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A RESEARCH STUDY ON SOIL
STABILIZATION

Thesis for the Degree of B. S.
MICHIGAN STATE COLLEGE

G. C. Blomquist
1940



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**A Research Study on Soil
Stabilization**

**A Thesis Submitted to
The Faculty of
MICHIGAN STATE COLLEGE
of
AGRICULTURE AND APPLIED SCIENCE**

by

G. C. Blomquist

**Candidate for the Degree of
Bachelor of Science**

June 1940

THESIS

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Part 1.

INTRODUCTION

This report is the result of a study of the factors that influence the service behavior of stabilized and surface consolidated soil-aggregate mixtures when calcium chloride is used either as an admixture or as a surface application or both. The experiment will be carried on in conjunction with the Michigan State College and the Research Division of the Michigan State Highway Department, who desire information regarding this type of road materials for maintenance of secondary roads with a decreased expense.

Highway development, during the recent years, has been toward the improvement of secondary roads. The rural residents are no more pleading for, but are demanding, year around road service, and as a result of these pleas and demands the highway departments are trying to find a type of road surfacing to fulfill it. Before any appreciable progress can be made on this type of roads, there is the problem of finding a low-cost type of surfacing.

Prominent in the field of low-cost construction is the stabilized wearing course, made up of a balanced mixture of aggregate, sand, clay, silt, with an admixture of some moisture retentative chemical for maintaining the moisture content in the mixture. This type of construction is very good both from the engineering and economic standpoint. These surfaces will provide an adequate and very satisfactory secondary road, and will also provide a very good base for later construction of higher type roads.

It is the aim of this report to afford and discover practical and serviceable information to the above mentioned cooperative agencies, and also to the engineer and contractor in road design, construction and maintenance.

Part 11

PRINCIPLES OF STABILIZATION

Stability is the resistance to lateral flow when loaded. This principle, in the case of road stability, is mainly dependent on the shear strength of the road metal, and the shear strength is controlled by the amount of internal friction and the cohesive properties of the materials.

The adoption of these principles in the construction of low cost roads should not be thought of as something entirely new, but rather an old principle with new ideas added to it. Low-cost roads have been built for many years and have been successful as far as practical, but due to the concentration of the construction of primary roads, there is a general lack of interest in the secondary road types. The road building in the secondary class were carried on in such a manner and with such plans that if a road was a success it was more accidental than intentional.

The application of the principles of stabilization to low-cost roads overcomes the faults with the secondary type roads and assures quality by properly combining the graded aggregates and materials to produce a stable road mixture.

In a stabilized road the function of the coarse aggregate is mainly to resist the wear of the heavy traffic the road will carry, the combination of the fine and coarse aggregate furnished the internal friction and the binder soil supplies the cohesion with a properly controlled moisture content.

Part 111

Stability is an old English word which, Webster informs us, means "having the properties of durability, permanency, fixity or of standing firm in place". From this it can readily be seen that stabilization as applied to soils, or to a combination of soil aggregates, is the resistance to flow laterally when loaded. The principle of stability is mainly dependent on the shear strength of the road metal, and the shear strength is dependent on the internal friction and the cohesive properties of the soil. Stabilization is the adoption of the recognised principals of soil mixture for acquiring the maximum density and durability after proper compaction.

Stabilization has been a practice on roads for a number of years, but their success fell far short of the value of the roads. Sand-clay roads were about the first type of stabilized roads that were built. They applied the principles of stabilization unknowingly. They used the sand for supporting and the clay for the binder or cementing value. This type of road was satisfactory without radical climate changes and under light traffic.

The next type of road to be tried was a combination of sand, clay, gravel or crushed stone. The addition of the gravel or crushed stone increased the stability and also the wearing quality of the road surface. At this stage of the development the value of gradation was realized.

With increasing investigation, it was found that certain clays served to lubricate, instead of bind, the larger particles. The lubrications of the clays vary with the molecular composition of the clay particles.

Commercial interests came into the picture and research projects were studied on the value of chemical admixtures to control the moisture content in the mixtures. The admixtures were found to aid in the high degree of compaction and retaining the quality over a long period of time. The action of the water, even after heavy rains was found to be negligible except for a fraction of an inch at the surface of the road metal.

With all of the experimentation it was found that regardless of the type of stabilization to be practiced there were basic principles that must be followed. A uniformly graded mixture from the maximum to the extreme fines is required. The larger percentage of any one size of particles the more void space there will be and as a result less stability.

It has been found from experiments that mixtures showing alkaline characteristics are more effective in stabilization than those which are acid.

There is a definite and extreme necessity of the control of moisture in the sub-surface of a stabilized road. One of the first investigations in a road project should be to determine the free moisture variations over different seasons of the year and the control of the extremes in the variations. There should be means of controlling underground water sources and surface water.

In a stabilized road, the selection of the material is an essential consideration and should be carefully considered. The aggregate from a local source may have the desirable physical characteristics - that is, hardness, toughness, and ability to resist wear - but yet be so sized that additional material to correct the deficiencies will have to be obtained from other sources.

Either gravel or stone can be used and a binder soil to produce the proper density. Many times pit run gravel can be found to fit the requirements with only the addition of a small amount of clay and fines.

While the stability of a cohesionless material may be less than 500 pounds per square foot and the binder soil will have a supporting value of 5,000 pounds per square foot, the proper combination of the two will give a mixture that will have a supporting value of more than 1,700 pounds per square foot. The internal friction is furnished by the sand, gravel, slag or crushed stone, which is usually referred to as the coarse aggregate.

Cohesion is furnished by colloidal clays and moisture films in the top soil, sand-clay, light textured soils and moisture film alone.

Whether the mixture of granular materials becomes a stabilized subgrade, soil road surface, or a higher type pavement, the grading and the method of construction are of greater importance than the kind of materials used or on the basic theory.

Regardless of the type of construction the ultimate stability of the mixture depends upon the permanent adhesive strength which can be developed by the binder films between the soil particles. This strength depends not only on the characteristics of the moisture or chemical admixtures, but also depends on the composition of the soil particles and films of gas surrounding it or other substances which may cover the soil particles.

The wetting power of a soil is an important factor in stabilization. The greater the adhesion, the higher the moisture will rise above the water table. The high tensile strength of water caused the moisture to be drawn up into the soil as a surface coating film for the particles, acting as rubber diaphragms to hold the particles in place. The smaller the pores

the higher moisture will rise in the soil due to adhesive attraction. This adhesive action is very important in soil stabilization and the use of chemical admixtures, mechanical consolidation and water proof coverings are used to aid it and provide the necessary conditions.

Some of the admixtures used are; properly proportioned soil materials, deliquescent chemicals to provide moisture films, chemicals to act to replace air films surrounding the particles with moisture films.

The consolidation required to furnish a well compacted mixture of graded aggregates is obtained by rolling during construction and by the action of traffic afterward.

The graded materials required to make a firm and well stabilized road consist of a coarse aggregate and a soil mortar. The coarse aggregate is that portion of the sample passing a No. 10 and retained on a No. 40 sieve, and contains natural gravel or supplemented with crushed stone or slag. The binder soil is all material passing a No. 40 sieve. The binder soil is silt, clay and colloidal material. The coarse aggregate acts as a bed for other materials and furnishes desired hardness and structural strength, the finer sand is a filler in voids of coarse aggregate, the silt is a filler to keep particles from rocking and clay and colloids furnish pores small enough for moisture films to cause cohesion necessary.

Satisfactory mixtures are designed to have interlocking grains and capillary moisture forces sufficient to furnish the mixture with high stability during wet weather and enough cohesion in the binder soil to maintain the integrity of the surface during dry seasons. The degree of satisfaction of mixtures to meet those requirements are indicated by the plasticity limits of all the soil passing a No. 40 sieve.

Liquid limits of 25-35 indicate the properties of capillarity in the soil that will serve for a satisfactory binder soil.

The greater the plasticity index of a soil will show greater presence of clays that will furnish cohesion, therefore, the greater the plasticity index the higher the cohesion. Plasticity indexes of 3 or less will be satisfactory for wet conditions, 3-9 under average moisture and 9-15 under arid conditions.

Absence of moisture films in a road surface will cause raveling and dust while too much moisture will cause rutting. The more a road surface dries out by evaporation the wetter future rains will make it.

Another reason soil road surfaces should retain moisture is that most of them are compacted partly by traffic. When the surfaces are allowed to dry out a large amount of the binder soil is lost by dust action and raveling action. If the moisture films are between the particles of soil compaction will progress and the soil particles will wedge themselves together. As the soil particles get closer together the cohesion increases and the graded mixture becomes a soil road surface closely bound.

Calcium chloride is the principal chemical used as a moisture retentive in soil stabilized roads. The hygroscopic properties of the chloride cause it to take moisture from the air during periods of high humidity and also slows up the action of evaporation of moisture from the soil. Calcium chloride aids in the compaction by retaining the moisture. The high density attained is shown by weight of 150 pounds per cubic foot for wearing courses treated with calcium chloride.

There is an optimum moisture content that will achieve the highest density and the greatest degree of compaction. This condition can be determined in the laboratory by the Proctor tests.

The stabilized material may either be mixed on the road by scarifying the existing road surface and adding needed ingredients for a stabilized surface or the materials may be mixed in a mixing plant and spread on the road surface ready for compaction. The calcium chloride is added to the mixture at the rate of about 1/2 pound per square yard per inch of thickness and then about 1/2 pound per square yard on surface later.

Any maintenance of a soil stabilized road should be done following a rain since it will soften the road metal so it can be worked without tearing up the surface, and also since the chloride solution will penetrate farther into the road following a rain and in this way the calcium chloride will not be exposed to the surface to be wasted.

Calcium chloride should be added in light applications to the road surface two or three times a year. About two pounds per square yard is added each year. The chloride should be added either following a rain or in the early morning to allow it to be used effectively and be able to absorb moisture easily.

The economic advantage of constructing stabilized roads seem to deem their value along with higher type construction and roads. With this type of construction the money for roads can be better utilized and cover more miles of secondary type roads.

Part 1V

OUTLINE OF PROCEDURE

A. EQUIPMENT

1. Circular test track and treadometer in the Highway Department Research Laboratory.
2. Soil testing equipment in the Highway Research Laboratory.
 - (a) Proctor tests equipment
 - (b) Mechanical analysis equipment
 - (c) Liquid limit equipment
 - (d) Ovens and equipment for determination of shrinkage limit.
3. Hydraulic stability testing machine, furnished by Calcium Chloride Association.
4. Camera and equipment for taking progressive pictures of the track tests.
5. Profilometer, or some device designed to determine the longitudinal and sectional profile of the track as the test progresses.

B. RECONSTRUCTION OF THE TEST TRACK AND TREADOMETER

1. Center to be taken from track to provide a cistern in the track section for a supply of water, and will enter from the bottom of the track sections. Drawing included to show finished section.
2. Some alterations are to be arranged for on the treadometer in the driving gears to silence them and also to eliminate jerking and jumping of the treadometer.
 - (a) Use balloon type tire
 - (b) New gear box
 - (c) New arrangement of gear ratio for drive

A. Materials

1. Coarse Aggregate - All coarse aggregate will conform to Michigan State Highway Department Specifications.
 - (a) Gravel aggregate
 - (b) Crushed stone aggregate
 - (c) Obtained pit run and graded in laboratory.
2. Fine Aggregate - All fine aggregate will conform to Michigan State Highway Department Specifications.
 - (a) Natural sand will be used
 - (b) Obtained from local source
3. Binder Soil - Binder soil will conform to Michigan State Highway Department Specifications.
 - (a) Binder soils will be from different sources to have different compositions.
 - (b) Plasticity indexes of the binder soils will be kept within a practical range.
4. Calcium Chloride - As specified by the Calcium Chloride Association.

