned is somewhat less than that indicated by the compaction tests. Maximum densities do not necessarily mean maximum strength whenever soil-aggregate mixtures containing varying percentages of soil near the optimum are compared. The tests on mixtures of soil and crushed stone resulted in the highest density and strength values of the materials, with the soil-gravel, soil-sand, and soil-dune sand mixtures resulting in the next highest values in the order given. It was concluded that insofar as densities and strengths are concerned, a small quantity of soil mixed with granular materials is desirable, but that larger quantities are detrimental.

547 - Yoder, Eldon J., "Effect of Calcium Chloride on the Compactive Effort and Water Retention Characteristics of Soils", Proceedings Highway Research Board, 1947, Vol. 27, pp. 490-504, (Discussions: pp. 504-509).

(F)

This paper reports the results of work carried out in the laboratories of the Joint Highway Research Project, Purdue University. It was found that, for most of the soils tested, the use of calcium chloride decreased the compactive effort required to produce a given density of soil; the lower percentages of calcium chloride apparently were more effective than the higher ones. The pH of the soils tested was reduced when calcium chloride up to 1.5 per cent was present. The effects of calcium chloride on liquid limit, plastic limit, load penetration and drying characteristics were also studied. Calcium chloride retarded drying out of soils which were subjected to accelerated drying tests.

Yoder, E. J. (see also 502, 542)

548 - Youard, G. B., "Soil Stabilization for Farm Roads", Agriculture, 1952, Vol. 59, No. 8, pp. 371-375.

(A)

Recommendations are made to give guidance to farmers. Details are given of simple tests for determining whether a given soil is suitable for stabilization with cement. Photographs illustrate construction methods.

Young, James L. (see 176, 177)

549 - Ziegler, C. M., "Essentials in Producing Plant-Mix Stabilized Material", Public Works, 1946, Vol. 77, No. 3, p. 24.

(A)

Reports on procedures employed in Michigan to further quantity production of stabilized material, abstract of paper before American Road Builders' Association.

550 - Ziegler, C. M., "Stabilization Pointers from Our Michigan Experience", Roads and Streets, 1946, Vol. 89, No. 2, pp. 65-69.

(A,B)

Necessity of continuous control, plant mixing of stock-piled aggregates, avoidance of high capillary sub-bases and of placement in rainy season are recommended for successful construction.

551 - Ziegler, Charles M. and Deibler, G. W., "The Value of Stabilized Roads in the Highway Program, Where the Stabilized Road Belongs in the County Highway Program", American Road Builders' Association Bulletin No. 99, 1946, pp. 1-20.

(A)

These reports contain information on methods of stabilizing road materials in Michigan and Minnesota with description of equipment used.

552 - Ziegler, C. M., "Using Stabilized Soil Mixture Properly", Public Works, 1946, Vol. 77, No. 2, p. 33.

(A,F)

Experiences in the use of chemically stabilized mixtures for patching and maintenance of roads in Michigan; precautions in their use stressed; abstracts of paper before American Road Builders' Association.

553 - Zube, E., "A Treatise: Experimental Use of Lime for the Treatment of Highway Base Courses", California Highways and Public Works, 1950, Vol. 29, pp. 7-13, 56.

(E)

This article describes two projects where agricultural lime was added to natural granular base materials for purposes of stabilization and in order to increase the load-carrying capacity and to decrease plasticity. In the one project the commerical agricultural lime used cost approximately as much as Portland cement would have done, if used for the same purpose. In the other project agricultural waste lime was used and this proved cheaper than Portland cement. Both lime-treated roads were provided with bituminous surfacings. These roads have proved to be more durable than adjacent roads without lime-stabilized base courses. An advantage of lime stabilization as compared with cement stabilization is that the treated base course need not be compacted immediately after mixing.

554 - Zwerski, P. and Graves, L. D., "Compaction Control for Earth Fills Made Easier by Rapid Moisture Test", Engineering News Record, 1951, Vol. 146, No. 18, pp. 39-40.

(H)

Illustrated description of test apparatus and test procedure used to determine soil moisture; equipment consists of sheet steel pan, spatula, electric hot plate, and torsion balance, sample size 100 g.; procedure takes 15 minutes.

APPENDIX

SOIL STABILIZING CHEMICALS

The underlined numbers listed below correspond to those preceding references in the Bibliography.

Abietic Acid, 283

Aerotil (American Cyanamid Co.), 168, American Cyanamid Co.: Aerotil Soil Conditioner.

Aggrecote 600 (Minnesota Mining & Manufacturing Co.), 283.

Aluminum Sulfate, 283

Amberlite PR-115 (Rohm and Haas Co.), 283, Rohm and Haas Co.: Technical Bulletin of Amberlite PR-115.

Amine 200 (Carbide and Carbon Chemicals Co.), 125, 126, Carbide and Carbon Co.: Technical Information on Cationic Amine 200.

Ammonyx T (Onyx Oil and Chemicals Co.), 126, Onyx Oil and Chemicals Co.: Technical Information on Ammonyx T.

Aniline, 283.

Aniline-Furfural, 181, 262, 283, 520.

Armac T (Armour & Co.), 126, Armour & Co.: Surface Treatment with the Armeens and Armacs.

Armac 12 D (Armour & Co.), 126, Armour & Co.: Surface Treatment with the Armeens and Armacs.

Armac 18 D (Armour & Co.), 126, Armour & Co.: Surface Treatment with the Armeens and Armacs.

Armour Amine 1180-B (Armour & Co.), 283.

Aroclor 1168 (Monsanto Chemical Co.), 283.

Aroclor 1170 (Monsanto Chemical Co.), 283.