B. PREPARATION OF MATERIALS

1. Coarse Aggregate - Will be kept in stock and will be graded into different screen sizes (1", 3/4", 1/2" and No. 4)
2. Sand - Will be in stock and will be graded into screen sizes of (No. 4, No. 10, No. 40 and No. 100) and stored in convenient form and place.
3. Binder Soil - Will be in stock and will have plasticity indexes such as to give 0, 5, 8 and 9 plasticity indexes to the resultant stabilized mixture, which also shall have a dust ratio for the four sections of 52, 49, 63 and 51 respectfully. Binder soil will be stored in a dry place in bags.

4. Calcium Chloride - Flake chloride will be in bags and kept in a dry place for future use on track tests.
5. Final base course mixture - Will conform to the following:

Sect. No.	Gradation - Percent Passing						Dust Ratio	P.I.
	1"	3/4"	No. 4	No. 10	No. 40	No. 200		
1	100	98	80	69	46	24	52	0
2	100	93	62	48	31	15	49	5
3	100	79	42	32	20	12	63	8
4	100	98	84	65	48	25	51	9

C. PHYSICAL TESTS TO BE CONDUCTED

1. Coarse Aggregate - The following physical tests will be performed
 - (a) Sieve analysis
 - (b) Absorption
 - (c) Specific gravity
 - (d) Fineness Modulus
2. Fine Aggregate - The following tests will be conducted on the fine aggregate
 - (a) Sieve analysis
 - (b) Absorption
 - (c) Specific gravity
 - (d) Fineness Modulus
 - (e) Percent silt and clay
3. Binder Soil - The following soil tests will be conducted on the binder soil:
 - (a) Liquid limit
 - (b) Plastic limit

- (c) Shrinkage limit
- (d) Field moisture equivalent
- (e) Shear strength
- (f) Compaction (Proctor test)

4. Calcium Chloride - Should meet requirements of the A.S.T.M.

D. SUBGRADE STUDY

Purpose: To determine best graded mixture and rate of compaction for a subgrade under tests.

1. Mixing the materials

- (a) Mix materials thoroughly in concrete mixer.
- (b) Add any admixtures to mixture and mix them thoroughly in mixer.

2. Placing material and compaction

- (a) Split sample in two portions and store half for later tests
- (b) Divide track into four sections in some convenient arrangement with means of keeping sections separated.
- (c) Place material in track, on top of 12" of coarse gravel in bottom, in two layers and compact it with regulated traffic. Add layers with compacting until within 3" - 4" from top of track walls.
- (d) Moisten mixture, before placing it in the track, to aid in compaction.
- (e) Continue compaction until sections show failure or complete compaction with no further subsidence.
- (f) Determine best sections with continued regulated traffic and then fill track with mixture of best sections and repeat building up process to subgrade for further tests.

- (g) Control temperature and humidity in room with test track.
- (h) Use sections in track with calcium chloride admixture as comparison with subgrade materials, without chloride.
- (i) Vary the water level in the track and note the action on sections at different elevations.
- (j) Trim sections smooth for the application of the road metal for further tests.

3. Subgrade study tests

- (a) Shear test with hydraulic shear testing machine
- (b) Wear test
- (c) Tests on water content
- (d) Rate of compaction by record with profilometer

4. Sub-base variations

- (a) Add chloride to portion of exact sample and run same operation again for comparison without calcium chloride
- (b) Use portion of same sub-base material and run tests on it with surface stabilization. Use same procedure as in previous experiment with same tests.

E. ROAD METAL

Purpose: To test different graded mixtures and determine the effects of admixtures of chloride in varying amounts on action.

1. Mixing

- (a) Mix materials thoroughly by blading materials with a spade.
- (b) Add water sufficient to dissolve calcium chloride and in amount to bring mixture to it's optimum moisture content predetermined by the Proctor test.
- (c) Vary amounts of calcium chloride in mixtures to get relative comparison and results.

2. Placing material and compaction

- (a) The mixture is added to the compacted subgrade in sufficient amount to have 1-1/2" of road metal when compacted.
- (b) Surface is compacted with pneumatic tire and uniformly distributed traffic until no subsidence is noted and then sections are in condition suitable to testing.

3. Tests on track with continued traffic

- (a) Rate of compaction should be noted at intervals and recorded
- (b) Profile of track, longitudinal and sectional, should be recorded.
- (c) Pitting action and loss of material should be noted.
- (d) Drying out and raveling of surface should be noted.
- (e) Action of artificial rain action should be tried and reaction to surface noted.
- (f) Vary height of the water table and note action of the road metal at the different heights.
- (g) Test sections with hydraulic stability machine designed by Mr. Fred Burggraf.
- (h) Add bar to track to give bumping action and cause chatter bumps and give impact.
- (i) Vary thickness of a stabilized base and also the thickness of the seal coat to give comparative results of the value of heavy coating and thin base or thin coating and heavy stabilized base

Section 11

FIELD STUDY

PURPOSE: To study stabilized gravel road in place for the purpose of correlating test track results with field conditions.

A. Survey of certain existing gravel roads

1. Observations to be made
 - a. General surface conditions
 - b. Failures
 - c. Subgrade condition
 - d. Shoulder condition
 - e. Drainage

B. Selection of gravel roads to be studied

1. With relation to geographic position
2. With relation to traffic count
3. With relation to materials
4. With relation to degree of maintenance care they have received
5. With relation to type of construction
6. With relation to appreciation of chemical conditions
7. With relation to public reaction.

C. Factors to be studied

1. Road failures and Causes
2. Maintenance
3. Physical characteristics
 - a. Condition when wet
 - b. Condition when dry
 - c. Calcium chloride content

d. Moisture and density

e. Gradation

f. Plasticity Index

D. Track tests on materials

1. Sample of road to fill sections of track will be sent to laboratory and tested there to determine deficiencies.
2. Carry same procedure as described in laboratory work on track tests.
3. Make necessary corrections in mixture to provide satisfactory stabilized road and proceed with tests on test track under conditions that gave poor results in the field.

Part V.

MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 3/27/40

ABSTRACTS

Subject: Subgrade Stabilization

Purpose: Study on Research Problem

Reference:

Author: Arthur R. Smith

Title: The ABC's of Soil Stabilization

Source: Burton Publishing Co. (Reprint)

Date: June 1938- January 1939 inc.

Volume and page: The Earth Remover and Road Builder

Contents:

- (1) General discussion of terms applying to stabilization of soils.
- (2) Drainage of soils and values of drainage to soils stabilization.
- (3) Soil identification and the grouping of soils.
- (4) Importance of gradation of soils and Stabilized mixtures.
- (5) Importance of stabilization and tests to determine varying properties of the soils that affect stabilization.

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that every entry, no matter how small, should be recorded to ensure the integrity of the financial data. This includes not only sales and purchases but also expenses and income.

The second part of the document provides a detailed breakdown of the company's financial performance over the past year. It includes a comparison of actual results against budgeted figures, highlighting areas of both success and improvement. The analysis shows that while sales were slightly below target, operating expenses were well-controlled, leading to a positive contribution margin.

The third part of the document outlines the company's financial strategy for the upcoming year. It focuses on increasing revenue through new product lines and expanding into new markets. Simultaneously, it aims to optimize costs by negotiating better terms with suppliers and improving operational efficiency.

The fourth part of the document presents a summary of the company's overall financial health. It notes that the company remains in a strong position, with a solid balance sheet and a healthy cash flow. The management team is confident in the company's ability to meet its financial goals and maintain its competitive edge in the market.

MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date #3/27/40

ABSTRACTS

Subject: Stabilizing Effects of Calcium Chloride

Purpose: Study on Research Problem.

Reference:

Author: Calcium Chloride Association Bulletin.

Title: Stabilizing Effects of Calcium Chloride.

Source: Calcium Chloride Association Bulletin.

Date: April 1938

Volume and page: Brief No. 134

Contents:

(1) Increasing Density by using calcium chloride in soil stabilization.

(2) Increase compaction by retaining moisture in the soil and therefore getting progressive consolidation.

(3) Adding calcium chloride will give base stability and add additional strength to the graded material.

(4) Calcium chloride added may determine success or failure of the road.

MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 3/22/40

ABSTRACTS

Subject: Calcium Chloride Stabilization.

Purpose: Study on Research Problem.

Reference:

Author: Arranged by Fred Purggraf.

Title: Soil Mechanics & Soil Stabilization.

Source: Proceedings Eighth Annual Meeting of Highway Research Board.

Date: 1933

Volume and page: Part 2 pp. 209 - 256

Contents:

- (1) Study of principals of stabilization.
- (2) Designing mixtures of soil and calcium chloride for stabilization.
- (3) Properties of calcium chloride and functions in stabilization.
 - (a) Moisture attraction.
 - (b) Vapor Pressure.
 - (c) Surface tension.
 - (d) Binding properties.
 - (e) Effects on density of mixtures.
- (4) Surface consolidation.
- (5) Design stabilized roads.
 - (a) Mixing plants.
 - (b) Methods of using and amount of calcium chloride used.
 - (c) Compaction methods.
 - (d) Crown design.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the integrity of the financial system and for the ability to detect and prevent fraud.

2. The second part of the document outlines the specific procedures for recording transactions. It details the steps involved in the accounting cycle, from identifying the transaction to posting it to the appropriate ledger account.

3. The third part of the document discusses the role of the auditor in verifying the accuracy of the records. It describes the various techniques used by auditors to test the reliability of the data and to ensure that the financial statements are presented fairly.

4. The fourth part of the document addresses the issue of internal controls. It explains how a well-designed system of internal controls can help to minimize the risk of error and to ensure that the organization's assets are protected.

5. The fifth part of the document discusses the importance of transparency and accountability in financial reporting. It argues that organizations should be open and honest about their financial performance and should provide clear and concise information to their stakeholders.

MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 5/28/40

ABSTRACTS

Subject: Stabilization with calcium chloride.

Purpose: Study on Research Problem.

Reference:

Author: _____

Title: 1939 Frought States more Miles of Better roads for Less Money

Source: Calcium Chloride Association News.

Date: January & February 1940

Volume and page: _____

Contents:

Photographic study and discussion of typical surface
consolidation and stabilizing effects on experimental roads.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that this is essential for ensuring transparency and accountability in the organization's operations.

2. The second part of the document outlines the various methods and tools used to collect and analyze data. It highlights the need for a systematic approach to data collection and the importance of using reliable sources of information.

3. The third part of the document describes the process of identifying and addressing potential risks and challenges. It stresses the importance of proactive risk management and the need to develop effective strategies to mitigate potential threats.

4. The fourth part of the document discusses the role of communication and collaboration in achieving the organization's goals. It emphasizes the importance of clear communication and the need for all team members to work together effectively.

5. The fifth part of the document outlines the various metrics and indicators used to measure the organization's performance. It highlights the need for a balanced scorecard approach that takes into account both financial and non-financial factors.

6. The sixth part of the document describes the process of reviewing and evaluating the organization's progress. It stresses the importance of regular reviews and the need to use the results of these reviews to inform decision-making and improve performance.

7. The seventh part of the document discusses the importance of continuous improvement and the need to seek out new opportunities for growth and innovation. It emphasizes the importance of a culture of learning and the need to embrace change and innovation.

8. The eighth part of the document outlines the various challenges and obstacles that the organization may face. It highlights the need for a proactive approach to problem-solving and the importance of developing effective strategies to overcome these challenges.

9. The ninth part of the document discusses the importance of maintaining a strong relationship with stakeholders and the need to communicate effectively with all parties involved. It emphasizes the importance of transparency and the need to build trust and credibility.

10. The tenth part of the document outlines the various conclusions and recommendations that have been drawn from the analysis. It stresses the importance of implementing these recommendations and the need for ongoing monitoring and evaluation.

MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 4/1/40

ABSTRACTS

Subject: Stabilized Road Surfaces.

Purpose: Study of Research Problem.

Reference:

Author: Project Committee on Stabilized Road Surfaces.

Title: Highway Research Board

Source: Highway Research Information Service.

Date: 1935

Volume and page: _____

Contents:

(1) Study of general theory of soil stabilization.

(2) Design of soil mixtures for stabilized road surfaces.

(3) Treatment for soils with calcium chloride.

(a) Calcium chloride as a dust layer.

(b) Construction principals with calcium chloride
as an admixture.

(c) Control of loose mulch on the stabilized mulch.

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MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 4/2/40

ABSTRACTS

Subject: Stabilization with Aggregates, Binder soil & Calcium Chloride.

Purpose: Study on Research Problem.

Reference:

Author: Calcium Chloride Association.

Title: Low Cost Roads.

Source: Calcium Chloride Association.

Date: 1939 Edition.

Volume and page: Bulletin No. 25

Contents:

(1) Principals of stabilization of soils.

(a) Specifications.

(2) Designing mixtures of stabilized Materials.

(a) Calcium chloride admixtures.

(b) Calcium chloride surface applications.

(3) Construction principals of stabilized road surfaces.

(a) Road mixing.

(b) Plant mixing.

(c) Drainage methods.

(4) Maintenance of stabilized roads.

(a) Application of calcium chloride.

(b) Patching.

(c) Shoulder maintenance.

(5) Values of stabilized roads.

(6) Properties of calcium chloride in connection to road
stabilization.

(7) Standard specifications and tests of soils.

[illegible]

MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 4/2/40

ABSTRACTS

Subject: Stabilization of soils.

Purpose: Study of Research Problem.

Reference:

Author: R. W. Miller.

Title: Effects of Quality of Clay on Soil Mortar.

Source: Highway Research Board.

Date: November 1936

Volume and page: _____

Contents:

Correlation of swell tests and compaction tests, with
plasticity index, on stabilized road soils.

The maximum plasticity index depends on clay binder soil
which is being used.

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MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 4/8/40

ABSTRACTS

Subject: Road Stability.

Purpose: Study on Research Problem.

Reference:

Author: Fred Burggraf

Title: Stabilisation with Calcium Chloride.

Source: Calcium Chloride Association Bulletin.

Date: 1939

Volume and page: _____

Contents:

The major advancement in the stabilized road composition with calcium chloride is the joint importance of gradation and the plastic properties of the silt and soils passing the no. 40 sieve. The upper limit of the plasticity index used should be about 6, and the amount of fines should be lowered. The relative stability varies with the moisture content.

There are two methods of construction; (1) surface consolidation, (2) Stabilization.

The addition of calcium chloride to the soil will increase the density appreciably and will also speed up the compaction.

Calcium chloride treatment saved about 60% on the loss of road metal due to raveling and dust losses on an experiment run in conjunction with the University of Michigan on their tests.

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STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 4/3/40

ABSTRACTS

Subject: Use of Calcium Chloride on Highways

Purpose: Study on ^h research problem.

Reference:

Author: T. W. Delahanty

Title: Chemical Products & Highway Progress.

Source: Chemicals

Date: January 12, 1931

Volume and page: Page 10

Contents:

Calcium Chloride was originally used as a curing agent in concrete and for a dust palliative on highways. Calcium Chloride is now coming into use as a binder in gravel roads and as a stabilizer.

The production of calcium chloride increased from 45,000 tons in 1914 to 200,000 tons in 1930. The original cost of calcium chloride was \$40-\$50 per ton and it is now only \$20-\$23 per ton.

Canada imported calcium chloride from the United States for the use of highway maintenance.

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RESEARCH DIVISION

Project
No. _____

Date 4/3/40

ABSTRACTS

Subject: Calcium Chloride for Construction & Maintenance.

Purpose: Study on Research Problem.

References:

Author: H. F. Clemmer

Title: Use of Calcium Chloride in Construction and Maintenance

Source: Roads & Streets

Date: December 1932

Volume and page: Vol. 75 pp. 497 - 8

Contents:

Calcium Chloride carries a direct value as a stabilizer on gravel roads and soil combinations.

Calcium Chloride is valuable as a dustpallative since it retains moisture and has a natural affinity for water. Calcium Chloride solution has a low vapor pressure as compared with water and this accounts for the slow evaporation.

Calcium Chloride is lost from the roads through three methods which are (1) Rainfall, (2) Chemical reaction with the soil (base exchange), (3) Maintenance manipulation. Calcium chloride is a practically intractable material if taken care of properly.

Calcium chloride flocculates soils thus bringing small particles together, giving permeable soil, and in this way it reduces the loss of the road metal by dust or rutting and raveling.

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Project
No. _____

Date 4/3/40

ABSTRACTS

Subject: Roadway Stability.

Purpose: Study on Research Problem.

Reference:

Author: H.F. Clemmer.

Title: Road Stability using Calcium Chloride.

Source: Roads & Streets.

Date: May 1933

Volume and page: Vol. 76, pp. 184-6

Contents: Road stability required a graded granular aggregate with binder soil. The binder consists of inner filler and cohesive cement. Silt is a good filler for soil road slabs since it does not expand much on moisture change and is fairly stable in the particles themselves. Collioids furnish cement for the granular soil particles.

The Calcium chloride added to maintain moisture in the soil, thus aiding in the stabilizing action of the soil, and it also reduces losses of dust and road metal considerably.

The losses of the calcium chloride is due to chemical action in the soil and is dependent on soil acidity, losses due to rain and the maintenance manipulation. Maintenance should be carried on following a rain when calcium chloride layer is down below surface considerable.

The amount of binder soil used in road metal is dependent on expansive properties of binder soil so as to fill the voids to a maximum.

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Project
No. _____

Date 4/4/40

ABSTRACTS

Subject: Calcium Chloride Stabilizations.

Purpose: Study on Research Problem.

References:

Author: C. A. Hogentogler, Jr.

Title: Stabilization of low cost Roads by Calcium Chloride.

Source: Roads & Streets.

Date: October 1933

Volume and page: Vol. 76 pp 359 - 60

Contents: Low cost roads consist of granular particles and silt filler with clay binder soil to furnish the cohesive properties within the structure.

The absence of water within the road and on the surface causes ravelling and rutting of the surface. The proper gradation of granular soil particles & binder soil with proper proportions of moisture stabilizing chemicals will give a stabilized road surface.

Stability is defined as the resistance of a road metal to rutting and ravelling.

The weight of the soil particles has a definite bearing on the stabilizing power of given soil mixtures.

The moisture film between particles is the factor with which high stability in soil structures are determined. Moisture films have produced higher pressures in soils than can be attained with mechanical means on the same soil sample.

The Calcium Chloride is added to soil mixture to retain soil moisture & absorb moisture from the air for storage in the maintenance of the road metal.

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STATE HIGHWAY DEPARTMENTMurray D. Van Wagoner
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RESEARCH DIVISION

Project
No. _____Date 4/4/40

ABSTRACTS

Subject: Soil Moisture ObtainencePurpose: Study on Research Problem.

Reference:

Author: _____

Title: Chemical "Rainmaker" Helps Modern Highways.Source: Scientific AmericanDate: September 1930Volume and page: Volume 143, pp. 218

Contents:

Chemical "Rainmaker" in the form of calcium chlorldie is used to draw moisture from the air, even on the hottest and driest days, to be used in the soils. The chemical acts during the periods when the humidity is high to collect mositure and hold it for later use in use as a dust pallative and also for use as a binding moisture film to increase the stability of the soil structure.

The usual procedure is two applications during hot summer months to the road surface and this will give the same effect as a shower each day as far as the dust preventive power is concerned, and will also give the required amount for the stabalizing qualities desired.

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Project
No. _____

Date 4/4/40

ABSTRACTS

Subject: Stabilization of Soils.

Purpose: Study on Research Problem.

Reference:

Author: Ray A. Giddings.

Title: Soil Concrete.

Source: Chemicals.

Date: September 18, 1933

Volume and page: pp. 9

Contents:

Stability and durability are the primary requisites of a good surfaced highway.

Soil concrete is an intimate mixture of natural graded soils proportioned so as to give the maximum density and stability. The stability of a simple structure of soil depends directly on the soil mortar, or the portion as used that passes a number ten sieve.

The primary factors in stability are, (1) Internal friction, (2) cohesion.

Calcium chloride used on soils to build up and maintain the very essential property of water films between soil particles to maintain stability at all times.

Roads treated with calcium chloride should not be scarred or bladed except after rain when the chloride layer, has gone down considerably below the road metal.

2. Theoretical Framework

3. Methodology

4. Results and Discussion

5. Conclusion

6. References

7. Appendix

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No. _____

Date 4/4/40

ABSTRACTS

Subject: Soil Stabilization

Purpose: Study on "Research Problem."

References:

Author: _____

Title: Chemicals in Highway Construction.

Source: Chemicals.

Date: January 18, 1932

Volume and page: Page 3

Contents:

Calcium chloride has been used as a dust pallative for many years, and throught its use as a dust pallative it has been found usfull as a binder in sand and gravel roads.

Calcium chloride is exported into foreign countries for use in road building and soil stabilization. In 1930 42,700,000 pounds were exported to Canada for road building purposes.

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No. _____

Date 4/5/40

ABSTRACTS

Subject: Road Stabilization
Purpose: Study on Research Problem.
Reference:
Author: R. P. Traver,
Title: Low cost Stabilized Road Construction in Onondaga County, N.Y.
Source: Roads and Streets.
Date: March 1934
Volume and page: Page 120 -24

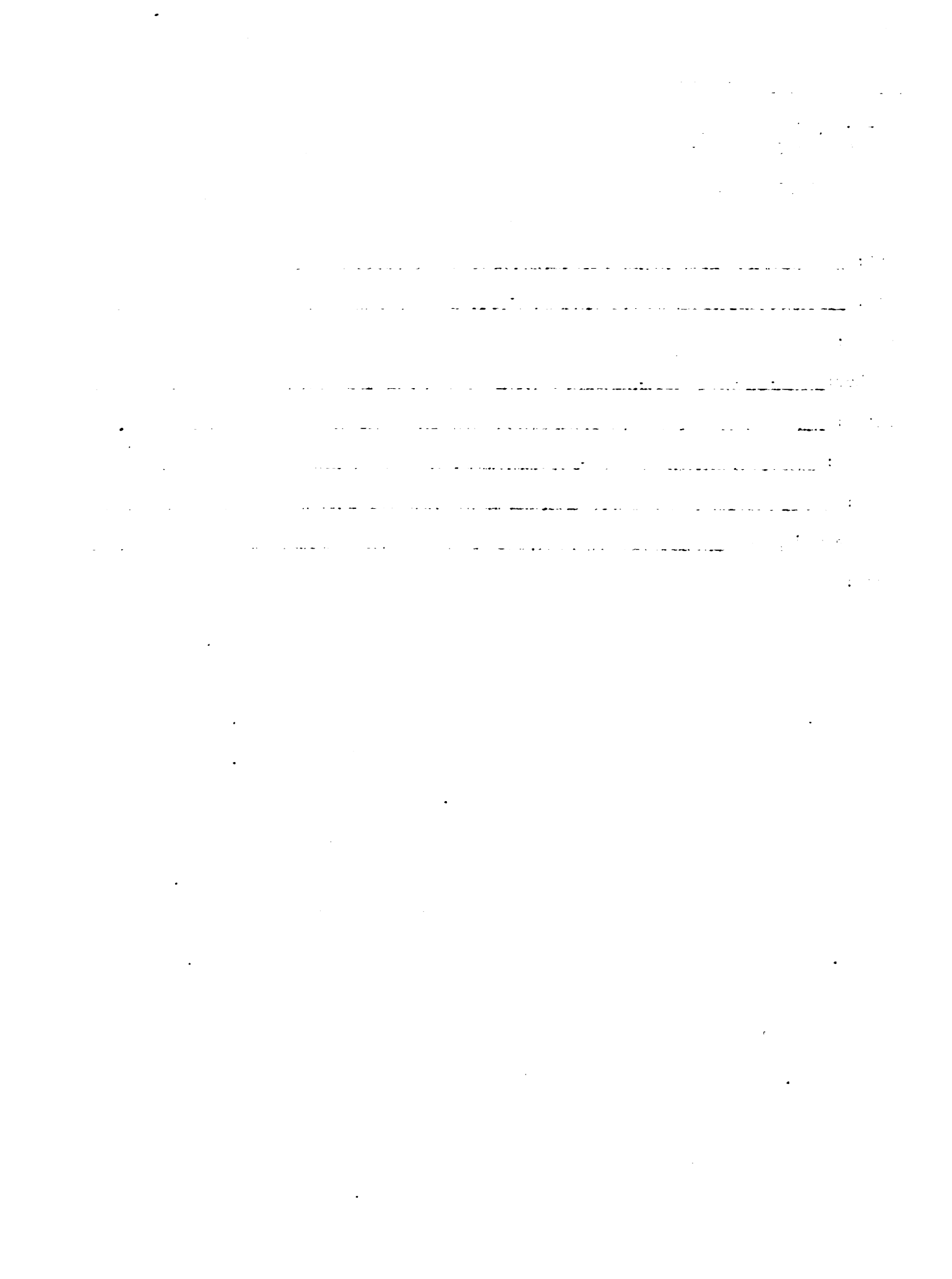
Contents:

Stabilized gravel roads are used in sections where concrete isn't practical but road improvements are necessary.

Stabilized gravel roads are a combination of coarse gravel, fine aggregate, silt, clay and calcium chloride. Ample drainage is a very important factor in stabilized roads.

Material in the base coarse, passing a forty mesh sieve, should have a plasticity index between 8 and 12, since the plastic index is a measure of the cohesive properties of the mixutre. The function of the gravel is to give rigidity and high internal friction, the fine sand fills the voids in the coarse aggregate, the silt has capillary properties and serves as a reservoir for the calcium chloride solution, and the clay in the mixutre supplies the cohesion. The clay also acts as a reservoir for the calcium chloride.

When the road has to much coarse material on it some of the sholder material, if suitable may be bladed in, and if not suitable material for the addition has to be hauled in.



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with ordinary type gravel roads. It is very important that stabilized gravel roads be maintained at the proper time. Patching done with mixture of clay, sand, chloride, close to mixture of original preparation used.

Blading should be done only following a rain when the calcium chloride has gone into the road metal considerably.

An advantage of stabilization is the increased benefits obtained from the use of calcium chloride, by two or three applications and will act as a dust palliative for the entire year.

4/5/40

Subject: Road Stabilization

Purpose: Study on Research Problem.

Author: Walter O. Dow.

Title: Method and Cost of Stabilization of gravel Roads in a Mich. County.

Source: Roads & Streets.

Date: May 1934

Volume and page: Vol. 77, pp. 203 - 6

Contents:-

Stabilization of loose gravel roads by the addition of clay and silt with applications of calcium chloride. Drainage is of prime importance and should be carefully exercised on a stabilized road project.

Soil samples taken from road and are tested in the laboratory to determine what was needed for the stabilization of the soil. The plasticity index of the soil mixture should range between 5 - 10.

Clay and gravel should be thoroughly mixed on the road bed and spread out uniformly on the surface. The road should be shaped with a crown at least of $\frac{1}{8}$ " per foot and up to $\frac{3}{4}$ " per foot. When the final shaping is done the calcium chloride is added at about $\frac{1}{2}$ cu. foot per sq. yd., and it will absorb moisture which will be used to aid in the process of compaction.

Maintenance cost on stabilized road is very low compared

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Date 4/8/40

ABSTRACTS

Subject: Admixtures for Frost Prevention.

Purpose: Study on Research Problem.

Reference:

Author: H.H. Miller & Don W. Smaith.

Title: Methods for Prevention of Road Failures due to Frost.

Source: Roads & Streets.

Date: June, 1934

Volume and page: Vol. 77 pp.210 - 21

Contents:

Failure of the road surfaces are due to the lateral or vertical flow of the subgrade. Failures are also due to frost action and they are vertical flow.

There are two methods of applying calcium chloride to the road subgrade; (1) drilling holes in the road metal and about 2 ft. deep and filling them with a mixture of pea gravel and calcium chloride. The holes are spaced uniformly on the road surface so the entire road is serviced by at least one of the wells of chloride and pea gravel, (2) pumping solution of calcium chloride under the road to prevent frost action. This operation is done during the winter and has proven very successful. The first method is the best and the most practiced method of the two mentioned.

These methods also serve as aids to stabilization of the soils by the addition of the calcium chloride.

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a proper amount of cohesive material such as clay, is kept constantly damp, it consolidates and hardens under traffic and continues highly stable against lateral displacement. The function of the calcium chloride is to retain moisture in the soil.

The stability of a soil to lateral displacement is a direct function of the internal friction and cohesion. The clay supplies the direct cohesion and it is a maximum when each particle is surrounded with a film of water.

Losses of calcium chloride due to (1) base exchange, (2) washing out by rain, (3) improper maintenance methods.

Calcium chloride when applied to a stabilized road surface acts as a primer to attract moisture into the capillary ducts, and by hygroscopic nature sets up surface tension which limits evaporation of the soil moisture into the air. As an additive value of the calcium chloride it also acts as a dust palliative,

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Date 4/8/40

ABSTRACTS

Subject: Road Stabilization.

Purpose: Study on Research Problem.

Reference:

Author: _____

Title: Stabilising Gravel Roads in Onondaga County, N.Y.

Source: Engineering News Record.

Date: December 2, 1933

Volume and page: Vol. 111 pp. 529 - 52

Contents:

Roads are constructed from pit run gravel and when it does not have a balanced grading the deficiencies are added to it to the correct the needed amount. The difference of this type of road to common gravel is in the addition of calcium chloride to the surface. Penetration of the surface layers by the chemical develops moisture film cohesion, consolidation of the clay which produces high internal friction, giving high induration of the road surface.

Maintenance of this type of road calls for honing down of the surface and retreatment at intervals with calcium chloride. Retreatment comes about twice a year with about $\frac{1}{2}$ of a pound per square yard. Honing should be done following a rain so as not to waste the calcium chloride, since chloride goes down with rain to return by capillary action when the soil dries out on the surface.

The theory of calcium gravel road is: If a gravel-sand mixture, graded to obtain maximum interlocking and supplemented by

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capillary action. Calcium chloride should be applied during the dryout period following a rain, when the surface has been properly leveled and bladed with a grader. When not able to apply it following a rain it should be applied in the early hours of the day. Calcium chloride should never be applied just prior to a rain since most of it is wasted by washing away.

An important factor in a stabilized road is to always maintain a crown of at least $\frac{1}{8}$ " per foot and not more than $\frac{5}{4}$ " per foot. Another important factor is the drainage of the surface and the subgrade for a well maintained stabilized road.

For the best maintenance the thin layers of stabilized road material should be added periodically.

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No. _____

Date 4/4/40

ABSTRACTS

Subject: Maintenance of Stabilized Gravel Roads.

Purpose: Study on Research Problem.

Reference:

Author: E. C. Tinney.

Title: Maintenance Methods of Stabilized Gravel Roads.

Source: Engineering News Record.

Date: November 16, 1933.

Volume and page: Vol. 111, pp. 594 - 5

Contents:

The old theory was that there should be a thin mulch of fine gravel on the road and it should be bladed frequently, but today the practice is to stabilize the road and no loose mulch or raveling occurs, and blading is done only following a rain.

With long periods of dry weather the road may develop small holes and these should be patched with the same grade of gravel as the surface is made up of mixed with calcium chloride added to provide the moisture for the compaction operation. When the time comes for blading and scraping it should be done intensively before the road dries out and the calcium chloride returns to the surface layers by capillary action.

Calcium chloride added to a road surface to maintain constant moisture content in the road at all times and prevents raveling and dust hazards. During a rain the calcium chloride solution in the soil goes deeper into the road bed and on the drying action of the road bed it comes to the surface again by

Let $f(x) = x^2 + 3x - 5$. Find $f'(x)$.

Answer: $f'(x) = 2x + 3$

Problem 1.1

Problem 1.2

Problem 1.3

Problem 1.4

Problem 1.5

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Problem 1.8

Problem 1.9

Problem 1.10

(Cont.)

moisture change and calcium chloride is added to obtain this condition.

The elementary soil properties which effect stability are: the internal friction, cohesion, capillarity, compressibility and elasticity. Internal friction and cohesion are the properties most desired in stabilizing soils.

Soil fines are made up of the fine sand, silt and clay. Soil mortar includes all of the material passing a No. 10 sieve, and on which mechanical analysis is determined.

The plasticity index is a measure of the cohesion of a soil. Plasticity index is the difference of liquid limit and the plastic limit of a given soil.

For maximum stability you must have: (1) true cohesion of soil fines, plasticity index between 6 - 14; (2) resistance of soil fines to water absorption; (3) moisture film cohesion in soil fines. Calcium chloride serves this purpose by absorption of water from the atmosphere; (4) internal friction of soil fines, which requires about one third of the soil fines to be fine sand; (5) quantity of soil fines, 30 - 50% of soil fines by weight are required.

The function of the calcium chloride is to provide the moisture for the proper cohesion in dry weather. Calcium chloride will dissolve in one pound of water approximately one pound of flake. The absorption power of calcium chloride varies with the relative humidity of the atmosphere.

Evaporation from calcium chloride solution decreases as the solution increases until a point of balance is reached.

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Project
No. _____

Date 4/9/40

ABSTRACTS

Subject: Stabilized Soil Pound Road Surfaces.

Purpose: Study of Research Problem.

Reference:

Author: W. R. Collings & L. C. Stewart.

Title: Theory of Soil Stabilization (Part 1)

Source: Engineering News Record.

Date: May 24, 1934.

Volume and page: Vol. 112 pp. 660 - 64

Contents:

Soil stabilization is defined as the proper combination or adjustment of the various soil fines and coarse material to produce a mixture that is stable in all kinds of weather and under all conditions of traffic, using local materials. The stabilization of a road surface is the same principal with calcium chloride added to supply the necessary moisture for cohesion of the various materials.

The reasons for the growing popularity of stabilized roads are (1) low cost, (2) minimum of maintenance required to maintain good roads, (3) hazard of loose pebbles and dust is eliminated.

The constituents of a stabilized road surface are gravel, coarse sand, fine sand, silt and clay. The moisture content is a very important factor in soil stability. Small amounts of water will act as a binder and excessive amounts will act as a lubricant. The most stable soils will resist any radial

the 1990s, the number of people in the world who are illiterate has increased from 1.2 billion to 1.5 billion. The number of illiterate people in the world is expected to reach 1.7 billion by the year 2015. The number of illiterate people in the world is expected to reach 1.7 billion by the year 2015. The number of illiterate people in the world is expected to reach 1.7 billion by the year 2015.

1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 26

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Figure 1. The effect of the number of trials on the number of correct responses. The number of correct responses was significantly higher than the number of incorrect responses for all conditions. The number of correct responses was significantly higher than the number of incorrect responses for all conditions. The number of correct responses was significantly higher than the number of incorrect responses for all conditions.

Figure 1. The effect of the number of trials on the number of correct responses. The number of correct responses was significantly higher than the number of incorrect responses in all cases. The number of correct responses was significantly higher than the number of incorrect responses in all cases. The number of correct responses was significantly higher than the number of incorrect responses in all cases.

Table 1. Demographic characteristics of study population

[illegible][illegible]

MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 4/9/40

ABSTRACTS

Subject: Stabilized Soil Bound Road Surfaces.

Purpose: Study on Research Thesis.

Reference:

Author: W. R. Collings & L. C. Stewart.

Title: Traffic Tests on Trail Roads. (Part 11)

Source: Engineering News Record.

Date: June 7, 1934.

Volume and page: Vol. 112, pp. 738 - 43

Contents:

General discussion of the construction of a test track
and of the operation of the same.

Some of the observations were:

(1) Wearing coarse mixtures having 50% soil mortar,
P.I. should be between 10 - 15 for the best wearing qualities.

(2) Some silt is valuable in improving both wet and dry
stability.

(3) Dry-weather raveling reduced by addition of $\frac{1}{2}$ pound
of calcium chloride per square yard.

(4) A P.I. of 5 or more required to obtain the desired
resistance to raveling under dry conditions when used with cal-
cium chloride.

the 1990s, the number of people in the world who are under 15 years of age is expected to increase from 1.1 billion to 1.5 billion. The number of people aged 65 and over is expected to increase from 200 million to 400 million. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion.

1. *Chlorophyll a* and *Chlorophyll b* were determined by the method of Lichtenthaler and Whistler (1972).

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Trial	Control	MCI	AD
1	95	85	75
2	95	85	75
3	95	80	70
4	95	78	68
5	95	75	65

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MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 4/9/40

ABSTRACTS

Subject: Stabilized Soil-bound Road Surfaces.

Purpose: Study on Research Problem.

Reference:

Author: W. R. Collings & L. C. Stewart.

Title: Construction & Maintenance (Part 111)

Source: Engineering News Record.

Date: June 14, 1934

Volume and page: Vol. 112, pp. 772 - 75

Contents:

Drainage is the first essential to consider in stabilized road construction.

Road mixing has been found to be the most adaptable and most used method of mixing stabilized road materials.

The most desirable clays are very cohesive and sticky. Clay put on road and then pulverized with pring tooth harrows or rolled to crush lumps of clay. Most of the moisture must be removed to obtain degree of fineness desired.

When shaping is started the materials are dampened slightly and extra material from windrows is bladed in for compaction. Compaction should be continued until the surface is dried out.

Calcium chloride added to surface and its purpose is to retain moisture and increase the cohesive powers. The crown should be maintained at 1/8" per foot.

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MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 4/11/40

ABSTRACTS

Subject: Stabilized Soil Bound Road Surfaces.

Purpose: Study on Research Problem.

Reference:

Author: W. R. Collings & L.C. Stewart.

Title: Construction & Maintenance Costs. (part IV)

Source: Engineering News Record.

Date: June 21, 1934

Volume and page: Vol. 112 pp. 806 - 8

Contents:

Cost practically the same to build a stabilized road as it does to resurface and stabilize the surface of an old gravel road. The large item of the cost is the purchasing and transportation of the clay.

The average cost of the materials, labor, and incidentals per mile was between \$275 and \$300 for a stabilized road.

The maintenance cost is made up of: (1) scraping expense, (2) replacement of material lost from surface, (3) the cost of the calcium chloride for surface treatment. The scraping cost on a stabilized road is only about one half that on a gravel road.

Stabilization with calcium chloride reduces the loss of material from the road surface as dust and raveling.

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(Cont.)

material passing the No. 40 sieve should be between 1 - 15, and a liquid limit not exceeding 35.

A crown of not more than $\frac{5}{8}$ " and not less than $\frac{1}{4}$ " should be maintained, for surface drainage and any other precautions for drainage should be carefully considered.

Use about two pounds of rock salt per square yard of road surface and build up road in layers of 1 to 2 inches in thickness.

MICHIGAN
STATE HIGHWAY DEPARTMENTMurray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project

No. _____

Date 4/15/40

ABSTRACTS

Subject: Road StabilizationPurpose: Study on Research Problem.

Reference:

Author: _____

Title: Salt Stabilized Road Practice Developing Rapidly.Source: Engineering News Record.Date: July 4, 1935Volume and page: Vol. 115, pp. 11 - 13

Contents:

Soil stabilization is a process of combining the friction aggregates and the clay binder to produce a stable mixture. For the clay to have it's maximum binding qualities it must have moisture and under evaporation the retention of the moisture calls for the addition of a moisture holding element to the soil, and in a salt stabilized road common salt is used. The addition of the salt also aids the clay as a binder and reduces the volume of shrinkage and causes very little change in the field moisture percentage.

When evaporation takes place the salt brine crystallizes and forms a crust which seals the surface from any further evaporation. When rain occurs the crystals are dissolved and the brine solution settles into the road to rise again by capillary action when evaporation starts again.

For Salt-stabilized roads the plasticity index of the

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STATE HIGHWAY DEPARTMENTMurray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____Date 4/15/40

ABSTRACTS

Subject: Stabilized Road Surfaces.Purpose: Study on Research Problem.

Reference:

Author: L. C. Stewart & S. J. White.Title: Premixed Stabilized Soil for Road Surfaces.Source: Engineering News Record.Date: September 19, 1935Volume and page: Vol. 115, pp. 389 - 91

Contents:

The general practice is to mix the materials on the roadbed for stabilized roads, but now the practice is leaning toward plant mixing and hauling it to the job in trucks.

The article gives a general plan and layout of mixing plant and details concerning its operation.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial matters. The text suggests that organizations should implement robust systems to track every detail, from procurement to sales, to ensure that all data is reliable and accessible.

2. The second part of the document addresses the challenges of data management in a rapidly changing environment. It highlights the need for flexible and scalable solutions that can adapt to new technologies and evolving business requirements. The author argues that investing in modern data infrastructure is not just a technical necessity but a strategic imperative for long-term success.

3. The third part of the document explores the role of data in decision-making. It argues that data-driven insights are crucial for identifying trends, opportunities, and risks. The text provides examples of how organizations can leverage analytics to optimize operations, improve customer experiences, and drive innovation. It also stresses the importance of data security and privacy in this context.

4. The fourth part of the document discusses the importance of collaboration and communication in achieving organizational goals. It suggests that cross-functional teams and open communication channels are essential for sharing knowledge, resources, and best practices. The author encourages a culture of transparency and mutual support, where team members are empowered to contribute their ideas and expertise.

5. The fifth part of the document concludes with a call to action, urging organizations to embrace change and innovation. It reminds readers that the only way to stay competitive in a dynamic market is by continuously learning and adapting. The text ends with a positive note, expressing confidence in the future of organizations that commit to these principles.

MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 4/15/40

ABSTRACTS

Subject: Soil Stabilization

Purpose: Study on Research Problem.

Reference:

Author: C. A. Hogentogler.

Title: Practical Soil Stabilization.

Source: Roads & Streets.

Date: March 1935

Volume and page: Vol. 78, pp. 92 - 99

Contents:

The materials that furnish internal friction in the soil are sand, gravel, ground slag or crushed stone, and the cohesion is furnished by the clays and the moisture films in the soils.

The grading of the material is a deciding factor as to stabilized condition will be obtained with a soil. The ultimate stability depends on the permanent adhesive strength of the binder films between the soil particles.

(Con't)

factor and should be very carefully controlled. There is no need for an excessive crown, but one of about .4 to .5 of an inch should be maintained and this give plenty for good drainage too.

Maintenance on a stabilized road is different than on ordinary gravel roads. Blading should be done only following a rain for two reasons, (1) Easier workability, (2) Presence of sufficient moisture to permit consolidation and reshaping loose laying material under traffic. Patching can be carried on with roads when weather does not permit blading, and patching material same as original road metal.

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STATE HIGHWAY DEPARTMENTMurray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project

No. _____

Date 4/16/40

ABSTRACTS

Subject: Road StabilizationPurpose: Study on Research Problem.

Reference:

Author: Fred EurggrafTitle: Progress in Road Stabilization.Source: Roads & StreetsDate: April 1935Volume and page: Vol. 78, pp. 135 -6

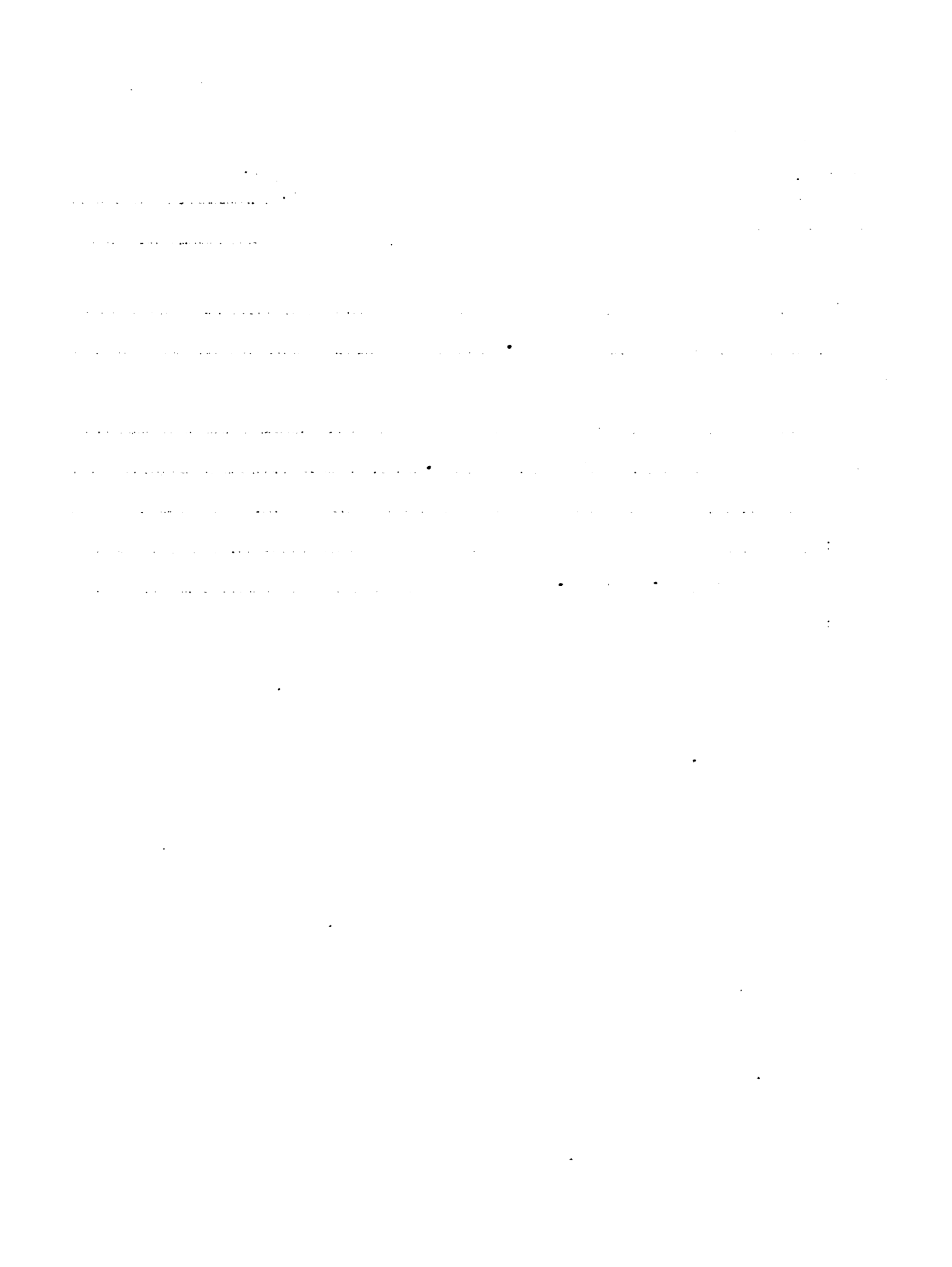
Contents:

The stabilization depends on the gradation and proportioned quantities, quality of the binder soil, and the degree of compaction with calcium chloride added to give proper moisture films.

Calcium chloride was originally used only as a surface treatment, but is now used as an integral treatment too. With the integral use of it, the compaction has been greatly accelerated and the moisture is regulated.

The materials were originally mixed on the surface of the road with graders but at present they are mixing the materials in either portable mixers or plant mixers on the roads. The compaction was originally handled with rollers but it is present practice to do compacting with truck traffic to a better advantage.

The crown on the stabilized road is a very important



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a thin layer of the mixed material is added. This operation continues until all of the mixed material is placed and the crown is maintained at $\frac{1}{8}$ " per foot during the compaction with controlled truck traffic; (8) after sufficient compaction the road is smoothed with a blade grader.

With a plant mix the mixture is hauled to the road and applied instead of previous description.

Average cost per mile of stabilized surface 3" thick is about \$1,650. The plant mix averages a saving of \$200 per mile. The average yearly cost of maintenance per mile is \$320 over an 18 mile section.

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STATE HIGHWAY DEPARTMENTMurray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project

No. _____

Date 4/23/40

ABSTRACTS

Subject: Stabilized Roads.Purpose: Study on Research Problem.

Reference:

Author: John H. Barr.Title: Stabilized Surface Methods & costs.Source: Engineering News Record.Date: June 27, 1935Volume and page: Vol. 114 pp. 907 - 8

Contents:

The first consideration in stabilized projects is the location of materials in proximity of the project. Clays used for stabilization should have a high P.I. since it is a measure of the cohesive properties of the clay. One of the prime requisites is a proper gradation in the mixture and the proportions of each grade.

The steps in the construction are as follows: (1) Windrows all loose material on the road to the center; (2) add the material to the windrow to give a course 3" thick and 20' wide; (3) Clay is added to give desired mix with the proper P.I.; (4) dry clay out and blade it back to the shoulders of the road; (5) spread the windrows of gravel and then the clay over it with the addition of calcium chloride at the rate of 4 tons per mile; (6) mix the materials thoroughly by blading and windrow it to the shoulders again by blading; (7) Road bed is moistened and then

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STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project

No. _____

Date 4/24/40

ABSTRACTS

Subject: Stabilized Surfaces.

Purpose: Study on Research Problem.

Reference:

Author: H. G. Sours.

Title: Stabilized Soil Road Maintenance.

Source: Engineering News Record.

Date: June 27, 1935

Volume and page: Vol. 114 pp. 910

Contents:

All of the loose and floating material should be avoided on a stabilized roads during dry weather since it acts as an abrasive and breaks down the road metal., to cause raveling.

Blading should be done only following rains so that the surface is workable and the calcium chloride has penetrated into the road so it will not be disturbed by the blading operations.

Small amounts of loose aggregate with sufficient binder soil may be bladed over the surface to fill the small holes. Material for blading is stored on the shoulders.

Patching small holes is not advisable but large holes should be filled with 50% graded gravel and 50% sand and clay mixture, with 100 - 150 pounds of calcium chloride per cubic yard.

MICHIGAN
STATE HIGHWAY DEPARTMENTMurray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project

No. _____

Date 4/ 22/40

ABSTRACTS

Subject: Stabilized Road Surfacing.Purpose: Study on Research Problem.

Reference:

Author: L.C. Stewart & S. J. White.Title: Plant Mixing of Stabilized Soil Road Surfacing Materials.Source: Roads & Streets.Date: November 1935Volume and page: Vol. 78, pp. 353-57

Contents:

The trend has been to have centralized mixing plants to deliver stabilized road mix to the roadbed for compaction.

The advantages of a central mixing plant are: (1) the use of expensive equipment is eliminated; (2) dust nuisance of mixing operation is eliminated, since the accurate is delivered to job damp; (3) more accurate control of properties and better mixing can be attained; (4) costly delays are eliminated while waiting for materials to dry; (5) road building season lengthened to nearly entire, year; (6) may be used by communities who don't own equipemtn for doing their own mixing.

There is a general discussion and discription of the central mixing plant and its operation.

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State Highway Commissioner

RESEARCH DIVISION

Project
No. _____Date 4/24/40

ABSTRACTS

Subject: Stabilization.Purpose: Study on Research Problem.

Reference:

Author: J.W. Reppel.Title: Experimental Stabilization in Ohio.Source: Roads & Streets.Date: December 1935Volume and page: Vol. 78 pp. 377 - 380

Contents:

Stabilized construction involves the use of a large part of the existing road metal and subgrade in conjunction with addition of binder soil as a cementing medium.

The road selected was graded down and loose material was windrowed on the sides. The stabilizing material ingredients were added to the road and mixed thoroughly. There were three sections tested, (1) with calcium chloride, (2) calcium magnesium chloride, (3) rock salt. All sections were compacted and worked in the same manner and after compaction the only variation was in the moisture contents. Calcium magnesium chloride was the most and rock salt the least satisfactory, but all were found to give satisfactory surfaces.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that this is crucial for ensuring transparency and accountability in the organization's operations.

2. The second part outlines the specific procedures for recording transactions, including the use of standardized forms and the requirement for double-checking entries to prevent errors.

3. The third part addresses the role of the accounting department in monitoring and reporting on the organization's financial health. It highlights the need for regular reviews and the timely submission of reports to the board of directors.

4. The fourth part discusses the importance of maintaining up-to-date financial statements and the impact of these statements on the organization's overall performance and reputation.

5. The fifth part provides a detailed overview of the organization's budgeting process, including the identification of key financial goals and the allocation of resources to meet these goals.

6. The sixth part discusses the importance of maintaining accurate records of all transactions and activities, which is a recurring theme throughout the document.

7. The seventh part outlines the specific procedures for recording transactions, including the use of standardized forms and the requirement for double-checking entries to prevent errors.

8. The eighth part addresses the role of the accounting department in monitoring and reporting on the organization's financial health, which is another recurring theme.

9. The ninth part discusses the importance of maintaining up-to-date financial statements and the impact of these statements on the organization's overall performance and reputation.

10. The tenth part provides a detailed overview of the organization's budgeting process, including the identification of key financial goals and the allocation of resources to meet these goals.

(Con't.)

act to furnish structural strength, hardness and friction. The fine sand adds inbedment support to the coarse sand. Silt acts as a filler to prevent the granular particles from roaking. Clay and colloids furnish close texture to have fine moisture films to produce high cohesion.

The necessity for maintaining the moisture in the clay binder is taken care of by adding salt to the stabilized mixture and this acts to retain the soil moisture.

It is very essential to have proper drainage on stabilized roads and without it the roads are not satisfactory.

Roads of this type need very little maintenance and when bladed it should be done following a rain or in the spring., when the surface is workable and will not tear up when worked. Applications of salt and new material are made in the spring and compacted down as part of original road metal. Binder materials may be taken from the shoulders when needed.

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RESEARCH DIVISION

Project

No. _____

Date 4/24/40

ABSTRACTS

Subject: Road Stabilization.Purpose: Study on Research Problem.

Reference:

Author: _____

Title: Use of ^ARock Salt in Stabilized Road Construction.Source: Roads & Streets.Date: August 1935Volume and page: Vol. 78, pp 269 - 71

Contents:

The secondary roads can be divided into two classes: (1) floating surface type; (2) soil stabilized type. On the floating surface type the material is loose and requires some constant maintenance to have good surface while on soil stabilized type the coarse material is held in place by the binder soil. This type does not require constant maintenance and remains a good surface.

A stabilized road consists of a compacted wearing course of gravel, sand, and the natural soil binder, which includes sand, silt and clay. These materials are mixed to give all weather stability.

The requirements of a stabilized soil road are that it be laid and compacted to conform to a satisfactory grade, typical cross-section and satisfactory finished surface.

In a stabilized road the coarse aggregate and coarse sand

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Project

No. _____

Date 4/23/40

ABSTRACTS

Subject: Stabilized Construction.Purpose: Study on Research Problem.

Reference:

Author: J. C. ElsakTitle: Plantemized Stabilized Construction in Illinois.Source: Roads & Streets.Date: August 1936Volume and page: Vol. 79, pp.21-24

Contents:

Job consists of mixutre of one part clay by weight to ten parts of sand and one pound of calcium chloride per square yard laid. After surface as been down two to four weeks, and well compacted, an additional $\frac{1}{2}$ pound of calcium chloride per square yard is spread only on surface.

Article gives a general procedure of consturcting old road into new stabilized surface and a discussion of the mixing plant and its operation for stabilized materials.

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RESEARCH DIVISION

Project

No. _____

Date 4/25/40

ABSTRACTS

Subject: Road StabilizationPurpose: Study On Research Problem.

Reference:

Author: S. O. Linsell.Title: Stabilized Road Surfacing in Ohio.Source: Roads & Streets.Date: November 1936Volume and page: Vol. 79, pp. 56 - 60

Contents:

This article deals with the discussion of the building up of a road and finding it not suitable for traffic, they proceeded to stabilize it by the addition of soil binder and calcium chloride which produced a very satisfactory road.

The aggregate on the road was mixed with fine sand and clay. The clay had a plasticity index of 14. The proportions were, 55% coarse aggregate, 20% sand, and 25% clay. One pound of calcium chloride was added per sq. yd. of surface and one pound per sq. yard added later on surface.

The maintenance cost was cut considerably on the stabilized roads.

(Con't)

There is a general grading scale given and the amounts of each used for the best results. The P.I. for the material passing a No. 40 sieve is given as between 6 - 15, and the liquid limit not to exceed 25.

There is a general discussion of construction methods and the mixing of the stabilized materials.

The seasoning period is the period during compaction and the calcium chloride plays an important part during this period. It lowers the vapor pressure of the contained moisture and thus reducing evaporation, thereby giving greater density with the same degree of compaction.

There is a discussion of the maintenance of stabilized roads. Grading should be done only following a rain, when the surface is workable and the chloride solution is far enough in the road bed so it will not be exposed and wasted. Calcium chloride should be applied to the surface to maintain the stabilized surface and these applications are made following a rain or early in the mornings.

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RESEARCH DIVISION

Project

No. _____

Date 4/25/40

ABSTRACTS

Subject: StabilizationPurpose: Study on Research Problem.

Reference:

Author: H. F. ClemmerTitle: Stabilization of soilsSource: Roads & Streets.Date: December 1936Volume and page: Vol. 79, pp. 41 -44

Contents:

Main principle in stabilization is to obtain the maximum density from the existing sources of materials to give year around stabilization.

Too much clay makes roads rutty when wet and not enough clay will make them dusty and cause a loss of the road metal.

A stabilized road is vitally dependent on the continued presence of moisture in an optimum amount and this is obtained by many engineers by the use of calcium chloride as a moisture retentive.

The grading of soil materials should be such as to furnish sufficient coarse aggregate to assure resistance to abrasive action and to provide coarse and fine sand in proper proportions to interlock and prevent sliding during wet weather.

(con't)

The base is compacted in 1 yers about 3" thick and with regulated truck traffic or pneumatic tire rollers.

Both sodium & Calcium chloride have been used to retain the moisture during the compaction period, and they have both been found very effective.

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State Highway Commissioner

RESEARCH DIVISION

Project
No. _____Date 4/ 26/40

ABSTRACTS

Subject: Road StabilizationPurpose: Study of Research Problem.

Reference:

Author: A. E. Stoddard.Title: Stabilized Base Construction.Source: Engineering News Record.Date: January 28, 1937Volume and page: Vol. 118 pp 122 - 3

Contents:

Common practice is to have a stabilized base from 3" to 12" thick and the average runs around 3". The stabilized base should be 2' - 4' wider than the road metal to prevent wearing of the edges.

The binder soil, clay, should be thoroughly pulverized before applying the compaction to the road surface. The clay may be pulverized on the road bed or in the pit with pulverizing machinery.

The materials may be either road mixed or plant mixed depending on the conditions and the distance of haul. In the final stages of the mixing the moisture content must be corrected to the plastic limit of the mixture. The moisture content has a direct bearing on the density that can be attained upon compaction, and the moisture content must be maintained throughout the compaction period.

(Con't)

cium chloride is specified to mixture about $2/3$ is added to mixture and remaining $1/3$ added to surface of the compacted road metal.

Experience has shown that a pneumatic tire roller is the best method of compaction since it provides a kneading action along with the straight compaction. When compacting the proper crown should be maintained since it will allow surface water to run off and will prevent raveling. The crown should be maintained between $1/2"$ and $5/8"$ per foot.

All blading of surface should be done following rains when the road metal is workable and the chloride is below the road metal sufficiently to prevent it from being exposed directly to the air and wasted.

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RESEARCH DIVISION

Project
No. _____Date 4/26/40

ABSTRACTS

Subject: Road StabilizationPurpose: Study on Research Problem.

Reference:

Author: L. L. Allen.Title: Methods & Costs of Road Stabilization in Minnesota.Source: Roads and Streets.Date: March 1937Volume and page: Vol. 80 , pp. 63-68

Contents:

The classification of stabilized roads are; (1) natural soil mixtures, (2) treatment with substances involving chemical reactions productive of permanent crystallization, (3) treatment with bituminous material, (4) treatment with a flocculating substances, (5) treatment with a flocculating chemical, as calcium chloride.

The plasticity index ranges between 6-15 for material passing a 40 mesh sieve. The thickness varies from 3-12 inches depending on the base.

The soil binder is pulverized on the road bed by traffic and also by working it with harrows and disks. When properly pulverized the soil binder is mixed with the gravel material and spread on the road bed to insure thorough mixing. When spread out on the road it is sprinkled with water and compaction of layer about 3" thick is started. When cal-

(Con't)

There are three methods of constructing soil graded roads: (1) Plant mix; (2) Road mix; (3) Stage Construction. In stage construction the material is just added to the road in amounts needed and it is depressed with traffic action and is regularly bladed and dragged.

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Project

No. _____

Date 4/29/40

ABSTRACTS

Subject: Stabilized Roads.Purpose: Study on Research Problem.

Reference:

Author: C. A. Hogentogler & E. A. Willis.Title: Stabilized Soil Roads.Source: Civil Engineer.Date: December 1935Volume and page: Vol. 5 , pp. 758 - 60

Contents:

Admixtures of soil materials are to provide a road material containing enough coarse aggregate to resist the abrashive action of traffic, coarse and fine sand to provide interlocking action and prevent sliding, silt to act as a filler, and provide capillary bod and clay to retain minute cohesive films to give stability. A delequesent chemical is added to maintain the surface dampness and calcium chloride is used for this. These chemicals have the property of absorbing moisture from the air and slows up action of evaportation.

The stability of a soil is dependent on the thin films of moisture surrounding the soil particals and the funtion of the calcium chloride is to displace the air films, that originally surround the particles, with moisture films.

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Shrinkage and swell must be under complete control is soil is to have proper stability for use in road building. Drainage is one of the prime requisits for good road construction.

Potassium clay is the most stable since it has less molecules surrounding it, and lithium clay the most unstable.

The principal aims of soils stabilization are; (1) make soil as dense as possible; (2) to prevent moisture films from changing.

Subgrade soils for the maximum stability must have the proper proportions of additional aggregate and binder soil. The density of the proportions depends on the thickness of the moisture films.

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Project
No. _____

Date _____

ABSTRACTS

4/29/40

Subject: _____

Purpose: ~~Soils Stabilization~~ _____

Reference: Study on Research Problem.

Author: _____

Title: ~~V. J. Brown~~ _____

Source: ~~Soil Stabilization (Part 1)~~ _____

Date: ~~Roads and Streets.~~ _____

Volume and page: ~~February 1938~~ _____

Contents: Vol. 81, pp. 25 - 30

Soil stabilization is the process of giving natural soils enough adhesive resistance and shear strength to accommodate traffic or loads under prevalent weather conditions, without detrimental deformation.

The optimum water content is fundamental with gradation.

The general methods of accomplishing stabilization are as follows:- (1) selection of natural soil with binder which furnishes high stability; (2) Adding soil binder to granular material or adding granular materials to clays; (3) Treating graded soils with delequent substance; (4) waterproofing soil with bituminous surface; (5) densification of natural soil by any means. The location will decide the method to be used and the materials to be used.

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2. The second part of the document is a list of the names of the persons who have been named in the document.

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Project
No. _____

Date 4/29/40

ABSTRACTS

Subject: Soil Stabilization

Purpose: Study on Research Problem.

Reference:

Author: V. T. Brown & C. A. Hogentogler, Jr.

Title: Soil Stabilization (Part 2)

Source: Roads & Streets

Date: March 1938

Volume and page: Vol. 81, pp. 33 - 40

Contents:

Article deals with testing methods and the classification of soil. The important properties of a soil are; (1) Texture; (2) Color; (3) Structure; (4) Consistency; (5) compressability; (6) Chemical composition. These are the properties that are noticed during the soil survey.

General discussion and discription of the tests run to determine properties of the soil. Such tests as plastic limit, liquid limit, Mechanical analysis, Moisture equivalents and shrinkage tests.

1. Introduction

The purpose of this report is to provide a comprehensive overview of the current state of the art in the field of artificial intelligence (AI) and its applications. This report will discuss the various sub-fields of AI, including machine learning, natural language processing, and computer vision, and will explore the challenges and opportunities associated with these technologies.

The report is organized as follows: Section 2 provides a brief history of AI, while Section 3 discusses the current state of the art in machine learning.

2. History

The field of artificial intelligence has a long and rich history, dating back to the early 20th century. The first major milestone in the history of AI was the creation of the first artificial neural network in 1943 by Warren McCulloch and Walter Pitts.

In the 1950s, the field of AI was dominated by the work of Alan Turing, who is widely regarded as the father of computer science. Turing's work on the Turing test, which is a method for determining whether a machine is capable of exhibiting intelligent behavior, is still a cornerstone of the field.

3. Machine Learning

Machine learning is a sub-field of AI that focuses on the development of algorithms that can learn from data and make predictions or decisions based on that data. There are three main types of machine learning: supervised learning, unsupervised learning, and reinforcement learning.

Supervised learning involves training a model on a dataset of labeled examples, so that it can learn to map new, unlabeled examples to the same labels. Unsupervised learning involves training a model on a dataset of unlabeled examples, so that it can learn to find patterns or structure in the data.

Reinforcement learning involves training a model to learn how to take actions in an environment in order to maximize a reward. This type of learning is often used in the development of intelligent agents, such as those used in video games or robotics.

Machine learning has a wide range of applications, from spam filtering and image recognition to recommendation systems and autonomous vehicles. It is one of the most rapidly growing and exciting areas of research in AI today.

There are many challenges associated with machine learning, including the need for large amounts of data, the risk of overfitting, and the difficulty of interpreting the results of the models. However, the potential benefits of machine learning are enormous, and it is likely to continue to play a major role in the development of AI for many years to come.

4. Conclusion

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No. _____

Date 4/30/40

ABSTRACTS

Subject: Soil Stabilization

Purpose: Study on Research Problem.

Reference:

Author: V. J. Brown.

Title: Soil Stabilization (Part 3)

Source: Roads & Streets.

Date: April 1938

Volume and page: Vol. 81, pp 33 - 40

Contents:

Article contains a general discussion of the methods of mixing aggregates and the mixes used with gradation scales.

Discussion of four types of stabilized road surfaces;
(1) Graded mix of best local materials, (2) Graded mix with proportioned mix, (3) Graded mix with bituminous surface treatment, (4) Natural soil base stabilized with admixtures.

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1. 1990年12月25日，苏联正式宣布解体，俄罗斯联邦成为独立国家。

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Project
No. _____

Date 4/30/40

ABSTRACTS

Subject: Soil Stabilization

Purpose: Study on Research Problem.

Reference:

Author: V. J. Brown

Title: Soil Stabilization (Part 4)

Source: Roads & Streets

Date: May 1938

Volume and page: Vol. 81, pp. 33 & 39

Contents:

General discussion of soil tests concerning internal friction, cohesion, shear and moisture variations.

By constructing curves of different properties and conditions of saturation or maximum density, from these curves you can determine the future behavior of the soils for different field conditions.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that this is crucial for ensuring transparency and accountability in the organization's operations.

2. The second part outlines the specific procedures for recording and reporting data. It details the steps involved in data collection, analysis, and the frequency of reporting to the relevant stakeholders.

3. The third part addresses the challenges associated with data management and provides strategies to overcome them. It highlights the need for robust security measures to protect sensitive information from unauthorized access.

4. The fourth part discusses the role of technology in enhancing data management processes. It explores various software solutions and tools that can streamline data collection, storage, and analysis.

5. The fifth part focuses on the importance of training and development for staff involved in data management. It stresses that continuous learning is essential to keep up with the latest trends and technologies in the field.

6. The sixth part provides a summary of the key points discussed throughout the document. It reiterates the importance of a systematic approach to data management and the role of each team member in ensuring its success.

7. The final part offers concluding remarks and expresses the organization's commitment to maintaining high standards of data management and reporting.

8. The document also includes a section on the importance of regular audits and reviews. It states that these are necessary to identify any discrepancies or errors in the data and to ensure that the reporting process remains effective and efficient.

9. Additionally, it mentions the need for clear communication and collaboration between different departments. This is essential for ensuring that all relevant information is captured and reported accurately.

10. The document concludes by expressing the organization's confidence in the ability of its staff to implement these guidelines and maintain the highest standards of data management.

11. It also includes a list of references to various sources of information used in the preparation of the document, ensuring that all claims and recommendations are backed by credible evidence.

12. Finally, the document provides contact information for the relevant departments, allowing stakeholders to reach out for further information or assistance.

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Project
No. _____

Date 4/30/40

ABSTRACTS

Subject: Soil Stabilization

Purpose: Study on Research Problem.

Reference:

Author: Frank H Newman, Jr.

Title: Soil Stabilization (Part 5)

Source: Roads & Streets.

Date: September 1938

Volume and page: Vol. 81, pp. 44 - 49

Contents:

The article deals with a discussion of the test methods in the Texas Highway Department in soils stabilization work.

The most important soil tests used are liquid limit, plasticity index and linear shrinkage.

There is a comparison of a number of tests samples taken from highways of known behavior and correlated and charted.

The present requirements of the Texas Highway Department are: (1) Passing 2"100%

Passing 40 mesh 15% - 50%

Passing liquid limit of binder .. Less than 45

Plasticity index of soil binder.. Less than 15

Linear shrinkage soil binder Less than 8.5

the 1990s, the number of people in the world who are illiterate has increased from 1.1 billion to 1.5 billion. The number of illiterate people in the world is projected to reach 1.7 billion by the year 2015. The number of illiterate people in the world is projected to reach 1.7 billion by the year 2015. The number of illiterate people in the world is projected to reach 1.7 billion by the year 2015.

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1. *Chlorophyll a* (Chl *a*) and *Chlorophyll b* (Chl *b*) were determined using a spectrophotometer (Shimadzu UV-1601U) at 663 nm and 646 nm, respectively. The concentrations of Chl *a* and Chl *b* were calculated using the following equations: Chl *a* (mg g⁻¹) = 12.7 (OD₆₆₃ - 2.13 OD₆₄₆) and Chl *b* (mg g⁻¹) = 22.9 (OD₆₄₆ - 0.21 OD₆₆₃).

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Figure 1. A schematic diagram of the experimental design. The subjects were divided into two groups: the control group and the experimental group. The control group received a standard training program, while the experimental group received a modified training program. The experimental group was further divided into two subgroups: the low-intensity group and the high-intensity group. The low-intensity group received a low-intensity training program, while the high-intensity group received a high-intensity training program. The subjects were then subjected to a series of tests to measure their performance and physiological responses.

1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 26

MICHIGAN
STATE HIGHWAY DEPARTMENTMurray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____Date 4/30/40

ABSTRACTS

Subject: Soil StabilizationPurpose: Study of Research Problem.

Reference:

Author: V. J. BrownTitle: Soil Stabilization(Part 6)Source: Roads & Streets.Date: December 1938Volume and page: Vol. 81. pp. 43.-46

Contents:

The article explains the use of and advantages of a stabilimeter for determining usable values and the principle upon which it is built.

1.1. The first part of the paper is devoted to the study of the properties of the function $f(x)$ defined by the equation

$f(x) = \int_0^x f(t) dt$ for $x \in [0, 1]$. It is shown that $f(x)$ is a continuous function on $[0, 1]$ and that $f(0) = 0$.

1.2. In the second part of the paper, we study the properties of the function $f(x)$ defined by the equation

$$f(x) = \int_0^x f(t) dt$$

for $x \in [0, 1]$. It is shown that $f(x)$ is a continuous function on $[0, 1]$ and that $f(0) = 0$.

1.3. In the third part of the paper, we study the properties of the function $f(x)$ defined by the equation

$$f(x) = \int_0^x f(t) dt$$

for $x \in [0, 1]$. It is shown that $f(x)$ is a continuous function on $[0, 1]$ and that $f(0) = 0$.

1.4. In the fourth part of the paper, we study the properties of the function $f(x)$ defined by the equation

$$f(x) = \int_0^x f(t) dt$$

for $x \in [0, 1]$. It is shown that $f(x)$ is a continuous function on $[0, 1]$ and that $f(0) = 0$.

1.5. In the fifth part of the paper, we study the properties of the function $f(x)$ defined by the equation

$$f(x) = \int_0^x f(t) dt$$

$$f(x) = \int_0^x f(t) dt$$

MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 4/30/40

ABSTRACTS

Subject: Stabilization of Soils.

Purpose: Study on Research Problem.

Reference:

Author: J. C. Flack

Title: Production and use of stabilized Maintenance Material in
Southern Michigan.

Source: Roads & Streets.

Date: June 1938

Volume and page: Vol. 81, pp. 33 - 39

Contents:

The article gives the specifications set up by the Highway Department for the job and the amount of materials or ingrediants to use for said job.

There is a general discussion and discription of the equipment and operation of such equipment and the stabilis-
ation practice.

The author tells of the hauling and placing of the stabilized material on the road shoulders and the compaction used. The project proved very satisfactory and is used a great deal today in all sections of the country.

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STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 5/1/40

ABSTRACTS

Subject: Stabilized Soils.

Purpose: Study on Research Problem.

Reference:

Author: E. A. Willis

Title: Graded soil Mixtures for Road Surface and Base Courses.

Source: Roads & Streets.

Date: January 1939

Volume and page: Vol. 82, pp. 25 - 30

Contents:

The following principles were presented in the article:

- (1) Control of both grading and plasticity index of the mixtures necessary to assure satisfactory service behavior over a period of years.
- (2) Thorough mixing is necessary to insure uniformity.
- (3) Presence of controlled amount of water is necessary before compacting action can produce maximum density. About 8% - 12% of water needed.
- (4) Should have completed and sufficient compaction of base course before adding surface course, to reduce movement in the base course.
- (5) Local materials can be used if properly proportioned.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that this is crucial for ensuring transparency and accountability in the organization's operations.

2. The second part outlines the specific procedures for recording and reporting these activities. It details the steps involved in data collection, analysis, and the preparation of reports for management review.

3. The third part addresses the challenges associated with implementing these procedures. It identifies common obstacles such as lack of resources, insufficient training, and resistance to change, and offers strategies to overcome them.

4. The fourth part discusses the role of technology in enhancing the efficiency and accuracy of the recording and reporting process. It highlights the benefits of using specialized software and digital tools to streamline data management and reporting.

5. The fifth part focuses on the importance of regular communication and collaboration between different departments and teams. It stresses that effective communication is essential for ensuring that everyone is on the same page and working towards common goals.

6. The sixth part provides a summary of the key points discussed in the document. It reiterates the importance of maintaining accurate records and the need for continuous improvement in the recording and reporting process.

7. The final part concludes the document with a call to action, encouraging all staff members to take ownership of their roles in maintaining accurate records and contributing to the overall success of the organization.

8. The document also includes a section on the importance of data security and privacy. It outlines the measures that should be taken to protect sensitive information from unauthorized access and ensure compliance with relevant regulations.

9. Additionally, there is a section on the importance of regular audits and reviews. It explains how these activities can help identify areas for improvement and ensure that the recording and reporting process remains effective and up-to-date.

10. The document concludes with a statement of commitment to transparency and accountability, reinforcing the organization's dedication to maintaining high standards of record-keeping and reporting.

MICHIGAN
STATE HIGHWAY DEPARTMENT

Murray D. Van Wagoner
State Highway Commissioner

RESEARCH DIVISION

Project
No. _____

Date 5/1/40

ABSTRACTS

Subject: Stabilization of Soils.

Purpose: Study on Research Problem.

Reference:

Author: D. M. Burmistuer

Title: Essential Consideration in Stabilization of Soils.

Source: American Society of Civil Engineers Proceedings.

Date: April 1938

Volume and page: Vol. 64, pp. 792 - 97

Contents:

Article contains a discussion of the essential qualities of soils for stabilization, and also a number of physical relation that are fundamental.

Some of the physical relations considered are, fineness, grading, plastic characteristics, coarse fraction of soil and clay content. There is also a general discussion on compaction tests and the grain size determination.

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1. $\frac{d}{dx} \left(x^2 + 1 \right) = 2x$ 2. $\frac{d}{dx} \left(x^3 + 2x^2 - 5x + 7 \right) = 3x^2 + 4x - 5$ 3. $\frac{d}{dx} \left(x^4 + 3x^3 - 2x^2 + x - 1 \right) = 4x^3 + 9x^2 - 4x + 1$ 4. $\frac{d}{dx} \left(x^5 + 4x^4 - 7x^3 + 6x^2 - 3x + 8 \right) = 5x^4 + 16x^3 - 21x^2 + 12x - 3$ 5. $\frac{d}{dx} \left(x^6 + 5x^5 - 8x^4 + 2x^3 - 9x^2 + 4x - 1 \right) = 6x^5 + 25x^4 - 32x^3 + 6x^2 - 18x + 4$ 6. $\frac{d}{dx} \left(x^7 + 6x^6 - 10x^5 + 4x^4 - 12x^3 + 8x^2 - 5x + 3 \right) = 7x^6 + 36x^5 - 50x^4 + 16x^3 - 36x^2 + 16x - 5$ 7. $\frac{d}{dx} \left(x^8 + 7x^7 - 14x^6 + 7x^5 - 21x^4 + 14x^3 - 7x^2 + 4x - 2 \right) = 8x^7 + 49x^6 - 84x^5 + 35x^4 - 84x^3 + 42x^2 - 14x + 4$ 8. $\frac{d}{dx} \left(x^9 + 8x^8 - 16x^7 + 8x^6 - 24x^5 + 16x^4 - 8x^3 + 5x^2 - 3x + 1 \right) = 9x^8 + 64x^7 - 112x^6 + 48x^5 - 120x^4 + 64x^3 - 24x^2 + 10x - 3$ 9. $\frac{d}{dx} \left(x^{10} + 9x^9 - 18x^8 + 9x^7 - 27x^6 + 18x^5 - 9x^4 + 6x^3 - 3x^2 + 2x - 1 \right) = 10x^9 + 81x^8 - 144x^7 + 63x^6 - 162x^5 + 90x^4 - 36x^3 + 18x^2 - 6x + 2$ 10. $\frac{d}{dx} \left(x^{11} + 10x^{10} - 20x^9 + 10x^8 - 30x^7 + 20x^6 - 10x^5 + 6x^4 - 3x^3 + 2x^2 - x + 1 \right) = 11x^{10} + 100x^9 - 180x^8 + 80x^7 - 210x^6 + 120x^5 - 50x^4 + 24x^3 - 9x^2 + 4x - 1$

1. *Journal of the American Medical Association*, 1997; 277: 1039-1043.

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1. *Journal of the American Medical Association*, 1997; 277: 1033-1036.

Figure 1. The effect of the number of trials on the number of correct responses. The number of correct responses was significantly higher than the number of incorrect responses for all groups. The number of correct responses was significantly higher than the number of incorrect responses for all groups. The number of correct responses was significantly higher than the number of incorrect responses for all groups.

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Part VI

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38. "Production and Use of Stabilized Maintenance Materials in Southern Michigan", by J.C. Black, "Roads and Streets", June 1938.
39. "Graded Soil Mixtures for Road Surface and Base Courses", by E.A. Willis, "Roads and Streets", January 1939.
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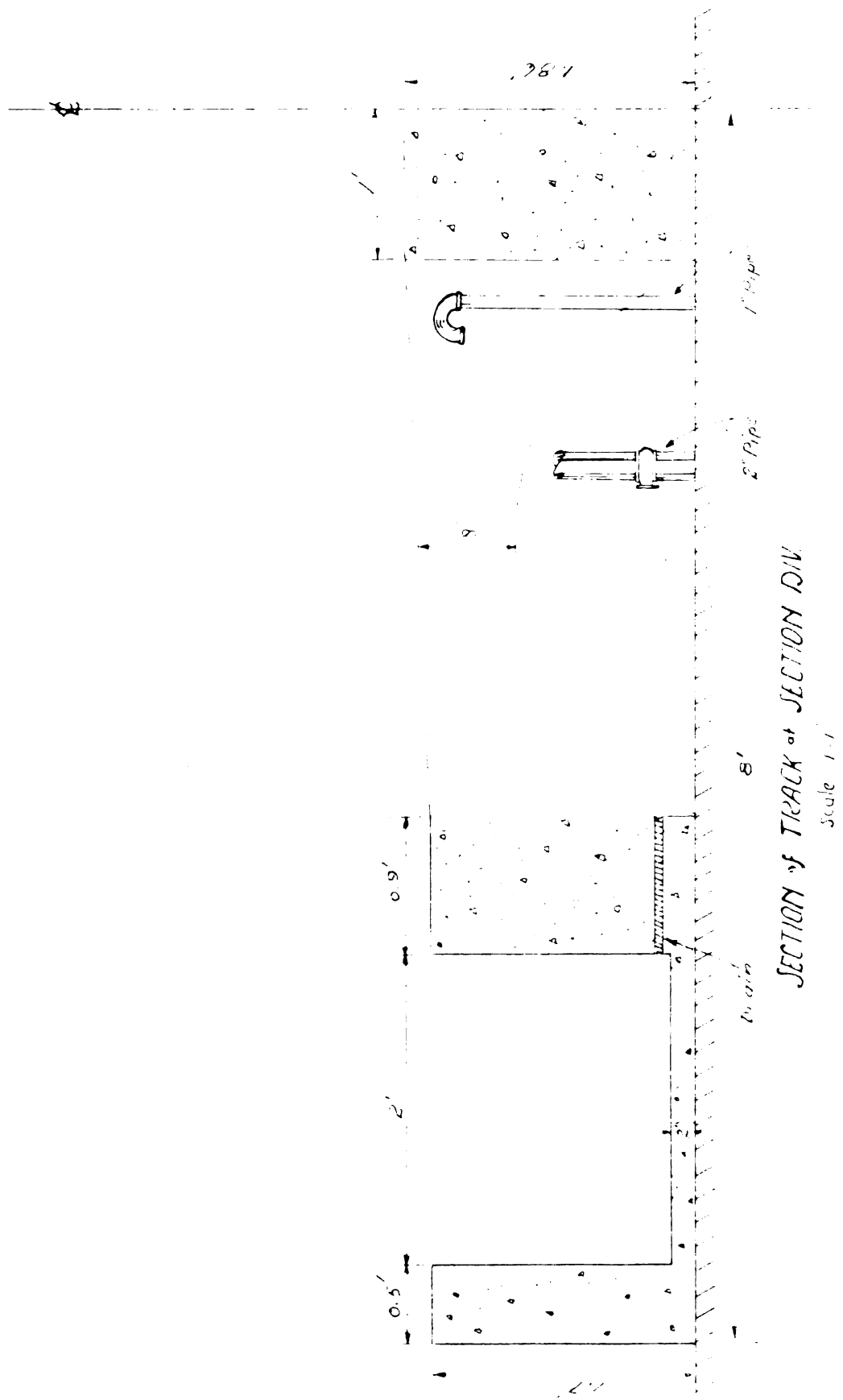
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Part VII



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